An Investigation of Early Forms of Index Finger Extension and Joint Engagement in the Development of Pointing

by

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Abstract

Human infants begin to point to objects around their first birthday, typically before they learn their first words. Pointing in infancy is associated with later social and communicative development and involves a level of complexity not found in other gestures, which is evident in the many functions it serves. Despite extensive research on pointing, there is a lack of consensus regarding the ontogenetic origins of this gesture. I argue that one reason for this is that the currently dominant cognitivist theoretical approach is grounded in problematic metatheoretical assumptions that constrain research in this area. For example, this approach has resulted in a focus on what communicative intentions infants are trying to express when they point, which I argue overlooks the process through which these intentions develop. An alternative is an activity-based approach, grounded in the process-relational worldview, which avoids pre-supposing communicative intentions in infants' emerging gestures and instead aims to investigate how this form of understanding develops within shared activities.

Accordingly, the present dissertation is based on the activity-based theory that pointing emerges through infants learning to anticipate others' responses to their initially non-communicative index finger use, within joint engagement with others. Through analyses of 33 caregiver-infant dyads' interactions within three routine activities at two time points, I found that index finger extensions not yet coordinated with the infant's gaze, and tactile exploration with the index finger at 9 months were significantly positively correlated with pointing at 12 months. Infants engaged in tactile exploration with all fingers before using the index finger to do this, which emerged and became more established through transitional phases. This was associated with time spent in infant-led joint engagement with caregivers, which was also significantly positively correlated with pointing three months later, whereas time spent in parent-led joint engagement was not. Finally, longitudinal qualitative observations of three dyads' joint engagement episodes suggest that alternating between responding to and re-directing the infant's attention might be more strongly associated with the emergence of pointing when compared to frequency of parental responses. The relevance of these findings for theories of communicative development and associated metatheoretical assumptions is discussed.

Keywords: pointing; gestures; cognitivism; activity-based; index finger; joint engagement

To my family

Thank you for surrounding me with your love and amazing humour every day

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List of Acronyms

IFT	Index Finger Touch
IFTExt	Index Finger Touch with other fingers Extended
IFTCurl	Index Finger Touch with other fingers Curled
SO	Slip Out index finger extensions
JE	Joint Engagement

Chapter 1. Introduction

Before they learn to speak a language, human infants learn to communicate with gestures. As pointing has not been found in other animals' communicative repertoire in the wild, investigating the emergence of this gesture provides insight into the origins of human forms of communication (e.g., Krause et al., 2018). Pointing already incorporates skills that form the basis of learning a language (Carpendale & Carpendale, 2010), and pointing behavior in infancy is associated with later social and communicative development (e.g., Butterworth & Morissette, 1996). Additionally, pointing involves a level of complexity that is not found in other gestures, which is evident in the many functions it serves, including to request objects, actions, and help, to ask and answer questions, to provide information, and to share interest. This has led to extensive research on the development of pointing in infancy, yet there is a lack of consensus about the ontogenetic origins of this form of communication, as well as the form of understanding required in infancy for the successful use of pointing gestures.

I argue that one reason for this disagreement is that the currently dominant cognitivist explanation is grounded in the problematic Dualist assumptions that mental states are separate from actions, and that infants are faced with the problem of getting to others' hidden mental states to make sense of their behavior (Begus & Southgate, 2012; Blake et al., 1994; Camaioni et al., 2004; Carpenter et al., 1983; Kovacs et al., 2014; Liszkowski et al., 2007; Lucca et al., 2016; Tomasello & Call, 1997; Tomasello et al., 2005; Tomasello et al., 2007; Tomasello, 2019). This approach often results in a search for the presence or absence of adult-like social understanding and, more specifically, the presence or absence of communicative intent. In the context of the development of pointing, supporters of this account argue that infants' pointing gestures are based on, and are caused by, underlying communicative intentions, such as an intention to help others, which is made possible by understanding others on a mental level.

Drawing on a Process-Relational conceptualization of meaning and communication, I argue that the cognitivist approach is problematic because attributing an adult-like understanding to infants leads to overlooking the importance of transitional events, emerging within relations between embodied infants and caregivers, that are key to communicative development. Supporters of the Process-Relational worldview, and

resulting activity-based approach[1], posit that infants develop a practical understanding[2] of social activity at first, which makes it possible for them to participate in triadic interactions in which pointing develops. Making sense of others' actions in terms of mental states is not a pre-requisite for the development of gestures, rather this form of understanding develops gradually through the convergence of various social skills, including gestures, emerging within various shared routines (Canfield, 1995, 2007; Carpendale et al., 2013; Carpendale et al., 2021; Carpendale & Carpendale, 2010; Carpendale & Lewis, 2015; Clark, 1978; Kettner & Carpendale, 2018; Lock et al., 1990; Vygotsky, 1978; Werner & Kaplan, 1964). In this way, the development of pointing is an essential constituent in the development of a mental level understanding of others, rather than being based on it, according to this approach. Because mental states are manifest in activity according to this approach, it is possible for infants to learn about mental states within activity. It follows from this view that methods involving a detailed, longitudinal description of infant-caregiver activity within shared routines should be prioritized.

The present dissertation is based on the activity-based theory that pointing originates in infants learning to expect others' responses to their initially non-communicative index finger extensions within shared routines, which include tactile exploration of close-by objects, as well as index finger extensions towards out-of-reach objects infants wish to touch (e.g., Carpendale & Carpendale, 2010; Carpendale et al., 2013; Kettner & Carpendale, 2018; Lock et al., 1990; Werner & Kaplan, 1963). Although pre-pointing index finger extensions have been described in the literature, there is limited research on the role of these early forms of index finger use in the development of pointing. Therefore, in the present dissertation I examined the associations between early forms of index finger use, joint activity with caregivers, and pointing. Caregiver-infant dyads were observed in three sessions which were based on the shared routines

[1] Although the activity-based approach discussed here shares some basic assumptions with the Activity Theory originating in the works of Vygotsky and Leont'ev (Cole & Gajdamaschko, 2009; Engeström, 2009), I am not drawing on Activity Theory in this dissertation. Rather, I describe an activity-based approach to communicative development within shared activities with others, drawing on the works of George Herbert Mead, Jean Piaget, and Ludwig Wittgenstein.

[2] Here it is not implied that we have either a practical level understanding or a mental level understanding of activity in the sense that these are two mutually exclusive forms of understanding. Rather, the goal is to show that infants have a practical understanding of activity that is not based on language. I describe a process through which complex, language-mediated understanding is likely rooted in earlier forms of understanding in several sections throughout Chapter 2.

of book reading, looking at and talking about objects, and playing with toys. Dyads were observed two times, when the infants were about 9 and 12 months.

In the rest of Chapter 1, I review previous research on pointing, early forms of index finger use, and parental responses to these. This is followed by a discussion of the currently dominant Dualist worldview and resulting approaches, with a focus on the cognitivist approach (Chapter 2). I then present criticisms of the assumptions associated with Dualist approaches before discussing the Process-Relational worldview and resulting activity-based approach. In Chapter 3, I discuss the results of quantitative analyses and qualitative observations of caregiver-infant interactions and forms of index finger use, followed by a discussion of the implications for research on pointing, and the theories associated with the two previously examined worldviews (Chapter 4).

1.1. Before Pointing

Infants can extend the index finger with other fingers curled soon after birth, yet they do not coordinate this action with their gaze direction until about 7 to 8 months when they begin to engage in tactile exploration. It remains to be investigated how these early index finger extensions are associated with pointing gestures. Research on gesture development has been dominated by studies in urban, middle-class, North American and European families, therefore most findings discussed in the following review are based on these limited samples of the world's population. Results of a smaller number of studies conducted in rural Canada, Indonesia, Peru, Papua New Guinea, and Mexico, and urban areas of Japan, China, and Taiwan, are also included.

1.1.1. Slip-Out Index Finger Extension

Index finger extensions not yet accompanied by arm extension or associated with indicative contexts (Carpendale & Carpendale, 2010; Fogel & Hannan, 1985; Hannan, 1987; Kettner & Carpendale, 2018; Lock et al., 1990; Masataka, 1995, 2003) have been referred to as "points slipping out" (Lock et al., 1990) or "pre-points" (Blake et al., 1994). During slip-out points, the index finger is not directed towards an object or event and is not coordinated with the infant's gaze direction, therefore it is not yet used in an intentionally communicative way (Carpendale & Carpendale, 2010). In the current study, the terms 'slip-out index finger extensions' and 'slip-out extensions' will be used instead

of ‘slip-out points’ to avoid confusion and emphasize that infants are not pointing at anything or coordinating their gaze during this form of index finger extension.

Although often dismissed as random events (e.g., Tomasello et al., 2007), slip-out extensions are associated with neutral or attentive states of infants from early on, as well as cooing, word-like vocalizations, and mouth movements (Fogel & Hannan, 1985). Infants tend to hold their hand in a slip-out hand configuration more often when in a state of arousal (Blake et al., 1994; Fogel & Hannan, 1985), and tend to coordinate it with speech-like (syllabic) rather than non-speech-like (vocalic) vocalizations (Masataka, 2003). When observed during a 2-minute face-to-face interaction with the mother, about 70% of 2- to 4-month-old infants were found to show slip-out extensions at least once, and this condition elicited more slip-out extensions when compared to the mother-toy condition (Fogel & Hannan, 1985; Hannan, 1987) or toy only condition (Blake et al., 1994). Interestingly, infants also tend to display more right-handed slip-out extensions during face-to-face interaction with the mother and more left-handed ones during the mother-toy condition (Hannan, 1987). Overall, what seems to be most important is the infant’s state of arousal, rather than the situation itself. Slip-out extensions, when compared to other hand positions, are often followed by curling all fingers before 9 months and by grasping between 9 and 12 months of age (Hannan, 1987). The duration of slip-outs is longer at 12 months when compared to duration before 9 months of age (Blake et al., 1994).

Slip-out extensions are associated with more favorable responses by adults such as contingent vocal responses by parents (Bloom et al., 1987) and more favorable ratings by unfamiliar adults, who rate infants who extend the index finger while vocalizing as more likeable and fun (Masataka, 2003). Analyses of longitudinal parental diary observations provide support for the above findings. Parents noted that they sometimes interpreted the infants’ behavior differently when the index finger was extended, even when it was not directed at anything in particular, and not coordinated with the infant’s attention (Kettner & Carpendale, 2018). For example, the parent might interpret the infant’s babbling when accompanied by a slip-out extension as a question or the extended index finger might give the impression of the infant emphasizing something (Kettner & Carpendale, 2018). Some parents note that they would respond to their infant’s index finger extension towards an object even when they felt it was accidental and not coordinated with the infant’s attention (Kettner & Carpendale, 2018). Slip-out

extensions increase right before, but then decrease rapidly with the emergence of pointing gestures (Lock et al., 1990; Masataka, 2003).

The above findings indicate that slip-out extensions might be one aspect of human infants' expressions of arousal, similar to smiling (Fogel & Hannan, 1985). Alternatively, or in addition to this association, later in development slip-outs might become more strongly associated with attending to an object or event, without the index finger being directed to what the infant is attending to at first. It remains to be explained through what process slip-out extensions might be linked to the emergence of pointing gestures.

1.1.2. Index Finger Touch

Tactile exploration, poking, and touching with the index finger to explore patterns or objects of interest emerges before pointing gestures (Bates et al., 1975; Blake et al., 1994; Carpendale & Carpendale, 2010; Kettner, 2014; Masataka, 1995). During index finger touch, the infant's attention and gaze are now coordinated with the extended index finger towards the object of interest. Bates et al. (1975) described an infant, Carlotta, using her index finger for the "examination of small book figures" before she learned to use pointing to communicate (p. 217). Similarly, Shinn (1900) observed that the index finger was at first used for "close investigations" (p. 220). Infants engage in index finger exploration of books, textures, objects, and faces, and in shorter index finger touches which sometimes function to share attention or answer a question (Kettner & Carpendale, 2018). For example, a common game that parents play with their infants is the "Where is X?" game in which parents name objects and expect their infants to answer these questions by pointing (Kettner, 2014; Kettner & Carpendale, 2018). Carpendale and Carpendale (2010) reported that the target infant in their diary study similarly engaged in tactile exploration before learning to point for others. In a follow up parental diary study, Kettner and Carpendale (2018) found that all 15 infants were reported to engage in index finger touch before the emergence of pointing gestures. Based on observations of 8-month-old infants in different situations involving within-reach and out-of-reach objects, Masataka (1995) argued that index finger extension at the age of eight months is associated with exploring objects, rather than requesting them. Finally, O'Madagain et al. (2019) investigated the angle of the pointing index finger in infants, children, and adults and found that all age groups tend to hold the index finger

as if they were about to touch the referent, providing evidence for the hypothesis that pointing originates in index finger touch. The authors argue that because adults tend to pay attention to what they themselves touch, they will similarly pay attention to objects their infants touch, therefore infants will then point at out of reach objects as if they were trying to touch them to elicit attention and a response (O'Madagain et al., 2019).

1.1.3. Imitation

Imitation of others' activities in infancy and childhood has been studied extensively and the question of whether imitation plays a role in the development of pointing gestures has also been investigated. One way to examine this is to look at the association between the pointing behavior of caregivers and their infants, but evidence is inconclusive regarding this relation (Liszkowski & Tomasello, 2011; Liszkowski et al., 2012; Matthews et al., 2012; Salomo & Liszkowski, 2013). Twelve-month-old infants of parents who pointed above average were found to point above average as well, but the frequency of parental and infant pointing were not related (Liszkowski & Tomasello, 2011). Cross-culturally, caregiver and infant pointing was found to be related across seven cultures; however, most pointing gestures by both parents and infants were initiating, rather than imitating the other's pointing (Liszkowski et al., 2012). Overall, instead of the frequency of others' pointing gestures in the presence of the infant, time spent in joint activity seems to be a stronger predictor of the emergence of gestures across three cultures (Salomo & Liszkowski, 2013). It is also possible that this inconsistency in the literature is the result of the presence of mediating factors, such as the caregiver's sensitivity. For example, Vallotton et al. (2017) found that caregiver gesture frequency had a positive association with infant gesture frequency only in the context of sensitive interactions.

1.2. Functions of pointing

Investigating pointing gestures based on whether they function to request an object or to share attention has dominated research on pointing. These two functions were first distinguished by Bates et al. (1975) and were originally described as the infant using the social partner to get an object (pointing to request or proto-imperative pointing) or using an object to get the social partner's attention (pointing to share attention or

proto-declarative pointing). There are several lines of evidence in support of proto-imperative and proto-declarative pointing gestures having different developmental pathways. For example, children with autism learn to make requests using pointing gestures but have difficulty using pointing to direct or share attention (Camaioni et al., 1997). Pointing to share attention is more often accompanied by vocalizations and infants' body posture is different in that they tend to lean towards the object more in imperative versus declarative situations (Cochet et al., 2014; Liszkowski & Tomasello, 2011). When infants do vocalize during pointing to request, these involve non-speech-like vocalizations more frequently when compared to pointing to share attention (Grunloh & Liszkowski, 2015). In addition, whole-hand pointing is more often associated with requesting gestures and an extended index finger with directing attention (Cochet & Vauclair, 2010a; Grunloh & Liszkowski, 2015; Liszkowski & Tomasello, 2011). Finally, infants who tend to point with the index finger rather than a whole hand show a better understanding of others' pointing gestures (Liszkowski & Tomasello, 2011). Liszkowski and Tomasello (2011) conclude that index finger and whole hand pointing are qualitatively different and that it is only index-finger pointing that is associated with "infants' understanding of communicative intentions" (p. 16).

By about 12 months, infants' pointing gestures function to request objects, actions, and help, to share interest or attention to objects and events, to answer questions, and to inform others (Begus & Southgate, 2012; Carpendale & Carpendale, 2010; Carpendale & Lewis, 2004; Kettner, 2014; Kovács et al., 2014; Liszkowski et al., 2006; Muñetón & Rodrigo, 2011; Tomasello et al., 2007). Infants also point to absent referents (e.g., when something falls and cannot be seen anymore), to places where something important had happened (e.g., something scary), and in the direction they are being carried (Kettner, 2014; Tomasello et al., 2007). Interestingly, around this age, infants also point directly at other people, often puzzling their parents who struggle to interpret the purpose of these actions (Carpendale & Carpendale, 2010; Kettner, 2014).

Studies of the order of emergence of the different functions of pointing have mixed results (Camaioni et al., 2004; Cochet et al., 2014; Liszkowski & Tomasello, 2011; Muñetón & Rodrigo, 2011). Some studies show pointing to request emerging before sharing attention (Camaioni et al., 2004), but natural observations of mother-infant interactions within everyday activities indicate the opposite (Muñetón & Rodrigo, 2011). The finding that infants develop whole hand pointing before index finger pointing (Liszkowski & Tomasello, 2011) provides support for request functions emerging before

pointing to direct attention. However, further investigations of these two hand configurations indicate that whether infants extend the index finger might depend on situational variables, such as target location, the salience of the target, and the complexity of the context (Cochet et al., 2014). For example, index finger extension seems to be more frequent, even in request situations, when the infant is trying to direct attention to a specific object in a crowded environment (Cochet et al., 2014). This finding illustrates the importance of observations within more naturalistic environments and in various contexts, including ones with many different objects and familiar social partners.

1.3. Parental Responses and Joint Engagement

Pointing with the index finger is widespread across cultures, although there are some differences in the use and emergence of pointing gestures (Kwon et al., 2018; Liszkowski et al., 2012; Salomo & Liszkowski, 2013). For example, Liszkowski et al. (2012) found consistency in the frequency and emergence of pointing gestures in one-year-old infants across seven cultures in a lab setting, whereas naturalistic observations of everyday interactions found that pointing emerged earlier in Chinese infants, when compared to Dutch and Mayan infants (Salomo & Liszkowski, 2013). In contrast, parental survey results of 714 infants between 6 and 36 months indicated less frequent pointing in Taiwanese infants when compared to German and American infants (Kwon et al., 2018). One possible explanation for these contrasting findings is that more time spent in triadic joint activity with caregivers might result in more pointing at a younger age in Chinese infants (Salomo & Liszkowski, 2013). Kwon et al. (2018) hypothesize that parents' collectivist views and encouragement of restraint and conforming might result in discouraging overt gesture use, and therefore less frequent pointing in collectivist cultures at older ages.

Findings show that parents tend to provide labels and ask questions in response to their infants' index finger extensions as early as 7 to 9 months, and this tendency increases after 9 months (Lock et al., 1990; Olson & Masur, 2011). In naturalistic diary observations in the home, parents report responding to their infants' index finger explorations by labeling in some contexts (Kettner & Carpendale, 2018). Before about 7 months of age, parents only respond to about 60% of index finger extensions, but Lock et al. (1990) point out that this might result from the fact that mothers only attribute meaning to their infants' actions in the appropriate context, which results in infants

learning what their actions mean to others within those meaningful contexts. Therefore, rather than focusing on the frequency of parental responses to early index finger extensions, an examination of the situations in which parents do respond might be informative when examining the role of these actions in the development of pointing gestures.

However, there is some evidence that frequency of responses by caregivers are positively associated with the frequency of infants' gestures (Cameron-Faulkner et al., 2015; Kishimoto, 2017; Miller & Lossia, 2013), and caregivers are more likely to provide a response to gestures when compared to vocalizations or combined gesture-vocalizations (Miller & Lossia, 2013). Parents provide more labeling responses to pointing when compared to object-directed vocalizations or reaching gestures (Wu & Gros-Louis, 2014, 2015) and more frequent caregiver points right after infant points at 12 months is associated with higher pointing frequency in infants seven months later (Kishimoto, 2017). It is theorized that this high rate of labeling response by caregivers might be one route through which pointing facilitates language development. Indeed, infants start to produce words earlier if they had heard them in response to their pre-linguistic gestures (Goldin-Meadow et al., 2007) and they learn words easier if their attention is already on the object (Tomasello & Farrar, 1986). By about 18 months, infants expect label- or function-responses (e.g., action on object) when pointing, and learn object labels more quickly when these are provided in response to their pointing gestures, but not to other actions such as gazing at or reaching towards an object (Lucca & Wilbourn, 2018, 2019). Finally, parental response rates to infants' early pointing gestures predict frequency of pointing and vocabulary later on (Ger et al., 2017; Harris et al., 1995).

Infants are able to participate in triadic joint engagement in which both the infant and the caregiver look at, and engage with, the same object (*passive joint engagement*, Bakeman & Adamson, 1984; deBarbaro et al., 2013), before they begin to show acknowledgement of the caregiver by gaze alternation, vocalization, or gestures (*coordinated joint engagement*, Bakeman & Adamson, 1984; *joint attention*, Tomasello & Farrar, 1986; Loy et al., 2018). The length of joint engagement resulting from parental responses to infants' showing and giving gestures is associated with index finger pointing at 12 months (Cameron-Faulkner et al., 2015). Salomo and Liszkowski (2013) conclude that it is likely that prelinguistic gestures of reference emerge within shared activities "in which others' actions structure infants' attention to objects" (p. 1305), noting

that further research is needed to investigate the qualitative differences between types of joint activity and whether some activities are more facilitative of the development of gestures than others (Salomo & Liszkowski, 2013). There is evidence that some forms of parental responses within these episodes are especially important for communicative development (Akhtar et al., 1991; Tomasello & Farrar, 1986). Although caregivers respond to their infants' actions differently across cultures (Broesch, et al., 2016; Chavajay & Rogoff, 1999; Kartner et al., 2008; Kline et al., 2018; Salomo & Liszkowski, 2013), caregiver responsiveness is universally related to a range of developmental outcomes, including emotional, cognitive, and communicative development (Begus et al., 2014; Broesch et al., 2016; Cameron-Faulkner et al., 2015; Ereky-Stevens, 2008; Paavola et al., 2005; Kishimoto et al., 2007; Salomo & Liszkowski, 2013). As mentioned earlier, it has been found that caregivers' follow-in responses when infants are already attending to an object might enhance learning (Akhtar et al., 1991; Kang et al., 2009; Begus et al., 2014); therefore, participating in triadic joint engagement episodes resulting from sensitive parental responses to the infant's interests might be especially important (Vallotton et al., 2017).

Chapter 2. Theories and Worldviews

Despite extensive research on pointing and its association with social-cognitive skills, hand shape, parental behavior, and later social and communicative development, there is a lack of agreement regarding its ontogenetic origins in infancy (Carpendale et al., 2013; Tomasello et al., 2007; Tomasello & Carpenter, 2013). Although numerous research studies have been conducted to resolve this debate empirically, examining the metatheoretical assumptions underlying these studies, which constrain all levels of scientific inquiry, has been neglected. It is important to examine these assumptions because they influence our theories, hypotheses, and research questions, as well as the selection of methods, and interpretation of results (Carpendale et al., 2013; Jopling, 1993; Overton, 2006; 2015; Racine & Carpendale, 2007, 2008; Witherington et al., 2018). In Jopling's (1993) words, we have to "question the questions we begin with whenever we investigate something [because] . . . the assumptions . . . these questions conceal consistently determine the form in which we frame our answers" (p. 290). Although they cannot be tested empirically, the coherence and validity of these beliefs and assumptions can be evaluated through conceptual analyses (Carpendale et al., 2013; Overton, 2006, 2015; Witherington et al., 2018). Because these assumptions are claims about the nature of human experience, they should be discussed explicitly, and reasons should be provided to support their validity (Overton, 2006).

Despite most scientists recognizing the value of conceptual analysis, empirical investigation is still often prioritized in research studies (Hogan, 2001; Overton, 2015; Witherington et al., 2018). This is the result of, among other factors, a historical separation of reason from observation, the belief that theoretical concepts only provide a way to organize and make sense of data obtained through observation, and the fact that different levels of theorizing are often conflated, resulting in attempts to resolve metatheoretical debates through empirical investigation (Overton, 2015; Witherington et al., 2018). However, whereas theories are

> designed to be operationalized, expected to yield testable, observable predictions, and, as such, are subject to adjudication through empirical activity, . . . worldviews involve a set of background concepts – various philosophical beliefs and assumptions that we, *as humans and as scientists* [italics added], hold concerning the nature of reality (ontology) and how we come to know that reality (epistemology). (Witherington et al., 2018, pp. 182-183)

In the context of communicative development, metatheories (also referred to as worldviews) provide the framework for research studies through assumptions about the "nature of mind, knowledge, and meaning, [which] influence theorizing about human development" (Carpendale et al., 2013, p. 381). Research on the development of communication has been dominated by cognitivist (rich) explanations[3], which are based on the Dualist worldview and the assumptions that mind is separate from body, and mental states are separate from behavior. These assumptions result in the belief that when learning to communicate, infants are faced with the problem of learning to infer others' mental states based on their behavior (Carpendale et al., 2013; Jopling, 1993). Lean explanations, similarly based on dualist assumptions, posit that infants at first only understand others on a behavioral level (e.g., Moore & Corkum, 1994). An alternative explanation that is not based on dualist assumptions is an activity-based, relational account, rooted in the Process-Relational worldview I endorse. Supporters of this approach argue that mental states do not underlie, but are manifest in behavior, and infants develop a practical understanding of different aspects of others' actions at first, including their embodied attention and mental states (Carpendale et al., 2013; Hacker, 1997; Racine & Carpendale, 2007, 2008). I argue that approaches rooted in the Dualist worldview are based on problematic assumptions that constrain theories, research questions, and methods, as well as overlook the importance of relations in the emergence of communicative meaning, and therefore communicative development in infancy. I now turn to a critical evaluation of these two worldviews and how the assumptions associated with them influence research on the development of pointing. I focus on the cognitivist (rich) and activity-based explanations because these accounts have been most prominently involved in recent debate about the development of pointing.

2.1. The Dualist Worldview

Dualist assumptions about the nature of the human mind and experience have a long history and can be traced back to not only Descartes, but even further to Saint

[3] Also referred to as individualism, mentalism, or Cartesian-Split-Mechanistic accounts, these approaches are based on assumptions involving dichotomies of pre-formed entities that interact, such as nature and nurture, mind and body, reason and observation, biology and culture, and so on (Carpendale et al., 2013; Carpendale et al., 2021; Overton 2006). These alternatives are then in competition with each other with regards to the nature and extent of the role they play in human development (Overton, 2006).

Augustine (Carpendale et al., 2013). Augustine described himself as an infant trying to use physical movements and vocalizations to communicate his inner demands to others (Carpendale et al., 2013; Carpendale et al., 2019; Hacker, 1997; Ryle, 1950; Wittgenstein, 1953/ 2009). This view splits mental states, such as thoughts and desires, from physical movements, which are claimed to express mental states. Descartes denied previous dualist views but arrived at the same conclusion through his own reasoning in his search for something certain and unquestionable – the foundation of knowledge[4] (Jopling, 1993; Hacker, 1997; Overton, 2015). He argued that mind was separate from body, and that it was only inner mental processes that were "unchanging and necessary" (Jopling, 1993, p. 292). This is a cognitivist account, according to which we know our mind and its contents directly, whereas we can never be sure about knowledge we gain through sensory experiences (Jopling, 1993). Mead (1934) compared this view of the mind to prisoners being locked in their own prison cells and inferring the presence of prisoners in other cells. These prisoners would have no direct way of communicating with others, therefore they would attempt to communicate in an indirect way, for example, by tapping on the wall (Mead, 1934, p. 6)[5]. Relations between individuals are therefore "indirect and cognitively mediated" (Jopling, 1993, p. 291), according to cognitivist accounts, and infants are faced with the problem of learning about, and learning to communicate with, others' hidden minds. This way of setting up the problem has been termed the "problem of other minds."

Based on these assumptions, cognitivist explanations propose that infants' inferential knowledge of others' hidden minds must originate in their own minds, the only mind they have direct access to. This view necessitates some form of knowledge or capacity to pre-exist in the mind and provide the foundation for the development of social understanding and communication.

[4] A further goal of dualist or split accounts is to determine which one of the already split-off, pre-existing elements is at the origin of the phenomena being examined, therefore providing the foundation for its emergence (Carpendale et al., 2021; Overton, 2006).

[5] Mead (1934) and others have criticized this view of communication because what it is not explained is how these arbitrary signals would gain communicative meaning. That is, how it would be possible to figure out what the other person's taps on the wall mean.

2.1.1. Solutions to the "Problem of Other Minds"

Cognitivist assumptions lead to research questions relating to how infants learn to infer others' mental states based on others' behavior. In this way, these assumptions constrain possible answers to ones that take the infant's mind as starting point. Accordingly, solutions include 1) infants observing their own experiences, including their own minds and mental states, and reasoning by analogy about others' mental states (*simulation*, e.g., Tomasello et al., 2007), 2) infants figuring out others' minds through theorizing about them (*theory theory*, Gopnik & Wellman, 1992, 2012), and 3) infants having innate mind reading mechanisms that compute others' mental states (Baillargeon et al., 2010; Baron-Cohen, 1995; Onishi & Baillargeon, 2005).

Simulating others' mental states has been offered as one solution to the "problem of other minds", which involves observing ones' own mind and mental states and reasoning by analogy about others' (Gallagher, 2007; Gallese, 2005; Goldman, 2002; Tomasello et al., 2007; Tomasello & Carpenter, 2013). However, there has been ongoing debate about how and on what level simulation occurs, how frequently it is used, and what types of mental states it can be applied to (Goldman, 2002). Implicit or sub-person level simulation has been described as an automatic process that does not require conscious introspection and awareness (e.g., Gallagher, 2007). That is,

> whenever we face situations in which exposure to others' behavior requires a response by us, be it active or simply attentive, we seldom engage ourselves in an explicit, deliberate interpretive act. Our understanding of a situation most of the time is immediate, automatic, and almost reflex like. (Gallese, 2005, pp. 101-102)

It has been argued that this form of simulation is based on neural resonance systems, through which the motor system is activated in response to seeing another person act (Gallagher, 2007). For example, mirror neurons are activated both in response to our own and others' actions and this has been interpreted as an implicit simulation of intentions (Gallagher, 2007). However, according to Gallese (2001), even implicit simulation involves a multi-level process including recognizing the similarity between others and the self, running "as if" processes to create "models of others," and the activation of mirror neurons (Gallagher, 2007; Gallese, 2005, p. 115).

In contrast, explicit simulationists argue that conscious awareness and reflection on one's own mental states, or introspection, is required to simulate the mental states of others (Baron-Cohen, 1995; Gallagher, 2007; Gopnik & Wellman, 1992; Humphrey,

1984). Additionally, simulation is the default way of understanding others, according to this theory (Goldman, 2002). Goldman (2002) posits that imagining oneself in the other's mental shoes is needed[6]. That is, "the basic idea of [simulation theory], of course, is that the attributor tries to mimic the mental activity of the target" (p. 6). This is done through pretend states that have "many of the same causal powers as ordinary, non-pretend states with the same contents," being fed into a "mental-state generating mechanism" which then compute pretend output that can be applied to others (Goldman, 2002, p. 7). According to Goldman (2002), neural resonance activity might also be part of explicit simulation because

> the observer can recognize that he does not himself act when he undergoes this experience; and in typical situations there isn't even an appropriate goal object for him to act upon. Furthermore, he sees that the person he is watching is acting in the appropriate way. So it might be easy for him to attribute the motoric experience he himself undergoes to the other actor. (p. 15)

Gopnik and colleagues argue that rather than having to observe their own minds and mental states, and reason by analogy about others', infants are born with a theory about others' minds which they then revise based on experience (Gopnik & Wellman, 1992). In this way, infants form increasingly complex theories about others' minds and mental states, which at first can help them understand non-representational, then representational mental states (Gopnik & Wellman, 1992). They state that "starting state" theories are innate and children are at first "mentalists", then become "representationalists" (Gopnik & Wellman, 1992, p. 168). Children at first have an implicit theory of others' minds, which works and changes over time in the same way as scientific theories do (p. 145). According to the theory theory,

> important conceptual structures [are] like everyday theories and . . . cognitive development [is] like theory revision in science. Children construct intuitive theories of the world and alter and revise those theories as the result of new evidence. (Gopnik & Wellman, 2012, p. 1086)

Infants do not need to theorize, according to Baron-Cohen (1995), who argued that "natural selection had produced a mindreading system" for understanding and predicting others' behavior, and that at least four separate mechanisms underlie the capacity to

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[6] An alternative explanation is that we only need to put ourselves in the shoes (but not the mental shoes) of others to engage in simulation, but for this the specifics of our own situation need to be replaced by the best hypothesis about the specifics of the other person's situation (Gordon, 1986). This is needed for forming the best predictions about others' actions and mental states, including beliefs (Gordon, 1986).

read others' minds. The Intentionality Detector (ID) and the Eye-Direction Detector (EDD) emerge first and these mechanisms help infants differentiate between non-agents and agents in the world, based on the presence or absence of self-initiated movements, to which they attribute primitive mental states such as goals and desires (ID). The EDD can represent forms of eye behavior, can compute what eyes are directed at, and can help the infant understand that the other organism is "seeing" based on "its own case" (Baron-Cohen, 1995, p. 39). The shared attention mechanism (SAM) receives input from ID and EDD and constructs triadic representations "by comparing another agent's perceptual state with the self's current perceptual state" (Baron-Cohen, 1995, p. 46). Finally, the Theory of Mind Mechanism (ToMM) needs to emerge for attributing higher level mental states, such as beliefs. In this way, we can engage in "mindreading", which has "an innate, biological, modular basis" (Baron-Cohen, 1995, p. 12).

An alternative modular explanation is that infants understand goal-directed actions through a "non-mentalistic interpretational system" or "teleological stance," before they understand causal mental states (Gergely & Csibra, 2003; Csibra, 2003). Csibra (2003), in discussing how infants understand object-directed actions, describes two separate systems for interpreting goal-directed and referential actions, which, he argues, "are triggered by different cues, apply different representations and computations, serve different functions, and are likely to be implemented in separate mechanisms" (p. 456). Tomasello et al. (2005) argue that it does not make sense to think of these capacities as separate modules; rather, "infants comprehend intentional action and perception as an integrated system" which is a "biological adaptation" (Tomasello et al., 2005, p. 688). Baillargeon and colleagues describe this process in terms of an abstract computational system, which equips human infants with the understanding that others have mental states, therefore only having to learn "which states underlie which actions and not coming to understand that such states exist at all" (Onishi & Baillargeon, 2005, p. 257; see also Baillargeon et al., 2010).

2.2. Dualist Explanations of the Development of Pointing

Dualist explanations of the development of pointing in infancy include the theory that pointing is based on understanding others on a behavioral level - the "lean" approach (e.g., Moore & Corkum, 1994), that it is based on understanding others on a mental level - the "rich" (cognitivist) approach (Camaioni et al., 2004; Carpenter et al.,

1983; Blake et al., 1994; Liszkowski et al., 2007; Tomasello & Call, 1997; Tomasello et al., 2005; Tomasello et al., 2007; Tomasello, 2019), and that pointing is a learning tool or mechanism for cultural transmission through infants intending to elicit information from others (Begus & Southgate, 2012; Kovacs et al., 2014; Lucca et al., 2016). What is common to these theories is that they begin from the assumptions that mental states are split from behavior, infants can understand others either on a behavioral or mental level, and intentions underlie and cause actions, including pointing gestures.

Supporters of lean explanations argue that pointing originates in infants learning to expect interesting and enjoyable interactions and attention to the self in response to their pointing gestures (Moore & Corkum, 1994; Moore & D'Entremont, 2001). This account is based on the findings that one-year-old infants point more when the caregiver is looking at them, and that they engage in gaze checking only after their pointing gestures, presumably because they are trying to influence others on a behavioral level, but not on a mental level at this age (Moore & Corkum, 1994; Moore & D'Entremont, 2001). However, Haynes (2004) found no differences in timing of visual checking across different age groups and argued that visual checking, independent of timing, signals an attempt to direct others' attention. Similarly, Tomasello and colleagues defend a rich explanation and argue that,

> infants thus comprehend and produce their pointing gestures - basically from their first points at around 12 months of age - in surprisingly adult-like ways, both in the sense that they are operating on a mental level and also in the sense that they are cooperating with others in acts of shared intentionality as they do so. (Tomasello et al., 2007, p. 715)

Skills and motivations of shared intentionality originate in infants' uniquely human motivation to share emotions with others from early on, and to share psychological states beginning around 9 to 10 months, resulting in uniquely human forms of cooperation and collaboration (Tomasello, 2019). Supporters of a third explanation argue that, rather than originating in an adaptation to engage in collaborative activities, pointing is a learning tool, and, instead of having the goal to share attention, infants point to obtain information from others (e.g., Begus & Southgate, 2012).

All of the above explanations are based on Dualist assumptions resulting in a search for the presence or absence of adult forms of understanding, and the ultimate motivation that underlies infants' pointing. I discuss criticisms of these assumptions in Section 2.3 and present an alternative, relational explanation in Section 2.4. Because

Tomasello and colleagues' account has been dominating research on the development of pointing, I now turn to a more detailed discussion of their approach.

2.2.1. The Cognitivist Explanation

Tomasello and colleagues argue that pointing cannot emerge through parental responses to infants' orienting actions, because of the variability in time spent in triadic joint engagement across cultures and because parents do not consistently treat their infants as intentional beings across cultures (Tomasello et al., 2005; Tomasello, 2019). In spite of this, infants across different cultures are able to participate in triadic joint engagement with others in similar ways (Tomasello et al., 2005; Tomasello, 2019). Furthermore, even if there was consistency in how caregivers engaged with their infants, infants could not learn this way, according to Tomasello and colleagues, because it cannot be assumed that infants are consistently rewarded for particular behaviors, such as pointing to an object the caregiver is looking for (Tomasello & Carpenter, 2013). That is, Tomasello and colleagues consider a lean explanation, but not any other alternatives such as activity-based accounts, as an alternative to their own rich explanation.

Based on these arguments and their cognitivist assumptions about the nature of mind and mental states, Tomasello and colleagues conclude that early social-cognitive capacities on which pointing is based result from "maturation of species-unique cognitive and social capacities" (Tomasello, 2019, p. 7) that are "the direct expression of human evolution by means of natural selection" (Tomasello, 2019, p. 33). This implies that these early capacities have to emerge through some process that is innate. One explanation the authors have proposed for how this form of understanding emerges in infancy is through simulation. In their words:

> infants begin to understand particular kinds of intentional and mental states in others only after they have experienced them first in their own activity and then used their own experience to *simulate* [italics added] that of others . . . on analogy with their own. (Tomasello et al., 2005, pp. 688-689)

This explanation has much in common with explicit simulation theories which posit that conscious awareness and reflection on one's own mental states, as well as reasoning by analogy, are required to simulate the mental states of others (Baron-Cohen, 1995; Gopnik & Wellman, 1992; Humphrey, 1984). However, Tomasello and colleagues later state that they do not think that reflecting on one's own mental states is required for

infants to simulate; rather, simulation only requires an understanding that others are like the self, based on which they would expect others to think, act, perceive, and experience the world as they do (Tomasello & Carpenter, 2013, p. 403)[7]. For example, "when the infant understands that someone 'sees' something, all she knows about seeing is her own experience of seeing, and so that is what she takes the other to be doing" (Tomasello & Carpenter, 2013, p. 402). This suggests that Tomasello and colleagues endorse a form of simulation that is implicit. In agreement with them, Gallese (2001) posits that implicit simulation involves seeing others as like the self, but he further argues that the activation of mirror neurons, as well as creating models of others, are also needed (p. 45). Tomasello and colleagues have not offered such an explanation for how it is possible for infants to infer others' mental states through implicit simulation and "non-verbal" reasoning.

At the center of Tomasello and colleagues' cognitivist account is the question of how human communication is unique compared to other animals, which results in a search for the origins of this uniqueness in the human infant's mind and cognitive capacities (e.g., Tomasello, 2019). It is argued that at the origin are infants' uniquely human skills and motivations of shared intentionality and the ability to engage in "socially recursive inferences" (Tomasello, 2019, pp. 16-17). When engaging in socially recursive inferences, "the individual conceptually embeds one intentional or mental state within another" which enables them to think about what the other *intends* them to *attend* to, as

[7] This claim was originally based on Meltzoff and Moore's (1977) work who argued that newborn imitation of others' facial expressions (e.g., tongue protrusions) provided evidence for an innate understanding that others are like the self (Tomasello, 1999). For example, newborn infants already know that the association between them smiling and feeling pleasure can be applied to others who, when smiling, must also be feeling pleasure. In Tomasello's (1999) words, "neonatal imitation reflects a tendency of infants not just to mimic known movements but in some sense to "identify" with conspecifics" (p. 60). Jones (2009) points out problems in Meltzoff and Moore's (1977) methodology as well as the fact that newborn infants only reliably imitate tongue protrusion, but not other facial expressions and actions, across different studies. Since infants tend to stick out their tongues in response to a variety of interesting stimuli, consistency in displaying this behavior in response to others engaging in the same activity it still does not provide convincing evidence for imitation of others in newborn infants (Jones, 2009; also see Carpendale & Lewis, 2006, 2015; Müller & Carpendale, 2004). More recently, Tomasello et al. (2005) stated that they "do not think that simple 'identification with others' is a sufficient basis for the simulation process" and, building on Hobson's (2002) discussion of the importance of early dyadic emotional engagement, argued that this ability depends on "skills and motivations for interpersonal and emotional dyadic sharing characteristic of human infants" (p. 689). However, later this ability was again described as a "simple, unconscious recognition that these beings are like me in some sense," leading to the claim that that reasoning by analogy does not require reflection because it can be done "non-verbally" (Tomasello & Carpenter, 2013, pp. 402-403).

well as to reflect on their own mental states (Tomasello, 2019, pp. 16-17). What underlies the development of uniquely human forms of communication, according to this account, is our ability to engage in cooperative and collaborative activities and this is built on our capacity to share attention, intentions, and knowledge with others. According to Tomasello et al. (2007), "these social intentions all involve in some way or another cooperative motives for helping and/ or sharing – the two main types of motivation in shared intentionality" (p. 714). Skills and motivations of shared intentionality are what make human communication unique because, in addition to the ape line understanding of others as intentional agents, human infants are motivated to share emotions within dyadic interactions from early on, and psychological states, including intentions, starting around 9 months (Tomasello, 2019). Therefore, according to Tomasello (2019)

> we need a theory of gestural communication of the "rich" variety that is not based simply on behavioral or interactive patterns between adult and child (for example, Carpendale et al. 2013), but rather is based in a richer set of cognitive processes involving such things as *attention alignment*, *perspective-taking*, and *recursive inferences* [italics added]. (p. 128)

2.3. Examining Cognitivist Assumptions

As discussed, Tomasello and colleagues' cognitivist account rests on the assumption that mental states underlie and cause behavior, which implies that mental states are key in providing the meaning of actions. An additional assumption is that mental states are hidden and not accessible to others, therefore they need to be inferred based on observing others' outward behavior. It follows from these assumptions that infants cannot learn about mental states within activity before they understand the relation between mental states and actions and learn to attribute meaning to others' behavior by inferring their underlying mental states. Consequently, infants' early social-cognitive capacities originate in their own minds, which they have direct access to. Finally, this account is based on a dichotomous conceptualization of human experience, which leads to a search for the presence or absence of adult-like competencies such as communicative intent.

I argue that this account is problematic for several reasons. First, there is extensive criticism of the assumptions that mental states are entities that cause behavior, and that can be associated with meaning in a way so that meaning can be inferred based on behavior (Jopling, 1993; Hacker, 1998; Racine & Carpendale, 2007, 2008; Zahavi, 2008). Second, two forms of experience are conflated in this account, that

of the infant's, which is an immediate, lived experience based on emerging practical social skills, and that of the adult's which is a reflective form of experience based on language (Carpendale et al., 2013). Finally, starting from a dichotomous "presence or absence" view of development is problematic because it leads to "adultocentrism" and overlooking important aspects of early communicative development (Fischer & Biddell, 1991).

2.3.1. The Nature of Minds and Mental States

The "Cartesian (and later the cognitivist) assumption, that the mind can be understood independently of its immediate physical and social world, places deep and mostly unwanted constraints on theorizing about interpersonal relations" (Jopling, 1993, p. 293). The assumptions that mental states are hidden, separate from, and cause actions, although often underlie research of the development of communication, remain overlooked in psychological research today, even in the face of extensive criticism. This way of thinking is associated with long held beliefs about human existence and experience, as well as our language and word use (Hacker, 1998; Racine & Carpendale, 2008). Hacker (1998) writes:

> The thought that a human being is a composite creature consisting of body and soul (or mind, or spirit) is an ancient one. It is bound up with our fear of death, with the craving for an afterlife in a happier world, with our grief at the death of our loved ones and our longing to be reunited with them (p. 14).

This is a view of communication that is "generated it seems by the very way we speak in everyday life about such things as language and thought" (Canfield, 1993, p. 169). Although our word use implies that mental states are inner entities that can be directly perceived in some way and then reported on (Hacker, 1998; Racine & Carpendale, 2008; Wittgenstein, 1953/ 2009), Hacker (1998) argues that this is not the case – there is nothing to perceive, and there is nothing to perceive it with. In Racine and Carpendale's (2008) words, "there is nothing like inner pointing and there is nothing like an entity that can be pointed to" (p. 6). When we say "the mind," it "looks as if it is the name of a substance or thing, like 'the brain', but it is not" (Hacker, 1998, p. 11). That is, mental states are not entities that we observe as we observe a room; rather, we reflect on our experiences (Hacker, 1998). Our mental states are not hidden, and we do not have direct, privileged access to them. They are manifest in our actions, and in this way,

they are accessible to others (Racine & Carpendale, 2008). Although our experience of our own mind and mental states is different from that of others', neither form of access is more direct, and both have advantages and disadvantages (Zahavi, 2008).

A second problem with the cognitivist approach is that it attributes to infants the capacity to interpret their own and others' experiences in terms of mental states. An alternative explanation that avoids this problematic assumption is that infants at first experience others as an "expressive unity" (Zahavi, 2008, p. 518) and "it is only subsequently, through a process of abstraction, that this unity is divided and our interest then proceeds 'inwards' or 'outwards'" (Zahavi, 2008, p. 518; Scheler, 1954). It is through learning words such as 'want,' 'see,' and 'hope,' within social interactions, and through caregivers interpreting and commenting on shared activity, that infants begin to make sense of human forms of activity in terms of mental states and behavior (Carpendale et al., 2013). According to this view of language, "a child might understand something about what a parent means by 'hope' without grasping the full nuance of the concept and corresponding range of application of the mental predicate in question" (Racine & Carpendale, 2007, p. 9). Understanding concepts related to intentional activity, such as 'wanting,' are abstracted "from many experiences with a particular phenomenon" (Racine & Carpendale, 2008, p. 181).

Bennett and Hacker (2003) argue that "a concept is an abstraction from the use of a word" (p. 339; see also Racine & Carpendale, 2007). This is related to Wittgenstein's private language argument (Carpendale et al., 2013; Racine & Carpendale, 2007; Wittgenstein, 1953/ 2009), according to which meaning cannot originate in words and utterances and associated mental states[8], rather it emerges from the use of words within

[8] This explanation is rooted in the dualist assumptions that knowledge is based on representations, thinking is computation, and development unfolds through a passive recording of information through our senses, which have been criticized extensively (e.g., Carpendale et al., 2021). This is because this theory does not explain how the world becomes meaningful for the infant, and how representations become associated with meaning. Piaget argued that this "copy theory" of knowledge is problematic because we have no way of checking the accuracy of our representations or copies of reality (Carpendale et al., 2019; Carpendale et al., 2021). The only way of checking would be to form another copy, but this is like buying a newspaper and attempting to check the accuracy of the information in it by buying a second copy of the same newspaper (Wittgenstein, 1953/ 2009). Furthermore, it is problematic to conceptualize thinking as computation, because this does not explain meaning and understanding – a camera can record and manipulate information, but it does not understand it (Carpendale et al., 2021). A bird can look at a bicycle and form a representation of it, but this representation will not be meaningful to the bird in the same way it is to us. This is because meaning is rooted in forms of life and forms of activity. This object is a bicycle for people who are familiar with the routine of using objects to travel as part of their ways of life. The same object will have no meaning, or have a different

particular contexts which constrain possible meanings. Therefore, rather than discovering pre-existing mental states and learning to associate these with the appropriate labels, infants at first have a practical understanding of others' goal directed, intentional activity and are only able to reflect on these activities in terms of mental states once they learn to talk about them (Racine & Carpendale, 2007). It follows from this approach that our actions gain meaning within shared activities with others which are structured by human forms of life, everyday routines, cultural customs, and shared knowledge (Carpendale et al., 2013; Mead, 1934; Racine & Carpendale, 2007, 2008). Mental states are manifest in shared activities which are at the origin of communicative development.

2.3.2. Common Ground

A central question relating to the investigation of the emergence of human forms of communication is the nature of meaning and how infants learn the communicative meaning of their own and others' actions (Carpendale et al., 2013; Racine & Carpendale, 2007, 2008). I argue that the cognitivist approach fails to explain how the world becomes meaningful to the infant, because it overlooks the role of context, shared routines, shared knowledge, and forms of life in conveying meaning (Canfield, 1995, 2007; Carpendale et al., 2013; Hacker, 1997; Racine & Carpendale, 2007, 2008; Wittgenstein, 1953/ 2009). Words and gestures can always be interpreted in multiple ways based on shared knowledge and experience within shared routines (Canfield, 2007; Carpendale et al., 2013). For example, depending on the routine in which it is used, the same gesture or word can function as a demand, question, answer, and so on. Tomasello and colleagues recognize this gap in cognitivist explanations and propose that, in addition to some "fairly serious mind reading," there has to be common ground, or some form of shared knowledge, for communicative partners to understand each other's gestures (Tomasello et al., 2007, p. 705). They state that "to correctly identify the intended referent requires that the communicator and the recipient know together that the indicated location is in some way relevant to some larger context they share" (Tomasello et al., 2007, p. 706).

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meaning, for people and animals unfamiliar with this routine. If a dog is part of a routine that involves their owner coming home on a bicycle, then this object will signify being reunited and will gain meaning through familiarity with this routine. Therefore, any explanation that overlooks the role of forms of life, forms of activity, and shared routines cannot provide a coherent account of the origins of meaning, and the development of communication.

There is agreement between the cognitivist and activity-based approaches that shared experiences are important, but they differ with regards to whether an understanding of this common ground by both social partners is needed for gestures to work, and with regards to their assumptions about the role of shared experiences in learning to convey meaning in infancy. Tomasello and colleagues acknowledge that it is necessary to have some form of shared knowledge to interpret the other's gesture, but they conceptualize this understanding as a "joint attentional frame" – an outcome of development in the first year of life, resulting from a process such as simulation. In contrast, the activity-based approach posits that shared experiences do not underlie pointing gestures in the sense of an underlying "understanding" in the infant, but are constitutive of the development of pointing. Activity-based explanations begin from the assumption that infants gradually develop an understanding of common ground as others respond and attribute meaning to their actions such as pointing, rather than this understanding being a pre-requisite for pointing (Carpendale et al., 2013). Therefore, what is necessary to explain communicative development is a detailed description and analysis of shared activities that infants become part of soon after birth. This approach is based on the view that the meaning of a gesture or word emerges through their use within activity, that "speaking a language is part of an activity, or a form of life" (Wittgenstein, 1953/ 2009, p. 15). That is, communication

> occurs in a context of human action and interaction [and] words derive their meaning from their roles in such patterns of interaction. Examples of word use from a child's earliest speech make it evident that our language is, as Wittgenstein claimed, a cultural extension of preexisting interaction patterns. (Canfield, 1993, p. 166)

2.3.3. Forms of Experience

The claim that infants make socially recursive inferences and engage in simulation implies that infants are able to make sense of their own and others' experiences in terms of mental states. This explanation is circular, however, because we are presupposing what needs to be explained – the development of understanding experience in terms of categories such as behavior and psychological states. Zahavi (2008) writes:

> In order for the argument to work, there has to be a similarity between the way in which my own body is given to me, and the way in which the body of the other is given to me. But if I am to see a similarity between, say, my laughing or crying and the laughing or crying of somebody else, I need to understand the bodily gestures and behavior as expressive phenomena,

> as manifestations of joy or pain, and not simply as physical movements. If such an understanding is required for the argument of analogy to proceed, however, the argument presupposes that which it is supposed to establish.

Simulation requires a form of experience that makes sense from an adult point of view because adults can reflect on their experiences and think and talk about intentions, thoughts, feelings, and actions. We can also reason by analogy about others' mental states, but this is an outcome of development, not the starting point. Tomasello and colleagues are conflating two forms of experience – immediate, lived experience and reflective experience (Carpendale et al., 2013). Infants are embedded in lived, immediate experience, which does not involve reflective awareness, therefore cannot account for attributing mental states to others through inference (Carpendale et al., 2013).

Furthermore, even though adults can reason by analogy after reflecting on their own experiences, this does not seem to be our default way of understanding others (Gallagher, 2007). Therefore, another criticism of simulation is that it explains only a narrow part of our social interactions and how we make sense of, and predict, others' behavior. Adults can reflect on their own and others' experiences, but more often we make sense of our interactions based on shared knowledge and context. Gallagher (2007) argues that "most of our encounters are second-person interactions in which I easily have a sense of what is going on with the other person based on our common pragmatic or socially contextualized interactions, with no cognitive simulation required" (p. 356). We only use simulation when things do not go the way we expect, or "our habitual strategies break down", and we have to reflect on what happened in order to make sense of the other person's actions (Gallagher, 2007, p. 356; also see Zahavi, 2008). Zahavi (2008) further argues that simulation focuses, too narrowly, only on "our ability to explain and predict the actions of others, as if our social life was exclusively a question of ascribing causally efficacious inner mental states" (p. 515).

An alternative explanation is that infants might be able to simulate through a simpler process involving neural resonance systems. For example, mirror neurons being activated both in response to our own and others' actions has been interpreted as an implicit simulation of others' intentions (Gallagher, 2007; Gallese, 2001). However, having the same neurons firing both when we act and watch someone else perform the same action does not account for the development of meaning and how we get from a sub-personal to a personal level understanding (Carpendale et al., 2021; Müller &

Carpendale, 2004). For example, the same neurons might fire when an infant extends the index finger and observes another person do the same, but this does not help the infant figure out the communicative meaning of their own or the other's pointing. This is because an extended index finger can convey many different meanings, therefore how infants learn to expect a specific response to their extended index finger and how they learn to attribute meaning to others' pointing gestures still needs to be explained.

2.3.4. Communicative Intent

One goal of research studies investigating communicative development has been to discover infant behaviors that are indicative of communicative intent (Begus & Southgate, 2012; Blake et al., 1994; Camaioni et al., 2004; Carpenter et al., 1983; Franco & Butterworth, 1996; Grunloh et al., 2015; Liszkowski et al., 2007; Tomasello et al., 2007; Tomasello et al., 2011, Tomasello, 2019). This is an approach that is based on dichotomies characteristic of Dualist accounts, leading to a search for the presence or absence of adult-like skills in infants. In the case of pointing, this manifests in a search for particular underlying motivations that drive infants' pointing gestures. For example, pointing with gaze checking has been considered to be an indicator of communicative intent (Bakeman & Adamson, 1984; Franco & Butterworth, 1996; Tomasello & Farrar, 1986), along with other behavior patterns such as pointing combined with vocalizing or smiling (Camaioni et al., 2004).

However, more recently it has been argued that there are some situations in which the caregiver's attention on the object is evident to the infant in how the dyad is oriented within the interaction. For example, caregivers carrying their infants in their arms while looking at objects, or infants sitting in their caregivers' lap while reading a book together are such situations (Liszkowski & Tomasello, 2011). Moreover, infants' gaze checking behavior changes with development (Bates et al., 1975; Franco & Butterworth, 1996) and infants might look at their parents as a result of their shifting attention or to seek comfort or information (Carpendale & Lewis, 2006; Moore & Corkum, 1994). As gaze checking is no longer considered to be a reliable indicator of communicative intent (Carpendale & Lewis, 2006; Harris et al., 1995; Liszkowski & Tomasello, 2011; Moore & Corkum, 1994), this criterion has been replaced by methods such as the elimination of alternative motivations by examining presumably associated aspects of the infant's behavior. This is done to arrive at one particular motive that is

thought to underlie the infant's pointing gesture (Begus & Southgate, 2012; Liszkowski et al., 2006). However, this approach is problematic because it begins from our adult forms of thinking and perspective.

2.3.5. Adultocentrism

Tomasello and colleagues argue that once infants understand others on a mental level, they can then intend to influence what others know, feel, and do, which is evident in their pointing behavior. For example, Liszkowski et al. (2006) observed infants' pointing behavior in response to an experimenter accidentally misplacing an object and found that infants were more likely to point at objects that were relevant for the experimenter when compared to distractor objects. The authors concluded that "infants were pointing as adults would in this situation – to inform the experimenter about the location of an object she was looking for" and further posited that this provides evidence that infants understand others' intentions and mental states, because "to understand that the other needs information the pointer must understand the addressee as an intentional agent" (Liszkowski et al., 2006, p. 185). However, Bates et al. (1975) noted that

> For the adult, the difference between assuming truth and attending to some event may be an important one. But for the very young child (and possibly for the adult as well), the offering of information and the demand for attention are inextricably mixed. Long before he can understand the utilitarian value of sharing information, the child will engage in 'declaring' for primarily social reasons (p. 209).

Although from an adult's perspective the infant's pointing can be interpreted as a gesture that informs the experimenter, this finding does not provide evidence for infants understanding what it means to help or inform someone or having the intention to do this[9]. Ascribing an understanding of complex concepts such as helping to infants has been termed as "adultocentrism" by Fischer and Biddell (1991), who describe the problem as follows:

[9] Alternative explanations for infants' actions within cooperative contexts include an activity-based explanation according to which infants participate because of an interest in others' activities (Carpendale et al., 2015). Infants become familiar with routines of helping and cooperation, within which they develop a practical understanding of particular action sequences, which facilitates the gradual development of an increasingly complex understanding of concepts such as "informing" and "helping". Therefore, rather than looking for underlying motivations, "helping situations" in which infants point should be carefully observed over time to gain insight into the emergence of an adult-like understanding.

> If an adult looking at an infant's behavior sees it as implying a concept . . . the inference is made that the infant must be using the concept. The jump from an adult interpretation to inference of a skill of concept in an infant is gigantic. Behaviors can look alike in terms of adult categories without actually being alike in a way the child produces them (p. 210).

Attributing adult-like understanding to infants is problematic for at least two reasons. First, using words that describe behavior based on adult understanding, such as the word "helping," creates the illusion of similarity in infants' and adults' understanding of a concept, based on similarity in behavior (Haith, 1998). Second, it introduces a false dichotomy and a search for the presence or absence of an adult-like understanding of a concept in infants and children (Haith, 1998), which might result in overlooking important aspects of development (Carpendale et al., 2013; Fischer & Biddell, 1991). I argue that infants' pointing gestures are not based on and caused by mutually exclusive motivations to influence others' emotions, knowledge, or actions (Gomez, 2007). Research questions aiming to discover motivations that underlie infants' pointing gestures are problematic because they presuppose what needs to be explained. That is, how infants learn that their extended index finger has meaning for others, and how they come to learn to use this hand configuration to achieve goals such as getting an object. Attributing a mind to infants that is like a language-speaking mind is problematic, because it is speaking a language that allows adults to

> have the experience of being able to introspect in the sense of imagining possibilities and considering how they would feel in such situations [and] to conceptualize their experience in psychological terms. It is a step that goes unnoticed to impose this view of the mind on infants (Carpendale et al., 2013, p. 386).

This has been referred to as the "psychologist's fallacy" by William James (1890) and James Baldwin (1902) who urged psychologists to avoid "reading into the mind [one is] examining what is true of [one's] own; especially of reading into lower minds what is true of higher" (p. 382).

2.3.6. In a "Rudimentary Fashion"

Beginning from an assumption of dichotomy means that the decision needs to be made with regards to whether the infant's behavior is indicative of an adult level of a particular competency or not. Tomasello and colleagues argue that once infants understand others on a mental level, they can then intend to influence what others are

attending to (referential layer of intentionality), and what others know, feel, or do (social layer of intentionality) (Tomasello et al., 2007). This is evident in their pointing behavior, according to this account, because they seem to use pointing gestures to share emotions or influence others' feelings (expressive declarative pointing), to inform others and therefore influence what they know (informative declarative pointing), and to get others to do things (imperative pointing) (Tomasello et al., 2007; Tomasello, 2019). In addition to these referential and social layers of intentionality, there is a communicative layer that underlies pointing. This means that, when they point, infants are aware that they are communicating; that is, both the social partner and the infant know together that the infant is attempting to communicate (Tomasello et al., 2007). However, the authors also state that "it is possible that infants operate with some kind of primordial, undifferentiated communicative intention that contains the basic structure, but not all of the adult details" (Tomasello et al., 2007, p. 715), and question whether one-year-olds understand the communicative layer of intentionality. In an attempt to resolve this issue, it is stated that infants only understand the communicative layer in a "rudimentary fashion" (Tomasello et al., 2007, p. 715). However, it is not further explicated how this *rudimentary* understanding is different from an adult-like understanding beyond restating that infants "understand *at least something* [italics added] about the communicative intention," which is "clearly an understanding of the mental states of others" (Tomasello et al., 2007, p. 715).

A difficulty arises for Tomasello and colleagues' account when infants display some, but not all, adult-like skills involved in an adult level competence. As it is implicitly recognized by the authors, infants' emerging skill sets do not seem to fit into either the "present" or "absent" category. This is not a problem for activity-based, relational approaches which expect gradual development involving various skills emerging within various contexts that only later converge to bring about an adult-level capacity such as communicative intent. However, describing infants' emerging skills as a "rudimentary" version of the adult-like capacity is problematic, because it suggests the "presence" of the adult from and therefore discourages further investigation.

Drawing on the Process-Relational approach, I argue that infants' emerging gestures cannot, and should not, be neatly grouped based on whether they involve communicative intent or not. This is because it is the examination of the ambiguous cases, some of which might be transitional, that provides insight into the processes through which the social world becomes meaningful to the infant. It is in these

transitional events, and the shared routines and activities in which they are observed, where the emergence of social skills can be described and examined. This is where development happens, therefore a dichotomous approach overlooks the very aspect of development that is most important.

2.4. The Process-Relational Worldview

Theories rooted in the Process-Relational worldview I endorse posit that communicative meaning, therefore gestures and languages, emerge from relations between people interacting within shared routines, which in turn are rooted in our human embodiment and human forms of life (Canfield, 1995, 2007; Carpendale et al., 2013; Carpendale et al., 2021; Wittgenstein, 1953/ 2009). Although most theories agree that both nature and nurture, or biology and the environment, are important for development, there are important differences in how different theories conceptualize the nature of how they influence each other and interact. It is not uncommon to begin from the assumption that nature and nurture are pre-existing entities that interact. This leads to the assumption that forms of knowledge and social understanding can pre-exist in either the individual or the environment. This view has been criticized because it doesn't fit with our current knowledge of how genes work and does not explain the origins of meaning and understanding (e.g., Carpendale et al., 2021). Theories rooted in the Process-Relational worldview posit that interaction between components of the human developmental system happen at a level where it is not possible to differentiate between the individual and the environment (Carpendale et al., 2021; Meaney, 2010; Gottlieb, 2007). Therefore, rather than originating in the mind or the environment, development originates within relations[10] among components of the human developmental system that are "thoroughly interwoven" and where "biological and social factors mutually create each other" (Carpendale et al., 2021, p. 5). Rather than being primary, concepts such as nature and nurture, "can only be artificially abstracted out of a thoroughly integrated

[10] The primary nature of relations between components of the developmental system is evident in Piaget's (1952) theory who argued that at the origin of knowledge were the dynamic relations between the infant and the world, which he argued became increasingly more complex through the process of equilibration. Piaget (1952) argued that infants learn about the world through activity and through learning to organize their activity with objects and people, through which a web of schemes are constructed which provide the framework for incorporating new experiences and new knowledge. In this way, new experiences are always incorporated based on previous experiences and resulting knowledge.

matrix" (Carpendale et al., 2021, p. 5). According to this view, for similarity in developmental outcomes across cultures to exist, it is not necessary to look for a pre-existing entity that houses the foundation of knowledge. Rather, this regularity in outcome could be the result of a highly consistent, but dynamic developmental system (Carpendale et al., 2021; Mameli & Bateson, 2006).

2.4.1. Human Forms of Life

For relational approaches, communicative development is rooted in our human embodiment and human nature - in infants' reflexes and natural tendencies, their interest in others' eyes and faces, the fact that they are born helpless and cry to express their physical or psychological needs, their tendency to orient towards objects and events by looking, turning, leaning, or reaching (Carpendale et al., 2013; Carpendale & Lewis, 2021; Farroni et al., 2002; Mead, 1934; Racine & Carpendale, 2008; Wittgenstein 1953/ 2009). In Piaget's words (1952),

> intelligence is based on practical or sensorimotor intelligence which in turn depends on acquired and recombined habits and associations. These presuppose furthermore, the system of reflexes whose connection with the organism's anatomical and morphological structure is apparent. A certain continuity exists, therefore, between intelligence and the purely biological processes of . . . adaptation to the environment. (p. 1)

For Piaget (1952), development unfolds through various skills emerging within various contexts, which converge and intertwine to form a dynamic, increasingly complex, constantly changing and developing web of schemes (Carpendale & Wallbridge, 2018). This web of schemes provides the framework for subsequent learning, which is activity-based, according to Piaget. That is, new information is always incorporated and organized based on previous experiences.

Another key part of the developmental system is the caregiver, who observes and monitors the infant and responds, because infants' interests are manifest in their actions (Canfield, 1995). These aspects of our human embodiment and human nature situate infants within social interactions in which increasingly complex social skills emerge. For example, from birth, infants are interested in human faces and eyes, and soon after show enjoyment of face-to-face interactions (e.g., Farroni et al., 2002). Although it is tempting to think of such tendencies as being innate, a closer examination of factors such as the structure of human eyes shows that these tendencies can reliably emerge through an interplay between various components of the human developmental

system (Carpendale & Lewis, 2015; Tomasello, 2014). For example, the relatively large white sclera of the human eye makes it easier to discern gaze direction, which facilitates the development of being able to differentiate between the social partner looking away or looking at the infant (Carpendale & Lewis, 2015). Similarly, caregivers can differentiate between the infant looking away or looking at them and will respond to their infants looking at their faces, resulting in social interactions that are enjoyable for both the caregiver and the infant (Carpendale & Lewis, 2015). These human tendencies emerging from the interplay between components of the developmental system place infants within social interactions with caregivers, in which they begin to learn to organize their activities with others, and learn about aspects of activity such as their caregivers attending and responding to them (Reddy, 2013). Infants' needs and desires are also manifest in their crying and orienting actions, which are meaningful to the caregiver, but infants are not aware of this meaning at first (Canfield, 1995). Rather, infants learn the communicative meaning of their actions through parents responding and attributing meaning to these actions. In Bates et al.'s (1975) words, "this adult response to the infant's signals establishes a circular means-end relationship which is the first step in the development of communicative intentions" (p. 212). These tendencies and forms of behavior displayed by caregivers and infants provide the basis of human forms of life and human forms of activity, such as shared routines. Therefore, rather than innate capacities or knowledge, human infants' embodiment and interest in human activity, coupled with parents' embodiment and interest in, and responses to the infant's activity within shared routines, which are embedded in culture and guide and constrain activity, are at the origin of communicative development. Canfield (1995) argues that shared routines range from "more loosely structured" patterns of activity, such as requests and greetings, to more specific and "narrowly circumscribed routines," such as book reading (p. 198). In this way, early social skills, gestures, and language emerge within a web of shared routines that vary in nature and complexity.

2.4.2. A Practical Understanding of Mental States

Understanding human forms of activity in terms of mental states is made possible by learning a language, according to this approach, which is based on skills and expectations emerging within particular forms of shared routines (Canfield, 1995, 2007; Carpendale & Wallbridge, 2018; Racine & Carpendale, 2008). Infants begin to expect

responses and action patterns within these routines because they are structured and repeated. Within these shared activities, infants are learning about action patterns, including the meaning of others' gaze direction, head turns, reaches, and other orienting behaviors, as well as the meaning of their own actions for others. As these actions and action patterns are aspects of mental states manifest in behavior, infants are developing a practical understanding of these aspects of mental states. Mental states are not hidden, waiting to be discovered and understood through simulation, theorizing, or innate modules, according to this account; they are embodied and present in activity and therefore accessible to others (Racine & Carpendale, 2008).

2.4.3. Lean or Activity-Based

Although activity-based approaches posit that infants learn the communicative meaning of their gestures through others' response, this is not a lean account of development as it is not claimed that the emergence of this understanding is based on conditioning the infant's non-communicative actions into gestures, or that infants only understand others on a behavioral level at first. This interpretation does not follow for an activity-based approach, because mental states are not separate from, and do not cause behavior according to this view. Consequently, it is not possible for infants to understand others on *either* a mental or behavioral level. Infants are learning to coordinate their own actions with others' and are learning about mental states through this process because mental states are manifest in actions according to this view. Adult-like understanding is built on this earlier, practical understanding of others' activity and mental states. In this way, the alternative explanation I endorse is not a lean approach, and cannot be similar to behaviorism. This is because it is based on a different worldview and therefore on different metatheoretical assumptions about the nature of the mind, communication, and knowledge.

Supporters of activity-based approaches argue that the emergence of gestures are embedded within structured and repeated interactions with caregivers, and through caregiver responses within these interactions, they can become gestures (Clark, 1978; Mead, 1934). Clark (1978), drawing on the work of George Herbert Mead, refers to these interactions as "communicative structures" which are "a negotiated coordination of activities which belong to the community whose social activity it helps regulate" (p. 236). Therefore,

> It is very important not to think of the child as learning a "response" to a stimulus, . . . but as coming to organize his activity in a certain way (which he can extend to other contexts) and co-ordinating this activity with the corresponding acts of the mother. (Clark, 1978, p. 240)

For example, infants become increasingly skilled at decoupling their gaze from their actions between 6 to 12 months, which allows them to shift their attention between their own and a social partner's actions with ease (de Barbaro et al., 2013, 2016). This form of sensorimotor development results in skillful participation in triadic interactions yet does not require an understanding of others' actions in terms of mental states. Although infants are learning about others' attention and intentional activity, they do not need to infer others' intentions from their actions to do this. Indeed, as they become able to shift their attention between different activities and objects, infants tend to pay attention to their caregivers' hands, rather than their faces and eyes (de Barbaro et al., 2013; Deak et al., 2014). Such findings shift the focus from social understanding as being based on an insight about others' mental states, which has been associated with head turns and gaze direction, to conceptualizing social development as the convergence of increasingly complex social skills of embodied infants within human forms of activity (Carpendale et al., 2013; de Barbaro et al., 2013, 2016).

Rather than happening through a serious of conditioned responses and associations, development unfolds through the continuous organization of existing knowledge and new information into an increasingly complex web of schemes, which provides the framework for the incorporation of new information, but is also continuously revised and reorganized, resulting in development (Piaget, 1952). In this way, infants are developing increasingly complex social skills through learning to organize their activity with caregivers within shared routines.

2.4.4. The Development of Intentional Activity within Routines

It follows from the activity-based approach that intentional actions and communicative intent emerge within human forms of shared activity. At first, caregivers structure and scaffold these activities, but they then gradually reduce their assistance to accommodate the infant's emerging skills, while also involving the infant in increasingly complex routines. Within a complex web of shared activities, ones that facilitate the emergence of gestures are based on earlier ones that facilitate the emergence of forms of intentional activity. For example, Reddy et al. (2013) found that infants as young as 2-

to 4-months old anticipate their parents' actions within routines such as being picked up - infants stiffened their bodies and adjusted their arms and legs in response to their caregivers' approaching arms and showed an increase in their monitoring of the caregiver's arms between 2 and 4 months. This indicates that infants become active participants within shared routines with their caregivers soon after birth, which is made possible by their practical understanding of others' intentional actions directed towards them (Reddy et al., 2013). In this way, learning about embodied aspects of intentional activity, and therefore mental states, begins soon after birth.

Clark (1978) describes how the intentional action of reaching for an object is co-constructed through the coordination of the actions of caregivers and their infants. First, the mother

> will take the grasping and reaching movements of a neonate . . . as evidence for intelligible intentions from her cultural standpoint, and by manipulating the environment *construct* the action that the movements imply . . .. Having preformed these actions with mother's assistance the child has been shown a relation between his body and the world. Thus, he can now *intend* to do this thing, having done it before, though he may be unable to achieve a successful completion of his intention without assistance. (Clark, 1978, p. 237, italics in original)

For example, to help her infant, the mother will "adjust the orientation of the object, its place of contact on the infant's hand" (Clark, 1978, p. 237). However, the infant's interest in objects and attempts to engage with these objects in various ways are essential as well. As the infant becomes skilled at grasping objects, the mother will gradually decrease her assistance and expect more from the infant. In this way both the mother and the infant will develop expectations and co-construct shared routines (Clark, 1978). They will organize their activity in a way so that it results in the infant successfully grasping the object.

Intentional activity, such as the successful grasping of an object, then enables infants to participate in routines in which learning to organize their activity with others leads to the development of gestures (Clark, 1978). According to Clark (1978), "the child's first gestural usage derives directly from primitive communication structures by *changes in the form and function of the child's role within these* [italics added]" (p. 248). Communicative intent is gradually constructed, according to this approach, through transitional phases. For example, Ramenzoni and Liszkowski (2016) observed a transitional phase in the development of request gestures – before the emergence of these gestures, exemplified by pointing or extending the arm without leaning, infants

were observed to extend the arm and lean towards out-of-reach objects more frequently in the presence of a social partner. Infants' increased reaching might result in more opportunities for the caregiver to respond, and more opportunities for the infant to learn about the other's role as an agent in their activity, leading to a gradual emergence of communicative intent.

A later and more complex routine related to requests is "giving". Clark (1978) describes how the caregiver and infant coordinate their activity that facilitates the emergence of giving, within routines of "object transfer". Caregivers at first might extend their hands palm up towards the infant, but before infants become aware of the meaning of this gesture, the caregiver might gently take the object from the infant. Infants will develop an expectation of this action sequence and will gradually learn to place the object in the caregiver's hand (Clark, 1978). Alternatively, caregivers might extend their hands palm up to catch objects accidentally dropped by infants. Such routines, when repeated, provide an ideal context in which infants learn about giving objects (Clark, 1978). These examples illustrate how communicative intent develops through infants learning to organize and coordinate their activity with others within an intricate web of increasingly complex shared routines.

2.5. Process-Relational Explanations of the Development of Pointing

Process-Relational approaches to the development of pointing include explanations which posit that pointing gestures originate in initially non-communicative actions, such as reaching and index finger exploration, which are meaningful to parents who respond. One activity-based explanation is that pointing originates in infants' failed reaching (Lock, 1980; Leung & Rheingold, 1981; Vygotsky, 1978). However, Werner and Kaplan (1964) argued that the assumption that pointing originates in reaching or grasping is based on similarities in form, rather than in function. Research findings indicate that the frequency of reaching stays constant during the first and second year of life rather than showing an association with the emergence of index finger pointing, but more frequent reaches at an earlier age are associated with the emergence of pointing later on (Cochet & Vauclair, 2010a; Franco & Butterworth, 1996; Lock et al., 1990; Masataka, 2003; Racine, 2005). It is possible that reaching gestures play a role in, but do not decline or disappear with, the emergence of pointing. However, infants tend to

use whole-hand pointing (all fingers open or closed) to request objects and extend the index finger when pointing to share attention (Lock et al., 1990), which suggests that pointing to request might emerge as parents respond to their infants' reaching actions, which often involve the arm and all fingers being outstretched or opening and closing. It remains to be explained, however, whether and how this becomes associated with index finger pointing.

An alternative explanation rooted in the Process-Relational worldview is that pointing originates in the initially non-communicative orienting action of tactile exploration with the index finger, which is followed by infants extending the arm and index finger towards out-of-reach objects they wish to touch, which elicit parental response (Carpendale & Carpendale, 2010; Carpendale et al., 2013; Kettner & Carpendale, 2018; Werner & Kaplan, 1964). According to this activity-based account, index finger extensions have an exploratory purpose at first, before becoming communicative. Because infants' interest is manifest in their index finger exploration, it is possible for this hand configuration to develop into pointing through parental responses. That is, caregivers interpret these early forms of index finger use as interest and respond to the infant. For example, Kettner and Carpendale (2018) found that, in a study based on parental observations of their infants in the home, some functions emerged within the context of index finger touch. More specifically, infants developed expectations and began to use index finger touch to ask and answer questions and to request (Kettner & Carpendale, 2018). However, it remains to be investigated whether and how these expectations might transfer to, or develop in, other situations involving out-of-reach objects. Infants' index finger activity is embedded within routines, in which they are learning to organize their activities with their caregivers in different ways, and so they are learning that their index finger extensions function differently depending on the routine. As these activities are dynamic and involve complex patterns of interaction, infants might learn to expect routines or sequences of action at first, before the emergence of communicative intent involving more specific goals such as pointing to request, to inform, to obtain information, and so on. It is also possible that infants learn to expect some responses, such as parents giving them objects, and then begin to use pointing in different situations resulting in different responses through which new expectations develop. Alternatively, or in a complementary way, it is possible that expectations developing within other contexts, such as reaching with the arm, index finger touch, or during the showing of objects, influence the emergence of functions of pointing.

However, overall, if follows from the Process-Relational, activity-based account that functions are gradually differentiated through the emergence of expectations within particular shared routines, rather than being based on pre-existing underlying motivations.

2.5.1. The Emergence of Functions of Pointing

Parents respond to at least some of their infants' index finger extensions but their responses are based on the particular context. For example, in the context of feeding, parents might respond to an index finger extension towards a piece of fruit by giving it to the infant, but in other contexts, such as an infant pointing at the lights on the ceiling, caregivers might label or talk about the object. As the feeding routine involves giving objects to the infant to eat, parents likely interpret the infant's pointing towards a piece of fruit as a request within that routine. However, the parent will likely interpret the infant's point towards the lights as a different form of interest, and in this way this particular interaction might be incorporated into shared routines involving naming and talking about objects. This could still be interpreted as the infant having an intention while pointing and the parent either reading it right or wrong. That is, we could still start with the assumption that, even with their very first index finger extensions, infants are expressing an underlying communicative intent, and are expecting the caregiver to respond in a particular way. However, unless we have evidence for this expectation (for example, the infant keeps pointing, vocalizing, and/ or persisting in some other way), this is an unfounded assumption. Furthermore, this approach is based on the cognitivist assumption that mental states underlie actions. Pointing is a dynamic communicative tool, and it is possible that many times it serves multiple functions or has a non-communicative orienting aspect even when used by adults. This is further complicated when we are investigating the emergence of pointing because it is likely that many of the infants' emerging gestures will be transitional. That is, the infant might not expect a response, or might expect a response without being aware of the social partner's role in this response or might expect sequences of actions based on shared routines. Overall, it is likely that during the emergence of pointing, infants' pointing gestures will fit into a mix of the above situations. For example, it is possible that the infant already has the goal to touch the light on the ceiling, perhaps because they have already experienced achieving this goal by pointing and touching objects in other contexts. In this case, they will

perhaps learn a new meaning, or learn that this situation fits with ones where the caregiver talks about objects. Alternatively, extending the arm and index finger might have just become part of the infant's orienting activity towards out-of-reach objects at this point in development.

Infants' actions such as their earliest index finger extensions are embedded within complex social routines, which are structured and repeated, therefore allowing for the development of expectations. It is possible that infants first expect their gestures to elicit routines and enjoyable activities, but at first specific functions of pointing might not be differentiated. That is, infants might expect the caregiver to "take up the usual interaction pattern" in response to the infant's pointing gesture (Canfield, 1995, p. 200). This might involve the caregiver looking at and smiling at the infant while also talking about, giving, and/ or acting on an object. However, within these routines, infants are also learning about their caregivers' responses which will be guided by context. Through these responses various functions of pointing will be gradually separated from the infant's point of view, the emergence of which might be indicated by repeated pointing and persistence in cases when the caregiver is not providing the expected response.

2.5.2. Do Infants "Point for Themselves" before They Point for Others?

Liszkowski and Tomasello (2011) argue that communicative pointing must emerge before non-communicative pointing because, although infants do point when alone, they point more when in the presence of others (p. 17). However, an increase in index finger extension within social interactions could be the result of social activities such as triadic interactions with objects, being facilitative of more frequent index finger extensions. Additionally, a lack of agreement on the meaning of "pointing-for-self" has resulted in debate regarding whether pointing is communicative to being with. That is, whether, with their first pointing gestures, infants are expecting particular responses from others. Liszkowski and Tomasello (2011) argue that pointing emerges within social interaction, before infants use it to point for themselves to direct their own attention. However, Carpendale and colleagues' argument that infant pointing is not communicative to begin with does not imply that infants are pointing "for themselves" in the sense that they are directing their own attention (Carpendale & Carpendale, 2010). Rather, index finger extension is at first a manifestation of infants' orienting responses to interesting aspects of their environment (Carpendale et al., 2013). At first, they shift their

gaze and turn their heads and bodies, they then start to explore with their mouths and hands, grasping and tasting things. These are early orienting behaviors, yet we do not think of them as infants turning or grasping to direct their own attention; that is, we would not say that infants are engaging in “turn-for-self”. Infants are not directing their own attention by turning; they are simply responding and orienting. Around 7 to 8 months, infants start to use all fingers, and sometimes their index fingers only, to touch and explore objects, textures, patterns, or others’ faces (Carpendale & Carpendale, 2010; Kettner, 2014; Kettner & Carpendale, 2018). Around the same time, or soon after, they extend their arms and index finger towards out of reach objects, before moving closer to touch them (Carpendale & Carpendale, 2010; Kettner, 2014; Kettner & Carpendale, 2018). These are orienting actions at first. It is within social interactions, within joint activity, that infants learn to expect responses to these orienting actions from others and communicative intent can emerge.

Chapter 3. Current Study

Based on my discussion and comparison of two approaches to the development of communication, the present study was designed based on the Process-Relational worldview and resulting activity-based approach. Accordingly, the research questions, methods, and operationalization of variables were based on the view that adult-like communicative skills develop gradually through the convergence of social skills emerging in various regularly shared routines, in which infants are developing a practical understanding of social activity at first. Specifically, my study is based on the theory that pointing originates in initially non-communicative forms of index finger extension, to which parents respond. From this it follows that these early forms of index finger use, and the shared activities in which they occur, should be described in detail.

Additionally, supporters of this account argue that a detailed, longitudinal description of caregiver-infant interactions in the home should be considered as the starting point for investigations of social understanding in infancy (e.g., Carpendale & Carpendale, 2010). Accordingly, analyses of naturalistic parental diary observations recorded by 20 mothers were taken into account in the current research design (Kettner & Carpendale, 2018). Mothers of infants living in a large Canadian city reported looking at things, reading books, and playing with toys being common daily routines they engaged in with their infants (Kettner, 2014; Kettner & Carpendale, 2018). In addition, frequent pre-pointing index finger extensions and great variation in these forms of index finger use before the emergence of pointing were reported.

Caregiver-infant dyads were video recorded as they interacted in three sessions based on everyday routines: looking at things, reading a book, and playing with toys together. These routines were chosen based on their tendency to elicit particular forms of index finger use (Liszkowski et al., 2011; Kettner & Carpendale, 2018). Mothers were provided with minimal instructions to keep interactions as similar to everyday interactions as possible. Dyads were invited to the lab two times, when the infants were about 9 and 12 months old.

To follow up on previous findings showing an association between time spent in joint engagement and the development of gestures (Salomo & Liszkowski, 2013), as well as between caregiver sensitivity and later communicative development (Akhtar et al.,

1991; Kang et al., 2009; Begus et al., 2014), I conducted quantitative analyses of the associations between time spent in joint engagement and forms of pre-pointing index finger extension, parental responses to these, and pointing. Additionally, I added longitudinal qualitative descriptions of the interactions of three dyads who visited the lab when their infants were about 7, 9, and 12 months old. I chose these three dyads out of six who visited the lab three times because they varied greatly in the amount of time spent in joint engagement involving objects.

I examined the developmental trajectory of pre-pointing index finger exploration through qualitative observations and conducted quantitative analyses to examine the associations between pre-pointing index finger use, parental responses to these, and pointing. Results are presented in two parts. *Part 1* is a quantitative analysis addressing the following research questions:

Research question #1. Is the frequency of infants' index finger touch during book reading at 9 months associated with the frequency of infants' pointing gestures at 12 months?

Research question #2.
(a) Is frequency of parental verbal responses to infants' index finger touch at 9 months associated with frequency of infants' pointing gestures at 12 months?
(b) Is the frequency of parental labeling responses to infant's index finger touch associated with the frequency of infants' pointing gestures at 12 months?

Research question #3. Is the frequency of infants' slip-out index finger extensions at 9 months associated with infants' index finger touch during book reading at 9 months and frequency of infants' pointing gestures at 12 months?

Research question #4. Is the amount of time spent in joint engagement, and infant-elicited joint engagement, at 9 months associated with frequency of infants' index finger touch and slip-out extensions at 9 months, parental response at 9 months, and frequency of infants' pointing gestures at 12 months?

Part 2 includes longitudinal qualitative descriptions of how three dyads co-structured joint engagement episodes during their three visits to the lab, as well as a description of the diversity in forms of index finger use across infants at both 9 and 12 months.

3.1. Methods

3.1.1. Participants

Thirty-three healthy infants (19 girls) of 56 infants recruited, were included in the longitudinal analysis. Their participation involved two visits to the lab, when the infants were about 9 and 12 months old. All participants were living in the Greater Vancouver area and were recruited through advertisements in Facebook groups, on campus, and through word of mouth. All but two mothers spoke their native language to their babies (English=24; Chinese=7; Other=2) and 17 parents reported speaking more than one language. Twenty-two mothers were teaching their infants baby sign. Thirty mothers had a bachelor's degree or higher and 11 of those mothers had a master's degree or higher. All but one infant were living with both parents; 18 infants had siblings. Twenty-three dyads were excluded from the longitudinal analyses because they only came in for one visit or the infant was fussy at one of the visits (13 infants), a lack of sufficient camera angles to accurately code the infant's behavior (3 infants), the infant being the twin sibling of another participant (3 infants), or the infant's hands being covered or otherwise not available for reasons such as eating a cracker (3 infants); one infant was diagnosed with Down syndrome and was therefore excluded from statistical analyses.

3.1.2. Design and Procedures

Caregivers and their infants were invited to the lab to participate for 40 minutes, twice, when the infant was 9 and 12 months old. Dyads were videotaped in a room decorated with colorful objects and toys on a shelf, a chair, pillows, a small lamp, and colorful posters on the walls. Three wide angle GoPro Cameras and two CANON Camcorders were placed in the corners of the room to capture the dyads' interactions as they moved around in the room.

After reading and signing the Consent Form at the first visit, caregivers and infants were left alone in the room as they progressed through the following 5 sessions at both Time 1 and Time 2:

Look Session (5 minutes): Caregivers were asked to walk around the room and show things to their infants while holding their infant in their arms or on their hips (Liszkowski & Tomasello, 2011). Pointing was not mentioned. This session was included to provide a context in which infants are likely to engage in pointing.

Read Session (5 minutes): Caregivers were asked to read a touch-and-feel book of nursery rhymes with their infants seated in their laps. Caregivers were asked to read the book as they would at home. This session was included to provide a context in which infants are likely to engage in tactile exploration with the index finger (index finger touch, IFT).

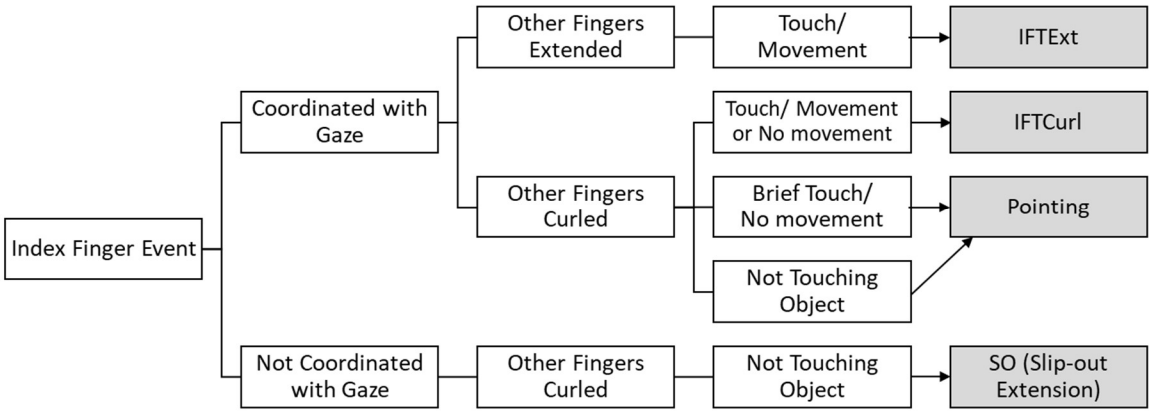
Play Sessions (3 x 5 minutes): Caregivers were asked to play for 5 minutes with their infants as they would at home (Wu & Gros-Louis, 2015). After this, they were asked to let their infants "lead" the play session for the next 5 minutes – they were told to "follow-in" on what their infants touch or look at. In the final 5 minutes, parents were asked to "take the lead" and introduce the toys to, and initiate interaction with their infants.

Parents received an e-mail shortly after their first visit with a copy of the Consent Form attached and a link to the Participant Questionnaire, which included demographic questions as well as questions about frequency and length of book reading at home (Appendix).

3.1.3. Variables and Measures

Infants' index finger extensions were coded into four categories based on criteria show in Figure 1.

Figure 1. Coding Criteria for Types of Index Finger Event



***Infant Index Finger Touch with other fingers Extended (IFTExt*).** IFTExt was coded when all fingers were extended but only the index finger was touching a picture or texture in the book. Alternatively, all fingers were touching, but only the index finger was moving in a scratching or tapping motion. An event was coded when the index finger made at least one full movement separate from the other fingers (e.g., all fingers are touching the picture and the infant fully curls and opens the index finger at least once with the other fingers remaining still). The infant's gaze direction was coordinated with the index finger.

This variable was operationalized by counting the total number of IFTExts during the first 4 minutes of the Read session at Time 1 and Time 2.

Infant Index Finger Touch with other fingers Curled (IFTCurl). IFTCurl was coded when all fingers were curled but the index finger was extended to touch a picture or texture in the book, either briefly or for a longer time. The infant might engage in scratching or tapping or might touch the picture without moving the index finger. All index finger extensions with other fingers curled, involving contact with the book and being coordinated with the infant's gaze were coded.

This variable was operationalized by counting the total number of IFTCurls during the first 4 minutes of the Read session at Time 1 and Time 2.

Infant Slip-out Index Finger Extension (SO). SOs were coded when the index finger was extended with other fingers curled with any arm position (not extended, half extended, or extended), but not coordinated with the infant's gaze direction.

This variable was operationalized by counting the total number and total duration of SOs in the first 4 minutes of the Look session at Time 1 and Time 2.

Infant Pointing Gestures (Point, Pointing). Pointing was coded when the arm was fully or partially extended away from the body with the index finger extended and other fingers curled (Liszkowski et al., 2007). The gesture had to be directed towards an object and coordinated with the infant's gaze direction (Wu & Gros-Louis, 2015). Gestures that included brief touches with the index finger were included in this category. For reasons discussed earlier, gaze alternation to the caregiver's face was not included as a criterion for pointing.

This variable was operationalized by counting the total number of points during the first 4 minutes of the Look session at Time 1 and Time 2.

Parental Response to IFT. Changes in parental verbal behavior within 2 seconds from the onset of the infant's IFT were coded (Wu & Gros-Louis, 2015). After an initial categorization of each instance of IFT into either a 'Parental Response' or 'No Parental Response' (**NPR**) category, observations in the 'Parental Response' category were further coded into one of the following two mutually exclusive categories: 'Verbal response' (**PVR**) and 'Non-Verbal Response'. Observations in the 'Verbal Response' category were further coded for the presence or absence of an object label: 'Label Response' (**PLR**) (Wu & Gros-Louis, 2015).

This variable was operationalized by counting the total number of NPRs, PVRs and PLRs in the first 4 minutes of the Read session at Time 1.

Triadic Joint Engagement (JE). JE events were coded when the infant and parent coordinated gaze towards an object followed by engaging with the object for longer than 5 seconds. The event ended when either the infant or the parent looked away, resulting in the dyad ending their engagement with the object. Events were only coded when the parent talked about, acted on, or both talked about and acted on the object (Loy et al., 2018). Infant's gaze alternation between object and caregiver was not required, based on reasons discussed above.

This variable was operationalized by coding the total amount of time spent in JE in the first 4 minutes of the Look session at Time 1. JE Events were categorized based on the following criteria:

Infant-led: The infant is already looking at the object at the beginning of the event. For example, mother and infant walk towards a poster and the infant shifts their attention to the poster before the parent begins gesturing or talking about it. Alternatively, the parent follows in on an action of the infant, such as a head turn or vocalization.

Parent-led: Event is elicited by the parent talking about and/ or gesturing towards and/ or acting on an object (e.g., bringing an object close to the infant's face or pointing at an object and saying "Look!"), which successfully directs the infant's attention to the object.

Book Reading in the Home. This control variable was measured with a question on the Participant Questionnaire (Appendix, Question #7).
5 categories: every day, several times a week, about once a week, sometimes, haven't started reading books with my infant yet

Parental Pointing. Parental pointing was coded when the caregiver's arm was fully or partially extended with the index finger extended as well and the gesture was directed towards an object and was coordinated with the mother's gaze direction. The index finger might briefly touch the object.

This variable was operationalized by counting the number of times the mother pointed during the first 4 minutes of the Look session at Time 1.

Parental Education. This control variable was measured on a 10-point scale for both the mother and the father (Appendix, Q. 23 & 25) (Callahan & Eyeberg, 2010).

The videos were coded using the video annotation software ELAN. About 40% of the events for each variable were coded by a second coder blind to the aim of the study. Resulting Cohen's Kappa values were between .80 and .85 for all variables, indicating near perfect agreement. In cases of disagreement, the primary coder's ratings were used.

3.2. Quantitative Analysis

All infants were observed to engage in at least one form of index finger use by 12 months (Table 1). Interestingly, in spite of being able to extend the index finger with other fingers curled soon after birth, results suggest that infants extend all fingers during early stages of tactile exploration. Overall, 24 infants used the index finger with other fingers extended (IFTExt) to touch textures and pictures at 9 months and 3 of these infants also touched with the other fingers curled (IFTCurl), while 5 infants always curled the other fingers. Only 4 infants did not engage in any activity involving the index finger moving separately from the other fingers at this age. Overall, results indicate that it is common for infants to engage in tactile exploration with the index finger before the emergence of pointing gestures.

All infants who were observed to point at 9 months also engaged in other forms of index finger use. That is, although many infants engaged in IFT and no other forms of index finger use, all of the infants who used pointing gestures at this age also displayed slip-out extensions or IFTs. Five of the 10 infants who were observed holding slip-out extensions were also pointing, but only 2 of the 24 infants who engaged in IFTExt also pointed. Frequency of index finger touch was higher for the 10 infants who engaged in IFTCurl, suggesting that index finger extenders might be more practiced in this type of exploration when compared to infants who only engaged in exploring with all fingers extended. Four infants did not extend the index finger at all with other fingers curled at either of the two visits.

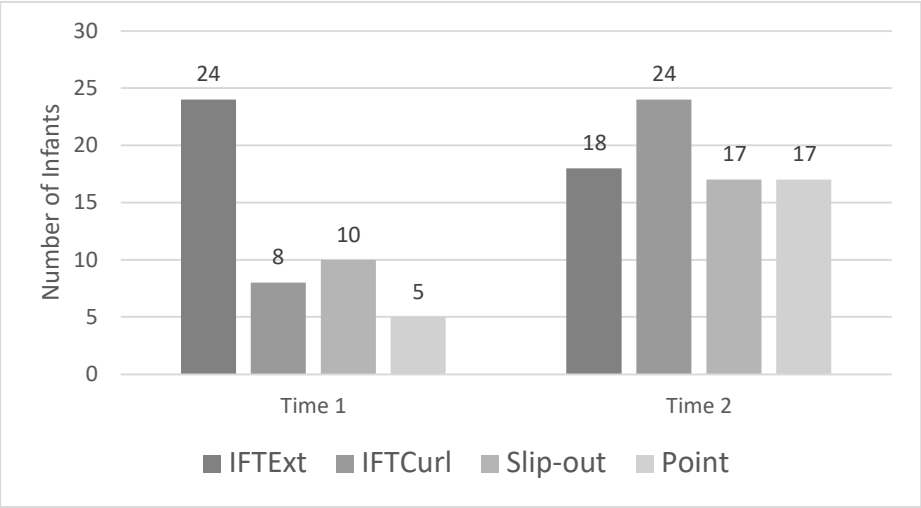
Only 6 pointing gestures out of 142 pointing events at 12 months involved gaze checking or looking at the caregiver's face. Similarly, infants only leaned forward infrequently while pointing. Interestingly, leaning seemed to be influenced by the proximity of the object - infants were more likely to lean forward when the object they were pointing at was closer to them, rather than further away, such as across the room.

Table 1. Frequency of Forms of Index Finger use at Time 1 and Time 2

	Time 1				Time 2			
ID#	**IFTExt**	**IFTCurl**	**Slip-out**	**Point**	**IFTExt**	**IFTCurl**	**Slip-out**	**Point**
4	8					6	8	17
8	1	5	8	3		26	11	12
11	7				10			
12		17	3			26	5	1
15	4						7	23
16	3				13			
20		6	4	5		12		3
21	1				3			1
22					4	4		
24	1	2			1	6	9	32
27	3		9	3		12	10	21
28	1				1		2	
29	1				13	2		
30	12					15	2	10
31	4		1		8	1		
32		9	2	7		35	9	6
33					6	12	2	1
36			3		2	1		
38	2				9	1		
40	5					6	10	11
41	13				4	15	1	2
42		1				9		
43					1	2	1	
44		15	9	8		9	2	24
46	5				5	6		
47	1		6		4		13	
48	1							
49	1		9			8	5	9
50	2				1			
52	1				3			
54	3	6				4		1
55	2				4	4		
56	1					13	12	35
TOTAL	**83**	**61**	**54**	**26**	**92**	**235**	**109**	**209**

Infants were significantly more likely to point at 12 months than at 9 months (Wilcoxon's z=-.319, p=.001). From 9 to 12 months, the number of infants engaging in IFTExt decreased from 24 to 18 infants, while the number of infants engaging in IFTCurl increased from 8 to 24 infants. Of the 24 infants who engaged in IFTCurl at either of the two visits, 16 infants were also observed to use pointing gestures. However, 15 of the 17 infants who used pointing gestures also used IFTCurl. That is, infants were likely to engage in IFTCurl either at the same time or before using pointing gestures. As shown in Figure *2*, more infants engaged in IFTCurl when compared to pointing gestures at both 9 and 12 months. These results suggest that IFTCurl is a developmentally earlier form of index finger use when compared to pointing gestures. The number of infants who displayed SOs increased from 10 to 17 infants between 9 and 12 months. Overall, the total number of IFTCurls increased from 61 to 235 events and SOs increased from 54 to 109 events across all infants. Twice as many infants engaged in SOs than pointing gestures at 9 months, but these numbers became equal at 12 months. Twenty infants were observed extending the index finger in SOs at either of the two visits, and 15 of the 17 infants who used pointing gestures were observed to have SOs either at the same visit or before. About a third of SOs during the Look session at 12 months were immediately followed by a pointing gesture. However, this number is based on all infants, including infants who just started pointing and infants for whom pointing gestures seemed to be more established. Therefore, it is likely that an even higher number of pointing gestures follow SO events at the time of the emergence of pointing, before they become established gestures in the infant's communicative repertoire. The number of infants using pointing gestures increased from 5 at 9 months to 17 infants at 12 months. A comparison with index finger use at Time 2 showed that IFTExt is likely the earliest form of index finger use that is coordinated with the infant's gaze direction before the emergence of pointing gestures. Therefore, results suggest that IFTExt is the earliest form of index finger extension, followed by IFTCurl, then an increase in SOs, and finally pointing gestures.

Figure 2. Number of Infants Showing Each Form of Index Finger Use at Time 1 and Time 2



3.2.1. Descriptive Statistics

Table 2. Descriptive Statistics for Variables of Interest at Time 1 and Time 2

	N	Range	Mean	Std. Deviation	Variance
TIME 1					
Total Joint Engagement (s)	33	187	141.85	47.936	2297.883
Infant Led Joint Engagement (s)	33	194	59.62	53.719	2885.744
Parent Led Joint Engagement (s)	33	185	82.00	50.785	2579.125
Index Finger Touch Freq	33	17	4.91	4.914	24.143
Index Finger Touch – Other fingers extended (IFTExt) Freq	33	13	2.52	3.249	10.553
Index Finger Touch – Other fingers curled (IFTCurl) Freq	33	17	2.39	4.505	20.299
Parent Verbal Response to IFT (%)	32	1.00	.4300	.27485	.076
Parent Label Response to IFT (%)	32	1.00	.2925	.28550	.082
Slip-out Extension Freq	33	9	1.64	2.983	8.898
Slip-out Extension Duration (s)	34	118	12.03	28.348	803.605
Infant Pointing Freq	33	98	.79	2.026	4.107
TIME 2					
Infant Pointing Freq	33	35	6.33	9.938	98.768
Slip-out Extension Freq	33	13	2.94	4.075	16.602
Index Finger Touch Freq	33	35	9.91	7.872	61.961
Index Finger Touch – Other fingers extended (IFTExt) Freq	33	13	2.79	3.804	14.470
Index Finger Touch – Other fingers curled (IFTCurl) Freq	33	35	7.12	8.499	72.228

On average, parents and infants spent about 2 ½ minutes (140 seconds) jointly engaging with an object (JE) during the first 4 minutes of the Look session at Time 1. Of these 2 ½ minutes, the dyads spent more time in JE that was elicited by the parent, about 1 minute 20 seconds, and about 1 minute in JE with the infant's attention already

on the object. Dyads spent between 30 to 216 seconds of the four minutes in joint engagement. Infants displayed 2 slip-out extensions, on average, in the first 4 minutes of the Look session at Time 1 (up to 9 seconds in length) and they extended the index finger for longer than 5 seconds less than once (ranging between 0 and 7 extensions). On average, infants extended their index fingers for about 12 seconds in total during the 4-minute session; with a maximum of 118 seconds.

The average number of index finger touches (IFT) was about 4 events during the first 4 minutes of the Read session at Time 1. Of these, about 3 times the index finger was moved to explore and about once the IFT was shorter without index finger movement. Parents verbally responded to about 45% of the total number of index finger touches across all infants and their responses included a label about 30% of the time. Infants' average pointing frequency in the Look session at Time 2 increased to about 7 gestures compared to about 1 gesture at Time 1. Slip-out extensions (SO) increased from 2 extensions at Time 1, to 3 extensions, on average, at Time 2.

Mothers' and fathers' education were measured on a 10-point scale (Appendix, Q#22); 18 mothers reported having a bachelor's degree and 11 had a master's degree or higher. Fourteen fathers had a bachelor's degree and 9 fathers had a master's degree or higher. Reading frequency was measured on a 5-point scale (Appendix, Q#7) and most parents (28) reported reading to their infants "several times a week" or "every day". The rest of the parents read to their infants sometimes or once a week. Parents pointed 17 times on average in the Look session at Time 1, with a minimum of 1 and maximum of 40 gestures.

3.2.2. Correlation Analyses

Because of violations of univariate and bivariate normality, Spearman's rank correlation coefficients (r_s) were calculated to examine the associations for the variables shown in Table 3. Pearson's correlation coefficients (r) were calculated for the three variables that did not violate normality assumptions (Table 4).

Table 3. Correlation matrix (Spearman's Rho, r_s) for the variables of interest

	IFT (T1)	SO (T1)	RF (T1)	PVR (T1)	PLR (T1)	JE (T1)	IL-JE (T1)	PL-JE (T1)	MEd	PP (T1)
Infant Pointing Freq T2 (P)	**.433***	**.408***	.148	.013	.279	**.391***	**.454****	-.002	.158	.274
Index Finger Touch Freq T1 (IFT)		.307	.070	.281	**.550****	**.494****	**.375***	.120	.215	.111
Slip-out Extension Freq T1 (SO)			-.133	.054	.294	**.387***	.084	.128	.104	.167
Reading Freq at Home T1 (RF)				.072	.096	.211	-.025	.100	.313	-.083
Parent Verbal Resp to IFT T1 (PVR)					.593**	--	.017	-.105	-.045	--
Parent Label Resp to IFT T1 (PLR)						**.409***	**.446***	.083	.012	.126
Total Joint Engagement T1 (JE)							.410*	.394*	.271	--
Infant-led JE								-.392*	-.061	.317
Parent-led JE									.097	.113
Mother's Education (MEd)										-.135
Parental Pointing Freq T1 (PP)										--

*p<.05 **p<.01

Table 4. Correlation matrix (Pearson's correlation coefficient, r) for the variables of interest

	JE (T1)	PP (T1)
Parent Verbal Resp to IFT T1 (PVR)	.066	-.123
Total Joint Engagement T1 (JE)		.345
Parental Pointing Freq T1 (PP)		--

*p<.05 **p<.01

3.2.2.1 Research Question #1

A significant positive correlation was found between frequency of IFT at 9 months and frequency of pointing at 12 months (r_s =.433, p=.013). To further investigate the association between different forms of IFT and pointing, I looked at the relationship between two types of hand configuration during IFT - other fingers curled (IFTCurl) and other fingers extended (IFTExt) at 9 months and frequency of pointing at 12 months (Table 5). No significant correlations were found. The lack of significant results after the breakdown of IFTs into further categories might be the result of a sample size that was too small for detecting these associations.

Table 5. Correlation matrix (Spearman's Rho, r_s) for two sub-categories of IFT and Pointing gestures

	IFT-Curled (T1)	IFT-Extended (T1)
Infant Pointing Frequency (T2)	.325	.050

*p<.05

3.2.2.2 Research Question #2

The activity-based account posits that infants learn the communicative significance of their actions through others' response. However, no significant correlations were found between pointing frequency at 12 months and frequency of parental verbal response (r_s =.013, p=.944) and parental label response (r_s =.279; p=.121) to IFT at 9 months.

Interestingly, while the frequency of parental label responses to IFTs were positively (although not significantly) associated with pointing later on, there was no association between total verbal responses and pointing later on. However, it has to be noted that only 10 infants engaged in IFT with an extended index finger and other fingers curled at 9 months and IFTs in general were not frequently used across infants at this age. Future studies could investigate this association with a larger sample size and more observation points between 9 and 12 months.

3.2.2.3 Research Question #3

Frequency of slip-out extensions at 9 months was significantly positively correlated with frequency of pointing gestures at 12 months (r_s=.408, p=.021). This finding provides further support for the hypothesis that early forms of index finger extension are linked to the emergence of pointing later on.

3.2.2.4 Research Question #4

Total time spent in joint engagement at 9 months was significantly positively correlated with pointing at 12 months (r_s=.391, p=.027), frequency of index finger touch (IFT) at 9 months (r_s=.494, p=.004), parental labeling responses to IFT at 9 months (r_s =.409, p=.020), and frequency of slip-out extensions (SOs) at 9 months (r_s=.387, p=.028). Further analyses of joint engagement, based on whether it was parent-led or infant-led, showed a significant positive correlation between infant-led JE at 9 months and pointing at 12 months (r_s =.454, p=.009) and this correlation was stronger than that between total time spent in joint engagement and pointing. In contrast, parent-led JE at 9 months was not correlated with pointing at 12 months (r_s =-.002, p=.990). Similarly, time spent in infant-led joint engagement was significantly positively correlated with IFT at 9 months (r_s =.375, p=.034) and frequency of parental labeling responses to IFT at 9 months (r_s=.446; p=.01), whereas time spent in parent-led joint engagement was not (r_s =.120, p=.513; r_s=.083, p=.651). In summary, the association between time spent in joint engagement episodes at 9 months and frequency of pointing gestures at 12 months was driven by time spent in joint engagement that was not initiated by the parent. This finding shows that previous positive correlations found between parental follow-in on infant gestures and language development extend back to preceding developmental stages of gesture development.

Parental pointing frequency and parental education were not significantly correlated with any of the variables in the current study.

3.2.3. Regression Analyses

The dependent variable, frequency of pointing at 12 months, is a count variable with a high number of zeros for infants who did not point and was therefore overdispersed. Taking this into consideration, Negative Binomial Regression analyses were conducted (Table 6). Negative Binomial regression was chosen over Poisson regression because of the violation of the equal mean and variance assumption for the dependent variable (Hilbe, 2007). In addition, Negative Binomial regression analyses were conducted with the dispersion parameter estimated based on the current data, instead of the default value of 1. Based on the Deviance and Pearson Chi-square values, this model was the best fit when compared to either the Poisson or the Negative Binomial model with the default dispersion value. Goodness of fit was tested by looking at the Deviance and Pearson Chi-Square values, which were reasonably close to 1 for all three models.

First, total time spent in joint engagement (JE) was regressed on pointing and the likelihood ratio chi-square test indicated that this model was a significant improvement in fit over the intercept only or no predictors (null) model ($p<.05$). JE at 9 months was a significant predictor of pointing at 12 months ($b=.015$, S.E.=.0056, $p<.05$). The incidence rate ratio ($Exp(B)=1.016$) indicated that for every second increase in JE, frequency of pointing gestures increased by a factor of 1.016, or 1.6%. Dyads spent between 30 to 216 seconds in joint engagement. Therefore, as an example, in the case of these two infants who spent the least and most amount of time in joint engagement at 9 months, the model predicts that, at 12 months, the latter infant would produce about 18 times as many pointing gestures as the first infant.

Next, frequency of slip-out extensions (SO) was added to the model and this model was a significant improvement over the null model ($p<.05$). However, with SO included, each second increase in JE now only explained a 1.3% increase in the frequency of pointing ($b=.013$, S.D.=.0062, $p<.05$) and SO was not a significant predictor ($b=.095$, S.D.=1180, $p=.420$). The incidence rate ratio ($Exp (B)=1.10$) indicated that each additional SO at 9 months accounted for a 10% increase in frequency of pointing at 12 months. Finally, adding index finger touch (IFT) resulted in a significant improvement

over the null model (p<.05), with all predictors being positive, but not significant. With the two additional predictors, every second increase in JE now only resulted in a 1.1% increase in frequency of pointing (b=.011, S.D.=0067, p=.111), every additional SO accounted for a 9.4% increase in frequency of pointing (b=.090, S.D.=1113, p=.420), and every additional index finger touch resulted in a 5.5% increase in frequency of pointing (b=.054, S.D.=.0554, p=.333). Overall, all three models were statistically significant; that is, the independent variables entered accounted for part of the variation in the dependent variable. However, only JE at 9 months uniquely predicted the variation in pointing at 12 months, and only in the first two models. Therefore, although all 3 models were statistically significant, it was time spent in joint engagement driving the overall association between the independent variables and frequency of pointing at 12 months.

These results provide support for the significant positive correlation found between time spent in JE at 9 months and pointing at 12 months. Considering that frequency of pointing gestures at 9 months ranged between 0 and 35 gestures and time spent in JE ranged between 30 and 216 seconds, a one second increase accounting for a 1.6% increase in frequency of pointing means that JE accounted for a relatively large increase in frequency of pointing.

Table 6. Results of Negative Binomial Regression Analyses

			Hypothesis Test			
Parameter	B	Std. Error	Wald Chi-Square	df	Sig.	Exp(B)
(Intercept)	.222	.8444	.069	1	.792	1.249
JE_Total_Look_T1	.015	.0056	7.464	1	.006	1.016
(Scale)	1[a]					
(Negative binomial)	1.641	.4504				

Parameter	B	Std. Error	Hypothesis Test			Exp(B)
			Wald Chi-Square	df	Sig.	
(Intercept)	.405	.8866	.209	1	.647	1.500
JE_Total_Look_T1	.013	.0062	4.557	1	.033	1.013
SO_3s_Look_T1	.095	.1180	.650	1	.420	1.100
(Scale)	1[a]					
(Negative binomial)	1.599	.4424				

Parameter	B	Std. Error	Hypothesis Test			Exp(B)
			Wald Chi-Square	df	Sig.	
(Intercept)	.538	.8817	.372	1	.542	1.712
JE_Total_Look_T1	.011	.0067	2.534	1	.111	1.011
SO_3s_Look_T1	.090	.1113	.650	1	.420	1.094
IFT_Read_T1	.054	.0554	.936	1	.333	1.055
(Scale)	1[a]					
(Negative binomial)	1.540	.4314				

3.3. Qualitative Observations

3.3.1. Observations of Joint Engagement in Three Dyads

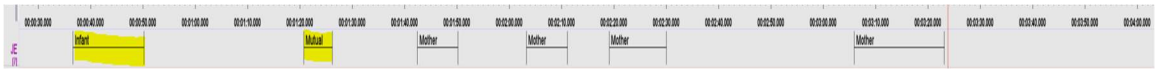
I found a positive correlation between time spent in infant-led triadic joint engagement at the 9-month visit, and frequency of IFT, SO, and parental responses at 9 months, as well as infant pointing at 12 months. These findings provide support for and add to previous findings showing an association between time spent in joint engagement and the development of gestures (Salomo & Liszkowsi, 2013), and findings highlighting the importance of the infant's attention being naturally drawn to objects, rather than being directed by the caregiver (Akhtar et al., 1991; Kang et al., 2009; Begus et al., 2014). With the purpose of gaining further insight into what it is about caregiver-infant interactions that might predict longer joint engagement episodes, and to describe details of these interactions that might be missed during the quantitative coding process, exploratory qualitative descriptions of three mother-infant dyads' joint engagement episodes at three time points were added. As shown in Figure 3, at the 9-month visit,

Dyad 1 and Dyad 3 spent significantly more time in joint engagement when compared to Dyad 2 (212 and 189 seconds versus 70 seconds), but the mother of the infant in Dyad 3 elicited most of the JE events, whereas Dyad 1 spent most of their time in infant-led joint engagement.

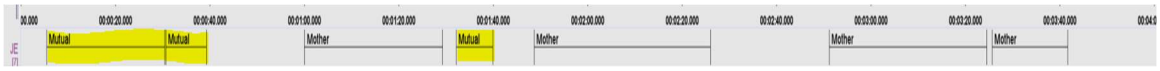
Figure 3. Time Spent in Joint Engagement (black lines) and Infant-Led Joint Engagement (highlighted) by Dyad at 9 months

Dyad 1

Dyad 2



Dyad 3



3.3.1.1 Visit 1

At Visit 1, the three infants were 7, 7.5, and 8 months old. They were all attentive and interested throughout the session, which was alternated with showing excitement through moving their whole bodies, flapping their arms up and down and kicking their legs. All three mothers walked around the room at roughly the same pace and introduced and talked about objects, with important differences in how they structured their interactions with their infants.

Dyad 1 spent most of their time in triadic joint engagement episodes, most of which were elicited by subtle actions by the mother, such as small turns, sounds, or walking closer to an object. This allowed for the infant to spontaneously shift her attention to objects. When the infant looked away, the mother was similarly subtle in redirecting the infant's attention, resulting in longer joint engagement episodes with the same object. Within these episodes, this mother pointed often and asked questions such as "What's this?" or "What color is this?". When talking about objects, she pointed out details and talked about the textures and colors, in addition to asking questions and labeling objects. Mutual joy was shown by the infant's excitement and squeals and the

mother's smiles, laughs, and tone of voice. For example, the mother would laugh in response to the infant's squeals and excitement. This infant showed the most excitement among the three infants. New joint engagement episodes often followed the infant turning away from the previous object.

For Dyad 2, joint engagement episodes often began by the mother walking closer to objects which successfully directed the infant's attention to the object. Once jointly engaged, this mother spoke in a low and quiet voice and did not point. She often asked questions such as "What's that?", but only labeled a few of the objects in the room and did not describe the objects in detail. She frequently ended JE episodes by commenting on the infant's actions unrelated to the object of joint engagement. Alternatively, she walked away from objects while the infant was still attending to them to introduce something new to the infant. The infant was calm and attentive and sometimes showed excitement. However, the mother's occasional displays of excitement and affection were not coordinated with, or contingent on, the infants' bouts of excitement, and these were not jointly directed towards objects.

The mother in Dyad 3 did not seem to attempt to sustain her infant's attention on objects by redirecting the infant's attention. Rather, she alternated between following-in on many of her infant's head turns and interests by labeling objects and directing her infant's attention to objects. This resulted in the dyad frequently shifting their attention between objects and therefore spending less time in joint engagement. This mother labelled many of the objects, pointed less frequently, and sometimes added detail to her descriptions of the objects. The infant was overall attentive and interested. Although both the infant and the mother displayed bouts of excitement about objects in the room, most of these displays were not coordinated or contingent on each other.

3.3.1.2 Visit 2

At visit 2, the infants were about 9 months of age. Time spent in JE at this age predicted frequency of pointing gestures at 12 months. Two infants (Dyad 1 and 3) showed high interest in the objects in the room, whereas the infant in Dyad 2 lost interest more quickly and spent less time attending to objects. The infant in Dyad 1 expressed her interest by extending one arm towards and visually attending to objects, whereas the infant in Dyad 3 frequently leaned towards and tried to grasp or touch objects with both hands.

The interactions of Dyad 1 were very similar to their first visit, but the infant was calmer and more in control of her body - she now showed interest through touching and extending her arm and sometimes index finger towards objects, rather than through whole body movements. The mother used more labelling and describing and asked less questions when compared to the first visit. The following is an illustration of this dyad's interactions at this visit:

> The mother walks up close to the poster while the infant is already looking at it. The infant extends her arm and index finger and touches the poster while the mother points and talks about the dogs on the poster. The infant keeps touching then looks away. The mother keeps pointing and talking and the infant looks back at the poster. She is attentive and vocalizes "ahh" and the mother responds by saying "yeah" and continues pointing and talking. In response, the infant reaches out and touches the poster again.

At the start of most of the joint engagement episodes of this dyad the infant's attention was already on the object; that is, the infant's attention was spontaneously drawn to objects, rather than being directed by the mother. The mother only used gestures and words to direct the infant's attention to new objects when these were in a location not easily seen by the infant (e.g., objects on a shelf).

Compared to their first visit, the mother in Dyad 2 spent more time labeling and talking about objects and asked less questions. She pointed less often than the other two mothers. She showed sensitivity by often responding to her infant looking away or becoming squirmy by saying something like "oh, I know you want to get down". However, as her comments were often not object directed, these responses tended to end the dyad's short triadic joint engagement episodes. Overall, the infant was squirmier and showed frustration more often compared to the other two infants. A short part of the dyad's second visit is described below:

> The mother and infant are standing close to the poster, but the infant is looking at something behind the mother's back. The mother starts talking about the poster and the infant turns his head, still not looking at the poster. The mother steps closer and starts pointing while still talking, and successfully directs the infant's attention who reaches towards the poster and touches with all fingers. The mother says "yes, you touch", then the infant looks away. The mother brings her own attention to the infant, gives him a kiss, and walks towards the other poster, but not in the direction the infant is looking.

During the interactions of this dyad, the infant's attention was sometimes drawn to objects spontaneously and other times by the mother directing it in in response to the infant becoming squirmy and impatient.

During the second visit, the mother in Dyad 3 was more directive when compared to the first visit. In some cases, this was in response to the infant leaning and reaching towards and wanting to touch and grasp objects. The infant did not display any arm extensions with one arm, either all fingers outstretched or in a pointing form. Rather, he showed engagement with being attentive, smiling, and leaning and reaching towards objects with both arms. Overall, this dyad spent a significant amount of time in triadic joint engagement, but, in contrast to the first dyad, most of the interactions were elicited by the mother. The mother described the objects in detail, pointed a lot, talked in an engaging voice, and often demonstrated the actions of different objects, sometimes involving the infant (e.g., she lifted the infant up to demonstrate flying). The following is an example of this dyad's interactions:

> The mother turns towards the poster, points and says "Look, Paw Patrol!" which successfully directs the infant's attention to the poster. She smiles and keeps talking and pointing in an excited tone, describing and labeling the dogs on the poster. The infant looks and smiles but does not vocalize or reach towards the poster. The mother keeps talking in an engaging voice, alternating her gaze between the poster and the infant. When the infant looks away the mother walks towards the second poster, but not in the direction the infant was looking.

During the interactions of this dyad, the infant's attention was often directed to objects by the mother, rather than being spontaneously drawn to them. This pattern was consistent throughout the dyad's visit and seemingly independent of the infant's reactions to objects (e.g., leaning and reaching vs. quietly looking and attending).

3.3.1.3 Visit 3

At Visit 3, the infants were about 12 months old. There was greater variation across the three infants' behavior at this age, when compared to the other 2 visits. The infant in Dyad 1 was squirmy but interested and had proto-conversations with her mother about objects, which involved turn taking through emotional displays, pointing, and vocalizing. The infant in Dyad 3 was interested but alternated between quietly attending and leaning/ reaching towards objects with both hands. He responded to the mother by smiling and looking at her face often.

Dyad 1's third visit was characterized by mutual joy, turn taking, and the mother re-directing her infant's attention by staying close to objects and talking about them. This dyad often engaged in simultaneous pointing, the infant stopping at times, then vocalizing and pointing again in response to something the mother said, to which the mother responded by saying "yeah," and repeating the word she just said. Despite the infant's frequent gaze shifts and attempts to touch and grasp objects, the mother successfully redirected the infant's attention to their ongoing triadic joint engagements by staying close and continuing to talk about the object. This mother never explicitly commented on the infant's actions; rather, she kept her attention on showing things to her infant and pointing, labeling, and talking about the objects. The infant's attention again was spontaneously drawn to most of the objects and new joint engagement episodes tended to follow the infant becoming uninterested in the previous object.

At the third visit the mother in Dyad 2 tended to ask the questions and play games with her infant. One theme throughout this session involved the mother playing a game of bringing the infant close to objects then quickly pulling him away and laughing. The infant's arm and index finger were often extended during these games as he was trying to touch the objects and he also responded by smiling. In contrast to their previous visits, the dyad showed mutual joy directed to objects at this visit. The mother tended to ask questions such as "What's this?" and often asked "Do you remember this?", rather than describing and labeling objects. Although the infant pointed during games, he often tapped at the posters with all fingers extended, instead of pointing. Rather than interpreting the infant's arm and index finger extensions and index finger touches as interest, this mother turned these actions into games, including the one involving repeatedly bringing the infant closer to the object then pulling him away. The infant was calm and attentive throughout the visit.

The infant in Dyad 3 was especially quiet, calm, and attentive during this visit as his mother pointed at, labelled, and talked about the objects in the room in an engaging tone of voice. The infant participated by being attentive, looking at the mother's face, and smiling, but did not vocalize or extend his arm or index finger, except for reaching with both arms twice during the 4 minutes while leaning to get to objects. Although the mother sometimes followed-in on the infant's shifts in attention by asking questions or labeling the object, most episodes of joint engagement were initiated by the mother.

3.3.1.4 Discussion

There were important differences in the way that the three dyads' interactions with objects changed and became more complex over the three visits. The first dyad consistently participated in longer joint engagement episodes as the mother was consistent in her aim to sustain the infant's attention on objects. Being subtle in her actions resulted in the infant often shifting her attention to objects spontaneously, rather than in response to direct cues from the mother. This mother rarely interrupted her infant's attention on objects by overt gestures or vocalizations. The dyad's interactions involved frequent mutual joy during the first visit which was paired with proto-conversations involving turn taking while the infant and mother pointed and vocalized about objects at the last visit. In this way, their interactions with objects involved increasingly complex communicative bids and turn taking. This infant tended to vocalize more frequently when compared to the other two infants at each visit. Additionally, this was the only infant who used pointing gestures in proto-conversations about objects in an appropriate way at the 12-month visit.

The mother in Dyad 2 was consistent across the three visits in that she did not talk in detail about objects and did not seem to aim to sustain triadic joint engagements with her infant. Rather, she made frequent comments about the actions of the infant. Overall, there seemed to be a lack of clear developmental progression in the dyad's referential communication about objects between Visit 1 and Visit 3. Although this infant did extend her arm and index finger towards objects by 12 months, these were embedded within dyadic games, rather than within triadic joint engagement episodes involving turn taking and talking about or gesturing towards objects. Rather, the mother seemed to interpret the infant's arm and index finger extensions as a desire to touch objects, and therefore did not respond by talking about or acting on objects. This infant displayed frustration vocalizations but did not vocalize in other ways at any of the three visits.

The interactions of Dyad 3 were consistent across the three visits in that the mother used an engaging voice, talked about the objects, and tended to direct the infant's attention with overt gestures and vocalizations. During the last two visits, the infant alternated between quietly attending to and leaning and reaching towards objects with both arms. He showed interest and had frequent shifts of attention but did not lean or reach for objects at the first visit. This infant did not vocalize at any of the three visits, but he attended to objects for longer periods of time at the third visit when compared to

the first and second visits. This extended attention on objects seemed to elicit longer and more detailed descriptions from the mother, resulting in longer joint engagement episodes.

Interestingly, mothers' frequency of following-in on their infants' interests by gestures, vocalizations, or actions did not seem to be associated with how much time they spent in infant-led joint engagement, and therefore with frequency of pointing three months later. Rather, following-in on the infant's interests paired with re-directing the infant's attention to the object seemed to result in longer joint engagement episodes at 9 months, which predicted frequency of pointing at 12 months. However, this is a relational process, therefore joint-engagement episodes observed in the lab result from a bi-directional relationship between the mother and the infant and their history of interactions. For example, the infant in Dyad 3 often leaned towards objects he was interested in and his mother often responded to this by directing the infant's attention to another object. It is possible that this resulted from being asked to avoid playing with the objects during the Look session, but this dynamic between the mother and the infant might have resulted in less time spent in infant-led joint engagement. However, at Visit 3, the mother often directed the infant's attention towards new objects even when the infant showed interest in other objects through actions such as head turns, without leaning or reaching towards them. This suggests that, although in some situations the mother's directiveness might have been in response to the infant wanting to touch and manipulate objects, it is possible that this mother was more directive in general when compared to the other two mothers.

3.3.2. Observations of Early Forms of Index Finger Use

Current findings indicate that, between 9 and 12 months, all infants use the index finger separately from the other fingers in some form. However, there was great variation in how infants did this. A close look at this variation suggests a gradual emergence of tactile exploration with the extended index finger, which originates in exploring with all fingers. I did not expect to see this developmental pathway considering that infants can extend the index finger with other fingers curled in slip-out extensions soon after birth. In the current study, the earliest form of tactile exploration involved touching the book with all fingers. The most developmentally advanced index finger touches were exemplified by actions involving extending the index finger with other fingers curled, then reaching

towards and briefly touching the book with only the index finger, which seemed to have a function other than tactile exploration. In between these clear examples at the beginning and end of the developmental pathway as displayed by infants in the current sample, were many forms of tactile exploration that seemed to be transitional events. Some infants reached for and touched a picture or texture with all fingers but showed very subtle, small movements of the index finger while exploring the texture. These subtle movements were coded as Ambiguous and were not included in the count of IFTs, which were defined as the infant completing one full movement with the index finger. IFTs ranged from being less than a second to several seconds long and sometimes involved a brief touch only and no movement, or the dragging of the index finger across a page. Another form of IFT involved all fingers extended while showing clearer movements of the index finger only, as they curled and extended this finger. In some cases, infants touched something with the index finger while curling and opening the other fingers and keeping the index finger still, or kept the fingers curled and the index finger extended and touching something, but not moving it. These latter forms of action looked very similar to pointing gestures but were slightly longer and proved to be difficult to code in terms of whether the infant was engaging in tactile exploration or not. This particular form of index finger touch might be important in the transition from exploratory index finger touches to index finger touch to refer. Although the latter form of IFT seems to resemble pointing gestures more closely, it is possible that these shorter index finger touches, although not exploratory, are still manifestations of the infant's attention and interest, without communicative intent. However, because of their similarity to pointing gestures, they might be more salient to the caregiver, resulting in more frequent response.

Almost all of one infant's index finger touches involved dragging the extended index finger down the page until she reached the bottom of the page. This was again ambiguous in that the actual touch of the picture was short but followed by the dragging of the finger. In some cases, parents took the infant's hand and placed it on the picture or texture to encourage tactile exploration and they would do this either to initiate this action or even when the infant was already touching and exploring. However, this form of parental encouragement of tactile exploration was infrequent. This suggests that infants' tactile exploration with all fingers and later with the index finger is a spontaneous form of exploration, rather than being directed by the caregiver.

Interestingly, infants' index fingers were sometimes exploring without being coordinated with their gaze – a slip-out index finger touch. This happened when they explored with the index finger independently from their gaze direction or they began with a coordinated gaze but then looked away while continuing to touch the book. These observations might demonstrate non-visual modalities of attending (Reddy, 2011) and call attention to the conceptualization of attending as a process that is embodied and distributed (de Barbaro, 2013; Reddy, 2011). Accordingly, in addition to investigating actions involving, and coordinated with, visual attention, other forms of attending should be investigated in the development of pointing.

Chapter 4. Discussion

The current study is the first to confirm with a larger sample size, observed at two time points, that both index finger touch with all fingers extended (IFTExt) and with other fingers curled (IFTCurl), as well as slip-out extensions (SO), are developmentally earlier forms of index finger use when compared to pointing gestures (Bates et al., 1975; Blake et al., 1994; Carpendale & Carpendale, 2010; Kettner, 2014; Kettner & Carpendale, 2018; Masataka, 1995). The number of infants who engaged in IFTCurl was higher when compared to the number of infants who engaged in pointing at both ages and increased in frequency at about the same rate, suggesting that IFTCurl is a developmentally earlier form of index finger use. Furthermore, frequency of IFT at 9 months was significantly positively correlated with frequency of pointing gestures at 12 months. One possible explanation for this finding is that tactile exploration with the index finger provides a context in which infants can practice index finger extension as a referential gesture with close-by objects, resulting in more frequent pointing later on. Alternatively, it is possible that some infants are more likely to show interest in their environment which manifests in more frequent tactile exploration as well as more frequent pointing later on. Overall, it is likely that these aspects of development interact and are complementary in the development of gestures. Most infants' IFTs became more defined and more frequent by 12 months of age, which suggests that rather than these differences indicating a general variation in index finger use across infants, they are transitional phases in the development of pointing. This provides evidence for theories positing that infants do not extend the index finger "to point" at first; rather, exploratory and communicative functions develop gradually over time within interactions with caregivers who respond to them (Carpendale & Carpendale, 2010; Carpendale et al., 2013; Kettner & Carpendale, 2018). Current observations indicate that brief index finger touches without finger movement are developmentally more advanced actions when compared to longer ones involving movement in tactile exploration.

The great variation in index finger touches across infants suggests that this early use develops gradually and possibly along different developmental pathways, but eventually resulting in the same end point for most infants: touching objects with an extended index finger, with other fingers curled, then pointing at out-of-reach objects. These findings provide support for the hypothesis that pointing originates in touching,

which is also supported by O'Madagain et al.'s (2019) findings that both children and adults tend to position their pointing index fingers as if they were aiming to touch the object. The current study provides additional support for this developmental pathway involving index finger touch through the finding that frequency of index finger touch at 9 months was significantly positively correlated with pointing behavior at 12 months. Furthermore, results confirm and provide support for the value of parental observations in the home, in which mothers consistently reported their infants engaging in index finger touches in various situations and these touches varying in form and length (Kettner & Carpendale, 2018).

In addition to pointing, frequency of index finger touch was significantly positively correlated with rate of parental labeling response, time spent in joint engagement, and time spent in infant-led joint engagement at 9 months. That is, at 9 months, infants who spent more time in triadic joint engagement with their caregivers were more likely to engage in tactile exploration with the index finger. Furthermore, high index finger pointers at 12 months had mothers who were more likely to label objects in response to their infants' index finger touch at 9 months. One possible explanation for these findings is that parents who are more likely to engage in triadic joint engagement with their infants as well as follow-in more frequently with object labels provide more opportunities for the development of index finger touch. Alternatively, or additionally, infants who are more interested in their environment, which might manifest in frequency of index finger exploration, might elicit more engagement and responses from their mothers. However, it is not clear why mothers of high explorers would provide more labels specifically, rather than being more responsive in general, and frequency of infants' index finger touch was only significantly correlated with label responses, but not overall verbal response. Therefore, it is likely that parental scaffolding of triadic joint engagement provides an ideal context for the development of tactile exploration. This alternative is further supported by the significant positive correlation between the ratio of parental labeling responses and time spent in joint engagement. That is, mothers engaging in longer joint engagement episodes with their infants in the Look session were more likely to label pictures touched by their infants in the Read session. However, particular forms of index finger touch by the infant, such as ones that resemble pointing gestures more closely, might also enhance and extend particular forms of joint engagement. The association between time spent in joint engagement and frequency of mothers' labeling responses to their infants' index finger touches indicates that the way mothers structure

shared activities involving their infants attending to objects is likely associated with how they respond to their infants' index finger extensions. However, the caregiver's response likely takes on a new significance when it is in response to infants' index finger extensions which carry an additional communicative potential when compared to other indicators of attention, such as gaze shifts and head turns.

Slip-out index finger extensions likely relate to pointing gestures differently when compared to index finger touch, but it is not clear why they become more frequent right before the emergence of pointing. This was reported by Masataka (2003) and was confirmed in the current study with a larger sample size. One possibility is that the link between infants' extended index finger and gaze direction becomes stronger through index finger touches, which then leads to more frequent, but involuntary slip-out extensions when the infant's attention is captured by an object out of reach. This is in line with previous findings that infants' slip-out extensions are already linked to their attentional states soon after birth (Blake et al., 1994; Fogel & Hannan, 1985). At 9 months, it might be through slip-out extensions that the index finger becomes paired with an arm extension in an action that resembles a pointing gesture, although likely without the infant's awareness of the meaning of this action at first. That is, at the time of emergence of pointing gestures, the index finger might be extended because it is linked to the infant attending to something, without being coordinated with the infant's gaze direction, as during a slip-out extension. Additionally, practice with exploring and touching close-by objects with the index finger might result in infants extending the arm and index finger intentionally, and already coordinated with gaze direction, towards out-of-reach objects they wish to touch. This form of index finger extension has been described in parental diaries, when infants pointed then walked towards objects to touch (Carpendale & Carpendale, 2010; Kettner & Carpendale, 2018). I did not analyze this form of index finger use because none of the sessions were ideal for eliciting it. Future studies could examine this "pointing-to-touch" gesture in situations in which infants are free to explore the room on their own.

Another indicator of pointing with the purpose of touching out-of-reach objects might be if the infant leans forward and persists until the mother walks closer to the object. However, my observations of infants in the current study indicate that leaning might not always be a reliable indicator of wanting to move closer or wanting to touch, as it seemed to be influenced by the proximity of the object. For example, some infants were observed to point but only start leaning when the mother walked closer to the

object. In addition, infants do not begin to persist during their pointing gestures until these gestures become more established, therefore this is likely not a good criterion for deducing the infant's intention during the emergence of pointing gestures.

Nevertheless, slip-out index finger extensions and early forms of index finger extension to touch out-of-reach objects are likely transitional events in the development of pointing, during which the infant does not yet expect a response. Even so, some of these actions are meaningful to the caregiver who will likely respond, providing opportunities for these actions to become communicatively intentional. Recent evidence suggests that infants' reaching gestures might become communicative through a similar process involving a transitional phase in which the infant becomes aware of a higher success rate when an adult is present (indicated by more frequent reaching) but is not yet using the gesture to communicate (i.e., the infant does not yet understand the social partner's role as an agent in the desired outcome) (Ramenzoni & Liszkowski, 2016). Therefore, at this point, the infant's action is not yet a gesture, yet it might already indicate an emerging awareness of the role these actions play within interactions.

Overall, time spent in joint engagement at 9 months was significantly positively correlated with not only frequency of pointing at 12 months, but frequency of index finger touches at 9 months, frequency of slip-out extensions at 9 months, and rate of parental labeling responses to index finger touches at 9 months. Importantly, most of these associations were driven by time spent in infant-led joint engagement – there were no associations between any of these variables and parent-led joint engagement. That is, triadic joint engagement elicited by highly directive parental behavior such as repeated gesturing and the use of words such as "Look!" were not associated with how often infants pointed 3 months later. Furthermore, through regression analysis I found that time spent in joint engagement at 9 months accounted for a relatively large increase in the frequency of pointing gestures at 12 months. In order to investigate what factors might be driving longer episodes of joint engagement and to capture details that might be missed during quantitative coding, qualitative observations of three mother infant dyads who visited the lab three times were added. Interestingly, the three mothers used very different strategies for scaffolding their infants' attention on objects. The mother in the first dyad clearly adapted her behavior to her infant's developing social skills. For example, she asked a lot of questions at the first visit, then alternated these questions with labels and descriptions at the second visit, and finally responded with mostly labels and descriptions at 12 months. She seemed to alternate between following-in on her

infant's interests by talking and gesturing with re-directing her infant's interest and being more directive in some situations. This was a successful strategy for lengthening the dyad's time spent in infant-led joint engagement, which most strongly predicted frequency of pointing at 12 months. In comparison, the second mother's behavior seemed to remain very similar over the three visits - although she did sometimes follow-in on her infant's interests by talking, she gestured less and interrupted joint engagement episodes with objects more frequently by either walking away or commenting on the infant's actions. This resulted in the dyad spending much less time in joint engagement. Finally, the third mother alternated between being very responsive to her infant's shifts in attention with being very directive and using overt gestures and words such as "Look!", resulting in more time spent in parent-led joint engagement, which was not associated with pointing or any of the other variables examined.

Findings indicate that rather than frequency of following in on the infant's interests, a more balanced parental responsiveness might be important for successful scaffolding of the infant's attention within joint engagement. Specifically, it seems to be key that the infant's attention is drawn naturally to objects, rather than being directed by the caregiver. This is in line with previous findings that indicate enhanced language development when the infant is already attending to the object being labeled (Akhtar et al., 1991; Kang et al., 2009; Begus et al., 2014). However, to my knowledge this relation has not been investigated with regards to the development of pointing.

Although it is common to measure caregiver responsiveness based on overt caregiver actions such as face to face interaction, smiling, talking, and gesturing, different forms of sensitive responsiveness have been described across cultures. The following description illustrates sensitive caregiver responses in the Philippines (Mesman et al., 2017, p. 7):

> An infant is sitting on her aunt's lap and next to her mother. The infant turns her head (apparently to look at some children who are passing by). Aunt, without speaking or looking at the infant, moves the infant's position so that she is now facing the children. The infant stretches her hand towards the children walking past. The aunt looks at the infant, waves her arm and says 'bye bye' in the direction of the children. Infant turns her head to face her aunt. Aunt changes her hold of the infant so that she is now facing her. Infant moves head to look at the children again. Aunt changes her hold of the infant so that she is now facing the children again.

Among the three mothers in the current study, the mother with the longest infant-led joint engagement episodes also showed appropriate but subtle responses most

frequently, similar to the ones described above. Therefore, examining this type of responsiveness across different cultures might be important. Previous studies have shown an association between joint activity and gesture development (e.g., Salomo & Liszkowski, 2013), but it remained to be investigated what it is about joint activity that is important for the development of pointing. The current quantitative analyses and qualitative observations provide a starting point for future studies that might investigate the association between how caregivers structure interactions with their infants and gesture development, with a larger sample of infants. In conclusion, current results confirm previously documented associations between joint activity and gesture development (Cameron-Faulkner et al., 2015; Salomo & Liszkowski, 2013), provide further insight into a multi-faceted relationship between joint engagement and various parental and infant actions, and finally show the importance of skillful parental scaffolding of the infant's attention within joint engagement.

Overall, results provide support for one developmental pathway through which pointing might develop in some infants within routine interactions with their caregivers. First, all infants were observed to engage in tactile exploration with the index finger, but only 17 infants used pointing gestures by 12 months, providing support for the theory that index finger touch is a developmentally earlier form of index finger use (Carpendale & Carpendale, 2010; Kettner & Carpendale, 2018; O'Madagain et al., 2019). Current results further suggest that engaging in index finger touch might provide a context in which coordination between the infant's gaze direction and the extended index finger first emerges and is further strengthened through increasingly defined index finger use. In addition, results provide support for the theory that joint attention skills, such as index finger pointing, develop within various routines (Bibok, Carpendale, & Lewis, 2008; Carpendale & Carpendale, 2010; Kettner & Carpendale, 2018). Even though infants can extend the index finger with the remaining fingers curled soon after birth, current results indicate that tactile exploration with the index finger might originate in exploring with all fingers extended, followed by moving the index finger independently of the other fingers, and finally engaging in tactile exploration with the index finger only. This was supported by the finding that the number of infants who explored with all fingers extended decreased between 9 and 12 months whereas number of infants exploring with the index finger with other fingers curled increased.

Slip-out index finger extensions similarly increased in frequency between 9 and 12 months. However, the number of infants engaging in SOs became equal to the

number of infants using pointing gestures at 12 months, indicating that the relationship between this hand configuration and pointing is likely different from that between pointing and index finger touch. These results are in line with that of Masataka (2003) who found that frequency of slip-out extensions increased until about 12 months of age after which they declined with the increase of pointing gestures. One possible explanation for this is that although index finger touches change in form, from very subtle movements to more defined index finger extensions with other fingers curled, they remain functional within interactions with close by objects. That is, a brief index finger touch with other fingers curled will be used as a pointing gesture with close by objects. In contrast, slip-out extensions become less frequent as infants begin to expect responses to their extended index fingers and begin to use this gesture intentionally.

Many of the infants' index finger extensions seemed to be transitional events between exploring with all fingers and extending the index finger to touch or point, with the remaining fingers curled. Moreover, infants' index finger use was not consistent across situations, indicating that pointing might emerge through the convergence of various uses of the index finger in different situations. Overall, current results indicate one possible developmental pathway involving a process beginning with the gradual emergence of coordinating the index finger with gaze direction in tactile exploration, followed by an increase in slip-out index finger extensions in triadic joint engagement with out-of-reach objects (possibly in part resulting from practice with close-by objects). This is followed by an increase in combining arm extensions with index finger extensions, possibly through a combination of extending the index finger with the aim to touch the object or having it extended in slip-outs. Functions of pointing might emerge through parents responding to forms of index finger use that more closely resemble pointing gestures, which are meaningful to the parent.

Current results suggest that following-in on the infant's interests, but also re-directing the infant's attention back to the object might be key for gesture development. Following-in on most of the infant's interests resulted in frequent shifts in the dyad's focus of attention and therefore in shorter episodes of joint engagement. These findings can serve as a starting point for future studies exploring the associations between the nature of caregiver-infant interactions, caregiver responsiveness and sensitivity, and the development of gestures such as pointing.

I have not tested mothers' and infants' temperament, sociability, and other factors such as particular cognitive abilities. It is possible that such factors underlie and

explain the associations between the variables I looked at. For example, infants who are more interested in their environment in general might engage in index finger exploration more frequently, as well as extend the index finger towards out-of-reach objects more frequently later on. This would provide support for the activity-based theory that index finger extensions serve an orienting purpose at first and that they are expressions of the infant's interest. These factors, and how they influence the associations between earlier and later index finger extensions, should be tested in future studies.

Although pointing gestures seem to emerge rather suddenly between 9 and 12 months, this does not eliminate the possibility that they emerge through a gradual process involving transitional events and small changes in the infant's actions which are noticed and responded to by caregivers. Infants begin to use the index finger as a non-communicative orienting response to objects and events of interest, but these actions are meaningful to parents. Parental responses might encourage infants to engage in activities such as tactile exploration more frequently in the presence of others, without an understanding of the social partner's attention or role as an agent at first. Current findings provide evidence for the theory that communicative skills such as gesture use emerge through practice within particular routines, which then converge and result in more abstract forms of social understanding. Finally, results show the value of describing transitional events, and provide insight into the gradual and dynamic nature of communicative development.

The aim of the current dissertation was to show the importance of examining the worldviews and resulting approaches and theories that research studies of early social and communicative development are based on, as well as to further knowledge of the ontogenetic origins of pointing gestures in infant development. In Chapter 2 I argued that the assumptions underlying the Dualist worldview and resulting cognitivist approach are problematic because they are based on claims and pre-conceptions that lack sufficient explanation, justification, and coherence. I argued that cognitivist approaches are rooted in assumptions of dichotomies between mind and body, nature and nurture, and the "presence" or "absence" of communicative intent (or adult-level competency). To avoid these problematic pre-conceptions which often underlie investigations of early communicative development, the present study was designed based on the Process-Relational worldview and activity-based approach, which emphasize the importance of detailed descriptions of infants' actions within everyday routines with familiar social partners. This methodological approach is based on the assumption that mental states

are embodied and therefore are manifest in actions, allowing for social understanding to develop within shared activity with others in which infants begin to participate at birth.

4.1. Limitations

One limitation of the current study is the small sample of largely middle-class parent-infant dyads recruited in a large Canadian city. In general, parents were sensitive to their infants' interests and pointed to and talked about objects within these contexts. However, research indicates that the quality and quantity of caregiver sensitivity varies greatly not only across cultures, but across different levels of socioeconomic status as well. In addition, the number and type of objects in the environment might influence infants' exploratory behavior, including index finger exploration. However, the current study is based on the view that gestures originate in human forms of activity which include infants being born helpless and being cared for, and human infants orienting towards interesting aspects of the world in similar ways (for example, through reaching and tactile exploration with the index finger). One of the routines in which dyads were observed in the current study was book reading, a routine that is specific to some cultures. However, a similar developmental pathway of index finger exploration might be possible within other routines involving food, plants, or other objects available in the infants' everyday surroundings. Indeed, in diary observations recorded by Canadian parents, index finger exploration of a variety of objects, including the carpet, the mother's clothes, small objects, and others' faces were often documented (Carpendale & Carpendale, 2010; Kettner & Carpendale, 2018). Overall, the developmental trajectory of forms of index finger use was highly consistent across infants in the current study. Future studies could explore the differences and similarities across the large variety of everyday routines infants participate in within and across cultures, and the different developmental pathways of pointing that might result from these various routines, the nature of objects available, and various forms and levels of caregiver sensitivity.

A second limitation is that infants and their caregivers were observed in the lab and not in their familiar environments at home. The unfamiliar environment might affect dyads in different ways, depending on both the caregiver's and the infant's temper and other characteristics. However, a strength of the current study was that the three routines were designed to be as similar to everyday routines as possible. Dyads were also left alone in the room to avoid distraction by the presence of unfamiliar researchers.

This made it possible to observe natural forms of interaction between caregivers and infants and avoid problems resulting from observing infants during controlled tasks with unfamiliar researchers.

A third limitation is that all caregivers who participated in the study were mothers. This is because families were asked that the primary caregiver who spent the most time with the infant participate in the study. It is possible that a more balanced gender ratio of caregivers would result in different findings.

Finally, a fourth limitation is that it was difficult to analyze the association between parental responses to index finger extensions at 9 months and infant pointing behavior at 12 months, because of the relatively low frequency of infant index finger extensions at 9 months. This problem could be addressed in future studies with a larger sample size and more frequent observation points between 9 and 12 months.

4.2. Conclusions

In the current dissertation, my goals were 1) to show the importance of examining worldviews and associated assumptions that underlie research on early communicative development and 2) to fill a gap in current knowledge of the origins of pointing in infancy. Results indicate that pre-pointing forms of index finger use are likely important events in infancy as indicated by their associations with not only pointing three months later, but other aspects of caregiver-infant interactions. Current findings are consistent with the activity-based theory according to which pointing originates in index finger touch and further show that, at least for some infants, this might be linked to pointing gestures through an increase in slip-out index finger extensions in the context of caregiver-infant joint engagements with objects at a distance. Therefore, findings are also consistent with the activity-based theory in a broader sense, positing that communicative intentions originate in infants learning the meaning of their initially non-communicative actions for others. This is the first study, to my knowledge, that highlights the importance of time spent in infant-led joint engagement in the development of pointing, when compared to time spent in parent-led joint engagement. Qualitative analysis of joint engagement episodes indicates that, rather than total frequency of parental responses, a more balanced structuring of the dyad's engagements with objects by caregivers might result in longer joint-engagement episodes. This involved opportunities for spontaneous attention shifts on the infant's part combined with more

subtle forms of parental re-directing of the infant's attention to the object. Finally, the current dissertation illustrates why it is important to examine underlying worldviews and associated assumptions, which influence research on all levels, including the research questions, methods used, and the interpretation of the results.

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Appendix.

Parental Questionnaire

Q1 . ID number

Answer :

Q2 . Infant's birth date

Q3 . Is your baby a boy or girl?

- ☐ Boy
- ☐ Girl

Q4 . Does your baby have any siblings?

- ○ Yes
- ○ No

Q5 . If your baby has siblings, please indicate their genders and year(s) of birth

Q6 . Was your baby born full term? Were there any complications at his or her birth? Are there any other health concerns?

Q7 . Do you read books with your baby?

- ☐ Yes, every day
- ☐ Several times a week
- ☐ About once a week
- ☐ Sometimes
- ☐ I haven't started reading books with my baby yet

Q8 . Please tell us about your book reading habits

Q9 . What kind of books do you read with your baby?

- [ ] Touch and Feel books
- [ ] Baby books with hard pages
- [ ] Children's books with longer text
- [ ] Other

Q10 . If you selected 'Other' in Q 9, please specify

Q11 . Does your baby attend daycare?

- ( ) Yes
- ( ) No

Q12 . If yes, at what age did he or she start and how many days a week?

Q13 . Approx. what percentage of his or her wake time at home does your baby spend with you?

- [ ] 25%
- [ ] 50%
- [ ] 75%
- [ ] 90%
- [ ] 100%

Q14 . Who else does your baby spend time with on a regular basis?

Q15 . Please describe your baby. What is she or he like?

Q16 . How many languages do you speak fluently?

- [ ] One
- [ ] Two
- [ ] Three or more

Q17 . What is your native language?

Q18 . Do you speak your native language with your baby?

- ( ) Yes
- ( ) No

Q19 . If not, what language do you speak with your baby?

Answer :

Q20 . Is your baby exposed to other languages? If so, which ones and by whom? Approximately how many hours per day or week?

Q21 . Do you teach your infant baby sign language?

- ( ) Yes
- ( ) No

Q22 . What is your educational background? Please indicate highest level attained.

- [ ] Elementary school
- [ ] Some high school
- [ ] High school diploma
- [ ] Some higher level education
- [ ] Bachelor's degree
- [ ] Some graduate level

- [ ] Master's degree
- [ ] Some doctoral level
- [ ] Doctoral degree
- [ ] Other

Q23 . Please describe your occupational background

Q24 . Do you live with a partner?

- ○ Yes
- ○ No

Q25 . What is your partner's educational background? Please indicate highest level attained.

- [ ] Elementary school
- [ ] Some high school
- [ ] High school diploma
- [ ] Some university
- [ ] Bachelor's degree
- [ ] Some graduate level
- [ ] Master's degree
- [ ] Some doctoral level
- [ ] Doctoral degree
- [ ] Other

Q26 . Please describe your partner's occupational background.