

CARDIFF UNIVERSITY

# The Roles of Seeing and Doing in Communicative Development

---

New insights into attention and movement  
from microanalytic and microgenetic methods

**Katherine Ellis-Davies**

Thesis submitted to Cardiff University for the degree of Doctor of Philosophy  
October 2012

## **Acknowledgements**

This thesis was undertaken in the School of Psychology at Cardiff University. It was funded by a 1+3 Open Competition ESRC studentship.

I would like to thank my supervisor Merideth Gattis, for the support and guidance I have received. I would also like to thank the support staff at Cardiff University, who worked during the First Steps project to solve countless unforeseen complications in the testing process. I am indebted to the families who took part in the First Steps study, without which this research could not have been completed. Their continued enthusiasm in participating is exceptional.

For everyone within the First Steps, Special Delivery, and WARC teams who gave much needed support, feedback, guidance, and cake, I thank you. I would particularly like to thank Elena Sakkalou, Mirko Uljarevic and Alice Winstanley for their encouragement and assistance.

Those who have I have shared offices with during my PhD have enabled endless discussion and debate over relevant, and more obscure areas of research related to this thesis. Those discussions have been invaluable, and I thank you.

For the members of Miller56, I would like to thank you for providing musical distraction, which has proven to be essential in the last year. To my family and friends, thank you for your patience. Thank you also for your endless supply of support and encouragement. Lastly, I thank Owen Davies for inspiring me for the

last 8 years to work towards my goals. This inspiration has been unfading and resolute throughout my PhD and I appreciate every patient conversation, and every demonstration of support, that I have been lucky enough to receive.

**This thesis is based upon the following publication, and conference presentations**

Ellis-Davies, K., Sakkalou, E., Fowler., Hilbrink, E & Gattis, M. (*in press*). CUE: The Continuous Unified Electronic Diary Method. *Behavior Research Methods*.

Ellis-Davies, K., Sakkalou, E., Fowler, N., Hilbrink, E., & Gattis, M. (2012). I Can Walk, I Can Talk: Emerging motor development predicts language development. *Symposium presented at the Biennial ICIS Conference*. Minneapolis, Minnesota.

Ellis-Davies, K., Sakkalou, E., Fowler, N., Hilbrink, E., & Gattis, M. (2012). The CUE: The continuous unified electronic diary method. *Poster presented at SRCD Methods Conference*. Tampa, Florida.

Ellis, K., Sakkalou, E., Fowler., Hilbrink, E & Gattis, M. (2011). The stability of infant preferences for socially based attention: observational, experimental and longitudinal analyses. *Poster presented to SRCD Biennial Conference*. Montreal, Canada.

Ellis-Davies, K., Sakkalou, E., Fowler., Hilbrink, E & Gattis, M. (*under review*). Beginning to See Through Your Hands: Attention to Hands Rather Than Faces Predicts Attention Following.

## Thesis summary

The aim of this thesis is to extend the understanding of early communication development through the design and implementation of methods, which enable close examination of developmental change as it happens. I pose that meaningful distinctions of infant's attentional abilities, and preferences, in the early period of infancy are necessary and valuable for understanding the ontogeny of communication. Chapter 2 describes the First Steps longitudinal study, where the work of this thesis took place.

Chapter 3 describes an adaptation to a coding scheme that allows for new advances in understanding of early infant's attention abilities and preferences for social and non-social stimuli. Results show that by 2-months infants demonstrate group levels of engagement, as well as notable individual differences in time spent attending to mother's faces and hand actions.

Chapter 4 further demonstrates the value of the methodological adaptation described in Chapter 3, by assessing the predictive power individual differences shown in attention at 2-months hold for the emergence of social attention at 5-months. Results show that individual differences in infant attention to the social stimuli of faces and hands, demonstrated at 2 months with the adapted engagement coding scheme, differentially predict the social attention skills of attention following. Chapter 5 further extends the relations found in Chapter 4, by examining the relation between point following at the end of the first year and the proclivity to attend to hands, during interactions, at 18-months. Results show infants' point following performance at 12-months predicts later durations of attention to hands, while playing with mothers at 18-months.

In this thesis I argue that infant communication development cannot be understood from examining one domain, as infant's employ multiple domains in the journey to communication. Secondly I argue that detailed observations following a multi-domain approach, offer significant potential for understanding communicative development. Chapter 6 details the design, application and assessment of the continuous unified electronic (CUE) diary method. Results show that the CUE diary method is reliable and valid method for the study of infant development. Chapter 7 utilizes the CUE diary method to examine whether the emergence of independent walking predicts later productive vocabulary. Results show that walking is a unique gross motor predictor of later vocabulary. Further, when entered into a predictive model for language, walking and pointing deliver independent predictive power, with walking demonstrating as strong an association as pointing.

Taken together, these observational, experimental, parent-report and electronic diary methods demonstrate the advances in understanding communicative development that can be made when sensitive methods are applied across periods and domains of developmental change.

## Contents

<b>Chapter 1</b> .....	12		Deleted: K 28/3/13
<b>General Introduction</b> .....	12		Deleted: K 28/3/13
Microanalysis.....	12		Deleted: K 28/3/13
Microgenetics.....	14		Deleted: K 28/3/13
Dynamic systems perspective in the study of development.....	14		Deleted: K 28/3/13
Summary.....	16		Deleted: K 28/3/13
Communicative development and the application of microanalytic and microgenetic methods .....	16		Deleted: K 28/3/13
Theories of communication.....	21		Deleted: K 28/3/13
Summary.....	28		Deleted: K 28/3/13
Microgenetic methods and communication.....	28		Deleted: K 28/3/13
Motor and communicative development .....	31		Deleted: K 28/3/13
Summary.....	34		Deleted: K 28/3/13
Overview of Thesis .....	35		Deleted: K 28/3/13
<b>Chapter 2</b> .....	37		Deleted: K 28/3/13
<b>First Steps Study</b> .....	37		Deleted: K 28/3/13
First Steps Overview .....	37		Deleted: K 28/3/13
First Steps Sample.....	38		Deleted: K 28/3/13
<i>Recruitment</i> .....	38		Deleted: K 28/3/13
<i>Sample Characteristics</i> .....	38		Deleted: K 28/3/13
<i>First Steps Procedure</i> .....	39		Deleted: K 28/3/13
Analysis .....	40		Deleted: K 28/3/13
Chapter Summary.....	41		Deleted: K 28/3/13
<b>Chapter Three:</b> .....	42		Deleted: K 28/3/13
<b>We look, we learn: Developing a microanalytic method for the study of     early infant attention</b> .....	42		Deleted: K 28/3/13
Early attention.....	44		Deleted: K 28/3/13
Method .....	51		Deleted: K 28/3/13
Participants .....	51		Deleted: K 28/3/13
<i>Apparatus</i> .....	51		Deleted: K 28/3/13
<i>Design</i> .....	52		Deleted: K 28/3/13
<i>Procedure</i> .....	52		Deleted: K 28/3/13
<i>Ethics</i> .....	53		Deleted: K 28/3/13
<i>Coding Development</i> .....	53		Deleted: K 28/3/13
Results .....	57		Deleted: K 28/3/13
<i>Figure 3.2</i> Distribution of infant onlooking at 2 months .....	59		Deleted: K 28/3/13

Descriptive Analyses of Infant Attention .....	61	Deleted
Discussion .....	67	Deleted:
Limitations .....	68	Deleted:
Implications .....	69	Deleted:
Future studies .....	70	Deleted:
Chapter Summary .....	71	Deleted:
<b>Chapter 4 .....</b>	<b>73</b>	Deleted:
<b>Beginning to See Through Your Hands; Hands and Social Attention .....</b>	<b>73</b>	Deleted:
<b>Method .....</b>	<b>78</b>	Deleted:
<b>Results .....</b>	<b>83</b>	Deleted:
Chapter Summary .....	91	Deleted:
<b>Chapter 5: .....</b>	<b>93</b>	Deleted:
<b>The role of hands in communication across attention development in the second year .....</b>	<b>93</b>	Deleted:
Chapter overview .....	93	Deleted:
<i>Mother-infant interaction. Materials.</i> .....	97	Deleted:
Discussion .....	102	Deleted:
Chapter Summary .....	108	Deleted:
<b>Chapter 6 .....</b>	<b>110</b>	Deleted:
<b>CUE: The Continuous Unified Electronic Diary Method .....</b>	<b>110</b>	Deleted:
Chapter Overview .....	110	Deleted:
Method .....	117	Deleted:
Participants .....	117	Deleted:
<i>Electronic Diary</i> .....	119	Deleted:
Procedure .....	121	Deleted:
Results .....	123	Deleted:
<i>Compliance Assessment</i> .....	123	Deleted:
<i>Reliability Assessment</i> .....	123	Deleted:
<i>Validity Assessments</i> .....	127	Deleted:
Discussion .....	132	Deleted:
Chapter summary .....	139	Deleted:
<b>Chapter 7: .....</b>	<b>140</b>	Deleted:
<b>Taking the next step in social object use and language: Emerging motor development predicts language development .....</b>	<b>140</b>	Deleted:
Chapter Overview .....	140	Deleted:
Method .....	147	Deleted:
Participants .....	147	Deleted:

Results .....	150	K 28/3/13 Deleted:
Discussion .....	152	K 28/3/13 Deleted:
Chapter Summary .....	156	K 28/3/13 Deleted:
<b>Chapter 8 General Discussion</b> .....	157	K 28/3/13 Deleted:
Chapter overview .....	157	K 28/3/13 Deleted:
Summary of main findings .....	160	K 28/3/13 Deleted:
Conclusion .....	166	K 28/3/13 Deleted:
<b>Appendices</b> .....	168	K 28/3/13 Deleted:
<b>References</b> .....	176	K 28/3/13 Deleted:



## Figures

Figure 2.1	<i>First Steps Overview of Measures</i> .....	39
Figure 3.1	<i>Distribution of infant engagement states at 2 months</i> .....	57
Figure 3.2	Distribution of infant onlooking at 2 months .....	58
Figure 3.3	Distribution of onlooking mother's hand actions at 2 months.....	59
Figure 3.4	Distribution of infant onlooking alternative object at 2 months ..	60
Figure 3.5	Percent of time infant's spent in each state, with unadapted coding scheme. ....	63
Figure 3.6	Percent of time infant's spent in each state, with adapted codes .....	64
Figure 3.7	<i>Percent of time infant's spent in each state, with adapted codes</i> .....	65
Figure 5.1.	Average duration, in seconds, of each episode of engagement, with adapted coding scheme. ....	100
Figure 6.1.	<i>Flow of CUE Diary Method questions on motor development</i> .....	119
Figure 6.2	<i>Range of ages of onset for motor behaviors reported in CUE Diary Method</i> .....	127
Figure 6.3	<i>Histograms demonstrating distortion in age-of emergence from researcher assessments compared to CUE Diary Method data, with lines of best fit</i> .....	128
Figure 7.1	<i>CUE Diary Method question flowchart for the verbal and gestural domains</i> .....	148

## Tables

Table 2.1	<i>First Steps Maternal Characteristics</i> .....	38
Table 3.1	<i>Definitions and examples of states of infant engagement</i> .....	54
Table 3.2	Average (mean) and variation (standard error) of duration of engagement states at 2 months.....	64
Table 4. 1	<i>Duration, in seconds, per episode (mean and standard deviation) and total time, in seconds, spent in the states of unengaged and onlooking states of engagement at 2months</i> .....	83
Table 4.2	<i>Associations between engagement states and later proximal attention following and checking back performance on the proximal attention following task</i> .....	85
Table 4.3	<i>Maternal object use at 2 months</i> .....	86
Table 5.1	<i>Correlation of point following with later duration of onlooking states of attention</i> .....	101
Table 6.1	<i>Demographic characteristics of maternal reporters, presented as a percent of each group</i> .....	117
Table 6.2	<i>Age of emergence for motor behaviors presented as mean +/- SD</i> .....	125
Table 6.3	<i>Example entries for each of the target motor behaviors</i> .....	130
Table 7.1	<i>Mean +/- SE age of emergence for motor development and CDI score</i> .....	150
Table 7.2	<i>Regression model for pointing and walking predicting later language</i> .....	151



## **Chapter 1**

### **General Introduction**

The aims of developmental science are to describe, explain, and predict processes and outcomes of developmental change. The need for sensitive and robust methods in delivering data, capable of meeting these aims, is therefore central to the study of development. Developmental methods are pivotal in advancing theory, knowledge, policy and practices. Theory has always driven method development and selection within developmental science. In recent decades theories such as connectionism and dynamic systems theory have made specific prescriptions for a move towards a multi-method approach, within longitudinal designs. These prescriptions concerning theory arise from ideological foundations regarding the need to study the incremental shifts in development, in the context that they occur, as they occur. Two methodological approaches have been central in the story of developmental science, and they are the microanalytic and the microgenetic approaches. Within this Chapter I will examine the utility of these methods, and the benefits they have, and may offer for the study in the field of communicative development.

#### **Microanalysis**

Microanalysis involves the exhaustive coding of behaviors of social partners during interactions, or experiments. Microanalysis represents not only a distinctive methodology, but also a distinctive way of thinking about communication (Beebe et al., 2012). Microanalysis places the context of communication as occurring within social interaction. As a result, studying micro changes in states of communication are often evaluated with microanalytic methods. Through the examination and dissection of interactions in the finest detail, interpersonal communication has become an area of

study in its own right, within developmental science. In turn the micro examination of infant behavior reflects fundamental features of the way in which we think about communication. Several key features of the microanalytic approach to studying communication enable a theory driven development of microanalytic approaches (Mirenda, Donnellan, & Yoder, 1983). The features below describe principles guiding the application of microanalytic methods:

1. Communication should be studied as it occurs.
2. Communication can be studied as an activity in its own right.
3. All features of interaction are potentially significant.
4. Communication has a structure.
5. Conversation can be regarded as a form of action.
6. Communication can be understood in an evolutionary context.
7. Communication is best studied in naturally occurring contexts.
8. Communication can be regarded as a form of skill.

Not all of these features described are taken up by all microanalytic methodologies. Those that apply microanalytic methods largely converge on the items regarding communication being worthy of study; that communication studies in natural contexts make a valuable contribution to our understanding of development; and that communication has a structure. In this thesis these features will be incorporated into designs of microanalytic approaches to the study of early communication.

## **Microgenetics**

Microgenetic research informed by the dynamic systems perspective, have been leading important advances in understanding change processes across a growing set of domains in early infant development. Physical-quantitative models have often examined motor developmental transitions observed during the first year of life. For example, to investigate the onset of reaching, Thelen and colleagues (Thelen et al., 1993) observed four infants in a standard reaching task and in a play session with their parents weekly, from 3 to 30 weeks of age, that is, before, during, and after the transition to reaching. Microgenetic analysis afforded opportunities for the discovery of dramatic individual differences not only in the age of reach onset- ranging from 12 to 22 weeks - but also in the strategies used by the infants to get the toy. As mentioned, dynamic systems theories prescribe the examination of micro changes, in order to understand macro level shifts in development. As such, microanalytic and microgenetic methodological approaches are espoused by dynamic systems theory.

## **Dynamic systems perspective in the study of development**

The dynamic systems perspective is an interdisciplinary approach that provides a model for the study of change processes (Fogel, de Koeyer, Secrist, & Nagy, 2002; Spencer, Perone, & Buss, 2011; Thelen & Bates, 2003). The dynamic systems perspective aims to address the problem of describing, and thus explaining, the ways in which complex systems change over time. Within this perspective the system is greater than the sum of its parts. For developmental science this is a fitting characterization of the developing infant, as there is no such thing as an infant devoid of context, but instead an infant is always developing within its environment. The focus of dynamic systems perspective is on examining change at the microlevel of relations between a system's constituents. In turn these microlevel changes are born

out in new patterns of behavior at macrolevels of the system. It is therefore of paramount importance to understand the relationship between the individual and their environment, in order to explain the processes of change.

Within dynamic systems perspective, there is a central principle of self-organization. This principle states that complex behavior patterns, periods of stability, and transitions within development, are all a consequence of the constituents of a system acting together to constrain the multiple actions of other constituents. This process of check and balancing results in stable patterns within the complex system, referred to as 'attractors' (Thelen, 2005). Examples of attractors include action schemes; emotions; and cognition; as well as communication within social systems (Fogel et al., 2002). Most attractors are dynamically stable, that is to say, although attractors constitute processes of change that occur in time, they preserve their veracity across a wide range of contexts. Dynamic systems perspective therefore conceptualizes change during development as arising from the reorganization of prior attractors and the emergence of new attractors. This reorganization in turn is conceptualized as resulting from self-organization processes observable at the micro-level.

The information-qualitative model is one informed by dynamic systems perspective (Fogel et al., 2002). Within this model, changes in the constituents of a system at the microlevel create the conditions for the emergence of new attractors. Put another way, differences occurring at the microlevel are perceived as meaningful, as change begets change. Within the area of infant communication, for example, if the infant turns their gaze away from their mother, in order to attend to an object, and the mother perceives this change as a disengaging, the mother may try to direct and engage her infant's attention. A mother may attempt to achieve this aim by using

familiar actions that have been previously successful. Such strategies one or a combination of touch; vocalizations; postural changes of the infant; and the introduction of new toys. However, the mother may alternatively perceive the change in the infant's gaze as a meaningful difference, with the infant directing their attention to an alternative location. In this vignette, the mother may follow her infant's gaze, maintaining their interest through animating the object, labeling it, or describing its features. Meaningful microchanges within the system, has been shown to facilitate new patterns of communication emerging (Fogel, 1995). The process of transition in this example is considered by the authors to be a source for developmental change. Within informational-qualitative models microanalytic and microgenetic designs are advocated for advancing theory relating to the changes at a microlevel that induce change across the system.

### **Summary**

This section discussed microanalytic and microgenetic methods, as approaches to the study of developmental change. Dynamic systems theory was described as a perspective applied to the understanding of development. Within this perspective development needs to be studied in the context in which it occurs, with a focus on micro level changes, at a sampling rate above the expected rate of change. In the next section of this Chapter, an area of infant development that benefits from microanalytic and microgenetic methods, communication, is discussed.

### **Communicative development and the application of microanalytic and microgenetic methods**

Communication is widely seen as the cradle of human social, cognitive, and language development (Fogel, 1995). Communication is defined broadly as information from a sender that causes a change in a receiver. This simple definition of



communication has been used in a wide range of fields, from semiotics (Sebeok, 1965b) to animal behavior (Sebeok, 1965a) to psychology (Collins, Maccoby, Steinberg, Hetherington, & Bornstein, 2001). It has the advantage of recognizing both spontaneous and intentional information transfer in biological systems as diverse as the human infant.

Communication is the process of creating, interpreting and negotiating meaning. Communication can be verbal, or nonverbal, and involves all the senses. It can be aural, visual, or physical. Infants are born with the physical faculties needed to communicate, but must acquire the communicative abilities of joint attention, gesture and language. Communication is fundamentally a social process (West & Turner, 2007). Infants gain these abilities not in isolation, but within the context of interaction. In this way communication is a collective and collaborative endeavor from its inception and interactions may be viewed as the cradle of communication's emergence.

### **Evolution of Communication**

Pinker (2010) describes language as a universal instinct to communicate, collaborate and affiliate with social partners. As a cultural construct communication, in its complexities and universal nature demonstrated in humans, is unparalleled in the animal kingdom (Tomasello & Farrar, 1986).

Bruner (1975) examines language as deriving from the evolution of pre-linguistic communication. Communication in the context of evolution is described by Bruner (1975) as deriving from an innate drive, evident from early in infancy, to attune to, imitate, and seek out interaction with con-specifics. Other researchers have also focused on the drive to engage with others, as key to driving along development (Lee, Mikesell, Joaquin, Mates, & Schumann, 2009). Lee and colleagues detail the

drive to engage with others as the “interactional instinct” which has driven the evolution of multiple domains, including upright locomotion, hands, and language.

Infants are driven to communicate with caregivers. Due to the state of immaturity of infants throughout infancy, there is a biological need for interaction in order to meet the most basic biological needs. Furthermore, through interaction information is gathered from others, and reciprocally delivered by the infant.

### **Communication trajectories**

Developmental changes in communication are first seen in infant’s engagement to socially relevant stimuli and followed by responding to attention of social partners followed by the communicative acts they carry out. As motor and vocal skill develops during the first year, communication becomes more infant driven and instigated by the infant, with babbling, cooing and limb movement. With emerging prehension comes object exploration and early gesture forms. Around the first birthday social object use and deictic gestures come into their own, followed by locomotion and the onset of language. Following these milestones in communication development, the infant social experiences are irrevocably altered, in both the perceptions carers endow them with intentionality, and the self-directed nature of communication bouts.

Before infants are able to actively communicate through verbal utterances, gestural movements, or controlled sequences, they engage in communication through their attention to others, their actions, and shared objects/events of interest. Preverbal communicative developments have also been examined as precursors to later developmental impairments. Most notably researched of these communicative disorders is that of autism spectrum disorders (ASD). Autism is a neurodevelopmental

disorder in which children show reduced attention to social aspects of the environment (S. R. Leekam, López, & Moore, 2000).

The advent of longitudinal studies tracking infants at an increased risk of autism, as a result of having an older sibling with ASD, research examining the predictive power of preverbal communication for later ASD diagnosis has been examined in several studies, see Wan et al., (2012) for an example (Wan et al., 2012).

Such relationships to later communicative ability assures that attention looks to remain a central theme in the research of early communicative development. Several research designs have been commonly applied in the study of this early form of communication.

Gesture is the non-verbal form of communication that comprises our early faculty of communicating and involves bodily movements alongside facial expressions and constitutes a key function of our hands. When the art of following the attention of others is added to the infant's repertoire the next shift in communicative ability is that of point following. Following the attention of another to a distal target, noted by a gaze shift that occurs with an extended point is a revelation in both social attention and communication (H.A. Ruff & Rothbart, 1996).

To follow a point is to acknowledge the communicative intent that the social partner is delivering, not only this but by acquiescing to the request inherent in the gesture, the infant is entering into a state of shared attention with the social partner. The ability to attention follow is achieved developmentally before the infants own production of pointing emerges. This step to producing a point to direct others attention occurs developmentally before their first words demonstrate their attention to others with points (Carpendale & Carpendale, 2010; Carpenter, Nagell, & Tomasello, 1998).

Importantly they direct the attention of others to their preferred location. This sharing of attention delivers opportunities for synchronous interaction and learning, beyond what is capable in isolation. Pointing is just one of the prolific portfolio of gestures we make. Some of the other gestures we use commonly, begging for example, are demonstrated in chimpanzee behavior. However the deictic gestures are a branch of gestural communication that evades non-human primates. This uniquely human stage of communication is followed by the culminating achievements of language comprehension and production. This crowning achievement of using symbols to generate and interpret meaning, enables a generative process of learning becomes dynamic and iterative that continues throughout life.

### **Communication as Multi-modal**

While studies of communication often focus on one domain at a time, there are reasons to consider the multi-domain approach. The central cause for considering multi-domain study of development is that communication itself recruits multiple domains in the process of development. As can be seen in the common trajectory of communication, across development one modality cannot be seen as the vehicle for communication. Instead communication is achieved through the multi-modal collaboration across the developing system. Complex skills like communication are multi-determined, incorporating cognition, perception, affect, and motor control. A communicative action cannot be planned and executed without all of the components skills present and available. Fogel and Thelen (1987) describe this necessity for collaboration across domains as a result of communication acts being a project of a system.

When defining the trajectory and process of these developments that rely on multiple domains, it is potentially misleading to solely focus on the domain where the

new behavior is being demonstrated. Fogel and Thelen (1987) warn of narrowing focus to the singular domain a new behavior pertains from. The cause of concern over examining a single domain arises from the recognition that new behaviors in communication arise by an orchestrated recruitment of multiple domains. As such, the study of communication development is best conducted with the co-investigation of multiple domains. Microanalytic and microgenetic methods are ideal candidates for studying communication in a way that is sympathetic to this multi-domain nature of communication.

### **Theories of communication**

Developmental psychology has long been occupied with characterizing the process by which infant communication develops. Approaches to the study of communication have historically concerned themselves with communicative actions exhibited during mother-infant interactions. When interactions are investigated it is often the communicative competence and style of the mother that is under scrutiny, with the quantifying of interactions with terms such as sensitive, positive, neutral, negative, symmetrical, asymmetrical or unilateral (Hsu & Fogel, 2001). Such approaches look to the role of the caregiver in raising competent, socially skilled, and emotionally attuned communicators.

One such perspective is that of social learning theory. Social learning perspectives concentrate on the caregiver providing models for infant behavior, which then contribute to the social communication with their infant (Malatesta, Grigoryev, Lamb, Albin, & Culver, 1986). Operant conditioning principles attribute communicative development to the focused attention occurring during infant learning that occurs when adults respond contingently to infants signals (Gewirtz & Pelaez-Nogueras, 2000).

Psychodynamic perspectives to communication development look to the contribution of maternal sensitivity to object relations development (Brody, Axelrad, Horn, Moroh, & Taylor, 1978) while ethological-attachment perspectives focus on the caregiver's prompt and appropriate responses to the infant's signals preparing the infant to explore the environment and encounter challenges with a developed sense of security (Ainsworth, 1979).

The above perspectives on communicative development share an identification of adult responsiveness to infant cues as the core process in communication development, where early dyadic interactions rely on the communicative skill of the caregiver and the infant is merely a passive recipient of communicative action. In recent decades there has been a palpable shift in enquiry from models of communication development arising from caregiver behavior, to models of mutual influence. Such models implicate infants in their own development, where infant and caregiver co-regulating the interactions in which communicative development arises (Papoušek, Papoušek, & Symmes, 1991). Notably the dynamic systems perspective has begun to be employed to investigate models of joint influence and change in the development of communicative action.

### **Microanalytic methods in the study of infant attention**

Microanalytic studies of infant attention have included experimental and observational measures of infant attention. Applying microanalytic methods enable the examination of when preverbal communication through attention may be demonstrated. More specifically, microanalytic coding of infant attention allows us to examine what are infant's attending during this intense period of developmental change. With such information developmental science may extend understanding of

the stability of preferences demonstrated for attending to social cues, and the impact attention preferences may have for communication.

Studies of communicative development during mother-infant interaction have provided a wealth of information regarding the development of infant attention from 6 months of age (Bakeman & Adamson, 1984). Such coding schemes highlight the role infants have on their own development, via their attention abilities and preferences during interactions. Furthermore, microanalytic study offers information on the social partner's responsiveness to the communicative behavior of the infant.

Given the wealth of information offered by Bakeman and Adamson's coding scheme for infant attention at 6 months it seems a natural question to ask what information may be gleaned from application from such an approach earlier in development. Such an application would allow for examination of questions pertinent to the understanding of the ontogeny of infant communication. Specifically, whether faces are the sole social focus of infants in early infancy.

However in the given example of microanalytic methods applied in pursuit of understanding the ontogeny and trajectory of early attention, faces were the main focus of the conceptualization of attention to social stimuli. However there are reasons to position hands within the field of early communicative development. These reasons arise from areas such as evolutionary psychology, perception and social cognition and will be discussed below.

## **Hands and Communication**

**“You need hands”**

(Napier, 1993)

The functions of hands impact on so many aspects of our functioning, such as tool-making, grooming and gesture. The beauty of the hands is demonstrated in the flow of action. “When the hands are at rest, the face is at rest; but a lovely hand is the product of a lively mind” (Napier, 1993). Hands emphasize our point in a way uncaptured by sheer intonation or facial expression alone. It is the combination of facial expression, intonation and gesture acting together in unison that delivers our messages and intentions so clearly that we can communicate in a manner unparalleled in the animal kingdom.

The hands are ubiquitous in their involvement in human affairs, to the degree that the stunning array of skilled movements at the beck and call of the typical adult are rarely considered noteworthy. The actions of the hands seem to deliver their purpose almost automatically. In development we can most clearly see the sheer concentration and practice required for infants and toddlers to perform the skilled hand actions we take for granted.

Hands are the primary vehicle of motor activity (Napier, 1993), and the chief organ of the fifth sense of touch. Alongside the eye the hand delivers the main sources of contact with the physical and social environment. The hand has a major advantage over the eye however, whereas both organs gather information on the environment, it is the hand that then returns the direction of information and acts upon the environment it has assessed through touch. In addition to this active advantage, the hand can “see” in the dark, giving us tactile perception in absence of the ambient light necessary for the eye to perform its function.

The placement of our hands at the end of the flexible, powerful levers that are our arms, allows for a truly collaborative process to occur between perception and action, in that our hands are able to act upon the world in a remote way on objects



distal to us, whilst our eyes monitor the object and our actions in a constant loop of feedback, and readjustment. This visual-tactile teamwork enables the dexterity of our hands to be managed by the high definition monitoring of our visual system.

This teamwork is so ubiquitous that we are often guilty of interchangeably describing our intentions for the visual and tactile domains, for example when we see an object of another we wish to investigate we exclaim “Let me see it”. Our actual intention is to handle the object whilst visually examining it.

A focus of evolutionary psychology involves investigating the function that hand structure affords (Tuttle, 1981, 2005). This examination of hand function is in line with Darwin’s notion that environment organism structure and function are a result of the constraints and challenges delivered by the environment.

### **Hand evolution**

The evolution of human hands was reliant on a multitude of other motor and cognitive aspects developing. Arboreal, tree swinging, apes’ hands were concerned with climbing and positioning on branches, whilst ground apes hand functions for manual tasks were superseded by their supporting function for brachiating locomotion, i.e. knuckle-walking and brachiatal (arm swinging) gait.

These pre-adaptation features involved the development of stereoscopic vision and prehensility, upright posture, bipedal locomotion, and cortical complexity (Kobayashi & Kohshima, 2001; Tuttle, 2005). Stereoscopic vision and prehensility in turn delivered hand-eye coordination. Upright posture, and bipedal locomotion freed hands from their locomotive function to engage in dexterous tasks. Cortical complexity and nervous system advances in tactile sensitivity, precision and power grips enabled the advances in tool-using, tool-modifying and tool-making. These

advances in tool production and utility in-turn created the incentive for the development of cultural practices and communication.

When acknowledging the role of the multitude of environmental and physical attributes that resulted in the hand structure and functions that we possess, it becomes clear that when we are examining aspects of culture and communication we need to retain a multi-domain approach, as this is the context in which we evolved. Put another way, our hands did not evolve in isolation, just as language or locomotion did not. Instead evolution and development are dynamic processes of interaction and connections where the milestones achieved in one domain are the culmination of these processes.

### **Hands, perception, cognition and memory**

In adults recent work has demonstrated that items near hands receive increased priority in perception, attention and memory (Davoli, Brockmole, Du, & Abrams, 2012; Davoli, Brockmole, & Goujon, 2012; Tseng & Bridgeman, 2011). Peripersonal space is represented differently from space away from body, as they represent different functional distances. Those objects in peripersonal space can be grasped and be candidates for immediate action or potential vehicles for performing functions. Alternatively they can potentially grasp us. The presence of a hand near an object changes the functional implications of the object, and therefore it changes the need to attend to it. The difference in representations for objects near hands could affect the attention these location receive. Hand-centered representations are spatially relevant representations.

Attention to objects near hands are also less susceptible to interference. Yolked attention is a phenomenon where volitional shifts of attention are relatively slower and more inflexible near hands. The cumulative effect of these adaptations are

that there is a resistant to intrusions from external information and effortful shifts to induce more deeply attended, “locked-in” processing of objects near hands (Davoli, Brockmole, & Goujon, 2012).

### **Mechanisms underlying hands’ impact on perception**

Visuo-tactile neurons in primates and humans (Graziano & Gross, 1998) are stimulated by tactile and visual information emitted from objects near the hand more readily than those outside of the peripersonal space. This process of spatially graded firing may account for the perceptual and cognitive findings of prioritized resources to those objects located near hands. Investigated mechanisms responsible for difference between visual processing of stimuli near and far from observer’s hands. As objects near hands are immediate candidates for change and action, perception may be biased towards the action-oriented magnocellular visual pathway, with high temporal resolution and poor spatial processing. In comparison objects out of peripersonal space may be supported by the parvocellular, where high spatial resolution and low temporal resolution is provided. Enhanced scrutiny from reduced disengagement to force a closer inspection, with slower attention shifts from inhibited changes in attentional scope. This phenomena speaks both to embodied cognition and dynamic systems perspectives.

So far in this section of the Chapter I have focused on the aspects of hands that suggest attention to hands, and the actions they perform, may be relevant to the study of communication development.

In this thesis I argue that the wealth of information gathered on infant communication through microanalytic coding of infant attention during mother-infant interactions rarely examines the point in development known to be a dramatic point of

developmental transition, the biobehavioral transition at 2-months-of-age. I pose that microanalytic distinction of infant's attentional abilities and preferences in this early period of infancy are necessary and valuable for understanding the ontogeny of communication in the mother-infant dyad. Furthermore, I have discussed aspects of hand's structure and function. These aspects are relevant to communication development. As such, delineating a microanalytic coding scheme, in order to distinguish between attending to faces and hands, would offer theoretically relevant information on development. Chapter 3 describes an adaptation to a microanalytic coding scheme that allows for new advances in understanding of early infant's attention abilities and preferences for social and non-social stimuli.

### **Summary**

The main focus of this section was on the need for further distinctions of attention, during interaction, in order to examine group patterns and individual differences in the founding skills of adaptive communication. Chapter 3 deals with this issue: in that chapter I describe a new adaptation to the established Bakeman and Adamson (1984) engagement coding scheme, with the notable distinctions between infant attention to mother's faces, hands and objects, and objects not attended to by the mother. This methodological advance holds theoretical potential for the examination of the social and causal stimuli of hands to be examined for their role in early social attention and communicative development. Chapters 4 (and 5) further extend the application of this methodological advance in testing theoretically driven questions of the stability and change that is demonstrated in the preference to attend to hands in communicative contexts across infancy.

### **Microgenetic methods and communication**

Microgenetic designs are specifically devised for documenting developmental change. Prescribed by rising theories in developmental psychology, such as dynamic systems approaches. In this section I will describe the need developmental science has recognised for studying change as it occurs within the context that it is occurring, and the relevance of this need for the study of communicative development specifically. Next, I will discuss microgenetic designs as one methodological approach available that offers potential for delivering the density of sampling , alongside the incorporation of context within the research design. With the primary characteristics of microgenetic designs discussed, the advantages such designs pose for the study of communication development are discussed, with examples of microgenetic designs evident in research into communicative development. Limitations of microgenetic designs previously will be evaluated under this review, before the aim of this thesis to incorporate microgenetic methods in the study of communication development across domains and the duration of infancy will be detailed.

The process of change represents a main, central issue for the study of development. Vygotsky (1978) argued that macrodevelopmental changes in development arise from microdevelopmental change, that must be examine within the context of the environment they occur. Nevertheless, observing and understanding how change occurs has been recognized to be a quite difficult and challenging task (Miller et al., 1999). This difficulty arises despite recent advances in both theoretical perspectives and methods focused on change processes that brought considerable progress in the research field.

Traditional cross-sectional and longitudinal studies of communication have enabled an investigation of the products of change, and in the case of longitudinal studies the pre-change state of communication. However, with the time-consuming

and costly nature of longitudinal studies, sampling is usually sparsely allocated across one specific window of change. Such a limitation ensures that intra-individual changes may be missed. In addition such longitudinal designs have been critiqued by (Thelen, 2005) and others for their lack of sensitivity to transient behavioural patterns that speak to the process of developmental change in communication development.

Case study designs offer the increased sampling, but lack the sample size traditionally required for normative law testing. In truth neither longitudinal approach incorporates the larger sample sizes, being tracked across an extended period of development; across multiple domains of development; at a sampling frequency dictated by the emergence of change; and within the context in which change occurs. These demanding set of characteristics are those advocated by the growing theoretical approach of the dynamic systems perspective. As stated the dynamic systems perspective is growing perspective adopted in psychology, originating in mathematics that has emerges as an interdisciplinary approach which ascribes a model for documenting change processes (van Geert, 1998).

Previously the intensity of observation involved in microgenetic designs have been confined to examining a single developmental domain, such as motor development, or a single transitional period in development, such as the period around reaching for objects and babbling emerging. Although such studies offer increased access to the processes underway in development, the insights gained remain partial, narrowed by examining a single developmental domain or single transitional period in development.

In the same way that this thesis aims to apply microanalytic methods to the study of attention across multiple transitional periods of infancy in the attention domain of communication development, so too will this thesis explore the potential of

assessing motor developments role in communication development through extending the microanalytic design across the multiple domains implicated in communicative development of motor and language development, throughout the duration of infancy characterised by rapid and cascading change in the developing communicative system.

### **Motor and communicative development**

Developmental science has been predominantly concerned with the vocal, gestural and attentional domain demonstrations of communication. In this section I will argue that motor development deserves to be included in the study of domains of communication. Secondly I will argue that microgenetic designs are best equipped for studying the contributions of motor development in communication.

Motor development is implicated in communicative development, through fine motor development achievements allowing for gestural communication; oral-motor achievements enable oral and verbal communication; and gross-motor developmental outcomes related to communicative action. Due to these motor skills involvement in communicative action, several perspectives have offered models that suggest associations between motor development and other domains required for communication. Theories of communication that centre on drives of infants to engage with social partners (Lee et al., 2009) often focus on the multi-domain nature of communication.

Studies of communication development have previously centred predominantly on the vocal domain of development. Other aspects of communication examined have included joint attention (Carpenter et al., 1998), gesture (Iverson, 2010b) and social engagement (D. S. Messinger, Ekas, Ruvolo, & Fogel, 2012). The

role of these domains is direct, unambiguous and involved in the receiving of (in the case of attention), or the delivery of (in the case of smiling, gesture and vocal) communicative signals. Microgenetic designs have enabled the intensive observation of typically one domain from the list noted above across an intense period of change in development. The benefits brought to bear from microgenetic designs include the study of change process over time, as well as identification of qualitative as well as quantitative change.

One branch of methods for studying motor development have included questionnaires, completed by parents, teachers, or clinicians. Examples of these questionnaires include the Ages and Stages Questionnaire, the Strengths and Difficulties questionnaire, and the Vineland. Benefits of these questionnaires are that they are readily available to researchers and clinicians, and that they are able to deliver a score demonstrating their motor achievements.

Criticisms or limitations levelled at questionnaires in the study of motor development include the focus on pass/fail question structures that lack the sensitivity to capture qualitative differences in the when, where, and how of infant motor achievements. This insensitivity is an important issue within the study of atypical development, as motor achievements may be considered as typical in early Rett's syndrome for example, in traditional questionnaires. However, when audio of infants' motor and verbal behaviours are analysed, they demonstrate meaningful deviations in their quality, that are particularly informative when examining the atypical trajectory of the disorder.

Another limitation on questionnaires is that they often lack information on the context in which motor developments occur. Such information would offer



information on the communicative context of the social setting that led up to, or followed the acquisition of a motor skill. In turn, this information speaks to the mechanisms and process underlying motor development within communicative action. The final limitation of traditional questionnaires in motor development is the sampling bias commonly introduced into the design of studies using questionnaires. Rather than capturing change as it happens, questionnaires often ask reporters to summarise a period of developmental change that has happened, or to generalise on an infant's motor ability. Adolph (1997) has challenged such designs, as missing the detail of developmental change that is essential for depicting the paths and mechanisms of developmental change.

A common addition or alternative to questionnaire methods in studying motor development are standardised assessments, see the Bayley Scales of Infant Development, or the Mullen Scales of Early Learning (Bayley, 1969; Mullen, 1995). Standardised assessments are commonly conducted by a researcher or clinician, and deliver scaled and composite scores of an infant's development, allowing the user to ascertain where an infant's motor development lies on the curve of ability. The limitations of sampling, lack of communicative context, and reduced sensitivity discussed in relation to questionnaires are also appropriate for standardised methodologies.

Studies of communicative development in recent years have begun to focus on the intensive study of an infant's development over a relatively short time period. The aim of such approaches is to reduce the limitations discussed above, of questionnaires and standardised assessments. The theoretical advantages of these microgenetic designs is that group and individual paths to developmental achievements may be observed with great sensitivity and accuracy. Adolph (1997) employed this method

for the study of the stepping action, crawling, and walking. Messinger and Fogel (2007) have also employed the microgenetic design in the study of smiling as an early example of communication. Challenges noted in the application of such methods include the need for high density observation, above the expected rate of change, as well as the related limitation of such studies typically focusing on one motor development at a time.

This last limitation is at odds with the theoretical basis of many microgenetic studies, dynamic systems theory. Dynamic systems theory views motor development as playing a role in communication through its impact upon other domain of development, and the environment, whilst being open to the effects of other domains, in a reciprocal manner. Following this characterisation of a reciprocal relationship across domains of development in the infant system, and the environment, change should be studied intensely over time, with sensitivity to the role of the environment and other domains of development. In this thesis, I have implemented a longitudinal design incorporating microanalytic and microgenetic methodologies to examine communication development across domains, while also strengthening demonstrations of the value of these methods that were reported in previous research.

### **Summary**

This section explored the utility of microgenetic methods in the study of infant communication development. Following this review, I went on to argue that central to communication's multi-modal nature, microgenetic designs must not only be longitudinal, with a high density of observations, but must also incorporate the domains of development implicated in communication, namely motor, gestural and language. In addition to this need, the dynamic systems perspective has given rise the prominence of studying infant development within the context in which it occurs.

Combined these aims have given support for the development of microgenetic longitudinal method for collecting a high density of observation across the domains of communication development. Chapter 6 will detail the development of the Continuous Unified Electronic (CUE) diary method, for the study of infant development across domain of development for the first 18 months of life. Chapter 7 incorporates the CUE method, alongside traditional parent-reports of communicative development, to examine the evidence for a motor-language network.

### **Overview of Thesis**

This review aimed to address perennial issues arising in the theoretically driven methods developed in studies of infant communication. In the first section of the review I described and discussed methods for investigating an early form of infant communication, attention. After describing developmental trajectories observed in attention development, including periods of macrolevel change including the biobehavioural shift at 2 months, the shift at 9-12 months and the other shift at 18 months, the need prescribed by dynamic systems theory for studying change in context was described, as well as the need to look beyond a singular attractor, namely attention to faces. I argued that only examining attention to faces resulted in theories of early communicative development that did not take into account the possibility of different developmental trajectories for social attention, as well as the role of individual differences in the stream of socially relevant information attended to, and what these individual differences may mean for later communicative performance.

In the following chapters, I first examine whether a new adaptation to a microanalytic coding scheme of infant attention offers improved sensitivity to infant attention ability and preferences, as well as trends in group level performance. Leading on from this, in the subsequent chapters 4 and 5 the theoretical significance

of the behavioral patterns that emerge with the application of the adapted coding scheme are illustrated in longitudinal analyses of social attention development. With social attention in communicative development given methodological advances in these chapters.

The theoretical question of across-domain networks being evidenced in communicative development across the second year, discussed in the second section of this review, are examined with the methodological development of the CUE diary method detailed in Chapter 6 and the application of the CUE diary method, longitudinally alongside the CDI in evaluating the motor-language communicative network are investigated in Chapter 7.

Through these chapters the thesis aim, of extending the understanding of early communication development through the design and implementation of microanalytic and microgenetic methods, will be achieved.

## **Chapter 2**

### **First Steps Study**

#### **First Steps Overview**

The following chapters that constitute the data of this thesis were collected as part of the First Steps longitudinal study of infancy. The broadest aim of the First Steps study was to track the normative development of infants from birth to two years. Examining development across infancy was aimed to give a greater understanding of how motor, cognitive, language, and social development emerge and change, both within and across modalities.

In order to achieve the aims of the First Steps study new methods were designed and traditional methods were adapted, to best deliver on a longitudinal design where every infant's performance was included at every level of the study. Among these methods were microanalytic coding schemes applied during mother-infant interactions, as described in Chapter 3, and a newly designed electronic diary method, described in Chapter 6.

The impact of the aim of total participant data collection can be seen across the design of the study, in both the design of experimental paradigms, support and training delivered to participating parents, and the analyses chosen. Following this aim enabled extensions to both group level and individual differences to emerge in an array of skills relevant to communication.

The First Steps team was comprised of three PhD students, one post-doctoral researcher, and the study's Principal Investigator. Within this thesis communication will be examined through the lens of the DST prescribed microgenetic design detailed

in the previous chapter. As such selected measures were designed and employed to best meet the aims of this thesis.

## **First Steps Sample**

### ***Recruitment***

Thirty-nine mothers were recruited during the last trimester of their pregnancy from community organizations within Cardiff. The main benefit of recruiting during the last trimester was that infant development could be tracked from birth. The First Steps design involved continuous electronic diary reporting from birth to 18 months, and monthly testing from 2 until 18 months. At each monthly testing session, families were given £25 in shopping vouchers and a baby gift, such as a toy, t-shirt, or book, in return for their participation. As an incentive to complete the study, families were given an additional £250 in shopping vouchers at the end of the study.

### ***Sample Characteristics***

Mother's age, previous children, education, for the First Steps sample can be seen in Table 2.1. Drop-out rate across the study was limited to 2 mothers who withdrew from the study before their infants turned 18 months. One infant was excluded from language measures, due to questions raised by parent over language development of their infant. From the Bayley cognitive scale conducted at 24 months were found to be within the normative range.

Table 2.1

*First Steps Maternal Characteristics*

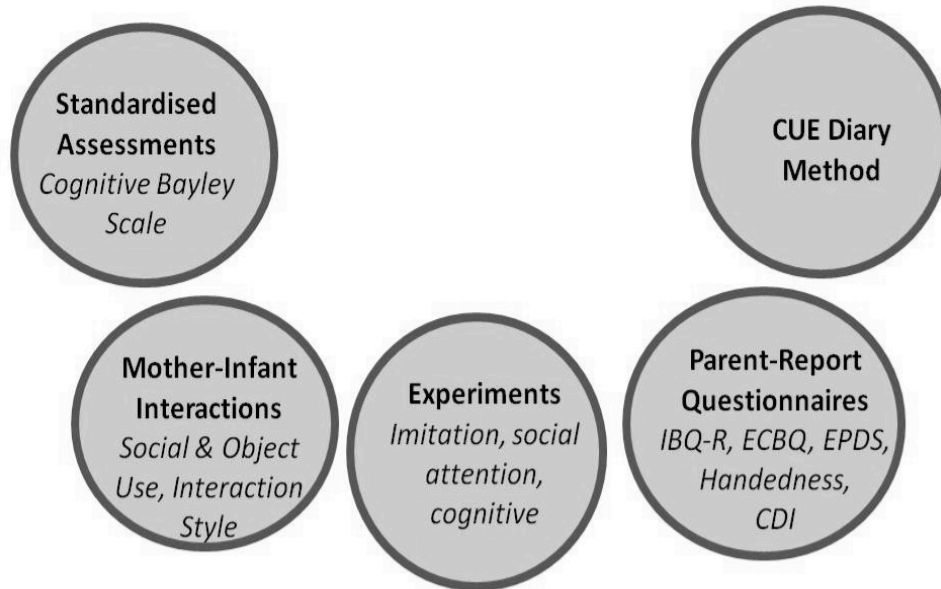
<b>Maternal Reporter Characteristics</b>	<b>Percent of Sample (N=36)</b>
<i>Age in Years at Recruitment into Study</i>	
16-20	2.78
21-25	13.89
26-30	11.11
31-35	36.11
36-40	36.11
<i>Highest Education Level Attained</i>	
High School	25
Undergraduate Degree	58.33
Postgraduate Degree	16.67
<i>Birth Order</i>	
Primiparous	58.33
Multiparous	41.67

*First Steps Procedure*

Monthly visits 0-18 months – 1 week window of monthly window, “breakfasts” group setting roughly 10 mother-infant pairs each week. During visits, CUE would be downloaded; training on behavior observation would be given; parent-report questionnaires would be filled out; experimental battery of tasks would be conducted across domains of motor, imitation, language, cognition, gesture, attention; mother-infant dyads would complete a 10 minute free-play interaction.

In between monthly sessions, mothers were assigned a FS researcher to contact in the event of questions or issues arising with meeting the requirements of the FS study. At 24 months mother-infants were invited back to FS to complete Bayley standardized assessment, and to complete imitation battery. A schematic of measures employed across the First Steps study can be seen in Figure 1.

# First Steps Design



*Figure 2.1.* Schematic of methodologies employed within the First Steps study.

## **Analysis**

In order to apply the microgenetic design in keeping with DST, to investigate the ontogeny of communication development, with the First Steps study, the sample size was restricted to less than 40 for reasons of practical management. The depth and breadth of the data collected on communication development is tempered by the samples limited size impacting potential analytical exploration of the data. In order to succeed in the aims of the thesis, as set out in Chapter 1, appropriate cross-sectional and longitudinal analyses were selected on the basis of appropriateness of fit for the sample and research question under investigation.



## **Chapter Summary**

Within this chapter I have given an overview of the First Steps aims, recruitment, sample demographics, methodologies and analyses focus. In the following chapters I will data from the First Steps study will be employed in asking the main question of this thesis, namely what can be learned of communicative development from advances in microanalytic and microgenetic methodologies, In the next chapter, Chapter 3 will describe a new adaptation to a microanalytic study of attention development, and the potential this new scheme holds for understanding early social attention will be discussed.

## **Chapter Three:**

### **We look, we learn: Developing a microanalytic method for the study of early infant attention**

#### **Chapter overview**

Social attention during interaction is a demonstration of an infant's motivation and ability to engage in communication with others. This demonstration can be seen before motoric prehension and vocalizations come online, as a dominant tool in communication. Put another way, when we look we learn. More than this, when we attend to others this very act has the power to influence what others show us. In the burgeoning literature on social attention, infants' propensity to attend to faces is well documented, alongside the implications for later social attention and communication resulting from typical and atypical attention to face behavior patterns. Theories relevant to the study of attention development include the dynamic systems approach described in Chapter 1. In this chapter I will argue that hands are a social stimuli that deliver a wealth of information about not only social models, but the existence of cause and effect, and the association between a social partner and the actions they engender upon the environment. The microanalytic approach, espoused by dynamic systems theory, will then be employed in the study of attention. After demonstrating infant attention to hands is in need of further scientific study, an adaptation to an attention coding scheme is described. This adaptation is to the seminal coding scheme of infant attention developed by Bakeman and Adamson (1984), that will allow for infant's attention to faces, hands and objects will be examined during mother-infant interactions. With the microanalytic method adapted, a microgenetic approach may then be possible.

Communication involves the giving and receiving of information. As described in the preceding chapters, several models have aimed to characterize the way in which this phenomenon occurs and develops throughout infancy, and beyond. One discussed set of approaches to this characterization includes the dynamic systems approach. Within this approach developmental change across the developing system is seen to arise following microlevel changes. As a result, the advocated method of study in communication would be to employ a design where microlevel information on ability and preference could be collected. Another message from dynamic systems approaches is that longitudinal study, with a combination of methods, is most likely to yield the most informative data on developmental change.

With the lack of prehension evident in the early stages of infancy, it is attention through which infants may engage with their environment most apply. By 1880 William James was already considering attention as a psychological construct deserving of scientific enquiry. The reason being that what we attend to determines what, how and when we engage with our surroundings. In this way attention is not a passive exercise, it is the gateway to adaptive behavior and communication. Theories of attention development aim to predict patterns of attention development, and the impact of individual differences over time. One method by which attention has been studied, is through the microanalytic coding of infant attention during interactions. When interactions are investigated it is often the communicative competence and style of the mother that is under scrutiny, with the quantifying of interactions with terms such as sensitive, positive, neutral, negative, symmetrical, asymmetrical or unilateral (Hsu & Fogel, 2001).

## **Early attention**

Understanding the ontogeny and developmental process of early attention development is necessary for improving our understanding of the earliest form of communication. Attention development has been extensively researched over the last few decades, and continues to be a central theme in communication development research. As detailed in Chapter 1, infant attention is a cornerstone to communicative development. With this proffered position in developmental science, the research interest in examining early attention development and preferences has been relentless in recent decades. As discussed in Chapter 1, The dynamic systems perspective advocates the study of the infant system in the context in which it emerges, to allow consideration of the abilities of the infant within the social context. Microanalytic coding methods of infant attention offer the means to conduct such research questions, both during experimental paradigms and during mother-infant free-play interaction. Through the exhaustive coding of infant attention, insights have been gained into the emergence of attention abilities, and the preferences for stimuli that may remain stable or change over the course of early infancy.

Of those studying social attention early in development, infant's preoccupation with faces has been a central point of research. Seminal studies demonstrating infant's preference for faces from birth (Fantz, 1964) as well as infant's recognition of faces (Farroni, Csibra, Simion, & Johnson, 2002) are indicative of questions asked about the emergence and characteristics of infant's propensity to attend to faces. The examination of infant attentional preferences through such methods has wholly neglected the examination of infant's preference to attend to other social stimuli, such as hands. Akhtar and Gernsbacher (2008) argues for the broadening of social attention

research in communication development to encompass more than the study of infant's attention to faces. Akhtar and Gernsbacher (2008) states that infant's social stimuli is more diverse than simply faces, and that if infant's were only attending to faces they would be missing out on an array of social stimuli, that are vital cues for infant's to attend to in the stages of early communication.

With the application of microanalytic coding schemes several seminal studies in social attention development have tracked the progression of social attention, such as Bakeman and Adamson (1984), Bornstein (1985), Scaife and Bruner (1975). These coding schemes have aimed to gather the wealth of information available on infant's attentional abilities and preferences during the mother-infant interactions that are the primary foundation for infant's early social and cognitive development.

Despite the vast citation and application of these coding schemes there is still a need for further developments into microanalytic methods in studying infant attention during mother-infant interaction. Firstly, Bakeman and Adamson's conceptualization of infant social attention was centered on the emergence of communicative attention occurring around 6 months, when infants have begun to demonstrate prehension skills and are therefore able to actively engage with the world through object manipulation. Additionally by 6 months infant's social engagement is evident through active social cues of smiling and laughing. This conceptualization based up on the timetable of prehension, smiling and laughing carries the same conceptual view that infant social attention's ontogeny begins with infant's preoccupation with faces and only when infant's begin actively engaging with the world do the fan out their social attention to peripersonal space and beyond.

Earlier in infancy the stage may be set for these communicative skills. While infant prehension skill necessary for active object engagement does not emerge until

around 4-months (Forssberg, 1999), at around 2-months there is a revolution in infant attention and affect regulation (Emde, Gaensbauer, & Harmon, 1976) that may drive early communication. After 2 months of age infants spend significantly longer periods of time awake, alert and viewing their environment (Wolff, 1965). Ruff and Lawson examine this 2 month transition, where infants are also able to track moving objects, with greater accuracy (1990). Further, infants will attend to the internal features of objects, where before infants will predominantly focus on attending to the external aspects of an object.

Over the first 3 months of life infants spend increasing amounts of time attending to objects (Keller, 2003). In addition, from Fantz's original 1964 study of preferential tracking for faces, at around 2 months of age the preference response to faces dropped below significance. Together these findings depict a developmental trajectory of infant attention where by 2-months infant attention abilities to attend and direct attention reach a point where more extensive preferences beyond faces, to objects in their environment enable a more diverse engagement experience for the infant during interaction.

The developmental transition seen during this period marks the beginning of infant engagement becoming intrinsically driven, rather than driven by the exogenous cues around them. It is at this point then that individual differences of infant attention ability and preference may be identified. Moreover, if hands are relevant social stimuli for infants, this should be evident from early on in infancy. The individual differences of infants to attend to hands, faces, and objects at this early stage of development, may also be meaningful for later development.

## **The need for applying microanalytic coding in early infancy**

With the need described above, for closer examination of group level change and individual differences during early infancy, Bakeman and Adamson's codes demonstrate a viable candidate coding scheme. In their original state the coding scheme differentiates between passive onlooking and active engagement. A further distinction is made between engagement with objects in isolation, and engagement that incorporates others. In applying to interactions in an exhaustive manner, these codes deliver data on micro change, that are relevant to a microanalytic approach advocated within dynamic systems approaches. Recently Perra and Gattis (2010, 2012) have attempted to apply these codes, in their original state, to the study of social attention in early infancy. What follows is a review of their methods and findings.

### **Review of Perra and Gattis (2012)**

Perra and Gattis (2012) applied the microanalytic coding scheme of Bakeman and Adamson (1984) to investigate the development of infant attention during interaction from 2-to-4-months. In their study Perra and Gattis (2012) had mothers hold their infants and play with them for approximately 4 minutes.

With the merit of applying a microanalytic coding scheme of attention, there are noteworthy limitations of the method and analysis of the Perra and Gattis (2012) that limit the conclusions drawn. During these interactions other family members and siblings were occasionally present, as well as a set of age-appropriate toys that were provided. Perra and Gattis found that during the first months of life infants showed an increasing level of onlooking and a decrease in unengaged states, when Bakeman and Adamson's (1984) microanalytic coding scheme was employed. The predominant

state of attention at 2-months was found to be unengaged, whereas by 4-months infants were unengaged for an average of 24% of the interactions. The findings of Perra and Gattis (2010, 2012) illustrate that whilst younger than the 6 month olds within the original Bakeman and Adamson (1984) study, infants as young as 2 months still demonstrate meaningful patterns (and individual differences) in what they pay attention to. Despite the notable transition of attention development noted in Perra and Gattis (2012) there are reasons to consider that infant attention ability and preference may not be fully depicted in these results.

Firstly, infant interactions were approximately 4 minutes in duration in this study, with some interactions totaling less than 3 minutes in duration. The norm duration for interactions that examine infant attention averages 10 minutes (Ruff & Rothbart, 2002). Whilst analyses within Perra and Gattis (2012) aimed to counteract the short duration, and the variation in interaction durations, this reduced duration impacts what conclusions can be drawn on infant attention. To maximize interpretations that can be drawn from interaction data, any adaptation to a microanalytic coding scheme would benefit from using a minimum 10-minute interaction period.

Secondly, mother's held their infants during interactions of Perra and Gattis (2012). The postural position of infants during interactions has been shown to influence both the degree of attention directing by mothers, and the attention durations of infants. By conducting interactions in this way, the ability to demonstrate variation and developmental patterns is influenced. To increase the opportunity for infants to demonstrate their attention ability and preference, seating infants in front of the parent would be preferential.



Thirdly, variation in the number social partners present during the interactions adds a level of complexity to the interactions that may impact an infant's demonstration of attention. Whilst analyses aimed to control for this variable, by varying the quantity of social input, as well as the individuals comprising the social input, variation in overstimulation creates a confound. Taken together these methodological details mean that conducting interactions in line with the suggestions made above might produce somewhat varied findings. For example, with a standardized length of interaction, where infants were sat facing the social partner (who was limited to only ever being the mother), periods of disengagement may appear reduced.

Finally, although previous research has demonstrated increasing a meaningful transition at 2-months, infant prehension does not emerge until 4 months. This important disconnect between attention and prehension means that infant engagement with objects will solely be demonstrated through attention in early infancy. Distinguishing between social and object directed attention in microanalytic coding schemes becomes more important therefore. Moreover, in search of examining the distinctions between attention to faces and the other social stimuli of hands, such a category in a microanalytic coding scheme is a meaningful addition.

As discussed, hands are an important source of information for infants. As a result with an adaptation to the coding scheme of Bakeman and Adamson (1984) it could be that attention is divided between faces, hand actions, and alternative objects/locations of interest. Moreover, the individual difference in the time spent in these locations may be meaningful in process accounts of social attention development.

In this chapter I will report on the design and application of an adaptation to the seminal microanalytic coding scheme of infant attention during interactions. The design of this adaptation will take influence from the dynamic systems approach, through the advocacy of microanalytic detailing of behavioral patterns. With the adaptations made the microgenetic aspect of dynamic systems approaches may be realized in other studies. Such studies would apply the microanalytic coding scheme in a microgenetic manner (i.e. at a frequency above the expected rate of change, in order to yield information about developmental shifts).

Several significant adaptations will be outlined for the microanalytic coding scheme. These adaptations will be assessed within this chapter, with the aim of examining infant attention during mother-infant interactions at 2-months. Firstly, due to the interest in distinguishing attention to faces, hands, and objects, the adaptation will involve breaking the original onlooking code into these 3 subcategories. Secondly, due to the age of the infants tested interactions will take place within a geometrically patterned tent, to offer an environment of interest to the infant. Thirdly, infants would be seated in a baby chair facing their mothers, thus enabling infants to demonstrate the optimal levels of attention.

The predicted outcomes from these adaptations include several predictions on infant attention. As hands are viewed as a relevant social stimuli within this thesis, it is predicted that attention will be distributed across the states of onlooking mother's face, onlooking mother's hand actions, and onlooking alternative objects. Secondly, due to the methodological changes to Perra and Gattis (2010, 2012) it was predicted that the period infant's spent unengaged would be lower than the 60% reported in Perra and Gattis, and more closely resemble the percent of the interaction infants

spent unengaged in Bakeman and Adamson's original study (around 25% of the interactions).

In order to evaluate these adaptations to the original application of the coding scheme, the scheme will be applied to interactions that are 10 minutes in duration, with only the mother present. Following the detailed adaptations, I predicted that unengagement would no longer be the most prominent state of engagement. With the documented levels of interest infant give to faces, it was predicted that infant onlooking of faces would be the most prominent onlooking state. As hands of mothers evoke change within the infant's environment from birth onwards, it was predicted that onlooking hands would be the second most frequented state of infant engagement.

## **Method**

### **Participants**

Forty mother-infant dyads were recruited by the Cardiff University website and National Childbirth Trust. Participation was part of a longitudinal study, First Steps, from birth to 18 months. Of the 40 dyads one mother withdrew from the study before the second month and one dyad was removed from this analysis due to technical difficulties. Within the remaining sample 18 infants were female and 20 were male. At the time of the second month observation the infants ranged from 7.5 to 8.5 weeks with an average age of 8 weeks.

### ***Apparatus***

*Mother-infant interaction.* To create a sense of privacy and to ensure consistency of visual environment across infants, mother-infant interactions were conducted in a colourful tent. The infant was placed in a baby seat and the mother sat

facing the infant. Three baskets contained toys appropriate for 2-month-olds as well as older ages, including soft toys, rattles, and books. The interactions were filmed with three separate cameras. Two cameras were static, with the first filming the mother and the second filming the infant. The third camera was mounted on the mother's head with a headband. The outputs of the cameras were combined with a quad to create a single time-synced digital video record. Coding was completed using INTERACT 7.25 (Mangold, Arnstorf, Germany).

### ***Design***

A within-subjects correlational design with the variables of infant attention and maternal toy use were examined within the context of an object mediated free play interaction between the dyad of infant and mother. The design was two fold in order to achieve the dual agendas described within the introduction. The research goal being to describe infant attention during interaction. For infant attention the variables of frequency of occurrence, variation, duration of occurrences and total time spent in each of the following states were examined. The eight states of attention included the infant being unengaged, onlooking a person, onlooking an object chosen by the mother, onlooking an alternative object, person engagement, object engagement, passive joint engagement and coordinated joint engagement.

### ***Procedure***

Mothers were asked to interact with their infant as they would do normally for 10 minutes, within the tent provided. They were not instructed to alter their behavior at any point during their interaction. The 2-month testing session was the second occasion that the mothers had to experience the tent. When the infants were 1 month

old infants and their mothers had the opportunity to get used to the setup of the tent and cameras.

### ***Ethics***

This research design was approved by the School Research Ethics and was gained by the mothers whilst they were pregnant. The interaction data was consented to under the condition that the data would be held confidentially, allowing for multiple uses of the data undertaken by assigned researchers.

### ***Coding Development***

As the current study was an expansion of previous research by Bakeman and Adamson (1984) into engagement states during infancy and maternal styles of interaction, a coding scheme was developed in line with that of Bakeman and Adamson's original quantitative, microanalytic and comprehensive coding scheme of infant's attentional states during interaction. That scheme involved temporally sensitive, fine grained coding of specific behaviors. The codes enabled rich detail of information on frequency, variation and duration information of pre-defined behaviors. In this case, the pre-defined behaviors of the infant related to states of attention in the infant.

The following are the behaviors examined by Bakeman and Adamson: unengaged, defined as scanning the environment with no clear focus of attention; onlooking, where the infant is a passive agent within the interaction but is visually attentive to a person, object, event; person, involving an active state of engagement whereby the infant is being responsive and engaging through verbal, gestural or other means; object, where the infant is solely focused on the active engagement with a chosen object; passive joint engagement, where the infant and mother are jointly engaging with an object but the infant is showing no signs of acknowledging the

presence or role of the mother; coordinated joint engagement, involving an active engagement both with an object and mother. The final state of coordinated joint engagement may be considered a sign of successful triadic joint attention (Bakeman and Adamson, 1983, 1984).

Although the current scheme stemmed from Bakeman and Adamson's work there was need for an adaptation in order to make it an appropriate scheme for the present study. This need came from the age of infants participating. Whereas the youngest age infants were tested in Bakeman and Adamson's study was 6 months, one of the aims of the present study was to expand upon this by observing dyadic interactions with infants of 2 months. This fact made the original coding scheme problematic for two reasons. Firstly, the infants at 6 months are capable of active object engagement, either by mouthing or manual manipulation of the object. This prehension ability is not fully developed in infants at 2 months (Butterworth, Verweij, & Hopkins, 2011).

Rather than potentially losing potential preference information on infants attention to objects the adaptation coding scheme subdivided the onlooking category into the following predefined behaviors: onlooking person, involving attentively visually attending on the mother and tracking the mother; onlooking mother's chosen object, where the infant is onlooking an object that the mother has chosen to engage with; the final subdivision of onlooking was onlooking other object involving the infant visually attending an object that is not being focused on by the mother. By this developed categorization of onlooking behavior it is possible to more closely analyze the looking preferences, abilities and influential looking behaviors the infant has at their disposal. A description of these codes may also be found in the table 3.1.

Table 3.1

*Definitions and examples of states of infant engagement*

<b>Engagement State</b>	<b>Description of Infant During State</b>	<b>Example</b>
Unengaged	Not engaged in any activity in particular	The infant scans the environment
Onlooking Mother's Face*	Observe mother's face without actively smiling, vocalizing, or reaching	Infant observes the mother's face without actively responding
Onlooking Mother's Hand Actions*	Observe mother's hands and the objects mother's are animating without smiling, vocalizing, or reaching	Infant observes the mother's hands and the objects they animate, without actively engaging
Onlooking Other Objects*	Observing an object that is not the focus of the mother's attention without smiling, vocalizing, or reaching	Infant observes an object that the mother is not focusing on, without actively engaging
Person	Actively interacting with another person by responding to the other person or by trying to initiate an exchange.	Infant smiles and then reaches toward the mother
Object	Playing with an object alone	Infant explores an object he/she has in his/her hand
Passive Joint Engagement	Playing with an object that is also the focus of the mother's activity but they do not acknowledge the mother's activity	Infant explores a rattle that is from time to time shaken by the mother to produce a particular noise. During this time the infant does not look back and forth between mother and the object
Coordinated Joint Engagement	Playing with an object that is also the focus of the mother's activity and acknowledge the mother's activity by actively coordinating attention between the object and mother	The infant explores manually a rattle that is from time to time shaken by the mother to produce a particular noise and during the time the infant looks at the mother and then back at the object

*Note.* \* denotes onlooking states that have been adapted from the original Bakeman and Adamson (1984) state of onlooking

### ***Coding Training***

With the adaptation to the coding scheme developed I completed the primary coding. Whilst doing so a secondary coder was trained on interactions that were not included within the analysis, but that were comparable to the study's sample and interaction procedures. For these levels of agreement no state was below the accepted levels of agreement within interaction coding (as described within Bakeman and Adamson, 1984). Above simply agreeing on the frequency of states, the coders were required to agree on the onset and offset of the stream of codes within the entire interaction to deliver agreement levels above 80% (and *kappa* scores above .65).

Once an agreement reached 80% across all codes within the coding scheme on training videos, the secondary coder coded a subsample of 25% of videos for this study. Interobserver was assessed for infant attention. An agreement of 80% for infant attention was achieved across all states of attention (mean percent agreement for infant attentional states = 84%), with kappa reaching mean *k* of .82.



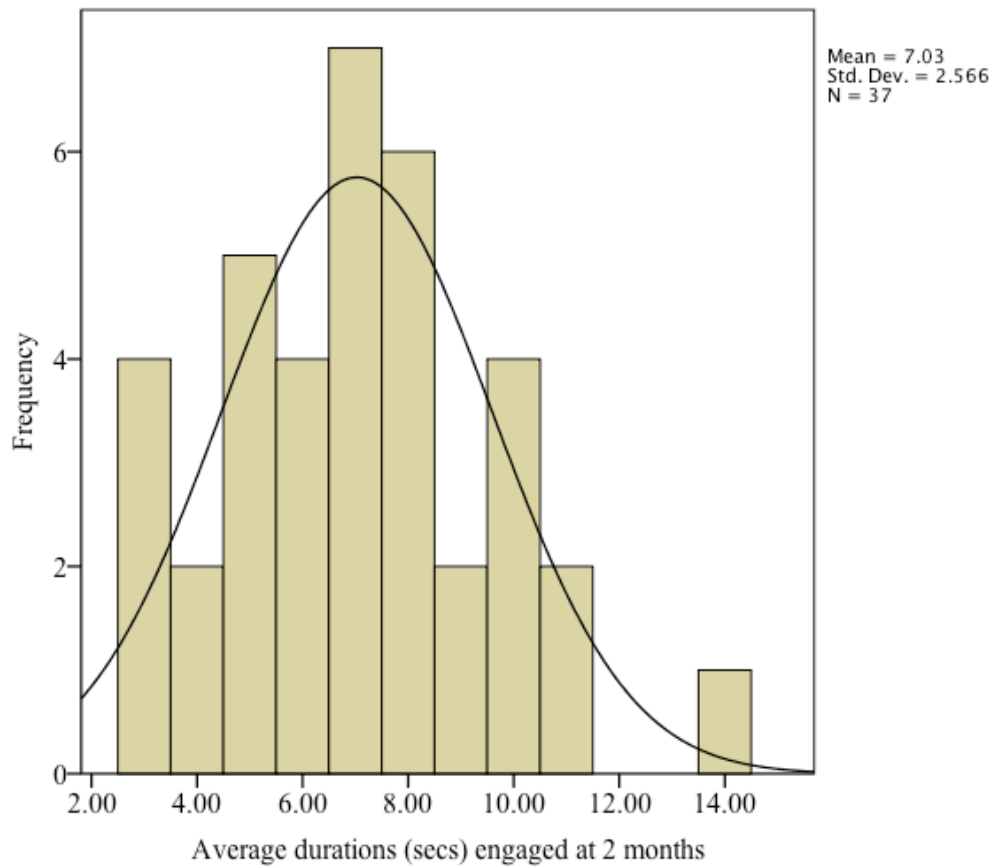
## **Results**

### **Analysis Plan**

In order to examine the value and meaning of the adaptation to Bakeman and Adamson's (1984) onlooking codes, several stages of analysis were conducted. These stages of analysis included data characteristics (such as missing data, distribution, and means and standard error); finally inferential statistics explored whether there were significant differences in the states infants entered into at 2 months. The aim of the analysis conducted in this chapter was firstly descriptively evaluate the prevalence of each state of engagement detailed in Table 1. As predicted coordinated joint engagement was not found to be prevalent at 2 months and was therefore removed from further analysis. Following on from descriptive analysis of state prevalence, inferential analysis was applied to determine whether states were more prevalent than others.

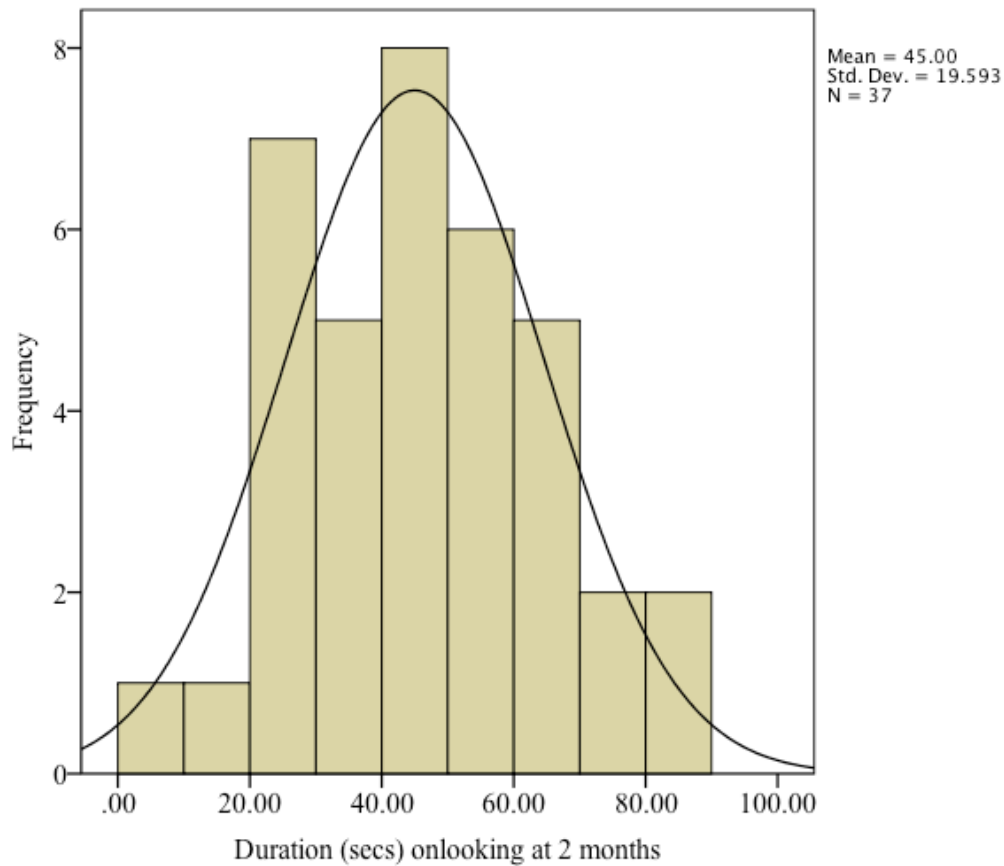
### **Data Screening**

All 39 infants were included within the analysis plan, with no missing data within the sample. Histograms were utilized to assess the distribution characteristics of infant attention variables. Before individual states of interest were examined for their distribution, aggregate variables of engagement were formed in order to assess the distribution of engagement over all. As shown in Figure 3.1, engagement collapsed across all engaged states yielded a normal distribution.



*Figure 3.1* Distribution of infant engaged states at 2 months

With onlooking of primary interest for this chapter, the next agregagte variable where distribution was examined included onlooking. This variable is as described in the coding definition of Bakeman and Adamson (1984), and how it is applied in Perra and Gattis (2010, 2012). In Figure 3.2, again a normal distribution is demonstrated.



*Figure 3.2* Distribution of infant onlooking at 2 months

As onlooking mother’s hand actions, and onlooking alternative objects, were the central focus of the adaptation they were next to be assessed for distribution and are shown in figures 3.3 to 3.4. As can be seen in the axis title of Figure 3.3, onlooking mother’s hand actions was transformed using a logorhythmic transformation to deliver a normal distribution.

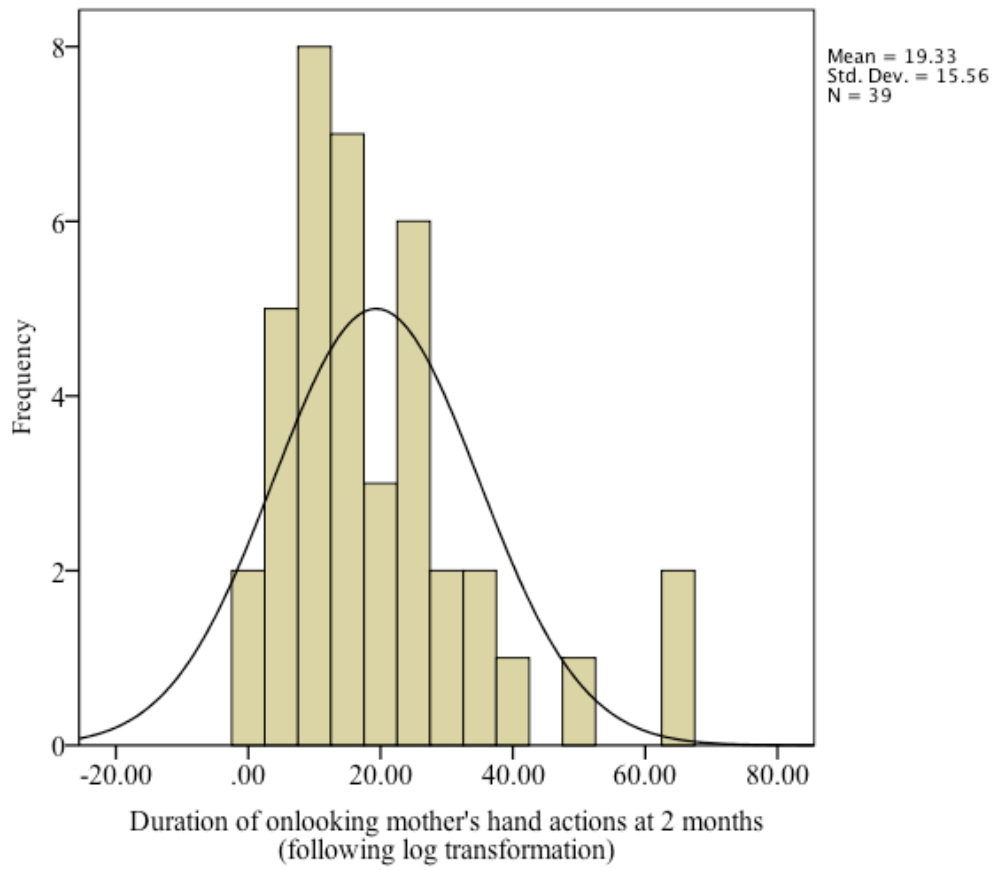


Figure 3.3. Distrubution of onlooking mother's hand actions at 2 months.

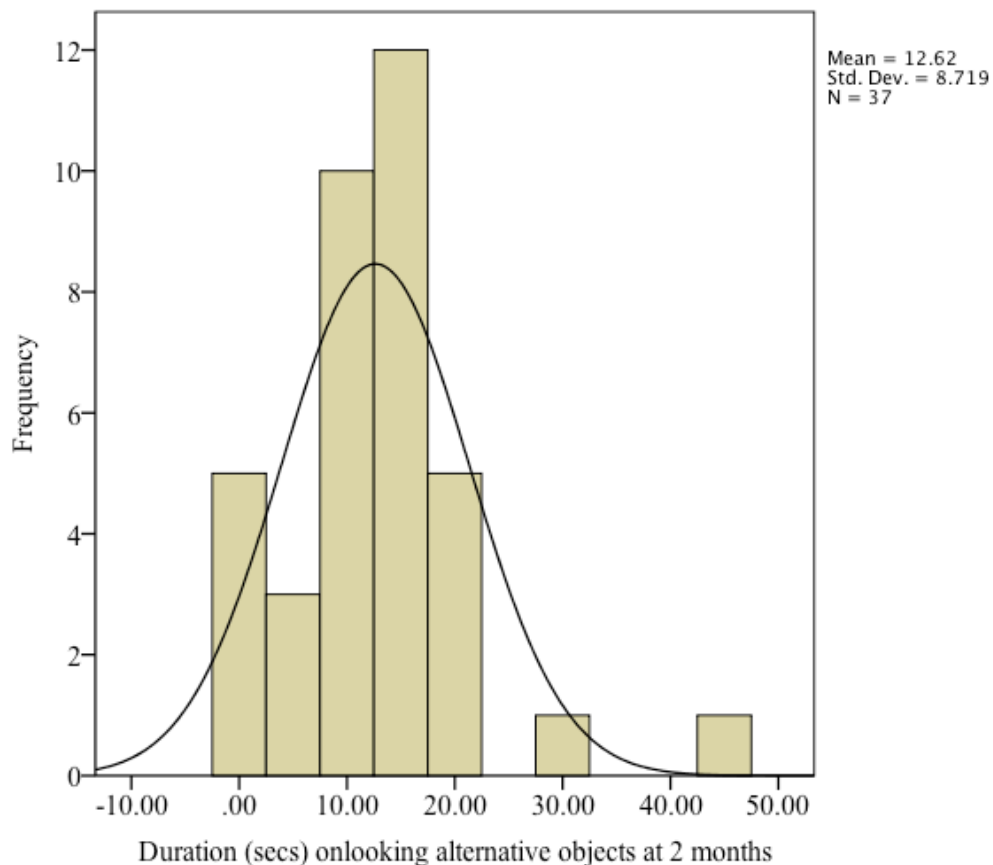


Figure 3.4. Distribution of infant onlooking alternative objects at 2 months.

### Descriptive Analyses of Infant Attention

The states of unengaged; onlooking mother's face; onlooking mother's hands, and object held; onlooking alternative object; person; object; passive joint engagement and coordinated joint engagement were analyzed descriptively to determine the frequency, variation, duration and total time spent in each state. Eight occurrences of the infant being out of view occurred out of the entire sample, and made up less than 1 percent of the time spent in any attentional state. As predicted coordinated joint engagement was not found to be a state occurring in infants at the group level, and therefore was not considered a variable for further analysis.

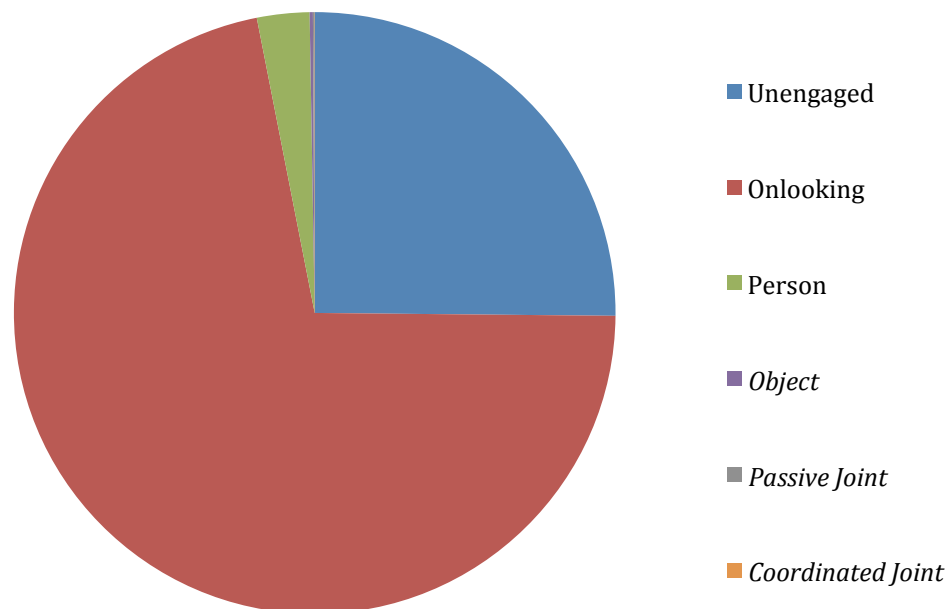
## **Inferential Analyses of Infant Attention**

Within the original Bakeman and Adamson (1984) analyses was largely focused on the descriptive characterization of infant attention, as well as the depiction of change across different age groups as part of a between subject design. Within Perra and Gattis (2010, 2012) analyses to assess group level and individual differences in infant attention over time were in part selected to account for variation in the procedure. Due to the within-subject nature of the study in this chapter, and the unilateral application of the procedure, an inferential analysis plan was chosen that was distinct from the previous studies mentioned. In this instance chi square goodness-of-fit was chosen. A chi square goodness-of-fit is null testing analysis. The test pits the null model, of no significant variation in frequency, against the observed data. A significant p value denotes a lack of support for the null model, of no difference between entered categories. In this instance the categories are states of attention.

Assumptions of the chi test that are met within this data are that the sample are random, in the sense that there is not a bias of infants to engage in a pattern of states. Secondly the expected frequency of states is at least 5 within each interaction. Degrees of freedom within the chi test are 1 less than the number of categories entered into any given null testing model, and the statistic does not change in if the order of the categories entered into the model is changed.

In the analyses that follow, null models will be tested. In this instance a null model would be that the spread of states across the interaction period is equal across engagement state, with no state exhibiting a higher state than others entered into the model.

To compare results with Perra and Gattis (2012) onlooking states were first collapsed to form the aggregate variable seen in the original Bakeman and Adamson (1984) coding scheme. As can be seen in Figure 1, onlooking was the state holding the highest percent of time during the interaction. A chi square goodness of fit statistic demonstrated onlooking to be significantly most prevalent ( $\chi^2(2)=72.970, p=.0001$ ).



*Figure 3.5* Percent of time infant's spent in each state, with unadapted coding scheme.

*Note.* Italic legends denote states summing less than 1% of the interaction.

Onlooking states were aggregated into the original Bakeman and Adamson (1984) onlooking state, as shown in Figure 1, onlooking comprised 71.32% of interactions.

Onlooking, as an aggregated score, was found to be significantly the most common state of engagement ( $\chi^2(2)=72.97, p=.0001$ ).

When the onlooking codes were separated into onlooking mother's face; onlooking mother's hands, and objects; and onlooking alternative object the percent of time spent in each onlooking state was not found to significantly different ( $\chi^2(2)=3.746, p=.154$ ), as can be seen in Figure 2.

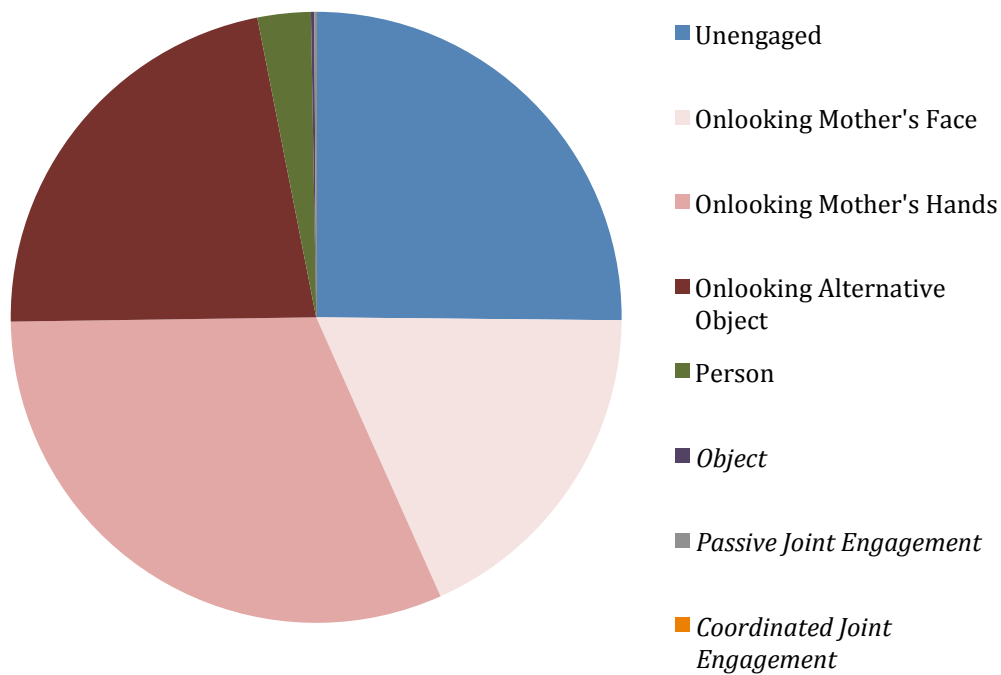


Figure 3.6 Percent of time infant's spent in each state, with adapted codes

Note. Italic legends denote states summing less than 1% of the interaction.

With percent of time during interaction not demonstrating a significant difference between onlooking states, a secondary assessment was made with the more fine-grained variable of duration of attention during each episode. As can be seen in



Figure 3 onlooking mother's hands was the state with the longest durations per episode. In Table 3.2 the average duration (mean) and variation (stand error) are shown for duration of engagement states described of *unengaged, onlooking mother's face, onlooking mother's hand and object, onlooking alternative object, person, object, and passive joint engagement*. In addition the duration of attention engagement

Table 3.2

*Average (mean) and variation (standard error) of duration of engagement states at 2 months*

Engagement State	Duration per episode (sec)	
	Mean	St. Error
Engaged	6.95	4.04
Unengaged	19.94	3.65
Onlooking	44.85	3.06
Onlooking Objects	32.54	2.48
<i>*Onlooking Mother's Hands and Object</i>	<i>19.33</i>	<i>2.49</i>
<i>*Onlooking Alternative Object</i>	<i>12.64</i>	<i>1.36</i>
<i>*Onlooking Mother's Face</i>	<i>32.54</i>	<i>2.48</i>
Object	3.26	0.26
Person	3.15	0.97
Passive Joint Engagement	3.38	0.77

*Note. \* denotes adapted states from original onlooking state. Engaged and onlooking objects denote aggregated states.*

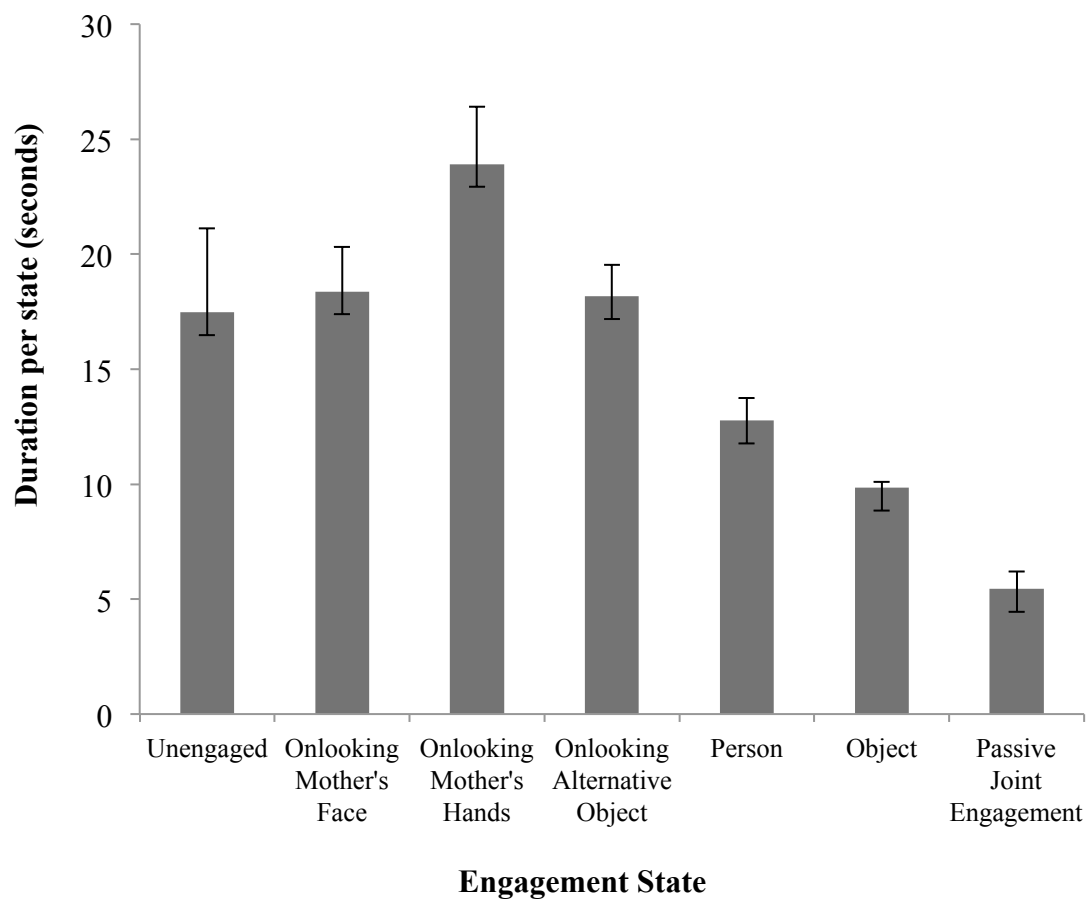


Figure 3.7. Average duration, in seconds, of each episode of engagement, with adapted coding scheme.

Note. Variation is shown with standard error bars.

A chi square statistic demonstrated that this difference with onlooking mother's hands being the longest in average duration was not significant, when analyzed against onlooking mother's face, onlooking alternative object, or unengaged ( $\chi^2(3)=.3750, p=.290$ ).<sup>1</sup>

<sup>1</sup> Similarly, a within-subject ANOVA was found to be non-significant

When the onlooking states were aggregated and compared to the aggregated active states of person, object and passive joint engagement, the significance was found to approach significance ( $\chi^2(1)=3.571p=.059$ ).

## **Discussion**

In order to closely examine individual group levels, and individual differences in attention to faces, hands and objects, Bakeman and Adamson's (1984) code was adapted for the most prevalent attention state of onlooking, to make it possible to identify meaningful differences in attention at two months, before the onset of manual dexterity in the majority of infants, that is needed for passive joint engagement. Three types of onlooking were identified: onlooking mother's face; onlooking mother's hands, and their actions on objects; and onlooking an alternative object that the mother is not attending to or engaging with, see Table 1.

The first research question was how infant onlooking is distributed in interactions with caregivers: to faces, to hands and the objects held by them, and to other objects in the environment that the mother is not engaging with. Infant attention during interactions with their mother to predominantly involve onlooking mother's hands, and their actions on objects; mother's face; and other objects not engaged with by the mother. This distribution of attention across the onlooking states is in line with the evaluation of faces, hands and objects as relevant stimuli to infants.

Within the original Bakeman and Adamson (1984) coding scheme infants were unengaged for approximately 25% of the time. Within this chapter similar rates were found. In contrast the rates of unengaged were notably higher within Perra and Gattis' studies. Whilst some of this discrepancy may be attributed to the differences

in procedure, replication of findings in this chapter are required to support current findings.

### **Limitations**

Interactions conducted within this study were limited to 10 minutes in duration. The limit on the duration of interactions may be considered a limitation within the design. Other coding schemes of development have utilized interactions of an hour, arguing that an hour enables strengthened statements regarding stable infant characteristics. Interactions within this study were conducted at a University, within the environment of the patterned tent, with toys available to mothers. The advantages of the structured set up must be seen in light of the disadvantages to such an approach. Namely, variation in mothers positioning of the infant may not be examined here as infants were seated in a baby chair. The conditions detailed during interactions may be viewed as optimizing the potential for understanding the processes of early communication. Studying attention in the context in which it develops, offers a degree of ecological validity. By highly specifying the coding scheme the benefits of studying attention in context may be realized.

The adapted Bakeman and Adamson (1984) coding scheme implicitly incorporate the mother's activity, but further examination could be conducted with the layering of coding schemes, where more explicit schemes for the study of mother behavior could be applied, such as maternal vocalizations. A specific limitation that may be leveled at microanalytic methods, are that they may be too narrow in focus, potential ignoring larger structural factors that may be influencing the behaviors under consideration within the microanalytic codes. An answer to such criticism may be to develop a macrolevel coding scheme of infant attention, where general states of

“object-directed” versus “person-directed” may elucidate the distinctions captured by the coding scheme described within this chapter. However, despite the value of macrolevel coding schemes in identifying larger factors, such a scheme simultaneously capturing distinctions in attention skill have proven elusive within the study of early communication.

While onlooking mother’s hand actions may be a meaningful distinction, it may be that attention to mother’s objects subsumes attention to hands alone. In the next chapter of this thesis time mothers spent with objects will be controlled for, to address this limitation. Within the 2 month interaction data on attention reported in this chapter, standard error was found to be considerable. Whilst attention during interactions has demonstrated large variation in other studies, it may be that conducting interactions as early as 2 months may result in larger variations. The procedure aimed to deliver control over confounding variance from methodological variance, it may be that having a researcher interacting with infants rather than mothers may help reduce the variation measure.

### **Implications**

Contrary to the view that early infant attention initially emerges with a preoccupation to attend to faces at the expense of other socially relevant stimuli, in an interaction setting at 2 months infants shared their attention across the socially relevant stimuli of faces, hands and objects. This finding speaks directly to the theoretical debate, concerning the point in development when attention extends from the face to peripersonal space. In Fantz’s (1964) seminal study of infant attention, by 3-months the preference for face stimuli noted in newborns had dissipated. Perra and Gattis (*in press*) demonstrated that infant attention makes notable developments from 2-to-4-months, with the emergence of passive joint engagement by 4-months. The findings

detailed in this chapter demonstrate that with a fine-grained approach to the coding of onlooking states, advocated by followers of theoretical approaches such as dynamic systems perspective, valuable insights into the ontogeny of attention during early interactions may be gleaned.

### **Future studies**

Bakeman and Adamson have applied the coding scheme with peers as well as mother-infant dyads, and have tracked the progression of joint engagement from 6-18 months (Adamson, Bakeman, Deckner, & Nelson, 2012; Bakeman & Adamson, 1984). A future direction for this adaption to a microanalytic coding scheme could be to examine father-infant interactions. Recent studies into the similarities and differences displayed between mother-infant and father-infant dyads in later infancy have yielded insights into the roles multiple caregivers play in the development of infant communication (Feldman, 2012; Moore et al., 2012).

The development of attention must be considered within the development of the infant as a complete system. Other aspects of communication development impact upon attention, as attention impacts upon other domains of development. Examining infant attention in isolation will never yield the level of predictive validity that a multi-domain approach will offer. Kopp (2002) detailed the co-development of early infant attention and emotion regulation. Kopp argues that infant attention is not possible to develop normatively without the adaptive development of arousal regulation. Layering of the adapted coding scheme detailed within this chapter alongside an analysis of infant emotion regulation, within the same interaction, could allow for sequential analysis to uncover distinct contingencies across attention states and levels of affect.

Advocates of microanalytic coding to infant development are often also advocates of microgenetic designs. In such cases, moment-by-moment coding is paired with frequent observation to yield precise measurement of infant stability and continuity (see Lavelli & Fogel, 2005). Employing the coding scheme in an intense observation schedule would allow for analysis of infant stability and variation in attention ability and stimuli preference over small increments of time.

### **Chapter Summary**

The adaptation detailed in this chapter was applied for the study of normative development. However, the study of early communication in infancy is of paramount importance for normative and atypical development. Several national studies are concerned with the documenting of early development in children born with an older sibling who has autism (see BASIS study for example, Wan et al., 2012). These children are themselves at an increased prevalence risk of being diagnosed with autism. Thus far early indicators of impaired social attention in at risk infants have been demonstrated within the first year. Applying the coding scheme detailed in this chapter would enable a more exhaustive examination of attention in these at-risk infants, to determine whether it is attention to mother's faces that separates these groups, or whether attention to mother's hand actions, and objects, is also impaired. The social motivation theory of autism (Chevallier, Kohls, Troiani, Brodtkin, & Schultz, 2012) suggests that such overall reductions in attention to socially relevant stimuli may result from such an extreme case of diminished social motivation.

Before such an extrapolation of the adapted coding scheme is applied to the study of atypical development, the first step in applying the adapted coding scheme, must be to establish whether differences in early onlooking behavior have developmental consequences for the emergence and progression of social attention. In

the next chapter this question will be asked through a longitudinal design, where onlooking states are differentially examined as predictors for aspects of early social attention.



## Chapter 4

### Beginning to See Through Your Hands; Hands and Social Attention

#### Chapter overview

In the research reported in this Chapter, attention to mother's hand actions and attention to mother's faces during early interactions were examined as predictors for later social attention. Attention allows focus on those stimuli that deliver the essential information we require. For developing infants, social partners are the quintessential example of sources of information who, when attention is paid to them, are invaluable in passing on information. Social attention develops during infancy and enables an array of pedagogical settings involving actions and consequences that are socially caused and, or relevant. Understanding the onset of the foundations for this social form of attention is fundamental in answering the questions of how and when change in attention occurs over infancy, resulting in a child that is capable of following others' attention to sources of interest, as well, as eliciting attention following to their locus of interest. Furthermore, results in this Chapter show the duration of attention to mother's hand actions rather than faces, was found to predict later social attention at 5 months. The theoretical consequences of attention to hands being implicated in the early foundations of social attention are discussed.

Attention following is a skill that allows infants to follow the attention of others, and as a result infants profit from all the learning opportunities that await them when the actions of others is attended to. Learning, tool use, imitation, social cognition and language are all abilities built upon this skill of following the attention of others (Axelsson, Churchley, & Horst, 2012; Fais et al., 2012). Attention is the earliest form of communication and delivers the infant access into the world of actions social partners commit at a near constant pace around them. It is claimed that “The eyes have it” and attention to faces is the foundation for early attention following. This assertion is extended by the view that attention develops in the direction of narrow focus on the face, and slowly extends out to the environment, culminating in combining attention between the social and non-social environment. In this study, for the first time, investigated whether attention to faces or the socially relevant stimuli of hands, predicted the most sophisticated form of early attention following. Attention to hands, not faces, at 2-months was predictive of later sophisticated attention following.

Social attention refers to the allocation of attention to social partners, including their facial expressions, gaze direction, and gestures to objects. Social attention allows individuals to learn from the actions, emotions, and interests of conspecifics. Not surprisingly then, social attention is closely linked to the re-orienting of attention: people utilize social cues such as gaze direction and facial expressions to determine where to look and what to expect, and neuroimaging data indicate that the visual analysis of social attention cues and attention shifting are controlled by a common neural network (Bayliss, Bartlett, Naughtin, & Kritikos, 2011; Birmingham & Kingstone, 2009; Emery, 2000; Frischen, Bayliss, & Tipper, 2007; Itier & Batty, 2009; Langton, Watt, & Bruce, 2000; Nummenmaa & Calder, 2009).

Felicitously, the most characteristic forms of human social attention, such as preferences for faces and voices over non-social stimuli, and attention following, emerge during infancy (Farroni et al., 2002; Johnson, Dziurawiec, Ellis, & Morton, 1991). Attention following can be defined as two distinct forms. The earlier emerging, and more basic attention following behavior is that of proximal attention following (PAF). This behavior allows for an initial orienting of attention in the direction another person has directed their attention to a proximal location. By 5 months this behavior is widely achieved (Perra & Gattis, *in press*). The next stage in attention following is the demonstration of checking back behaviors. Checking back involves a pattern of behavior that includes successive shifts from the other person's face, to their locus of interest, before returning to the other person's face. This checking back to the person is more sophisticated as a behavior, demonstrates an overcoming of sticky fixation, and allows infants to gain feedback and to recalibrate attention when necessary.

This early emergence of social attention allows infants to benefit from social partners as a source of information about the world around them. Social partners introduce infants not only to social roles and rules, but also to the non-social world by holding and manipulating objects before young infants have the physical strength and control to do so themselves (Yu, Smith, Shen, Pereira, & Smith, 2009). For decades, research on the emergence of social attention has for the most part focused on children's responses to facial cues, such as emotional expressions and gaze direction (Farroni et al., 2002; Langton et al., 2000; Scaife & Bruner, 1975; Sorce, Emde, Campos, & Klinnert, 1985; Symons, Hains, & Muir, 1998). This focus on facial cues reflects an hypothesis about the developmental progression of social attention: infants first direct attention to faces, after some months they follow faces to objects, and a

period of intense interest in objects begins, until the approach of the first birthday, when infants become capable of shifting attention back and forth between faces and objects in a coordinated fashion (Kaye, 1982; Kaye & Fogel, 1980).

Attending to action is vital for causal understanding (Saxe, Tenenbaum, & Carey, 2005). We learn causal relations from attending to the actions of others. Hands induce change upon the world, demonstrating a biological force of causal relations for change. Attending to hands by 21 months has previously been demonstrated to strengthen the perception-action loop, aid in the selecting of attention to relevant information, and the filtering out of irrelevant information (Yu et al., 2009). These findings support manual action in the setting of development is found to be critical in establishing the perceptual experiences of infants. For these reason hands should be of primary focus to those investigating the development of social attention and causal understanding. In this study the area of action understanding is moved forward by examining attending to this social stimulus of hands, that act upon the world, in infants before their own prehension skills have emerged, enabling self-induced hands acting up on the world.

The attending to actions of others is a necessary developmental achievement for learning, tool use, language, and social cognition (Shi, Weng, He, & Jiang, 2010). Studies of action observation, however, point toward another possibility for the ontogeny of human social attention. Humans direct their interactions with the environment not only with their eyes, but also with their hands and their entire bodies (Akhtar & Gernsbacher, 2008). Correspondingly, studies of attention to biological motion indicate that humans of all ages are particularly good at processing the actions of others. For example, adults, children, and even newborn infants attend to the actions of social agents and to biological motion, more than they attend to the actions

of non-social agents and non-biological motion (Fox & McDaniel, 1982; Johansson, 1973; Kuhlmeier, Troje, & Lee, 2010; Shi et al., 2010; Simion, Regolin, & Bulf, 2008; Yoon & Johnson, 2009). Furthermore, Shi et al., (2010) reported that biological motion displays, such as a figure walking, trigger reflexive attentional orienting, but non-biological motion does not.

Hands are significant agents of action, and studies of action understanding show that as early as 5-months, humans are sensitive to the relation between hands and their goals. For example, Woodward and colleagues have shown that infants habituated to a hand reaching for one of two toys subsequently look longer when the hand reaches for a new object in the same location than to the old object in a new location (Woodward, 1998, 2003). Studies of looking patterns also show that infants are sensitive to the relation between hand and face, shifting attention from an adult's averted head to the hands, and shifting attention from disembodied hands to the space above, as if looking for a face (Amano, Kezuka, & Yamamoto, 2004; Slaughter & Neary, 2011). Together the results of these studies suggest that the path to coordinating attention between social partners and objects is found in attending to the actions of social partners, including hands and the objects in them, rather than faces.

The proposed account that hands are where early attention following begins, was examined within the First Steps longitudinal study. This chapter builds on a longitudinal study of early social attention from two to four months that compared infant attention engagement in naturalistic social interactions with infant attention following in an experimenter-administered task (Perra & Gattis, 2010, in press). Within this study significant advances on Perra & Gattis' work by applying a fine grained analysis to the prevalent state of onlooking during interactions at 2 months, in

order to assess whether difference in children's attention to faces, and hands would differentially be related to later attention following.

In the current study, social attention in a naturalistic interaction at two months was compared with attention following at five months. Our research question was whether specific aspects of early social attention, in the form of onlooking behavior at 2-months, might predict attention following at five months. Where attention following encompasses the two behaviors of proximal attention following (PAF) and the more sophisticated checking back (Perra & Gattis, 2010). Proximal attention following is found to be largely achieved at the group level by 5 months, whereas checking back shows individual variance in performance at 5 months. Checking back is demonstrably the more sophisticated attention following behavior, as it requires more attentional control by the infant, and demonstrates a pattern of attentional shifts. Checking back is considered a transition skill of attention before joint attention in earnest can emerge. For these reasons checking back was the attention following behavior of interest within this study.

If attention to faces lead social attention, infants who spend more time onlooking mother's face at two months should show higher rates of attention following in an experimental scenario at five months. If actions lead social attention toward objects, infants who spend more time onlooking mother's hands at two months should show higher rates of attention following at five months.

## **Method**

### **Participants**

A total of 40 mother-infant dyads were recruited by the Cardiff University website and National Childbirth Trust. Participation was part of First Steps, a longitudinal study of development from birth to 18 months. For more information on participant characteristics see Chapter 2. Of the 40 dyads one mother withdrew from the study before the second month. Within the remaining sample 18 infants were female and 21 were male. Naturalistic observations were conducted at two months ( $M = 56$  days, range 52 to 60 days). An experimental measure of attention following was conducted at five months ( $M = 150$  days, range 137 to 151 days).

### **Apparatus**

*Mother-infant interaction.* To create a sense of privacy and to ensure consistency of visual environment across infants, mother-infant interactions were conducted in a colourful tent. The infant was placed in a baby seat and the mother sat facing the infant. Three baskets contained toys appropriate for 2-month-olds as well as older ages, including soft toys, rattles, and books. The interactions were filmed with three separate cameras. Two cameras were static, with the first filming the mother and the second filming the infant. The third camera was mounted on the mother's head with a headband. The outputs of the cameras were combined with a quad to create a single time-synced digital video record. Coding was completed using INTERACT 7.25 (Mangold, Arnstorf, Germany).

*Attention following.* The attention following task involved 2 hand puppets, held by the experimenter near each shoulder. Two cameras recorded the session, one focused on the infant and one on the experimenter. The outputs of the cameras were combined with a quad to create a single time-synced digital video record. Coding was completed using INTERACT 7.25 (Mangold, Arnstorf, Germany).

*Social Referencing* Four speakers were situated around the infant with one speaker to 90 degrees to the left and one speaker 90 degrees to the right of the infant, both side speakers were 60 cm from the infant raised to the infant's head height. Two speakers were located in front of the infants at the infant's head height at approximately 30 degrees to the left and 30 degrees to the right of the infant. The speakers located to the sides of the infant were connected to MP3-1 and the speakers located in front of the infant were connected to MP3-2. Each MP3 player held 2 tracks, each consisting of 6 seconds of 2 distinct non-social sounds recorded from age appropriate toys. A toy concealed the two MP3 players.

### **Procedure and Design**

*Mother-infant interaction.* Ten-minute interactions between infants and their mothers were recorded at two months to assess early social attention. More information on the mother-infant interaction is detailed in Chapter 3.

*Attention following.* An experimental task was conducted at 5 months to assess proximal attention following and control. The primary experimenter sat on the floor facing the infant, who was held by a second experimenter wearing a blind-fold. The blindfold worn by the person holding the infant ensured that the infant was not inadvertently moved towards the target puppet by the person holding the infant. The distance between the primary experimenter and infant was approximately 100cm. The primary experimenter held two identical puppets, one by each of her shoulders. The experimenter attracted the infant's attention and then slowly turned her head 90 degrees to look at one of the puppets and maintained this position for 10 seconds. While the experimenter was attending to the puppet she would describe features of the puppet without including directive terms such as "Look" or "Watch." After 10



seconds, the experimenter turned to the infant again and called the infant's name, ensuring the infant was attending before the next trial began. Four trials were administered in the order left-right-right-left or right-left-left-right, with the order counterbalanced between participants. Throughout the trials the puppets remained stationary, as in Perra and Gattis (2010).

*Social Orienting.* Infants were sat facing the experimenter, with the experimenter sat holding the toy which concealed the MP3 players. A baseline set began the experiment with the experimenter moving the toy from side to side while looking down at the toy for 10 seconds followed by 6 seconds where the experimenter continued to move the toy in the same fashion while shifting gaze from the toy to the infant. There were no head or facial expression changes that accompanied the shift of gaze. Following the baseline periods 4 trials followed with each trial comprising of 10 seconds where the experimenter moved the toy in the same manner and a 6 second playing of a track from the connected speaker whilst the experimenter moved the toy in the same manner and shifted gaze from the toy to the infant. The experiment was completed once 4 trials were completed.

## **Coding**

*Mother-infant interaction.* Infant social attention at 2 months was coded categorically and exhaustively. The eight possible states of social attention, and their coding definitions, are provided in Table 1. These codes were adapted from Bakeman and Adamson (1984), with the primary difference that their onlooking code, originally defined as all visual engagement without active motor engagement, was refined to include three different states. The refined onlooking codes were: onlooking mother's face, onlooking mother's hands and any object in the hand, and onlooking other

object, or in other words, any object not held, pointed at, or manipulated by the mother.

A secondary coder independently coded 25% of the recordings (10 videos). Agreement was calculated by comparing inter-rater reliability, with agreement for any secondary coded video being above 80%.

*Attention following.* Infant attention in the experimental task was coded exhaustively with mutually exclusive codes as: infant looking to experimenter, infant looking to left puppet, infant looking to right puppet, infant looking away, or infant not in view. Experimenter turns were coded separately as turn to left puppet or turn to right puppet. Infant attention and experimenter turns were then combined to assess two behaviors, proximal attention following and checking back, as defined by Perra and Gattis (2010). Proximal attention following referred to when an infant looked to the same puppet as the experimenter within 3 seconds of the experimenter's turn. Checking back concerned infant attention after proximal attention following, and referred to three successive attentional shifts without break between the experimenter's target and the experimenter. To be credited with checking back, after demonstrating proximal attention following an infant had to shift attention from the experimenter's target to the experimenter's face, back to the experimenter's target, and back to the experimenter's face.

A secondary coder independently coded 25% of the recordings (10 videos). Agreement was calculated by comparing percent of inter-rater agreement. Agreement for any video secondary coded was found to be above 80%.

*Social Referencing.* Infant attention in the experimental task was coded first, with a mutually exclusive , exhaustive coding scheme including the codes: infant looks to experimenter, infant looks to toy, infant looks to left, infant looks to right, infant looks away. This coding was conducted with the sound off to ensure the coder was blind to the beginning and ending of the sound during trials. The onset and offset of the sound stimuli was then coded with the sound on, without the video showing. Coding was conducted with Interact software, and 25% of videos were secondary coded with all coding reaching above 80% agreement.

## **Results**

### **Descriptive Statistics**

*Infant attention at 2 months.* Infant attention states during the mother-infant interactions were analysed descriptively to determine the average percent of time spent in each state of attention (see Chapter 3). As an overview durations of the onlooking episodes are shown in Table 4.1.

Table 4.1

*Duration, in seconds, per episode (mean and standard error) and total time, in seconds, spent in the states of unengaged and onlooking states of engagement at 2-months.*

Engagement State	Duration per episode (sec)		Total time in state (sec)	
	Mean	St. Error	Mean	St. Error
Unengaged	19.94	3.65	182.36	19.83
<i>*Onlooking Mother's Hand Actions</i>	<i>19.33</i>	<i>2.49</i>	148.54	19.78
<i>*Onlooking Alternative Object</i>	<i>12.64</i>	<i>1.36</i>	98.23	18.29
<i>*Onlooking Mother's Face</i>	<i>32.54</i>	<i>2.48</i>	138.05	24.23

*Attention following at 5-months.* At 5-months of age, at the group level, forty-seven percent of infants demonstrated the sophisticated form of attention following described by Perra and Gattis (2010) as checking back. The performance of infants in the attention following task was categorised into no attention following; proximal attention following only; and checking back. A chi square goodness-of-fit demonstrated that checking back multiple times was the most prevalent category of infant performance within the attention following task,  $\chi^2(3, N = 39) = 16.282, p = .001$ . The mean latency between the experimenter turning to a puppet and the infant following was 1.13 seconds with a standard deviation of 1.37 seconds. The attention following behaviour of checking back was the focal behavior of interest in longitudinal analysis, with onlooking mother's hands. This was the case for two reasons, firstly proximal attention following is performed at ceiling at 5 months. Secondly, checking back, as an attention following behavior, is more sophisticated and thus demonstrates a more progressive form of attention following.

*Social Orienting at 5-months.* At 5-months the dominant response was to orient to the non-social sound stimuli (39.5%) with no shifting to sound occurring (34.2%) of the time. Orienting to the experimenter was 3<sup>rd</sup> most common (21.1%). Joint Attention in the form of visual checking back between the sound and experimenter occurred in 5.3% of the time. These descriptives illustrate that at 5-months infants are able to orient to sound, with infants responding to the sound in 65% of the time, either in a social or stimulus orientated manner (with infants initially orienting to sound 44.8% of the time and socially orienting 21% of the time. The results also show individual differences in the social preferences in responding to non-social stimuli by 5-months.

### **Longitudinal Attention Analyses**

The second aim of this paper was to examine whether infant's propensity to spend time onlooking mother's hands, and their actions on objects, during mother-infant interactions at 2-months would predict later social attention at 5-months. In order to test this relationship inferential statistics were conducted across social attention at 2- and-5-months. Duration of state episodes was used as the unit of interest for infant attention at 2-months. The reasoning for this choice of measure being used resulted from the need for infants to switch to a stimuli (such as mother's hands) when they are active, as well as being capable of maintaining sustained attention to those actions. Therefore increased duration of onlooking mother's hands would indicate ability in these attentional skills. On the other hand, a high frequency of a state may be coupled with low durations per episode, which may result in less information processing of the stimuli (i.e. the mother's hands).

Non-normalcy within the variable of duration of episodes spent onlooking mother's hands, and their actions on objects, were resolved by applying a square root

transformation of the variable. Outliers were removed from all variables where the  $z$  score was 3 standard deviations from the mean. This resulted in 3 participants being removed from inferential analysis.

From the remaining sample a Pearson correlation between onlooking mother's hand, and their actions on objects, and checking back was conducted. A significant correlation ( $r = .524$ ,  $N = 36$ ,  $p < .001$ , two-tailed) was found with infant's duration of onlooking mother's hands, and their actions on objects, and later checking back performance.

Table 4.2

*Associations between engagement states and later proximal attention following and checking back performance on the proximal attention following task*

<b>Duration of Attention</b>	<b>Correlation with Frequency Checking Back Across Trials</b>
Onlooking Mother's Hand Actions	0.488**
Onlooking Other Object	-0.123
Onlooking Mother's Face	-0.051

*Note.* \*\* indicating significance at  $p < .001$ .

Onlooking mother's hands, and their actions on objects, was found to be a significant predictor of later checking back performance, in the subsequent linear regression ( $F(1,34) = 12.87$ ,  $p < .001$ ), with 25% of variance explained by the model (adjusted  $R^2 = .253$ ).

Finally, mother's use of objects is described in table 3.3. As can be seen, mother's used objects on average for a total of 3 minutes of the 10 minute interaction, with on average 3 different objects used within an average of 5 separate instances of object use.

Table 4.3.

*Maternal object use at 2 months.*

<b>Maternal Object Use</b>	<b>Mean</b>	<b>Standard Error</b>
Variation of objects used	3.36	0.25
Frequency of object based instances	5.44	0.63
Total time spent using objects (mins)	3.06	1.53

Mother's object use was coded as any time the mother engaged with an object. This coding was conducted by the same coders that coding infant attention at 2 months, and was subject to the same inter rater reliability coding (with 25% of coding secondary coded, with over an 80% inter rater agreement found). To assess whether objects were the source of association, rather than hand action, object use, as measured by mother's time spent with objects, two analyses were conducted. The first was a correlation between mother's time spent manipulating objects at 2 months, and checking back at 5 months. No significant correlation was found between these two variables. Furthermore, when time spent using objects was partialled out of the correlation between onlooking mother's hand actions, and checking back the correlation remained significant ( $r = .399$ ,  $p = .015$ ).

## **Discussion**

In this longitudinal study of early attention, the duration of episodes infant spent attending to mother's hands, and the objects they manipulated, uniquely predicted later social attention at 5-months. In contrast the duration of episodes infant spent attention to mother's faces at 2-months, during interaction, was not shown to predict social attention at 5-months. Attention itself was not found to be the predictor

of later attention following. Together these findings support the view that when studying social attention, the hands of others are powerful cues for infants. Moreover, infant's ability to attend to this powerful cue facilitates later attention following achievements. When the time mother's spent with objects was partialled out, attention to mother's hand actions remained a significant predictor of checking back. In contrast, mother's time with objects per se was not associated with checking back.

### **Limitations**

Within this study there are methodological and theoretical limitations that require discussion. Firstly, hands are largely moving. In this way it may not be equitable to contrast objects and hand actions. Experimental designs that tease apart the moving element of hands may be useful in addressing this limitation. The notable variations within the attention data may also be considered a consequence of the procedure. Further constraining the context may be required in order to reduce such variance. It also may inherently be a characteristic of attention data from interactions in such a young sample. Lastly, regressions and correlations were employed within this chapter. Both forms analyses preclude a discussion of causation. In this way interpretations that can be made from the results are constrained. Developing between-subject, experimental paradigms with procedures that differentially predict attention to hand actions may be one way of addressing this limitation within the design and analysis. Combined these ensure a cautious interpretation of results should be made.

### **Implications**

Actions upon the environment aid in filtering irrelevant information, and reinforce the perception-action loop that facilitates learning (Yu et al., 2009). This



facilitation demonstrates that what children perceive is guided not only by their actions, but the actions of others. This guidance by action is formative in the development of causal understanding (Saxe et al., 2005) that is so necessary for the typical trajectory of development across domains.

Historically research examining the ontogeny of social attention has centred on the premise that there is a preoccupation during early infancy with faces (Akhtar & Gernsbacher, 2008), and that over the first months of life this preoccupation extends outwards from faces to other stimuli resulting in early social attention phenomena such as proximal attention following. In this chapter evidence is shown for an alternative developmental account for social attention's development. This alternative account begins with attention during early infancy to hands as well as faces.

Accounts of attention following development have previously worked on the assumption that attention fans out over the months, from an initial preoccupation to faces that extends out later to incorporate other social and non-social stimuli. In this study this account is challenged. With attention to hands, and not faces, predicting later attention following hands are proposed to be a key focus of interest that are necessary for the infant's developing understanding of actions, causal understanding and social actions engendering change. It is fallacious to state that a pre-occupation is preferable in attention following development. Williams Syndrome is a developmental disorder that exemplifies the atypical trajectory that emerges from a singular interest in faces. The preoccupation that children with Williams syndrome are characterised by (Mills et al., 2000), results in deficits in social attention, social cognition and later language development.

The importance of action in development, both in its production and perception, has been increasingly focused on by researchers within typical and

atypical development (Sommerville & Woodward, 2005; Sommerville, Woodward, & Needham, 2005). Such research has been characterized by the attention infants give to the actions of others, and how their own action experience may play a role in the perceptual experience of attending to other's actions. In this study the statement is made that the actions of others are meaningful for infants from early in development, and whilst in previous research infant's actions have been shown to aid action perception, the results within this chapter demonstrate the power attending to others actions may hold before infant action is apparent.

Previous research conducted with infants' later in development, by Woodward and colleagues, has demonstrated that infants' encode information of hands they see as object-directed, before they assume the same intentionality for gaze alone. (Woodward, 2003).

Impaired social attention is implicated in an array of developmental disorders. Concurrently, the consequences of social attention impairments stretch across a range of the child's developing modalities of functioning required in normative communicative development. Research examining atypical social attention development has historically examined such sample's reduced propensity, in early infancy, to attend to faces as the sign of altered social attention development. The findings of this study provide support for a shift in research's focus, to encompass early attention to hands, in the research of populations at risk of delayed social attention. Through applying the fine-grained assessment of infant attention, such pertinent questions of when and how attention to hands may play a role in atypical developmental trajectories, may be tackled. Deficiencies in the propensity to attend to social partners' hands may well have a cumulative effect on the pedagogical experiences such infants encounter. Furthermore, identifying how once off this typical

path for development, individuals may find their way to the most functional trajectory possible holds both theoretical and practical significance (Dawson et al., 2004).

Removing the distinction between faces and non-face social stimuli in the ontogeny of social attention development allows for a re-evaluation of our assumptions for the developmental patterns of social attention (Akhtar & Gernsbacher, 2008).

Research examining early attention following has been extended by the current study. An alternative account for social attention's ontogeny has been shown to hold validity, whilst reinforcing the need to research individual differences in the ability and propensity to follow the actions of others. Further investigating this ability as a predictor of increased attention, will offer greater insights in the paths infants take to developing an understanding of the meaning and relevance of others' actions.

## **Chapter Summary**

Hands are agents of change that act upon the world, turning the distal into the proximal and the inanimate into the animate. In addition to providing valuable cues to direct attention (Tomasello, Carpenter, & Liszkowski, 2007), hands transform the non-social and social targets they encounter. For these reasons attention to these dynamic and goal orientated social stimuli may draw infants' attention and serve a supporting function, guiding the infant's attention to see what others see. From the previously relegated position of a poor cousin to the social stimuli of faces, the findings within this chapter help to demonstrate that hands matter in the development of social attention. Such an extension to the burgeoning body of work examining social attention suggests that, just as hands are demonstrably an important locus for infant attention, so too should they be for future research into the development of social attention. In the next chapter the stability and reciprocal nature of infants'

proclivity to use the actions of hands to direct their attention, will be investigated across the second year of infancy.

## **Chapter 5:**

### **The role of hands in communication across attention development in the second year**

#### **Chapter overview**

The adapted Bakeman and Adamson (1984) microanalytic coding scheme of infant attention, discussed in Chapter 3, has demonstrated that hands are a relevant cue and stimulus that infants attend to in early infancy. Further, attention to hands predicts early attention control. In this chapter the stability of this propensity to attend to hands is explored across the second year of infancy. In order to assess the stability of the attention to hands preference, point following at 12-months was examined as a predictor for later attention to mother's hand actions during interaction at 18-months. It was predicted that point following would predict onlooking mother's hands during later interactions. It was also predicted that attention to hands would not necessarily predict onlooking mother's face. Results show that infants at 12-months were, at a group level, able to distally point follow in the Carpenter et al., (1998) experimental paradigm. The frequency of point following was predictive of the duration of infant's onlooking mother's hands. A relation between point following and later onlooking mother's face was not found to be significant. Such a tendency to attend to the actions of hands, and the impact on our attention to distal targets, are discussed as a founding feature within communication development.

Understanding that others have the intention to communicate information to us about a distal object or event of interest, by gesturing to it, is a cornerstone in communicative development. The human universal of pointing, whilst deeply social, does not pertain to a specific meaning above “If you look over there you’ll understand what I mean”. In contrast to the gestures incorporated with more specific meanings, or those embedded within sign-language, the lack of specific content for a point requires substantial intention understanding for successful comprehension (Tomasello et al., 2007). Further, the motivation to follow-up on this recognition of the communicative intent of another, by following attention to the distal location, demonstrates the ability and proclivity that is singularly demonstrated in humans.

The emergence, utility and consequences of pointing have been examined in great detail, as a classic demonstration of the human ability and drive to communicate. Carpenter, Nagall, and Tomasello (1998) longitudinally examined the trajectory for point following and production across the period of emergence in late infancy. In their study of infant communication, point following marked a transition in development where infants exponentially increased their learning opportunities by incorporating intention understanding, a social motivation to engage, and attention control.

Following the points of others enables shared attention to be achieved for distal targets and events of shared interest. Sharing attention in this way opens the door to developing shared intentions, goals and understanding. Given these communicative advantages point following has been extensively examined as a predecessor of later language development.

The absence of this communicative achievement has been shown to be a consistent signal for those later diagnosed with autism (Barbaro & Dissanayake,

2010). A multitude of functions are served by the attention we give to others. Language is one notable example. Chavellier et al. (2012) describes autism as characterized by a deficient ability and interest to social stimuli. These deficiencies in turn are evidenced in the communication deficits comprising a core feature of autism. Other examples of atypical development are also characterized by atypical attention to social stimuli, and communication impairments (Laing et al., 2002).

Socially based models of pointing comprehension revolve around the ability of point following as built upon previous social cognitive advances. Above an iterative increase in endogenous attention shifts control, point following is considered within social cognitive models as emerging from the ubiquitous tendency to attend to the actions of others. Motivational theories, such as the interactional instinct (Lee and Schumann, 1999) predict that there will be specific demonstrations of stability of an infant's demonstration to attend to socially relevant stimuli. In their model of infant communicative development, infants are driven to engage in collaborative interactions. Whereas previous accounts of social attention development are centered on a focus on faces as the social stimuli, that slowly permeates to the peripersonal space and beyond, several researchers have demonstrated the role hands may play in social attention. Amano et al. (2004)(2004) for example, demonstrated in their study of attention in infancy, that attention to hands was a prerequisite for social attention.

As with early social attention, the role of hands in a more explicit sense in later infancy demonstrations of social attention has yet to be given widespread research focus (with the previously mentioned notable exceptions of Woodward, 1998; Amano et al., 2004; and Slaughter, 2011). The impact of the recent work on adults demonstrating the impact hands have on the attention given to the objects located nearby highlights that mental processing of visual world is not independent of

our physical actions within it (Davoli, Brockmole, & Goujon, 2012). This suggests that the world within our reach is cognitively different from the world beyond our reach.

Within this Chapter two assertions will be simultaneously examined. Firstly, the motivational and social cognitive models of point following development will be considered. If point following demonstrates a skill and motivation combination delivering on a desire to engage, with the cognitive ability to understand attention and spatially track the area of interest, then the propensity to point follow should be associated with a propensity to attend to the actions of others during later interactions. Such an association would demonstrate infant stability in drives and abilities in the domain of attention for communicative development. If point following is not accurately characterized as resulting from a stable infant drive to attend to the actions of others, and is more aptly a demonstration of advances in attention shifting ability, then attention in general and not attention to action of other specifically should be seen.

Secondly, if hands continue to play a role in communication development in the later period of infancy, point following will specifically predict later attention to hands. Conversely, if attending to the actions of hands are secondary to the mechanisms underlying point following, then point following is more likely to predict later attention to faces, rather than hands.

Building upon the adaptation of the microanalytic coding scheme detailed in Chapter 3, shown to yield data on infant's early propensity to attend to hands during mother-infant interaction at 2-months, and the longitudinal relationship this propensity holds for early social attention demonstrated in Chapter 4, the aim of this chapter is to examine whether the propensity of attending to hands would continue to



be a stable attention behavior into the second year of life. Specifically stability of infant attention to hands was assessed through examining the predictive power point following to a distal target at 12-months had upon attention to hands during mother-infant interactions at 18-months. Based upon the longitudinal relation shown of attention to hands and social attention in early infancy, and previous literature demonstrating point following's predictive relationship with later communicative development, I predicted that point following at 12-months would be related to the duration infant attention to hands demonstrated through the application of the adapted Bakeman and Adamson (1984) coding scheme at 18-months.

## **Method**

### **Apparatus**

#### *Mother-infant interaction. Materials.*

At 18-months, a 2 meter squared play-pen was the setting for the mother-infant interactions, with a baby seat and 17 designated toys available for the mother to use, including soft shaped objects, wooden rattles, books and plastic toys. Toys were chosen to include toys that would be age appropriate for infants from birth to 18 months. The interactions were filmed with three separate cameras. Four cameras were statically positioned to offer recordings on the infant, mother, and the mother-infant dyad. The recording of all 4 cameras were combined by a quad.

*Point following.* The attention following task was based upon Carpenter et al's (1998) point following task, and involved the experimenter facing the infant, who was sat on an experimenter at a distance of 100 cm from the experimenter. Two toys were

placed at 90 degrees to the left, and 90 degrees to the right of the infant, with each toy located at 90cm from the child. Two cameras recorded the session, one focused on the infant and one on the experimenter. The outputs of the cameras were combined with a quad to create a single time-synced digital video record. Coding was completed using INTERACT 7.25 (Mangold, Arnstorf, Germany).

### **Procedure and Design**

*Mother-infant interaction.* Mother-infant interactions, at 18-months, involved mothers playing with their infants for 10 minutes. Seventeen toys were made available, and mothers were asked to play with their infants as they would naturally. Several adaptations to the procedure noted in Chapter 2 and 3, in order to be appropriate for 18-months-old infants. Firstly, the infant was seated in an appropriate baby seat on the floor of the play-pen, facing their mother who was also sat on the floor of the play pen, at a distance of approximately 60 cm at the start of the interactions. The toys present remained consistent to those detailed in study 1. Interactions were filmed with four separate cameras, in addition to those camera angles detailed in study 1, at 18 months due to the lack of tent, and additional camera could be staged to give an overview shot of the interactions. The outputs of the cameras were combined with a quad to create a single time-synced digital video record. Coding was completed using INTERACT 7.25 (Mangold, Arnstorf, Germany).

Mothers were asked to interact with their infant as they would do normally for 10 minutes, within the tent provided. They were not instructed to alter their behavior at any point during their interaction. The 2-month testing session was the second occasion that the mothers had to experience the tent. When the infants were 1 month

old infants and their mothers had the opportunity to get used to the setup of the tent and cameras.

*Point following.* An experimental task was conducted at 12 months to assess distal attention following and control. The point following task was based upon a distal attention following task designed and employed by Carpenter et al. (1998) in their longitudinal study of infant attention. The primary experimenter sat on the floor facing the infant, who was held by a second experimenter wearing a blind-fold. The blindfold worn by the person holding the infant ensured that the infant was not inadvertently moved towards the target puppet by the person holding the infant. The distance between the primary experimenter and infant was approximately 100cm. The experimenter attracted the infant's attention and then slowly turned her head 90 degrees to one of the toys located to the left or right of the infant. Whilst turning to the toy, the experimenter simultaneously pointed to the same location, always with the right hand's index finger. The experimenter held gaze and point to the toy for 3 seconds before retracting the point and returning gaze to the infant. This procedure was repeated twice more to the same location, giving a total of 3 points and gaze to the toy. On completion of the third point to the toy, the experimenter centered their attention on the infant before repeating the procedure to the alternate side, pointing and gazing at the toy on the opposite side. The six trials were administered in the order left-left-left-right-right-right or right-right-right-left-left-left, with the order of left trials or right trials going first counterbalanced between participants.

### **Coding**

*Mother-infant interaction.* Infant social attention at 18 months was coded categorically and exhaustively, with the coding scheme detailed in study 1, see Table

2. A secondary coder independently coded 25% of the recordings (10 videos).

Agreement was calculated by comparing inter-rater reliability, with agreement for any secondary coded video being above 80%.

*Point following.* Infant attention in the experimental task was coded exhaustively with mutually exclusive codes as: infant looking to experimenter, infant looking to left toy, infant looking to right toy, infant looking away, or infant not in view. Experimenter turns with points were coded separately as turns with point to left toy or turn to right toy. Infant attention and experimenter turns were then combined to assess two behaviors, distal attention following and checking back, as defined by Perra and Gattis (2010). A secondary coder independently coded 25% of the recordings (10 videos). Agreement was calculated by comparing percent of inter-rater agreement. Agreement for any video secondary coded was found to be above 80%.

## **Results**

*Descriptive analysis of point following.* Two infants were excluded from analyses, due to technical difficulties resulting in their data not being collected. At 12 months at a group level, the following pattern of attention, subsequent to the experimenter pointing to a location was of the infant following the attention of the experimenter to the pointed hand, then to the correct location, before returning gaze to the experimenter. The mean point follows, across the 6 trials, was 4.43, with a standard deviation of 2.00. A chi square goodness of fit test was found to demonstrate that this was the most common pattern of attention shifts of infants, subsequent to the experimenter's point ( $\chi^2 (1) = 4.829, p = 0.028$ ). There was no bias demonstrated to

one side location. These results were in keeping with previous research into point following, that has demonstrated a group level performance by 12 months.

*Descriptive analysis of attention at 18 months.* Duration of attention across the onlooking states was assessed, with attention to mother's hand actions found to have the longest duration per episode with 47.5 seconds. Attention to mother's faces was found to have the shortest of duration per episode with 2.4 seconds per episode, see Figure 5.1. Passive joint engagement was found to be the most common state of engagement ( $\chi^2(5)=96.08, p=.0001$ ).

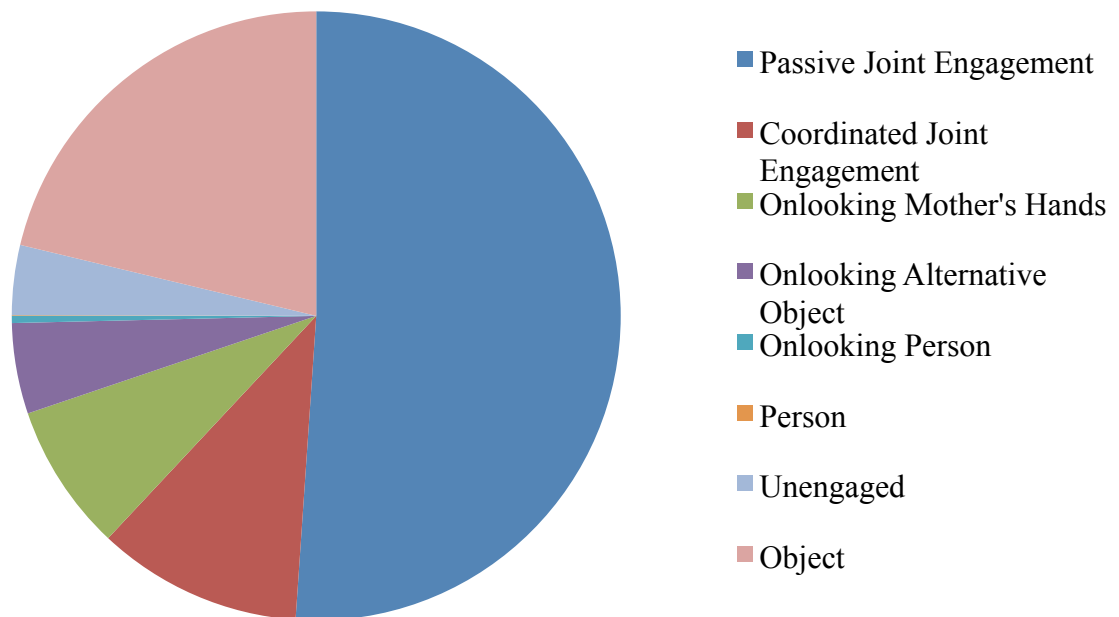


Figure 5.1. Percent of interaction at 18-months in states of engagement

### Longitudinal analyses

To assess the prediction that attention to hands would remain a stable social attention feature across time and context, the frequency of point following was

correlated with the onlooking states of onlooking mother's hands, onlooking other object, and onlooking person. As predicted point following was solely associated with the onlooking state of onlooking mother's hands, as shown in Table 5.

Table 5

*Correlation of point following with later duration of onlooking states of attention*

<b>Duration of Onlooking Duration at 18-months</b>	<b>Correlation with Frequency Point Following at 12-months</b>
Onlooking Mother's Hand Actions	0.62**
Onlooking Alternative Object	0.13
Onlooking Mother's Face	.162

*Note.* \*\* Denotes significance at  $p < 0.001$ .

Following this significant correlation a linear regression was shown to be significant, with frequency of point following at 12 months significantly predicting duration of attention to mother's hand actions and objects held during mother-interactions at 18-months-of-age ( $F(1,33)=20.67, p=0.0001$ ), explaining 38.5% of variance.

## **Discussion**

In the previous chapter an adaptation to the Bakeman and Adamson (1984) microanalytic coding scheme of attention was applied within a longitudinal study of early social attention. Attention to hands during early interactions was found to uniquely predict early demonstrations of attention following. In order to examine the reciprocal and stable nature of this preference for attending to hands, this chapter is

concerned with infant's ability to follow a point to a distal location, at 12-months, predicting later attention to hands during interactions at 18-months.

Distal attention following of other's points was found to be predictive of later attention to hands during interactions at 18 months. This extension to examining the role of hands in social attention development indicates that infant's propensity to draw information from hands is a stable characteristic both in time and context. This finding reiterates the position of hands being central in early communicative development, with hands not only shown to scaffold early social attention, but also demonstrated to remain a stable source of information for infants.

### **Limitations**

Within this Chapter, point following performance was assessed at a single time point in development, 12-months. Assessing point following earlier, and longitudinally, as in Carpenter and colleagues longitudinal study of point following (Carpenter et al., 1998) would offer details of the stability of relation between point following and later attention to hands. Within the First Steps longitudinal study, such an approach could be taken.

Within this chapter point following was assessed. Although pointing has been viewed as the cornerstone in didactic gestures, it is not uniquely so. The findings within this chapter cannot be assumed to speak to relations that may, or may not, exist between attention to hands and responsiveness to other gestures. Point following is an index of understanding geometric and spatial properties, but that there is an inference made, when assuming point following indexes comprehension of communicative intent. Adopting a method requiring further demonstration of comprehending pointing's communicative intent, could potentially satisfy this limitation. However,

the argument of point following's association with geometric spatial properties alone has been challenged by Leekam, Baron-Cohen, Perett, Milders, and Brown (2011). In their study a dissociation was found between geometric and joint attention skills within a population with autism spectrum disorders. Given the central deficit of autism pertaining to communication development, finding a dissociation between joint attention and geometric skills, challenges the critique that suggests point following is one and the same as a geometric skill. For an alternative to a point following measure as an index, several methods could assess this critique of point following.

Firstly if point following and point production were found to correlate this would strengthen the link between point following and comprehending pointing as a communicative act. Secondly, as Carpenter recently demonstrated, pointing comprehension could be assessed through an alternative index. In their recent study, Carpenter and colleagues examined pointing comprehension through the hiding-finding game, whereby an experimenter pointing to hidden toy to 12-month-old infants. Infants who followed the point to retrieve the hidden toy were evaluated as comprehending the communicative intent.

As discussed in the previous chapter, hands are moving stimuli which may confound a comparison between object and hand actions. Furthermore regression analyses do not enable a discussion of causality. Between-subject experimental designs would be required to be more direct in concluding statements. The variation in time spent in attention remains noteworthy within this sample. Constraining the social partner to be consistent across participants may be a way of reducing such variation.



The application of the microanalytic coding scheme has demonstrated that the distinction between onlooking states may be most appropriate in infancy, before the more advanced states of passive joint and coordinated joint engagement emerge. Once these more advanced states emerge, the onlooking states may be subsumed within them. These limitations determine that tentative conclusions may be drawn from the results in this chapter, and ensure that further studies are required to address the limitations described.

### **Future Directions**

Interactions within the First Steps longitudinal study were conducted with mother-infant dyads. Examining differences in attention to hands across social partners of father-infant and peer-infant dyads would allow the questioning of whether attention to hands was predominantly a preferred attention pattern when infants were interacting with “skilled” social partners of adults. Previously Bakeman and Adamson (1984) have demonstrated that infants spend a higher percentage of time during interaction in more advanced engagement states when paired with skilled adult social partners.

Further to this point of social partner skill. Examination of social partner’s skill could delineate responsiveness of the mother during interactions as a mediator of the attention to hands relationship. Sequential analysis of attention maintaining and re-directing strategies implemented by the mother would enable contingency to be examined as a moderator of the effect demonstrated in this chapter.

Several studies have studied the dynamics between dyadic and triadic social competence. Although indexes of dyadic social competence were not of central focus within this Chapter, there are reasons why this may be a valuable consideration for future studies. Striano and Rochat (1999) have previously examined the

developmental link between dyadic and triadic social competence during the first year of infancy. In their study of 7-and-10-month-olds, infant re-engagement attempts during a still-face paradigm was associated with infant monitoring of partner in object exploration recorded for triadic. In addition, those infants who attempted to re-engage with the social partner in the still-face manifested most signs of joint engagement, attention following and attention monitoring at both ages tested. Meins et al. (2011) examined joint attention behaviors between an infant and their mother, as well as a stranger. Those insecurely attached to their mothers exhibited increased initiations of joint engagement with strangers. The suggestion being made from this result is that insecurely infants are increasing their initiating bids to engage more with strangers as a result of diminished secure attachments with their mothers.

Studies such as these evoke the multi-domain nature of communication development and offer insight into the role of attachment, affect, and self-regulation in social attention development. In the First Steps longitudinal study mother-infant attachment was not evaluated directly. In future studies including such measures of mother-infant attachment and dyadic behaviors would be a valuable extension.

Within First Steps mothers were the social partner observed during interactions with the infant. There are several reasons why including fathers within future studies enable further theoretical and practical assessment of communication development. Differences have been noted between the style of play that mothers and fathers engage in with their infants (Lamb, Frodi, Hwang, Frodi, & Steinberg, 1982). These differences in object versus person based interaction may demonstrate alternate paths to facilitate communication, as well as an infant's ability to flexibly adapt their communicative behaviors according to their social partner. In addition to the theoretical value such questions may hold, this line of research holds practical merit.

The changing dynamics of modern families, where fathers may be taking on a more central caregiving role, (Golombok, Tasker, & Murray, 2006).

In addition to extending future research to incorporate different family structures, further research is warranted in examining the role of attention to an array of social stimuli in supporting later language. Brooks and Meltzoff (2008) evaluated infant's social attention as a predictor for later language performance. In their growth curve modeling study, infant gaze following and pointing at 10-and-11-months jointly contributed to growth of vocabulary through to 2-years. When maternal education was controlled for, the model remained explanatory. Given the demonstration of infant's propensity to attend to the actions of hands across infancy, a future direction that could extend findings, may involve assessing a growth curve model for attention to non-face social stimuli as a predictor of later social cognition and language development.

Communication deficits increasingly investigated for those infants at risk of autism, due to an older sibling being diagnosed with autism spectrum disorders (ASD). Point following and social attention are among the areas of deficit and impairment in those later diagnosed with ASD. Such patterns of development and impairment speak to the need for developing methods that are able to track social attention through infancy, for extending understanding of typical and atypical communicative development. Falck-Ytter, Fernell, Hedvall, Hofsten, and Gillberg (2012) assessed social attention performance in ASD children as predictive of later adaptive communication. In their study of social gaze and cognition, infant accuracy of performance on gaze measures was found to predict later adaptive communication skills. Furthermore, infant gaze behavior was related to verbal intelligence in infants with ASD at 5-years. Such associations suggest that preverbal communication is not

only a diagnostic feature for autism, but is relevant for predicting the level of adaptation and responsiveness within the spectrum. Similarly Clifford and Dissanayake (2008) demonstrated, through retrospective coding of home videos, that infants dyadic and triadic demonstrations during infancy predict the social responsiveness of children later diagnosed with ASD.

De Shumyer, De Groote, Beyers, Striano, and Roeyers (2011) further examined the association between dyadic and triadic social competence, within preterm development. In their study gaze following at 9-and-14-months was correlated with attempts to re-engage during still-face at 6-months. Secondly, triadic and dyadic social competence was found to predict later language outcomes. Applying the adapted coded scheme within a study incorporating dyadic and triadic communication may enable greater examination of the specific role forms of social stimuli play in early communicative development. Additionally, incorporating the study of atypical populations would offer new opportunities for understanding the role attention development plays in communication.

Given the multi-modal and context dependent nature of communication development, it is imperative that gesture comprehension and production are understood with these features of communication in mind. Within this Chapter, attention has been the central focus of communication under investigation. In order to further understanding of the development of communication, it is necessary for these studies to be extended by the development of methods that allow for the contributions of context and multiple domains to be acknowledged.

## **Chapter Summary**

This Chapter has focused on extending the microanalytic coding scheme discussed in Chapters 3 and 4, in order to examine the social cognitive model of

attention following across the second year of infancy. Within the social cognitive model, point following emerges from a skill set allowing for motivations to engage with others to be realized. The index of communication, of point following at 12-months, was therefore evaluated as a predictor of later attention to hands during interaction at 18-months (using the adapted coding scheme of attention). This relation was shown to be evident within the results of this Chapter. In the following Chapter I will describe the design and application of an electronic diary method that is capable of delivering longitudinal, contextual and event driven information across the domains of communicative development.

## Chapter 6

### CUE: The Continuous Unified Electronic Diary Method

#### Chapter Overview

This chapter introduces the Continuous Unified Electronic (CUE) Diary Method, a longitudinal, event-based, electronic parent report method that allows real-time recording of infant and child behavior in natural contexts. Thirty-nine expectant mothers were trained to identify and record target behaviors into programmed handheld computers. From birth to 18 months, maternal reporters recorded the initial, second, and third occurrences of seven target motor behaviors: palmar grasp, rolls from side to back, reaching when sitting, pincer grip, crawling, walking and climbs stairs. Compliance was assessed as two valid entries per behavior: 97% of maternal reporters met compliance criteria. Reliability was assessed by comparing diary entries with researcher assessments for three of the motor behaviors: palmar grasp, pincer grip and walking: 81% of maternal reporters met reliability criteria. For those three target behaviors, age of emergence was compared across data from the CUE Diary Method and researcher assessments. The CUE Diary Method was found to detect behaviors earlier and with greater sensitivity to individual differences. The CUE Diary Method is shown to be a reliable methodological tool for studying processes of change in human development.

A unifying aim for developmental psychology is to understand the processes of change in human behavior (Adolph & Robinson, 2008; Muller & Giesbrecht, 2008). Theories of development are often contrasted in terms of their accounts of change, in particular whether processes of change are qualitative or quantitative, and continuous or discontinuous. Importantly, methodological tools often influence theoretical accounts of change by yielding data that favors one account of change over another (McCall, 1981). In this chapter I briefly review the major methodological tools in developmental psychology and then introduce a new method, a continuous unified electronic diary method for gathering developmental data.

Experiments are systematic and rigorous methods for studying elicited behavior, typically in a laboratory setting. Because they involve the manipulation of an independent variable, experimental methods allow clear analysis of cause-effect relations, and are useful for addressing questions about the relation between a specific behavioral phenomenon and a specific eliciting context (Cronbach, 1957; Danziger, 2000; Holmes & Teti, 2008). Experimental methods are not suitable, however, for addressing questions about the spontaneous emergence of behavioral phenomena, and are of limited usefulness for addressing questions about behavior across time and context, or in other words, behavioral change (Stone, Broderick, Kaell, DelesPaul, & Porter, 2000). In addition, experiments are susceptible to data distortion caused by low sampling frequency (Adolph, Robinson, Young, & Gill-Alvarez, 2008; Kuhn, 1995). As a result, experiments may miss periods of instability and change, leading to inaccurate estimates of developmental trajectories. These problems are especially critical for low-frequency and/or newly emerging behaviors. For these reasons, experimental methods have limited utility for addressing questions about processes of change.

Observations are a practical method for studying naturally occurring behavior, whether spontaneous or elicited, and whether in the laboratory, home, or daycare environment. Observational methods allow analysis of relations between children and the contexts in which they are developing, and are useful for addressing questions about the bidirectional influences that parents and children have on one another (Bakeman, 1983; Bornstein, 1985; Danis, Bourdais, & Ruel, 2000; Mitchell, 1979). Observational methods deliver greater contextual information and, as a result, can have greater generalizability compared to experimental methods. Observational methods are labor intensive, however, and are prone to the same problems of sampling frequency as experimental methods, with the result that they too have limited utility for addressing questions about processes of change.

Parent-reports are a form of observation that rely on parents as observers and reporters of behavior, based on their day-to-day experience with a child. The most common forms of parent-report are checklists and questionnaires (Dekker, Nunn, Einfeld, Tonge, & Koot, 2002; Dunn, 1990; Fenson et al., 2000; Gartstein & Rothbart, 2003; Reznick & Goldfield, 1992). Because they draw on parents' regular experience with their children, checklists and questionnaires are less susceptible to some of the problems of sampling frequency associated with experimental and observational methods. Because parent-report methods are usually retrospective, however, they are susceptible to other sources of data distortion (Seifer, 2005), in particular parents' abilities to recall behaviors that have occurred in the past (Reznick & Goldfield, 1994). Importantly, most studies using checklists and questionnaires have limited options for assessing parents' compliance or reliability as reporters. In addition, because checklists and questionnaires are administered at a specific moment in time, they are of limited utility for identifying emergence or change in behaviors. Most



checklists and questionnaires also lack critical contextual information such as social and physical context, which in turn limits their utility for addressing questions about processes of change in development.

Methodologically, parent-report diaries address many of the limitations of the experimental and observational methods discussed above. Because parent-report diaries are based on continuous observation, they provide a high sampling rate over a specified period, and in addition, offer data about children in their natural environment (Robinson & Mervis, 1999; Wolfson, Lacks, & Futterman, 1992). Even the most rigorous schedule of experimental testing can miss critical points in development due to sampling distortion (Adolph, 2008). By comparison, the event-based data from diaries reveal patterns of behavior and development with less sampling skew and distortion (Bolger, Davis, & Rafaeli, 2003). Parent-report diaries thus have the potential to yield extremely valuable developmental data, including information on age of emergence, age of skill progression, and contextual variables such as precursor variables, eliciting factors, and rewards.

Diary studies have, however, historically lacked the rigor and systematic strengths of experimental methods. In particular, previous studies involving parent-report diaries have frequently had very small sample sizes, high attrition, and lacked sufficient assessment of compliance and reliability (Hufford, Stone, & Shiffman, 2002). Until recently, the only method for collecting parent-report diaries was paper-and-pencil, with the result that reporting was an onerous task, and it was not possible to monitor when entries were made or to assess compliance with reporting instructions, such as entering reports at requested times. Reliability of reporters has also been a concern with diary methods. Low reliability may result from insufficient training of reporters to observe and record behaviors; from the onerous nature of

paper-and-pencil diaries, which may lead to fewer and/or more retrospective reports; or simply from parental biases in reporting.

Over the past decade, psychologists and social scientists have increasingly turned to electronic diaries to address these problems while at the same time exploiting the many advantages of diary data (Green, Rafaeli, Bolger, Shrout, & Reis, 2006). Electronic diaries allow for easier and more consistent reports across participants (Hufford & Shields, 2002). For example, in one study comparing paper and electronic diary reports of infant fussiness and caregiver holding, maternal reporters described paper diaries as more onerous, and made more frequent entries with electronic diaries (Lam et al., 2010). In addition, because electronic diaries contain automatic time-stamp information for entries, they allow researchers to monitor and assess participant entries for compliance and reliability (Ebner-Priemer & Trull, 2009). Electronic diaries, sometimes referred to as ecological momentary assessment or ambulatory assessment, are now increasingly used by researchers investigating psychological phenomena such as emotional functioning, mood disorders, stress, organizational behavior, and health treatments (Alpers, 2009; Conner, 2008; Ebner-Priemer & Sawitzki, 2007).

In this chapter, I introduce a new event-based adaptation of electronic diaries intended for use by developmental psychologists. Electronic diaries are a potentially valuable methodological tool for developmental psychologists because they draw on continuous observation and allow the study of behavior in natural contexts, while at the same time offering consistency and ease of use across reporters, as well as assessment of compliance and reliability. Most studies using electronic diary data collection have involved self-report, however, whereas collecting data on infants and children requires another person, usually a parent, to do the reporting.

The Continuous Unified Electronic (CUE) Diary Method has two components. Firstly, a reporting method suitable for parent reporters that yields data containing sufficient contextual information to be useful to developmental psychologists interested in change processes. The Experience Sampling Programme (ESP.4) (Barrett & Barrett, 2005) was used to develop a series of event-based questions that allowed parents to identify and record target behaviors on a continuous basis. The questions were designed to elicit accurate behavioral observations with appropriate contextual information, and at the same time to ensure ease of use and consistency of reporting across parents. To do so, there were a combination of open-ended questions with free-text response fields and closed-class questions with categorical answers available from a drop-down menu. The complete CUE Diary Method addresses the development of communicative, imitative, and motor behaviors, but this chapter focuses on motor behaviors only, as they were critical to our assessment of the method (see Figure 6.1).

Second, a training and support system was developed to ensure that parent reporters knew how to use the electronic diary, had sufficient understanding of the target behaviors to be able to identify them accurately, and were able to remember what was requested of them. This was an important step in adapting electronic diary methods to the study of human development, since electronic diaries have previously been used primarily for self-report rather than the reporting of parent-observed infant and child behaviors. To provide training and support for parent-observed recording of developmental phenomena, mothers were recruited into the study during pregnancy, trained them to identify and record infant behaviors, and gave them supporting materials to take home. Mothers were given clear definitions of target behaviors and instructed to record the first three occurrences of each behavior as soon as possible

after it was observed. Mothers were asked to identify and record target developmental phenomena from birth to 18 months. To help maintain accuracy and motivation throughout that period, maternal reporters also attended monthly assessment meetings and were given monthly feedback on a separate occasion.

To test the utility of the CUE Diary Method, compliance was evaluated, reliability and validity of maternal reporters. To evaluate compliance, reporting of three target motor behaviors was examined: palmar grasp, pincer grip and walking. These three behaviors were chosen because they span the complexity of motor development over infancy, where the palmar grasp is a reflex, pincer grip is a fine motor behavior, and walking is a gross motor behavior. Compliance evaluation focused on whether behaviors were accurately identified (or in other words, were consistent with the provided definition), had been recorded at least twice, and had been recorded as soon as possible after observation.

To evaluate the reliability of the CUE Diary Method as well as the reliability of individual reporters, CUE diary data was compared to researcher assessments of the three target motor behaviors (palmar grasp, pincer grip and walking). Reliability evaluation focused on whether maternal reporters identified a behavior at least as soon as a researcher identified it, and not more than two months before.

Having developed an event-based electronic diary method for the study of infant and child development, the aim then was to demonstrate the value of the data yielded by this method. To do so, data was analyzed about onset for the seven motor behaviors of palmar grasp, rolls from side to back, reaches when sitting, pincer grip, crawling, walking and climbs stairs. These behaviors span the first 18 months of life, encompassing reflex, fine and gross motor development. Secondly age-of-emergence was compared for the three target motor behaviors of palmar grasp, pincer grip and

walking, from CUE diary data and researcher-assessed data, to examine whether electronic diary data would be less prone to data distortion. Because reflex and fine motor behaviors involve fewer components, it was expected that it would be easier for maternal reporters to identify such behaviors accurately. By comparison, gross motor behaviors involve multiple components, and it was therefore expected that it would be more difficult for maternal reporters to identify them accurately. It was also expected that the continuous, event-based sampling of the CUE Diary Method would yield estimations of developmental trajectories without the sampling distortion of researcher-assessed data.

The study presented here is the first step of a larger study using the CUE Diary Method to investigate interactions between cognitive, communicative, and motor development. Evaluating compliance and reliability was critical to our study because doing so not only allows us to establish the validity of the method, but to identify and exclude unreliable reporters at subsequent steps in the larger study.

## **Method**

### **Participants**

Forty expectant mothers were recruited during their last trimester of pregnancy to participate in First Steps, a longitudinal study of infant development from birth until 18 months. Expecting parents were recruited from community organizations within Cardiff. The First Steps design involved continuous electronic diary reporting from birth to 18 months, and monthly testing from 2 until 18 months. At each monthly testing session, families were given £25 in shopping vouchers and a baby gift, such as a toy, t-shirt, or book, in return for their participation. As an incentive to complete the study, families were given an additional £250 in shopping vouchers at the end of the study. The sample of reporters ranged in age, nationality, ethnicity,

education level, socioeconomic status, marital status, and the number of previous children, as shown in Table 1. One mother did not begin the study. Of the remaining 39 mother-infant dyads, all infants were born to term with 18 females and 21 males.

The Cardiff University School of Psychology Research Ethics Committee and the South East Wales Local Research Ethics Committee of the Cardiff and Vale National Health Service Trust both reviewed the study protocol and granted ethical approval. Each maternal reporter gave informed consent prior to participation in the study.

Table 6.1

*Demographic characteristics of maternal reporters, presented as a percent of each group*

<b>Maternal Reporter Characteristics</b>	<b>Total Sample (%) (N=36)</b>	<b>Excluded Sample (%) (N=7)</b>	<b>Final Sample (%) (N=29)</b>
<i>Age in Years at Recruitment into Study</i>			
16-20	2.78	14.29	0
21-25	13.89	0	17.24
26-30	11.11	14.29	10.34
31-35	36.11	28.57	37.93
36-40	36.11	42.86	34.48
<i>Highest Education Level Attained</i>			
High School	25	28.57	24.14
Undergraduate Degree	58.33	42.86	62.07
Postgraduate Degree	16.67	28.57	13.79
<i>Birth Order</i>			
Primiparous	58.33	57.14	58.62
Multiparous	41.67	42.86	41.38

### *Electronic Diary*

Palm Pilot Z20s were installed with version 4 of the Experience Sampling Programme (ESP.4) (Barrett & Barrett, 2005). ESP.4 is free, open-source software for collecting questionnaire data electronically. The software presents questions and records answers and response times, and creates an automatic time-stamp for each entry. Once a question is completed, the software proceeds to the next question automatically. To prevent participants from changing entries post hoc, the software does not allow reviewing or changing of entries. For analysis, data from individual handheld devices can be uploaded onto a central computer.

A series of event-based questions were created in ESP that allowed parents to identify and record communicative, imitative, and motor behaviors on a continuous basis (see Figure 6.1). Because our assessment of the reliability and validity of the method focused on motor behaviors, only motor behaviors are reported here. Some questions were open-ended and had free-text response fields, while other questions were closed-class and had categorical answers available from a drop-down menu. Each entry thus identified a particular infant behavior and various contextual variables, including the social setting, the physical setting, whether the behavior was elicited or spontaneous, and whether this was the first, second or third occasion on which the behavior occurred. Sampling was event-based, and therefore determined by the frequency of infant behavior, rather than in response to a time-based prompt from the handheld device.

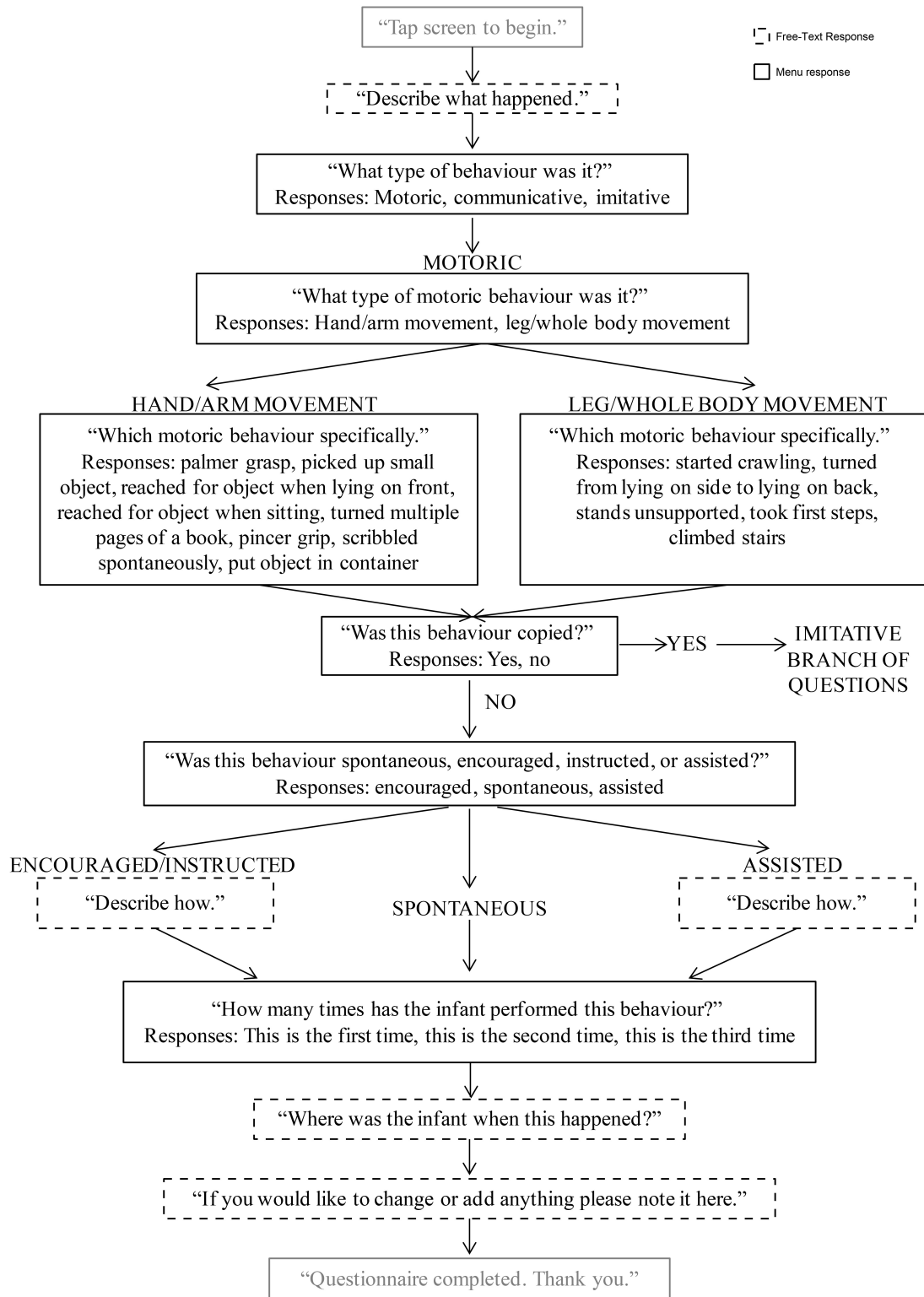


Figure 6.1. Flow of CUE Diary Method questions on motor development.



## **Procedure**

*Initial training and support material.* During the last trimester of pregnancy maternal reporters participated in an introductory training session. During the session a researcher demonstrated the CUE Diary Method, asked the mother to create practice entries, and gave the mother a study notebook with supporting materials (see Appendix A and B for examples). An important component of the study notebook was the first What to Expect (WTE) sheet (see Appendix C for an abbreviated example). Each WTE sheet provided a brief summary of infant development during the specified period and identified target behaviors for maternal reporters to observe and record. WTE sheets with new target behaviors were provided in 3-month intervals so that mothers did not need to hold a large number of target behaviors in mind at one time. Further training was provided with each WTE sheet. At the end of the training session, maternal reporters were instructed to create further practice entries at home.

Maternal reporters were instructed to begin reporting from the birth of their infant, and to enter each target behavior as soon as possible after it occurred. ESP creates an automatic time-stamp for each entry, including both date and time. If mothers reported an event that had occurred on a previous day, they had to enter the date it had occurred. This allowed us to evaluate entries on the basis of compliance with this reporting requirement. In some instances mothers kept notes in their personal diaries and created ESP entries on the basis of these notes. To ensure a clear threshold, mothers were told that recording any event more than 2 weeks after it occurred would invalidate the entry.

*Monthly assessments.* All maternal reporters and their infants attended monthly assessments. These assessments were organized into groups, with infants

allocated into a group according to the week of the month that s/he was born. This ensured that monthly visits occurred close to infants' monthly birthdays.

At each monthly assessment, diary entries were uploaded onto a researcher computer, and after the visit, entries were transferred to an online database. At this time, mothers were asked whether they had any problems with identifying or recording behaviors, or needed any clarification. At the 4-, 6-, 9-, 12-, and 15-month visits, a new WTE sheet was given to the mother, together with further training on identifying target behaviors.

At each monthly assessment, infants were also tested by a trained researcher. This testing included researcher-assessed motor milestones that formed the basis of our reliability evaluation, and other experimental measures (not reported here). As in previous parent-report diary studies, such as Bodnarchuk and Eaton (2004), the CUE Diary Method was retrospectively validated and the reliability of maternal reporters by comparing the age-of-emergence of target behaviors as recorded by the maternal reporter with the age-of-emergence found in researcher assessments. These researcher assessments followed World Health Organization (WHO) methods for assessing motor development (Wijnhoven et al., 2004).

*Further support and training.* Each maternal reporter was assigned a key researcher who was present at the introductory training session and maintained regular contact with the mother throughout the study. Following each monthly visit, key researchers reviewed the entries of maternal reporters, and created a feedback sheet identifying the target behaviors for which the maternal reporter had created valid entries in the previous month and the target behaviors that the maternal reporter needed to watch for over the coming month. This monitoring and feedback system

was designed to increase ease of observation for participants and to maximize reporting compliance.

## **Results**

### *Compliance Assessment*

For an entry to be considered valid it had to contain sufficient detail to match the target behavior definitions given in the WTE sheets (see Appendix C for an example). Entries were considered invalid if they were recorded before distribution of the WTE sheet that described the behavior, or if they were recorded more than two weeks after occurrence. This delay was evaluated by comparing the time-stamp of each entry with the reported date of occurrence. Entries that failed to meet these criteria were excluded from analysis. Such entries made up less than 1% of the total number of entries analyzed.

Two maternal reporters failed to complete the study and their data was excluded on this basis. One infant was referred for developmental delay and was excluded on this basis, as the instructions and training procedures were designed and piloted with typically-developing infants. One maternal reporter failed to comply with the requirement of having two or more valid entries for palmar grasp, pincer grip and walking and was excluded from the sample.

### *Reliability Assessment*

To assess reliability of the method as well as reliability of individual maternal reporters, maternal reports were compared with researcher assessments for three target motor behaviors (palmar grasp, pincer grip and walking). For any data from a maternal reporter to be included in the final CUE diary dataset, she was required to be reliable for all three of the target motor behaviors. A maternal reporter's reliability for each behavior was evaluated according to the following criteria: each behavior must

have been recorded by the maternal reporter at least by the date on which a researcher assessment identified the behavior; and each behavior must have been recorded by the maternal reporter not more than two months before the researcher assessment identified the behavior. Following the reasoning of the WHO study (Wijnhoven et al., 2004), it was reasoned that because mothers have more opportunities to observe behavior, they would identify behaviors as soon as or before researchers could do so, but that there needed to be a reasonable threshold for the researcher to identify the behavior. Two consecutive months of testing were chosen as this threshold, reasoning that if an infant was capable of a behavior, s/he might not evidence the behavior during the first assessment, but should be able to demonstrate the behavior during at least one of two assessments. This somewhat conservative threshold was designed to ensure maximum reliability across the dataset, and in so doing to increase confidence in future analyses of CUE diary data. Seven maternal reporters failed the described reliability criteria and were excluded from the final sample of CUE data, as a result. After the application of compliance and reliability criteria, 81% of maternal reporters remained. Table 6.1 presents demographic information for maternal reporters grouped according to inclusion status. Maternal reporters whose data were included or excluded in the final sample had similar ages, levels of education, and number of children.

### *Means and Other Descriptives*

The mean age and standard deviation for the CUE diary motor behaviors of palmar grasp, rolls from side to back, reaches when sitting, pincer grip, crawling, walking and climbs stairs are shown in Table 6.2. The first column denotes the full sample before exclusion criteria were applied. The second column contains information from maternal reporters excluded based on compliance and reliability

criteria. The third column shows information from the final CUE sample, and the final column shows data from researcher-administered assessments. The range of age-of-emergence was quite small for the palmar grasp, a reflex behavior observed shortly after birth. By comparison, the range of age-of-emergence was larger for the pincer grip, crawling and walking.

Table 6.2

*Age of emergence for motor behaviors presented as mean +/- SD.*

Motor Behavior	Total Sample (N=36)		Excluded Sample (N=7)		Final Sample (N=29)		Researcher Assessment	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
	(days)		(days)		(days)		(days)	
Palmar Grasp	7.56	12.36	13.4	20.85	5.56	7.15	29.00	4.00
Rolls From Side to Back	88.21	47.56	110.60	35.72	80.21	49.22	n/a	n/a
Reaches When Sitting	147.37	49.45	147.43	38.98	147.36	52.36	n/a	n/a
Pincer Grip	230.13	34.42	250.67	60.23	223.76	18.75	242.02	8.01
Crawling	256.16	53.07	263.00	88.64	254.03	38.17	n/a	n/a
Walking	393.49	59.02	416.01	54.04	387.86	59.78	411.00	57.04
Climbs Stairs	407.93	1.02.51	422.00	99.17	405.73	104.72	n/a	n/a

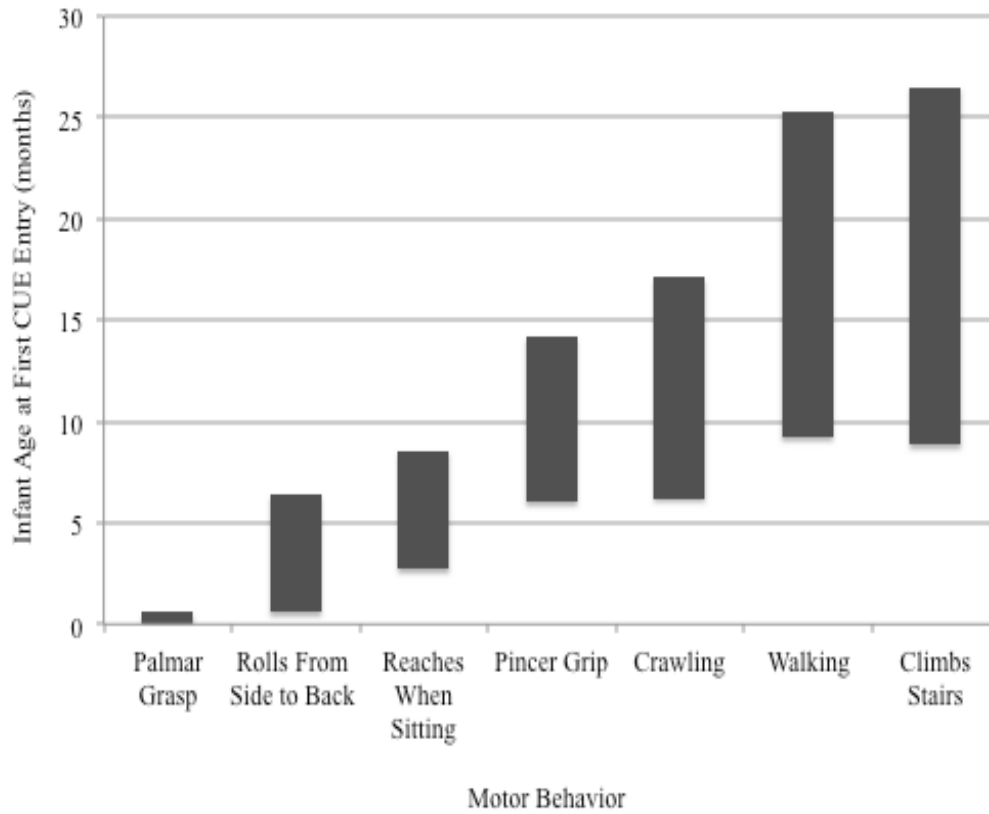
*Note.* The first column identifies the total sample before exclusion criteria applied. The second column denotes data for those excluded following exclusion criteria, and the third column contains the remaining final sample. The final column identifies researcher-assessed age-of-emergence where relevant. In the case of n/a this denotes behaviors not assessed by researchers.

### *Validity Assessments*

Finally, the CUE Diary Method was evaluated by comparing age-of-emergence from CUE data for the final sample with age-of-emergence from researcher assessment (columns 3 and 4 in Table 6.2). Researcher assessments consistently yielded higher age-of-emergence data, and reduced within-group variation.

Figure 6.2 demonstrates the range of onset ages for all seven motor behaviors. Periods of overlap between certain behaviors, such as reaching when sitting and pincer grip, are evident. In one case, such overlap suggests reporting errors: the earliest report of climbing stairs preceded the earliest report of walking entry, a contradiction that suggests climbing stairs was not reported accurately.

Figure 3 shows a comparison between the distributions for age of emergence yielded by each method. The CUE diary data consistently produced earlier data on infants meeting milestones.



*Figure 6.2.* Range of ages of onset for motor behaviors reported in CUE Diary Method, indicating overlap for periods of motor skill emergence. Palmar Grasp, Pincer Grip and Walking validated via researcher-administered assessment.



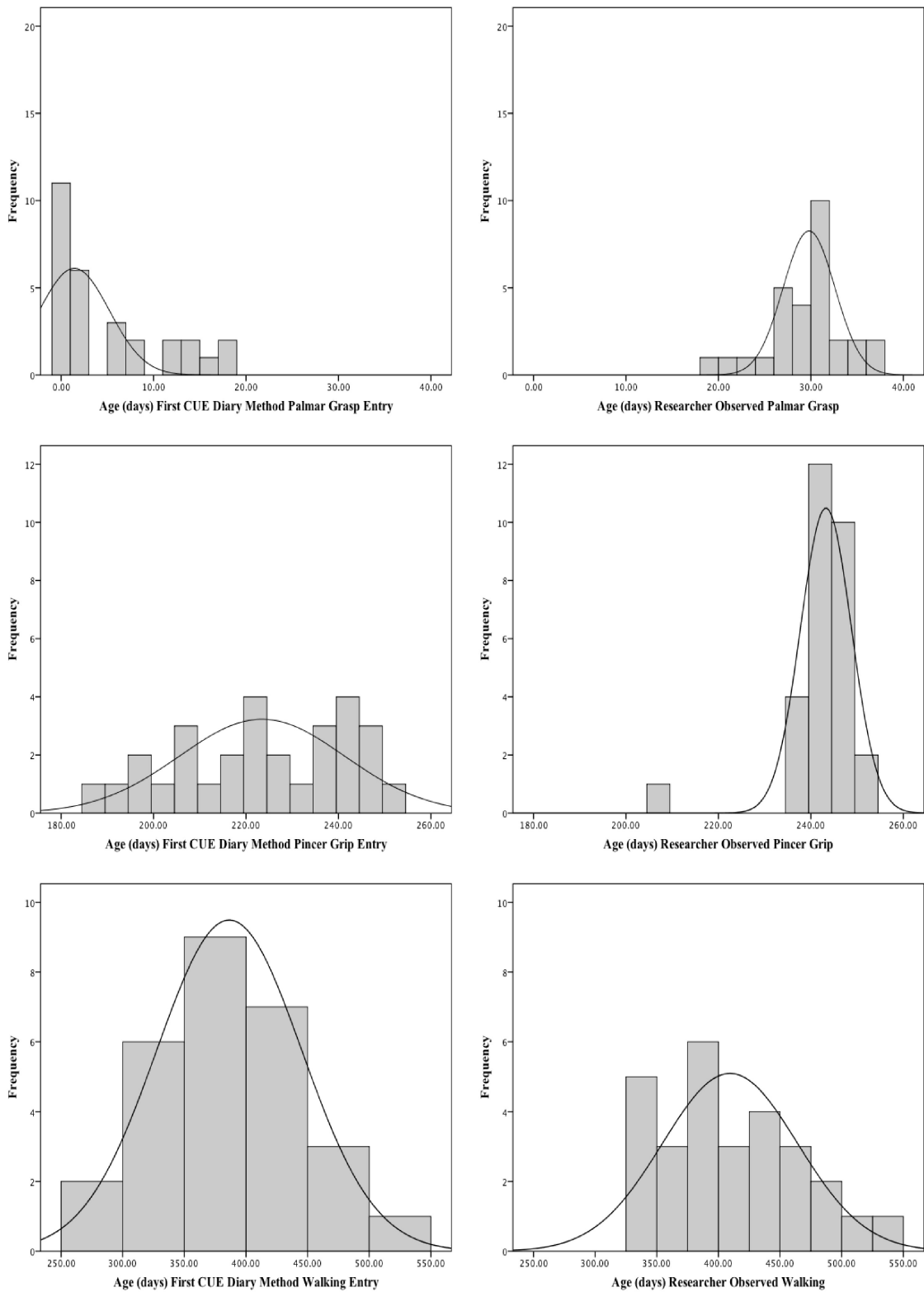


Figure 6.3. Histograms demonstrating distortion in age-of-emergence from researcher assessments compared to CUE Diary Method data, with lines of best fit.

Finally, example CUE diary entries for each behavior are shown in Table 6.3. Within the example it is interesting to note the contextual information provided for the fine and gross motor entries.

Table 6.3

*Example entries for each of the target motor behaviors.*

<b>Question</b>	<b>Palmar Grasp</b>	<b>Pincer Grip</b>	<b>Walking</b>
Describe what happened	Palmar grasped mothers finger	Baby is really dexterous now and can pick up tiny objects using a pincer grip	Baby took first steps unaided
Describe where this happened.	At home during a feed	At home	Living room
What type of behavior was it?	Motoric	Motoric	Motoric
What type of motoric behavior was it?	Hand/Arm movement	Hand/Arm movement	Leg/Whole body movement
Which motoric behavior specifically?	Palmar grasp	Pincer grip	Took first steps
Was this behavior copied?	No	No	No
Was this behavior spontaneous, encouraged or instructed, or assisted? Describe how.	Spontaneous	Spontaneous	Encouraged or instructed  I held baby upright and facing her sister and said "you walk to your sister now"
How many times has your baby performed this behavior?	This is the first time	This is the third time	This is the first time
If any objects were involved, describe how.		Little pieces of Lego bricks	Baby carrying her sisters birthday present

## Discussion

This chapter has been concerned with detailing the design and evaluation of an event-based, electronic maternal reporting method that allows real-time recording of infant and child behavior in natural contexts. Event-based electronic diary methods allow parents to create entries based on continuous observation, increase consistency across different entries and reporters, and allow for assessment of compliance and reliability.

*Designing a Continuous Unified Electronic Diary Method*. The primary aim was to design an event-based electronic diary reporting method suitable for the study of infant and child development. Diary data is valuable for the study of development because it draws on continuous observation, and because it allows researchers to draw on rich contextual information. New parents have many demands on their time, and electronic diaries have previously been shown to offer greater ease of use than paper and pencil diaries (Lam et al., 2010). As a result, electronic diaries as a method encourage compliance and continued participation (Hufford et al., 2002).

The CUE Diary Method allows researchers to gather contextual information using a combination of open-ended and closed-class questions. Understanding the role of context in shaping behavior is critical to understanding human development, and previous studies have shown that emergent behaviors are influenced by both physical and social environments (Collins, Maccoby, Steinberg, Hetherington, & Bornstein, 2000). The CUE Diary Method can be used to identify age-of-emergence as well as the physical and social contexts in which behaviors emerge.

The CUE Diary Method is suitable for studying development across a range of domains. This study was focused on motor behaviors because of their reliable

elicitation once present in the infant's behavioral repertoire, and because that aim was to assess the reliability and value of the CUE Diary Method by comparing diary data with researcher assessments. Our complete CUE Diary Method included questions on cognitive and communicative development. The CUE Diary Method thus allows for the unified study of development across domains. Future research from our dataset, for example, will examine the relations between motor and communicative development.

The ESP software was used because it offered an easy-to-use platform with sufficient flexibility for our study, and installed the software on Palm Pilots. The CUE Diary Method is independent of the platform, however, and could easily be adapted for more recent versions of handheld computers, smartphones, or tablets.

#### *Training Maternal Reporters*

Previous electronic diary studies have for the most part involved self-report. Those studies that have involved parental reporting of infant behavior have focused on crying and sleeping, states that are both easily identified (Lam et al., 2010). To ensure that maternal reporters could remember and identify specific behaviors correctly, a training and support system was developed to accompany the electronic diaries. Future studies might implement these training components electronically, by using video training and other electronic resources.

Because the overall study involved comparisons across experimental and naturalistic data, the study design also included monthly visits to the university laboratory. Diary data was uploaded during these monthly meetings, and any immediate problems with the diaries were addressed. This regular contact may have had a positive effect on continued participation and compliance, but in future studies many of the conditions could be met by a combination of internet-based data

collection and personal contact, which could include telephone conversations as well as electronic chats.

Feedback was also critical to the training and support system. Because the ESP software locks an entry as soon as it is completed, maternal reporters were not able to review previous questions or previous entries. To ensure that mothers knew which behaviors to watch for at any point in time, and to limit their dependence on memory for previous entries, entry feedback was given to mothers on a monthly basis. Following each upload of diary data, individual reports were created by researchers and sent to each maternal reporter. The reports summarized the past month's entries and gave a list of the yet-to-be-recorded target behaviors. Although other software could be configured to generate reports automatically, our researcher-led reports had the benefit of allowing researchers to screen for any incorrect entries and then reiterate behavioral definitions to reporters.

For future studies, the CUE Diary Method could be adapted for other designs with reduced training and support and larger sample sizes. Our training and support systems for maternal reporters required a substantial investment of researcher time. Further studies are needed to address whether similarly high levels of reliability could be achieved with reduced training and support.

#### *Assessing Maternal Reporter Compliance*

Compliance evaluation focused on reporting of three motor behaviors: a reflex, a fine motor behavior, and a gross motor behavior. Our evaluation criteria concerned the timing of the entry, the quality of the entry, and the number of observations.

An important disadvantage of traditional paper-and-pencil diaries is the impossibility of monitoring when entries are made, and in particular whether

participants comply with time-related reporting instructions. maternal reporters were asked to create an entry for each target behavior as soon as possible after it had been observed. Because the CUE Diary Method included automatic time-stamping of each entry, it was possible to compare the reported date of an observed behavior with the actual entry date, and to disallow entries that were outside of an acceptable temporal threshold. Future studies could automate this evaluation procedure to reduce researcher time.

To further assess compliance, trained researchers reviewed each entry, checking whether the entry contained sufficient detail to identify the behavior, whether the entry met the definition provided for the behavior, and how many entries had been recorded for each behavior. The electronic format of the data facilitated this process by providing researchers with easy access to the entries in a spreadsheet format. The expert judgment of trained researchers was critical to this aspect of our evaluation, and provided the basis for feedback and further training. In future studies, this aspect of compliance evaluation could be handled through internet-based communications as well as telephone conversations.

#### *Assessing Maternal Reporter Reliability*

Reliability was evaluated by comparing CUE diary data with researcher assessments for three target behaviors. Our evaluation criteria focused on whether maternal reporters identified behaviors at least as soon as a researcher identified them, and not more than two-months before that.

Our evaluation criteria were relatively strict. The design required that each maternal reporter recorded each of our three motor milestones within this two-month window for any of her data to be included in future analyses. Our motivation for this stringent assessment method was that our overall dataset also included other

behaviors that were not compared against for researcher assessment. In order to be more confident about the reliability of those data, the design applied a no-fails rule to the data where there were researcher assessments. Over eighty percent of maternal reporters were deemed reliable, indicating that the Continuous Unified Electronic (CUE) Diary Method is a valid and reliable method for collecting data on infant development.

Future studies using the CUE Diary Method could adopt one of two strategies for assessing reliability. A technology-based strategy would be to ask parents to provide documentary evidence of a select number of behaviors, in the form of photographs or videos. Researchers could then compare entries against documentary evidence to assess reliability. Because handheld devices were used that did not contain cameras, this option was not available to us, but because of recent increases in the availability, quality and affordability of smartphones with cameras, this should be a good option for the future.

A second strategy for assessing reliability in future studies would be to combine CUE diary data with researcher assessments, as described here, but to require fewer researcher assessments. In our study, the majority of participants who failed reliability criteria for one target behavior also failed the reliability criteria for other target behaviors, suggesting that future studies adopting this strategy could use fewer researcher-assessments to identify unreliable reporters. This strategy seems particularly useful for mixed-method studies where the overall study design might require laboratory testing for other purposes.

*Advantages of Electronic Diaries When Examining Developmental Change*



Our final aim was to compare CUE diary data with researcher assessments to establish the value of the CUE Diary Method. In the development of the CUE Diary Method, the design was particularly interested in whether the CUE Diary Method produced a more accurate and detailed account of development. The CUE Diary Method yielded greater detail of contextual information, earlier ages of emergence across motor behaviors and a finer depiction of individual differences.

Studying the shape of developmental change requires an accurate tool for gathering information on the emergence of target behaviors. The CUE Diary Method combines the richness and flexibility of parent-report diary data with a diary method approximating the systematicity and rigor of experimental methods, and allows testing of causal hypotheses about human development. With appropriate piloting, the CUE Diary Method could also be adapted for the study of atypical development, including developmental delay. For example, the CUE Diary Method would be suitable for recording motor behaviors of infants whose motor development appears to be delayed, if training materials and support were designed for such samples. The contextual information contained in the CUE Diary Method, as well as the unified approach to studying development across domains, may be particularly useful for examining questions about developmental delay.

#### *Limitations of Electronic Diaries for Developmental Studies*

At present, electronic diary studies are expensive compared to other forms of parent-report, including checklists, questionnaires, and paper-and-pencil diaries. Because smartphones were not widely available when our study began, every participant was provided with a handheld computer, at a substantial cost per participant. In addition, our study procedures included extensive support for maternal reporters, and this support was time-consuming, and therefore expensive. Importantly,

however, the relative cost of electronic diary studies is likely to change quickly as technology changes. Future studies could adapt the CUE Diary Method for smartphones and might even rely on participant-owned devices. Future studies might also use electronic resources for training and feedback to reduce costs. For example, video training and electronic messaging could be used for some of the procedures that involved one-on-one staff time in our study.

In our study, some motor behaviors appeared easier for maternal reporters to accurately identify and record than others. For example, comparison of the earliest entries for walking and climbing stairs suggests that some maternal reporters may have been recording climbing stairs inaccurately, for instance, recording a scaffolded version of climbing stairs, rather than independent, upright climbing. In comparison, CUE data for all six of the remaining motor behaviors showed emergence within the range expected, and in the order of emergence expected. Similarly, the three behaviors of palmar grasp, pincer grip, and walking, all showed high levels of reliability, as predicted. Future studies would need to include piloting to ensure clear definitions which support accurate reporting of complex behaviors.

### *Conclusions*

The CUE Diary Method is the first adaptation of event-based electronic diary methods for the study of infant and child development. Like historical parent-report diaries, the CUE Diary Method is based on continuous observation and provides data about infants in their natural environment. As a result, the CUE Diary Method allows researchers to collect data on age of emergence and important contextual variables such as precursor variables, eliciting factors, and rewards. Unlike traditional paper-and-pencil diaries, the CUE Diary Method allows for larger samples and reduced attrition because it is easier and quicker for participants to use due to menus, data

uploading capabilities, and other time-saving features. In addition, it facilitates assessment of compliance and reliability. Through its adaptable design the CUE Diary Method may be applied to other hand held devices such as smartphones in the future.

Kuhn (1995) argued that developmental psychology aims to see the process of change, rather than simply its products. The CUE Diary Method is an excellent methodological tool for investigating the mechanisms of change in human development, and yields event-driven, context-rich, longitudinal data across development. The CUE Diary Method opens the door to examining the dynamic nature of human development.

### **Chapter summary**

With the CUE Diary Method demonstrated to deliver reliable, and valid data on the emergence of developmental milestones in the motor domain, in the following chapter the CUE Diary Method will be brought to bear to examine the role motor development plays in communication development, as well as communication's effect on the onset of motor skill acquisition.

In keeping with the commitment to microgenetic design the CUE Diary Method will be imbedded within a multi-method, modal and longitudinal design in order to assess communication and motor development's associations.

## **Chapter 7:**

### **Taking the next step in social object use and language: Emerging motor development predicts language development**

#### **Chapter Overview**

The emergence of self-produced locomotion (SPL) is one of the crowning achievements in infant development. Increasingly research has sharpened its focus upon the relationship between this significant achievement, of independent locomotion, with arguably the singular differentiating feature of the human species of language. Much has been made of the link between gesture and language, what this link means for the evolution of language, connectionist and modular theories of development and explanations of atypical development. More recently the discussion within developmental psychology has reignited upon the topic of locomotion's relationship with language development. In this chapter the legacy of SPL is examined in facilitating developmental change within the domain of language development. Specifically, the hypothesis is tested that when infants are observed using the CUE Diary Method from birth to 18 months, the emergence of walking would be predicted by showing behaviors with adults. It is through this mechanism that locomotion was expected to predict later language development.

## **Introduction**

Bipedalism presented humans with a tipping point in the evolution of hands. From a role of supporting posture, hands evolved to enable foraging, hunting, and communication. In this way, the evolution of bipedalism and modern day hand structure and function in communication are inextricably linked. With the modern structure of hands, humans were able to extend their dexterity to commit to tool use, and symbolic gesture. These endeavors alter the way in which humans communicate, hands became agents of change within the environment, and our desire to interact others was developed through the co-developed creation of cultural practices that occur during social acts of collaboration.

Motor development has often been considered a nuisance variable within studies of communication development. Lenneberg (1967) documented a correspondence between motor and language milestones, but centered an explanation of general consequences from maturation, therefore ruling out motor development as a factor in communicative development. Over recent years the rise in theoretical positions such as the dynamic systems theory have eluded to a broader developmental story, one whereby motor developments play a role in the emergence of other domains concerned with communication. The dynamic systems perspective dictates that motor milestones have the potential to alter the social context, and the social partner's behavior within this context. Combined these changes facilitate a transition state in communicative development. Motor milestones in locomotion are one example of a milestone in motor development that may have this impact on the developing communicative system.

Interactions are the context in which communication may shape, and be shaped by, developmental transitions in motor development. Campos et al. (2000)

detail changes in the mother's view of their infant's intentionality once they become locomotive. Changes in both an infant's didactic behavior, and a mother's labeling response to infant's didactic behavior with the emergence of locomotion have been detailed by Karasik and colleagues (Karasik, Tamis-LeMonda, & Adolph, 2011). From a perceptual stance, the altered perspective enables the freeing of hands to be concerned with the reaching and manipulation of objects within the environment. With the emergence of hominid bipedalism there was a major shift in hand functions from support of locomotion to manipulation. In this way bipedalism can be seen as effectively grounding the foundations of early tool use. Evolutionary psychology places the evolution of upright locomotion as central to the emergence of gesture and language, and tool use.

Over the past two decades, researchers of motor development have endeavored to go beyond the description of the motoric timetable of development. In examining the links of motor development with other aspects of development, theoretical assumptions may be tested and insight may be gained into the organization of developmental systems (Kamm, Thelen, & Jensen, 1990; Smith & Thelen, 2003; Thelen, 1995). Specifically the reciprocal nature between perception and action development has shown itself to be fruitful in its questioning of infant development (Bushnell & Boudreau, 1993; Hill, 2010a). The topic of interrelated motor and language development has recently enjoyed a highlighting in research focus. The motivation for research arises from theoretical questions raised by inter-system connections, questions of infant and environmental contributions and what the relationships between domains of development means for non-normative development. Motor development has been looked at through the lens of understanding the evolution of language within the human species, through the

connection of bipedalism evolution and tool use (Iriki & Taoka, 2012; Steele, Ferrari, & Fogassi, 2012; Stout & Chaminade, 2012; Tuttle, 1981).

Motor development is also implicated in communication. Motor development achievements allow for the infant to engage in gesturing, a widely studied area of nonverbal communication. Specifically the relationship between gesture and language has been repeatedly shown to be stable (Bates & Dick, 2002; Gentilucci & Corballis, 2006; Goldin-Meadow, 2006; Goodwyn, Acredolo, & Brown, 2000; Iverson & Braddock, 2011; Iverson & Goldin-Meadow, 2005; Parlade & Iverson, 2011; Thal & Tobias, 1994).

The concept of social object use, where manipulation of objects or the attending to other's use of objects, (Vandell, 1980; Vandell, Wilson, & Buchanan, 1980), is also of relevance to the theoretical discussion of motor-language development (Karasik, Tamis-LeMonda, et al., 2011). The earliest forms of social object use may be seen as the passive states of observing the objects others "bring to life" before prehension skills have developed. Once motor development gives rise to reaching, grasping and SPL a new phase of social object use is well established, with infants reaching, sharing, showing and co-acting on objects with a social partner.

This view of motor development facilitating domains of development outside of motor development relating to objects, people and the environment, has in part come from the study of co-morbidity with motor and specific forms of atypical development (Hill, 2010a). The co-morbidity associations span Specific Language Impairment (Hill, 2001, 2010b; Rechetnikov & Maitra, 2009; Vukovic, Vukovic, & Stojanovik, 2010; Webster, Majnemer, Platt, & Shevell, 2005), dyslexia (Viholainen et al., 2006), down's syndrome (Cobo-Lewis, Oller, Lynch, & Levine, 1996), dyspraxia (Alcock, Passingham, Watkins, & Vargha-Khadem, 2000) and autism

(Gernsbacher, Sauer, Geye, Schweigert, & Hill Goldsmith, 2008; Iverson & Wozniak, 2007) to name a few specific examples.

Within the typical development literature evidence for motor development's cross-domain influence includes research demonstrating links with cognitive (Diamond, 2000; J. P. Piek et al., 2004; Jan P. Piek, Dawson, Smith, & Gasson, 2008) perceptual (Anderson et al., 2001; Bushnell & Boudreau, 1993; Soska, Adolph, & Johnson, 2010), and spatial reasoning (Clearfield, 2004). Theories relating to the connection between motor development and other domains of development include embodied cognition (Fischer & Zwaan, 2008), neuroscience demonstrations of areas of co-activation (Hicks & Onodera, 2012; Wilson, Saygin, Sereno, & Iacoboni, 2004), including (Grossberg & Vladusich, 2010) Circular Reactions for Imitative Behavior (CRIB) and an oral-motor system account (Alcock & Krawczyk, 2010; Oller, 2010; Olzak et al., 2006) and mirror neuron theories (Lieberman & Mattingly, 1985; Rizzolatti & Arbib, 1998).

Several theories concerning communication development have focused on the drive to engage in interactions as a central motivating force through development, see DePue and Collins' (1999) Behavioral Facilitation System; and Lee & Schumann's (1999) Interactional Instinct for examples. All place the central drive to engage with social partners as a compelling force in development, across multiple domains and periods of change. Chevallier, Kohls, Troiani, Brodtkin & Schultz (2012) autism to be a disorder characterized, and resulting from, an extreme deficit in the motivation for engagement with social partners that is so ubiquitous in typically developing children.

Another theoretical stand point for predicting an association between motor and language development is that relating to social object use, and the social changes arising from SPL generally and independent walking specifically (Adolph, Tamis-



Lemonda, & Karasik, 2010; Biringen, Emde, Campos, & Appelbaum, 1995; Karasik, Adolph, Tamis-Lemonda, & Zuckerman, 2011). When an infant acquires SPL experiences that facilitate change in perception, cognition, and social development are initiated. Social object use becomes progressively more active, moving from the passive gaze to objects others are attending, to pointing to objects, to showing objects to others while stationary, to achieving SPL and the independence this affords (Carpenter et al., 1998; Karasik, Adolph, et al., 2011).

The advantages self-produced locomotion (SPL) offer are broad and iterative across the domains of development. SPL results in independently determined exploration of the environment and this begins to change how others perceive you. Walking advantages over crawling as SPL include that hands are free; head is up for joint attention; different perceptual experience from floor; increase independent mobility with reduced effort compared to crawling so more resources for environment/object exploration (Campos et al., 2000). Much has been made of the infants developing understanding of intentions (Carpenter et al., 1998; Rakoczy, Tomasello, & Striano, 2005), significantly less focus has been given to the developmental pathway of mothers considering their infants to be intentional, goal driven individuals, what factors co-act to result in this shift and importantly, what this shift in thinking about their infants agency may mean in relation to how they interact with their children, and the developmental outcomes of this.

Campos et al., (2000) have been one such research group who have engaged in the question of mothers shifting cognitions about their infants as a function of infant SPL status. In their study they found that SPL status altered how parents of infants of the same age viewed their children on measures such as responsibility, intentionality and affect.

Additionally SPL status was shown to alter how parents interacted with their children. (Karasik, Adolph, et al., 2011) are among those viewing motor development from the stance of increasing the active social object use and the dynamic relationship this has with mother-infant interactions. It is now timely to examine the emergence of motor development within the context of social object use and the effect this may have on language development. Investigating a motor-language system, where an action-perception system has already been demonstrated. Ideally to examine a developing system and the effect of one domain over others in process a microgenetic, longitudinal study needs to be undertaken with the rate of data collection determined by the rate of skill emergence.

In this study just such a method is employed. The CUE Diary Method (Ellis-Davies et al., *in press*), is an electronic diary method that enabled the continuous monitoring of infant development across motoric, communicative and imitative domains for the first 18 months of life by their mothers. In addition to the CUE data, language development was followed in the same group of infants by CDI data collection near to the time of emergence, where large degrees of individual differences may already be evident. 14 months is also around the time of infant development of intention understanding.

The integration of methods was needed in order to answer questions relating to the predictive nature of social object use and motor development emergence on language development.

Based on the perceptual, cognitive and social changes that walking affords (Campos et al., 2000; Karasik, Adolph, et al., 2011) it was hypothesized that showing objects whilst stationary would be a social form of motivation for increased levels of interaction and would therefore predict walking emergence. Secondly, it was

predicted that due to the independent exposure to objects within the environment, as well as social, cognitive and perceptual advantages walking gives to the process of word mapping, that walking would predict language production at 14-months.

The current study takes the model of examining development across domains, and applies it to motoric and communicative development. In doing so new findings are discussed, relating to the specificity of motor and language relations, paths and mechanisms for this interrelated developmental trajectory and the stability of this relationship over time. In engaging with the topic of interrelated motor and language development, developmental trajectory and system organization is investigated with the theoretical and applied implications explored.

## **Method**

### **Participants**

Twenty-nine expectant mothers were recruited during their last trimester of pregnancy to participate in First Steps, a longitudinal study of infant development from birth until 18 months. Expecting parents were recruited from community organizations within Cardiff. The First Steps design involved continuous electronic diary reporting from birth to 18 months, and monthly testing from 2 until 18 months. At each monthly testing session, families were given shopping vouchers and a small gift in return for their participation.

The sample of reporters ranged in age, nationality, ethnicity, education level, socioeconomic status, marital status, and the number of previous children, as shown in Chapter 2, see Table 2.1. All infants were born to term with 15 females and 14 males. The Cardiff University School of Psychology Research Ethics Committee and the South East Wales Local Research Ethics Committee of the Cardiff and Vale National

Health Service Trust both reviewed the study protocol and granted ethical approval. Each maternal reporter gave informed consent prior to participation in the study.

## **Design**

This Chapter's design incorporates longitudinal, within-subject, and mixed methods. Locomotive, gestural and verbal behaviors are of interest within this Chapter, and are studied simultaneously, in line with a microgenetic approach.

## **Materials**

The CUE diary method was applied within the First Steps study, tracking communicative development from birth to 18-months. The modes relevant to this study were Motoric and Communicative. Details of the question flow for the Motoric branch of questions can be found in Chapter 6. Figure 7.1 shows the question flow for entries of the verbal and gestural domains.

Productive language data was collected through the communicative development inventory (CDI) (Fenson et al., 2000). The CDI is a parental questionnaire designed to deliver information on the productive and comprehensive vocabularies. Parents complete the questionnaire by noting the items which their infant comprehends, as well as noting those items that the infant is able to say. Using the syntax provided, entries are then converted into raw scores.

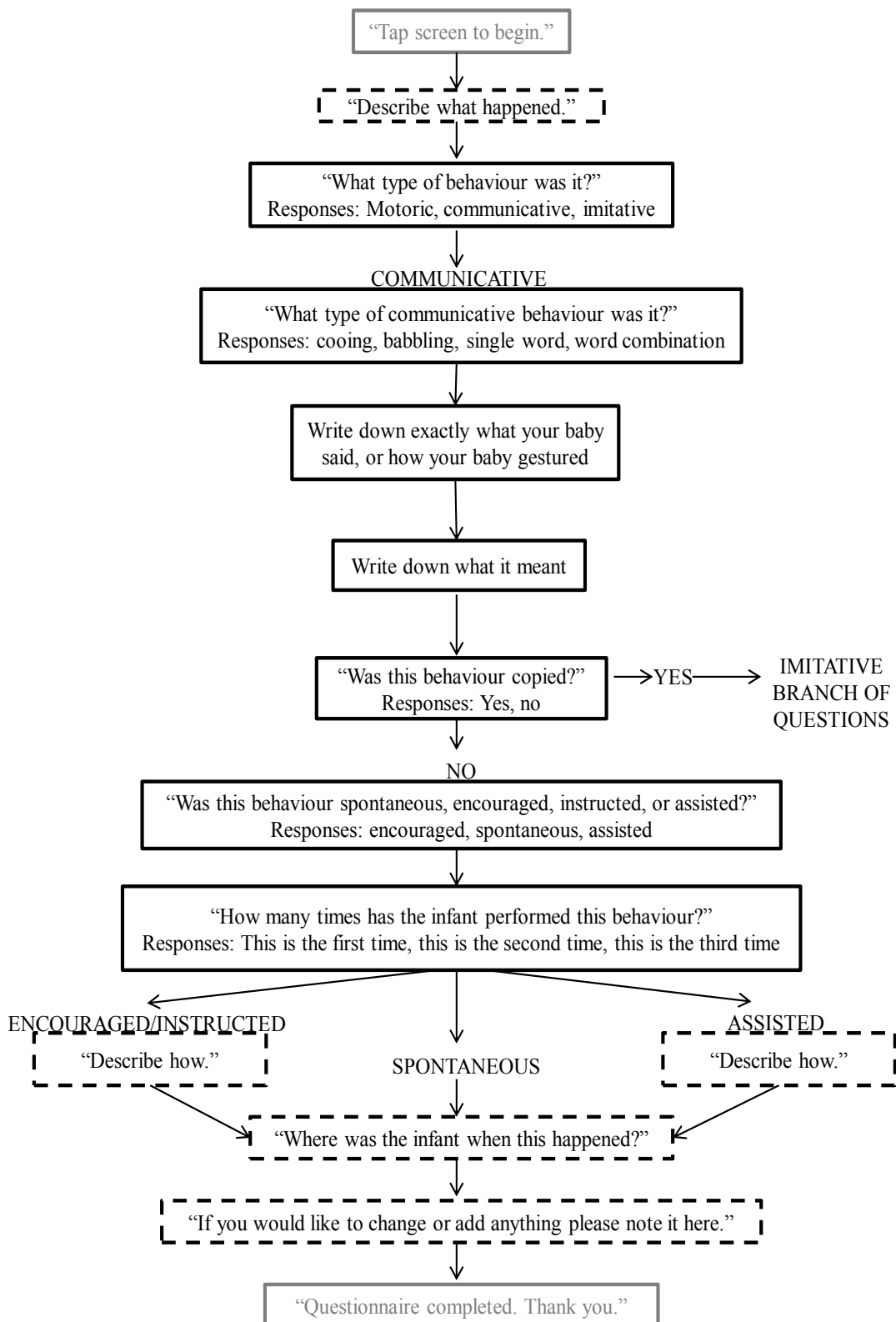


Figure 7.1. CUE Diary Method question flowchart for the verbal and gestural domains

## **Procedure**

As part of participation in the First Steps study, mothers observed the first three instances of target behaviors using the Continuous Unified Electronic (CUE) Diary Method, as described in Chapter 6. Within this Chapter, motoric and communicative behaviors are of interest. As part of this longitudinal study mothers attended monthly visits to the University where CUE diary data was downloaded. Whilst at the University mothers completed the Communicative Development Inventory (CDI, Fenson et al., 2000). The CDI was completed at 12, 14, 16, 17, and 18-months. Fourteen month CDI data is of interest in this Chapter, as this is a point in development when individual differences are evident in both language and locomotion attainment. In addition 14-months is noted as a stage where infants are on the cusp of an “explosion in language learning” (Fenson, 2000).

## **Results**

The average age of emergence, with standard error as an index of variation, are shown in Table 7.1. Also contained within this table is the average productive vocabulary score of infants at 14-months.

Table 7.1

*Mean +/- SE age of emergence for motor development and CDI score*

<b>Behaviour</b>	<b>Mean</b>	<b>Std. Error</b>
CDI 14 Month Production Score	16.76	3.10
Age (days) Walks Unaided	387.86	11.30
Age (days) Stands Unaided	335.14	14.31
Age (days) Shows Object	321.62	14.59
Age (days) Points	296.00	9.83
Age (days) Crawls	254.03	7.09
Age (days) Pincer Grip	223.76	3.48
Age (days) Palmar Grasp	5.55	1.33

#### *Motor-Language analyses*

All but one of the infants achieved independent walking by 18 months. Social object use, defined by sharing and showing objects to others, was significantly correlated with the emergence of walking ( $r = .411$   $N = 28$ ,  $p = 0.03$ ). A linear regression was then found to be significant ( $F(1,26) = 5.275$ ,  $p = .030$ ), with 17 percent variance explained. As shown in Table 7.1, the mean CDI production score at 14 months was 16.76. The hypothesized relationship between walking and CDI score was assessed through a parametric correlation and found to be significant ( $r = .520$ ,  $N = 28$ ,  $p = 0.005$ ).

A linear regression was then found to be significant ( $F(1,26) = 9.652$ ,  $p = .005$ ). With 24 percent of variance explained. This relationship was predicted to be unique among the gross motor achievements seen in Table 2. This was found to be the case, with crawling, and standing failing to demonstrate a significant association with later

language production. Of the fine motor behaviors it was predicted that pointing alone would make a unique contribution to the model for predicting language, alongside walking. In line with this prediction, pointing contributed to a regression model for later language, while pincer grip and the palmar grasp lacked a significant relation with later language. The pointing and walking model of later language was found to be significant ( $F(2,25)=9.381, p=.001$ , explaining 42.9% of variance. As can be seen in Table 3, pointing and walking provided equitable proportions to the predictive model.

Table 7.2

*Regression model for pointing and walking predicting later language*

<b>Variable</b>	<b>B</b>	<b>SE B</b>	<b><math>\beta</math></b>
Pointing	-.131	.050	-.412*
Walking	-.117	.045	-.412*

*Note.* \* Denotes significance at  $p<0.05$  level.

## **Discussion**

The CUE Diary Method was employed to investigate the relationship between showing objects and walking, and the relationship between the emergence of walking on later language production. Showing object while stationary was predicted not to have a strong enough relationship with language as the child is not exposed to the benefits gained by social object use whilst walking. These benefits of walking while engaging in social object use relate to perceptual, cognitive and social advantages to word mapping. Instead a direct relationship was predicted between walking and language. The role of showing objects whilst stationary was predicted to be by



predicting walking, by the proposed mechanism of increasing motivation and social awareness.

In the current study reflex, fine and gross motor development were evaluated as predictors of later language. Given the cognitive and social advantages gained by increased locomotion, gross motor development was hypothesized to show predictive power over productive vocabulary above and beyond that of reflex and fine motor skills.

The predictions of the current study were tested via the administration of a multi-method, microgenetic, longitudinal study of 29 infants from birth to eighteen months. The Continuous Unified Electronic (CUE) Diary Method was employed for data continuous data collection on motor development, with maternal reporters recording the emergence of reflex, fine and gross motor development. Alongside maternal diaries on motor development receptive and productive vocabulary was collected via regular administration of the Communicative Development Inventory (CDI) from 12-to-18 months. Gross motor development of walking was shown to be a stable predictor of language development.

In the last decade traditional views of domains of development in psychology have been challenged. Specifically the assertion that pitted motor development as an independent domain of development has been found to be redundant in light of mounting evidence to the contrary. When the basic premise of domains of development organized into connected systems is considered, functional connections between motor and other domains of development can be explored, with the potential benefits for theory and application. Recent findings provide support for motor development influencing the developmental timetable of language development. This

relationship shown with typical and atypical developing samples have raised questions of how, when and why such an association exists.

The onset of infant locomotion has shown itself to extend infants' opportunities to learn about their environment. In addition to the functional advantages gross motor development gives to infants, anatomical proximity of the motor cortex has offered a new opportunity to examine the dynamic nature of development. The findings of this chapter demonstrate stable and specific relations across aspects of motor development that are involved in the infant engaging with others. Models discussed earlier that focus on the drive of the infant to engage in collaborative endeavors with others, through attention and action, are supported by the findings within this chapter. However, for a fuller assessment of these accounts more work is needed into the mediator and moderator effects that may be at play in the evidenced motor-language network. Additionally, it is suggested in this chapter that a specific path through which pointing and walking emergence may facilitate language development may be changes in parent's attributions of infant's intentionality. This account needs to be thoroughly investigated through the longitudinal evaluation of mother-interactions, in a microgenetic design across the emergence of pointing and walking, to assess changes in mother's labeling.

### **Future Directions**

With the aim of further unpacking the mechanisms and developmental pathways behind the walking-language relationship, extensions to the current findings may now be possible. In order to assess the changing style of interaction during the period of walking emergence, mother-infant interactions recorded at monthly intervals

during the First Steps study may hold the potential to yield information on how maternal behavior changes as a response to walking status.

Extending the work on motor-language relationships to involve a broader look at language, with a focus on language complexity and the context language emerges could also extend the current study. By doing so the evaluation of a motor-language system where change is driven by the experiences motor maturation yields, may be tested. The view that motor development is redundant in discussions relating to perceptual, social, cognitive and communicative development is challenged by this study's findings. Examining the dynamic relationship across time and domain of development is needed. By better understanding the roles motor development has on the infants greater broader development I propose normative and atypical development will benefit. This unique pattern of organization between motoric and language development holds significance with understanding the temporal sensitivity and functional nature of gross motor development on later language.

Following on from this position of pointing and walking contributing to a predictive model of language development, several strands of research are now open for enquiry. Firstly, with vocabulary shown to be predictive, a question of language type may be asked, namely are there specific word forms that are facilitated above others with the onset of walking?

Secondly, within atypical populations shown to have deficits in communication development, such as specific language impairment, and ASD, is the same pattern of development demonstrated. Previous work by Hill (Hill, 1998, 2010a, 2010b); and Iverson (Iverson, 2010a; Iverson & Wozniak, 2007)(2010) for example, have demonstrated co-morbid developmental impairments in a series of developmental disorders between language and motor development. Within studies

such as the BASIS study it may be possible to assess whether the same predictive pattern is demonstrated for at-risk infants.

Lee and colleagues' (2009) interactional instinct model for communicative development argues that communication derives from an innate drive to attune to, imitate, and seek out interaction from con-specifics. Chavellier et al., (2012) discuss ASD as resulting from an extreme deficit in this social motivation. Leading on from the results in this Chapter, examining the multi-domain communication development of infants both with ASD, and those at increased risk of an eventual ASD diagnosis, may speak to the arguments stated by Lee and colleagues (2009) and Chavellier et al., (2012).

Language and creativity have previously been examined as associated within development. One direction for future studies may examine the role of the motor-language network in the emergence of later pretend play. Within the First Steps study mothers were the caregivers examined as social interaction partners, an extension to the work detailed here could examine the changes to interactions that occur for mother-infant, father-infant, peer-infant interactions before, during, and after developmental transitions in locomotion.

## **Chapter Summary**

In this chapter I have examined a motor-language network with the application of the CUE diary method. Specific motor developments including pointing, social object use, and locomotion, were found to be related to later language development. The theoretical underpinnings for this chapter have been based within motivational accounts of infants' early drive to engage as impacting upon multiple aspects of communication development, as well as producing stable patterns of skill emergence.

## Chapter 8 General Discussion

### Chapter overview

This thesis has been embedded within the First Steps study, a longitudinal, microgenetic study of infant development across the formative months of infancy. Bringing to bare microanalytic and microgenetic methods to the study of communication development has involved examining communication from its earliest guises in early infancy, through to the achievement of social object use and language emergence in later infancy. Examining the mechanisms and outcomes of developmental change are central to the aims of developmental psychology. Through examining these indexes of development, the pathways to typical and atypical development, it is hoped will be better understood. Developmental methods play a pivotal role in the advancing of developmental theory, knowledge, policy and practices.

Communication, by its very nature, arises within a social context, and employs a multitude of domains in order to attend to, respond to, and engage with social partners. These features of communication lend themselves to the benefits offered by microanalytic and microgenetic methods. Dynamic systems theory is a perspective that is rising in prominence within communication development research. Within the account of development from dynamic systems models of development, infants do not exist alone. Instead they must be considered always within the social and non-social context in which they develop. In addition infants are viewed as self-organizing systems, emerging and impacting the mother-infant system (for example). The implication within these principles includes the prescription of methods that capture the dynamic nature of change and stability relevant to social communication. Recent proponents of dynamic systems perspectives of infant communication have delivered

microgenetic designs of motor development, for example (Iverson & Goldin-Meadow, 2005). Other examples incorporate microanalytic methods to study one domain of development across time, see Messinger et al., (2007).

Within this thesis I have developed microanalytic and microgenetic methods, that are applied within a longitudinal study of infant communication development. This study of infant communication relies on these methodological adaptations, in order to examine the roles of attention and action on early communication development. Microanalytic methods offer close examination of dynamic processes of change underway during interactions. Within this thesis it is the behavior of the infant that has been the central focus of microanalytic study. In particular the domain of infant attention during interaction has been of interest within this thesis. The detailed characterization of infant behavior during interactions, delivered by microanalytic methods, enables the rich detailing of patterns for developmental change.

The seminal work of infant attention during interactions, by Bakeman and Adamson (1984), has been central to the work within this thesis. In their original conception of a microanalytic coding scheme for infant attention engagement, engagement was tracked from 6-to-18-months. This coding scheme allowed for the gradual progression from ‘passive’ onlooking states, to the ‘active’ states incorporating action into the attention engagement. Moreover, among the 700 citations of the original coding scheme, applications of the coding scheme have been enlightening to the understanding of the reciprocal nature of infants with their social partners, how infants alter their engagement behavior dependent on the social partner they are engaging with, and how individual differences in engagement relate to later engagement progression, as well as aspects of symbol learning (see Adamson, Bakeman, Deckner, & Nelson, 2012).

While the coding schemes of infant attention have delivered on data revealing aspects of social attention, this area of research has largely focused on the social part of social attention relating to faces. There are compelling reasons why faces are considered the “King of Social Cues”. Firstly, from neonate studies newborns have demonstrated a preference for faces above other related stimuli (Farroni, 2008; Fantz, 1964). The ubiquitous preference of faces is paired with the information rich stimuli present contained within faces. Facial expression and gaze direction are uniquely attributed to faces, as well as being the location of speech the infant hears. Predictably, an absence of a preoccupation to this information rich stimuli is implicated in an array of neurodevelopmental disorders that involve impaired communication, such as ASD and fragile X syndrome.

To say that from the beginning of infancy faces are important, however, is not to say that other social stimuli are absent in the valuable input attended to. Akhtar and Gernsbacher (2008) argued for social attention to engage in a discussion where other valuable social inputs were incorporated into the study of social attention and communication development. I have argued within this thesis that hands are one such social stimuli that are deserving of inclusion within early communication research, and that an adaptation to the Bakeman and Adamson (1984) codes are an appropriate way to closer examine their role in communication development. The theoretical basis for focusing on attention to hands as meaningful in communication is derived from previous work examining the evolutionary importance of hands. Napier (1993) discusses hands as the most social tool we possess, while Abrams and Davoli (Davoli, Brockmole, Du, et al., 2012) examine hands as a yolker of human perception. Both directions of focus on hands discuss the peripersonal space hands act upon as perceived qualitatively different to the extrapersonal space. Observing the actions of others hands offers meaningful cues to the

communicative intent of others, as well being an essential component to tool learning. Within this thesis new progressions were made in understanding the temporal nature, and specificity of relations evident between attention to the hands of others, and measures of communication development. However, as discussed communication evokes multiple domains, in a dynamic and interactive manner. To solely focus upon *seeing* the actions of others then, would limit the discussion of early communication.

To avoid the limitation of focusing upon a single domain, the role of *doing* was examined in the second half of this thesis. Specifically Chapter 6 was concerned with the design and application of a new method, that would allow for a microgenetic study of communicative development across infancy (the continuous unified electronic, CUE, diary method). Following the design and evaluation of the CUE method a microgenetic application of the method allowed for an evaluation of a motor-language network in communication development. This motor-language network focused on the facilitating roles of locomotion and pointing to the emergence of language development.

Taken together, the Chapters within this thesis were intended to address the main of this thesis, namely to extend the understanding of attention and action's role in early communication through the application of microanalytic and microgenetic methods. In the next section of this Chapter I will summarize the main findings of this thesis, along with a discussion of limitations and suggestions for future directions.

### **Summary of main findings**

In the first half of this thesis, an adaptation of this microanalytic coding scheme was developed and applied across infancy. The aim of the adaptation to Bakeman and Adamson's (1984) codes was to extend the application to periods of infancy before prehension skills emerge.



This period of infancy (from birth to around 5-months) encompasses periods of extensive development in perception and attention development. Due to the infant's inability to manipulate and engage with objects manually, at this young age, fine grained measures of attention are needed to examine engagement with social and non-social stimuli. Within Bakeman and Adamson's (1984) original study began examining infant engagement with infants as young as 6-months, when prehension development allowed for more 'active' behaviors to demonstrate differing interests to social and non-social stimuli.

To accommodate younger infants, the third Chapter of this thesis described an adaptation of the onlooking state within the original coding scheme, where onlooking was delaminated into 3 distinct onlooking codes: onlooking mother's face; onlooking mother's hands, and the objects they act upon; and onlooking alternative object, that the mother is not attending to. Applying this adapted microanalytic coding scheme for mother-infant interactions, when infants were 2-months-old, enabled several insights into early communication to be observed. Firstly, during a 10-minute interaction infants were as a group coded as unengaged for 25% of the interaction. Further, infants spent roughly equivalent proportions of the interaction in the 3 onlooking states.

Limitations noted with these findings were related to the benefit that could be gained from naturalistic interactions within the home; the additional information that could be gained through the addition of measures of the effect of the infant; and the increased focus that could be made by layering coding schemes of infant and mothers behaviors (in order to enable analysis of sequential patterns of communication). Future directions for the adaptation to a microanalytic coding scheme of attention included could expand upon the mother-infant interaction dyad, to examine infant engagement in father-infant dyads. Previous research has demonstrated flexibility in the communicative behaviors demonstrated by infants, as well as responses given to social

partners initiating joint attention bids. With the adaptation development the application of the coding scheme, Chapter 4's focus was on the application of this method in order to examine onlooking to mother's face, and onlooking mother's hands differentially predicting aspects of later communication development.

Chapter 4 applied the adapted coding scheme of to determine onlooking mother's hands relation to later attention following, while simultaneously examining onlooking mother's face to later social orienting. The prediction of these specific relations was born out within a longitudinal study, where onlooking behavior at 2-months was regressed onto social attention performance measures at 5-months. These findings lead on from the call to examine social cues in addition to the face that form the foundations of early social attention.

Limitations to the findings discussed within Chapter 4, included the social orienting task at 5-months not being passed at the group level. This may suggest that the task is too challenging for some infants, and that a simpler assessment of social orienting may strengthen the findings. Other limitations within this Chapter may be drawn against the interactions occurring within the context of the First Steps study. As such these findings should be considered as infant onlooking behavior in optimized conditions. Social attention is implicated in the later ability to self-regulate arousal. This study did not incorporate dyadic measures of attachment security, or arousal regulation. Future studies incorporating such measure would enable an extension to the findings on early communication. The examination of the relation between attention to hands during mother-infant interaction, and social attention in later infancy was the focus of Chapter 5.

Distal attention following demonstrates infant's acknowledgement of hands being agents of change at 12 months. The propensity to follow points is a stable preference for hands, demonstrated through the point following predicting onlooking mother's hands at 18 months.

This finding extends previous demonstrations of the importance of point following in successful communication, through the demonstration that following the actions and deictic nature of hands is a propensity that extends across age and context, to inform infants of the objects, actions and events others are engaged with, enabling a shared attention necessary for active communication. Limitations within this Chapter were discussed in terms of other indexes of pointing comprehension offering a more stringent measure, such as the hiding-finding paradigm employed by Tomasello, Carpenter, and Liszkowski (2007). Within the interactions at 18-months it is noteworthy that there was less coordinated joint engagement, and more passive joint engagement, when compared to Bakeman and Adamson (1984). This variation to the original coding scheme may have arisen from the infants being seated in baby chairs within touching distance of their mothers. This fixed proximity may have reduced ambiguity in the actions of the mothers. This level of ambiguity has previously been linked to increased checking back behavior, inherent in coordinated joint engagement.

The yoking of attention to locations near hands may demonstrate several other developmental relations for cornerstones in infant cognition and social cognition. A summary of these relations are now discussed. At a cognitive level, attending to the hands of others may support the perception of object permanence. Likewise, attention to hands determines that we are attending to the actions and outcomes of the change engendered by hands. This change may support the learning of means-end relations. Leading on from this association, a proclivity to attend to the actions of hands may facilitate the emergence of imitation of actions. It is well documented that imitation and creativity are benchmarks required for the acquisition of tool-use, and development.

The findings contained within this thesis call for an examination of whether there is a deficit in the propensity to attend to hands early on in development that, in children later diagnosed with

autism contributes to their communicative deficits. Children with William's Syndrome are characterized by a preoccupation with the faces of others, that does not advance their social attention development but impairs it, as their prioritizing of faces above other stimuli road blocks their ability to attend to other stimuli needed to progress to shared attention. Again, the finding of attention to hands contributing to later social attention should be extended in future work to establish whether the social stimuli of hands is ignored in those with William's Syndrome.

In both cases of atypical development a massive amount of research has focused on identifying and intervening in deficits in attention to faces. Extending the work of this thesis with atypical populations described above could enable a new branch of intervention strategies aimed at improving social attention attainment in these children.

In the latter part of this thesis, the continuous unified electronic (CUE) diary method was designed and applied, in the study of communication across domains of development through infancy. The CUE methodology was designed for mothers to be trained to electronically record behaviors they were trained to observe. The tracking of infant development in a microgenetic, multi-domain, context driven manner was shown to be effective, valid and reliable. Developing an electronic diary method enables the benefits seen within the areas of health studies to be reaped within developmental psychology. Not only does the CUE Diary Method enable extensive contextual information, there is reduced skew inevitably generated by sampling schedules that occur in traditional developmental methodologies. Gaining such fine grained information on the age and context in which developmental milestones emerge will allow for an expansive re-examining of previously held views on the interrelation of communicative development.

Future studies that could apply the diary method, include those that would extend reporters beyond mothers, used within this thesis. Fathers, for example, may be compared to mothers in their reporting, as well as support, of communicative development.

With the CUE Diary Method developed and applied in the developmental setting, the opportunity now exists to extend the application of the CUE Diary Method to be incorporated into large scale studies with sufficient sample sized to allow for multilevel analysis, including multi-level mediated moderation models, and SEM for example. Such sample sizes and analyses would allow for a deeper exploration of mechanisms involved in development. With the CUE Diary Method offering up information on the multiple modalities implicated in communication development, an extension could be to incorporate the CUE Diary Method into the diagnostic process for developmental disorders. To extend this application, future work may incorporate video or images into entries, in order to build up multiple modes of data within the method.

Chapter 7 employed the CUE diary method in a longitudinal design, in order to examine whether a motor-language network would be evident. Specifically, the emergence of walking and pointing were predicted to contribute to a model that would predict later language. Interaction models, where the drive to engage with others facilitates motor development, as well as language development. In addition, walking was hypothesized to predict language through the changes noted by previous research (see Campos, 2000; Karasik et al. 2010, 2011), where mother and infant behaviors change following the onset of walking. These changes manifest with parents cognizing that their infant's actions are intentional in nature. From the infant's behavior, infants engage with social partners, by increasing their movement behaviors when sharing objects. From this association it was also predicted that the earlier demonstration of social object use, showing objects, would predict the emergence of walking.

Applying the CUE methodology to the study of engagement with others, as a form of communication, demonstrated that showing objects to others predicted the age at which an infant begins to walk independently. Furthermore, a motor-language network was demonstrated, where pointing and walking contributed to a predictive model of later language production. The motor-language association demonstrated a degree of specificity, with the motor developments of crawling and standing failing to show a significant association with later language. This null finding was in keeping with the prediction that only motor behaviors that are likely to alter infant social object use, and mother's changes in attributing intentional action to their infants, will predict later language. It is noteworthy that changes in parent's cognitions, or the labeling behaviors changes to assigning intention may bring, were not directly evaluated in this Chapter. Further research is needed, to directly evaluate mother's cognitions and behavior during interactions during the transition of infant's walking. The nature of the CUE diary method enables future research to examine data on the context in which infants make their first point, and walk their first step. Data such as this, allows for questions into examining the role of social partners encouragement, and varying roles of mothers, fathers and siblings. Examining the roles, and mechanisms through which interactions alter with motor achievements, and how these changes impact on communication.

## **Conclusion**

Developmental methods play a pivotal role in advancing theory, knowledge and policy practices. Designing and applying a new coding scheme for visual attention in early infancy has yielded new insights about the role of visual attention to hands and faces in early communication. The CUE diary method has opened up the way in which developmental psychology may design, collect, and analyze relations in infant development, across domains.

Both advances have highlighted the need for microanalytic and microgenetic methods, applied in longitudinal designs, in order to capture the development of communication.

## Appendices

### Appendix A

## FIRST STEPS HANDBOOK

### Introduction

By now we will have met with you and will have given you your own Palm. We will have tried our best to explain how to use it, and what we expect from you and your baby during this First Steps study. Since our meeting, your bundle of joy will have arrived and everything will have suddenly become very hectic and disorganized! With all this commotion, it would be highly unusual if you remembered everything that we have told you. This guide is meant to refresh your memory and provide some useful hints and tips.

### What is expected of me?

We would like you to complete the brief set of questions on your Palm as soon as your infant performs any of the new behaviours that we are interested in. Please note that we would like you to record only the first *three* times that your infant performs each behaviour. Examples of the behaviours that we are interested in are: when your infant copies your actions, sounds, facial expressions, gestures, uses objects, and when your infant reaches specific motor milestones. The sooner the questions are completed after your infant has performed a behaviour the better. This helps to ensure that you are able to provide the richest description of what has happened. The information that you provide us with, by answering these questions, will form the basis of a “memory book” which we will give you as a gift at the end of the study. This “memory book” will contain details about your baby’s firsts... the first time your baby walked, talked, and copied you. Therefore, the more details that you can remember, the better equipped we will be to try and preserve the memories of your baby’s firsts in the “memory book”. It will also help ensure that the data that we gather is as accurate as possible.

We would like to meet with you once a month for brunch, on a Friday at Café Junior. Other mothers and their babies who are taking part in the First Steps study will also be there. This will give you the chance to socialize with other mums who have babies of a similar age and enjoy a change in scenery. During this meeting we will have a chat with you and check that you have not encountered any problems. We will download the information that you have been recording for us from your Palm onto our computer. During this session we



will also want to see how your infant responds to certain things, for example, their reactions to faces, sounds, toys, and actions such as grasping, sitting up, and walking. These meetings will last between one to two hours and they are critical to the study, so please try your very best to make these meetings. At every third meeting, we will give you a “what to expect sheet” detailing which specific behaviours we want you to look out for over the following months. We will also give you a toy or book for your child, and a £25 gift voucher to thank you for helping us.

We will phone you once a week to have a chat and see if everything is going okay. During our call we will discuss how you are finding things and whether you have encountered any problems. We will also remind you when your next meeting will take place at Café Junior. However, if you encounter any problems before this weekly phone call, please contact us. To maximize consistency for you, we are going to pair you with a key researcher. Therefore, the person who initially starts corresponding with you will be the person who continues to keep in touch with you over the course of the study. This will be the person you should contact if you encounter any problems or have any questions.

### **How do I use the Palm pilot?**

Before your baby arrives it is a good idea to practise using your Palm. It would be useful to practise writing using the touch screen. The fastest and easiest way to write on the Palm is to use the touchscreen keyboard. To access the keyboard, tap on the ABC icon on the bottom left of the screen. This will allow you to complete text response questions using a keyboard that will appear on the touch screen. Simply tap a letter to insert it in your entry.

Alternately you can write using strokes on the graffiti pad at the bottom of the screen. Each letter of the alphabet is assigned a specific stroke. Most of these strokes are the same as you would use when writing normally but there are a few tricky ones. There is a very useful sticker on the back of your Palm illustrating the different strokes required to write each letter of the alphabet, punctuation, and numbers. This guide (see page 7) states whether you should perform the strokes on the left or the right graffiti pad. Please note that letters and the most common types of punctuation need to be written on the left graffiti pad (eg . , ? “ ”). Numbers and the more complex forms of punctuation (eg / \ ( )) need to be written on the right graffiti pad. This guide also illustrates which strokes will create a space between words, and which will delete a single letter. A space can be created between words by making a forward horizontal stroke on the left graffiti pad, whereas, you can delete a single letter by making a backward stroke on the left graffiti pad.

It would also be a good idea to practise recording behaviours on your Palm. For instance, if you have another child you could complete the brief series of questions based on behaviours that he or she exhibits, or alternatively, note behaviour that your partner performs. Practice recording behaviours on the Palm will give you an impression of what details to look out for when your baby performs a behaviour. It will also allow you to identify any problems that you may encounter, so that they can be rectified before your baby arrives. If you practise completing these questions before your baby arrives, please note down on the final question ("If you feel you have made any mistakes in completing this questionnaire, or you would like to change anything, please note it here.") that it is a practice.

To record what behaviour your infant has performed, please turn the palm on, and tap the "esp" icon on the main menu. This will start a brief series of questions that will help you to recall the specific details of your infant's behaviour. There are three different types of questions that you will be asked; button response questions, pop-up response questions, and text response questions. With button response questions, you just need to tap the button on the touch screen that seems most relevant. With pop-up response questions, you need to tap on "click to choose a response" on the touch screen. This will display a pop-up menu where you can tap on the response that is most relevant. Once you have done this, you will need to tap on the "done" button in the bottom left corner of the touch screen. With text response questions, you may need to refer to the stroke guide on the back of your Palm. Use the left graffiti pad, or keyboard, to write your brief text response. Text response questions are limited to just 120 characters. When you have finished writing, tap the "done" button in the bottom left corner of the touch screen.

It is important that you complete all questions until the screen reads "Questionnaire completed. Thank you". Unless you answer all the questions the Palm will not save what you have recorded. Once the questionnaire is complete you can exit by tapping on the clock icon in the bottom left graffiti pad. This will bring up a screen which will have the option "go to clock". Tap on "go to clock" and once you are in the clock, tap on the home icon on the left graffiti pad. This will bring you back to the main menu. Once on the main menu, you can safely turn the Palm off.

### **Looking after my Palm**

Please charge your Palm every evening. This will ensure that the battery will not run out at a crucial time when your infant is performing a behaviour, or achieving a milestone for the first time.

It is very important that you do not use the memo function on the Palm as it will interfere with the questions that are programmed into the Palm, and these questions are vital to the experiment.

You are free to use the diary and contacts applications, but we ask that you not put photographs on the Palm. Storing photographs puts a high demand on the Palm's limited memory and could mean that there is no memory left for you to record the behaviours your infant performs - we would miss out on information about some of the crucial steps in your child's development.

Please do not connect your Palm to a computer. Your Palm is set to be synchronised to one of our computers. If you connect your Palm to another computer during the course of the study it may confuse the Palm. This could result in the information that you have recorded being erased, and the questionnaire that is programmed into the Palm being altered.

Try your best to keep your Palm away from water and out of direct sunlight. However, accidents do happen, especially when your infant becomes mobile and likes to hide or drop things. Please let us know as soon as possible if anything happens to your Palm.

### **Troubleshooting with the Palm Pilot**

Once you have started filling in the series of questions, please try your best to complete them. There is purposely no direct exit button as we want to encourage people to complete all the questions. However, if you have made a mistake, you can exit the questionnaire relatively quickly, without affecting the information that you have already recorded. Simply selecting "done" for responses to the text entry questions without writing an answer, and by selecting any of the button or pop-up answers. If you use this method it is *vital* that you complete the final question. This final question asks you whether you feel you have made any mistakes in completing the questionnaire. Please note down what mistake you have made. This final question will allow us to identify that the information you have entered is incorrect and that we should disregard it.

If you encounter any problems that prevent you from recording your infant's behaviour on your Palm, please contact us as soon as possible and do not wait for our next meeting. We will try our best to sort problems out as quickly as possible.

Our goals can be summarised in two steps.

- 1) Observing your baby. You can help us by observing your baby's behaviour closely. Most parents find this comes quite naturally!
- 2) Telling us about your baby. Please record each observation of your baby's behaviour in your Palm diary as soon as possible after you observe it. Please provide us with as much detail as you can. Doing so will help us understand the details of what your baby did, where it happened, and how it happened. It will also help to create a more rewarding "memory book" for you at the end of our study!

The first two questions ask you to provide a general description of what happened, and where it happened. Your answers don't need to be long, but they should provide a recognisable summary of the behaviour. You might want to think of the first two questions as a snapshot memory for your memory book.

**DIARY TIP:** Each text entry has a limit of 120 characters. This is about one long sentence or two short sentences.

After telling us about what happened and the context where it happened, you will be asked whether the behaviour you are recording was communicative, imitative, or motoric. On the following pages we provide information about questions within each of those categories.

**DIARY TIP:** You may find it easier and faster to use the touchscreen keyboard for text entry. Just tap on the ABC icon to access the keyboard.

## MOTORIC BEHAVIOURS

### **Which behaviour?**

To make diary records easier and faster for you, we have divided the motoric behaviours we would like you to record into two questions. First you need to choose whether the movement involved the hands and arms or the legs or whole body. Then you need to choose the specific behaviour from a list.

#### *Hand/arm movement*

- palmar grasp
- picked up small objects
- reached for object when lying on front
- reached for object when sitting
- turned multiple pages of a book
- pincer grip
- scribbled spontaneously
- put object in container spontaneously

#### *Leg/whole body movement*

- started crawling
- turned from lying on side to lying on back
- stands unsupported
- took first steps
- climbed stairs

**DIARY TIP:** We will provide you with more detailed information about key motoric behaviours in the “What to Expect” sheets. You only need to watch for a particular motoric behaviour once it has been presented in one of your “What to Expect” sheets.

***Was the behaviour copied?***

If you or someone else modelled the behaviour for your baby, and your baby’s behaviour followed closely after, your baby may have copied the behaviour. This is going to make more sense with some behaviours than others. For instance, even though your baby may have seen you walking just before taking his or her first steps, you would not consider those first steps to be copied.

***What else was involved in the behaviour?***

In the following questions we will ask you to provide details about whether you assisted or encouraged your baby, how many times your baby has performed this behaviour, and whether any objects were involved. We are only asking you to record a behaviour the first three times your infant does it. If you cannot remember how many times your baby did the recorded behaviour, make your best guess. We can check this against the previous diary entries.

## Appendix C

### **What to expect from your baby girl from birth to 3 months**

#### **Motoric Development**

From birth your daughter will most likely be able to grasp a finger (surprisingly strongly!) when her palm is touched. She will probably show signs of rooting and sucking. If her cheek is touched at the corner of her mouth, she may turn to that side and try to suck the finger.

By the first month, although your daughter's eyesight is still in the initial stages of development, for a short time she will probably be able to follow with her eyes a large object that is moving on a slow and predictable path.

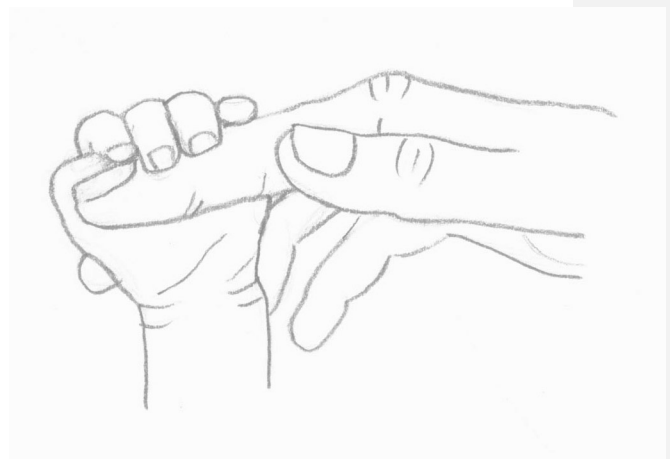
Your daughter may start to show an interest in her hands. She may start to inspect her hands, bringing them in front of her face, and later play with them (flexing and unflexing her fingers). This is often referred to as "Finger Play". At around 3 months, she may even start trying to pick up small objects, such as a cube.

When lying on her front, or back, her position may gradually loosen, changing from being in a tightly curled up foetal position, with knees and arms tucked in towards her body, to stretching out with legs and arms extended, or with arms gently relaxed by the side of her body.

Over the course of the first 3 months, the muscles in your daughter's neck and back will likely strengthen. She may become able to roll from lying on the side to lying on the back. She may be able to sit up whilst being held, and gradually be able to hold the head and chin steady, unsupported, for several seconds.

#### **Developmental Milestones**

*Palmar grasp - object or finger is held in palm with a strong grasp*



## References

- Adamson, L. B., Bakeman, R., Deckner, D. F., & Nelson, P. B. (2012). Rating Parent–Child Interactions: Joint Engagement, Communication Dynamics, and Shared Topics in Autism, Down Syndrome, and Typical Development. *Journal of Autism and Developmental Disorders*, 1-14.
- Adolph, K. E. (1997). Learning in the development of infant locomotion. *Monographs of the Society for Research in Child Development*, 62(3), I-VI, 1-158.
- Adolph, K. E. (2008). Learning to Move. *Current directions in psychological science : a journal of the American Psychological Society*, 17(3), 213-218. doi: 10.1111/j.1467-8721.2008.00577.x
- Adolph, K. E., & Robinson, S. R. (2008). In defense of change processes. *Child Development*, 79(6), 1648-1653. doi: CDEV1215 [pii] 10.1111/j.1467-8624.2008.01215.x
- Adolph, K. E., Robinson, S. R., Young, J. W., & Gill-Alvarez, F. (2008). What is the shape of developmental change? *Psychological Review*, Vol.115(3), pp.
- Adolph, K. E., Tamis-Lemonda, C. S., & Karasik, L. B. (2010). Cinderella indeed - a commentary on Iverson's 'Developing language in a developing body: the relationship between motor development and language development'. *Journal of Child Language*, 37(2), 269-273. doi: S030500090999047X [pii] 10.1017/S030500090999047X
- Ainsworth, M. S. (1979). Infant–mother attachment. *American Psychologist*, 34(10), 932.



- Akhtar, N., & Gernsbacher, M. A. (2008). On Privileging the Role of Gaze in Infant Social Cognition. *Child Development Perspectives*, 2(2), 59-65.
- Alcock, K. J., & Krawczyk, K. (2010). Individual differences in language development: relationship with motor skill at 21 months. *Developmental Science*, 13(5), 677-691. doi: 10.1111/j.1467-7687.2009.00924.x
- Alcock, K. J., Passingham, R. E., Watkins, K. E., & Vargha-Khadem, F. (2000). Oral dyspraxia in inherited speech and language impairment and acquired dysphasia. *Brain and Language*, 75(1), 17-33. doi: DOI 10.1006/brln.2000.2322
- Alpers, G. W. (2009). Ambulatory Assessment in Panic Disorder and Specific Phobia. *Psychological Assessment*, 21(4), 476-485. doi: Doi 10.1037/A0017489
- Amano, S., Kezuka, E., & Yamamoto, A. (2004). Infant shifting attention from an adult's face to an adult's hand: a precursor of joint attention. *Infant Behavior & Development*, 27(1), 64-80. doi: DOI 10.1016/j.infbeh.2003.06.005
- Anderson, D. I., Campos, J. J., Anderson, D. E., Thomas, T. D., Witherington, D. C., Uchiyama, I., & Barbu-Roth, M. A. (2001). The flip side of perception-action coupling: locomotor experience and the ontogeny of visual-postural coupling. *Human movement science*, 20(4-5), 461-487. doi: S0167-9457(01)00063-X [pii]
- Axelsson, E. L., Churchley, K., & Horst, J. S. (2012). The right thing at the right time: why ostensive naming facilitates word learning. *Frontiers in psychology*, 3, 88. doi: 10.3389/fpsyg.2012.00088
- Bakeman, R. (1983). Theory and Practice of Observing Behavior - Fassnacht, G. *Contemporary Psychology*, 28(8), 589-590.

- Bakeman, R., & Adamson, L. B. (1984). COORDINATING ATTENTION TO PEOPLE AND OBJECTS IN MOTHER-INFANT AND PEER-INFANT INTERACTION. *Child Development*, 55(4), 1278-1289.
- Barbaro, J., & Dissanayake, C. (2010). Prospective identification of autism spectrum disorders in infancy and toddlerhood using developmental surveillance: the social attention and communication study. *Journal of developmental and behavioral pediatrics : JDBP*, 31(5), 376-385. doi: 10.1097/DBP.0b013e3181df7f3c
- Barrett, L. F., & Barrett, D. J. (2005). ESP, the experience sampling program. Retrieved March, 1, 2007.
- Bates, E., & Dick, F. (2002). Language, gesture, and the developing brain. *Developmental Psychobiology*, 40(3), 293-310. doi: 10.1002/dev.10034
- Bayley, N. (1969). Bayley Scales of Infant and Toddler Development® 3rd Edition (Bayley-III®).
- Bayliss, A. P., Bartlett, J., Naughtin, C. K., & Kritikos, A. (2011). A direct link between gaze perception and social attention. *Journal of experimental psychology. Human perception and performance*, 37(3), 634-644. doi: 2010-22330-001 [pii] 10.1037/a0020559
- Beebe, B., Lachmann, F. M., Markese, S., Buck, K. A., Bahrnick, L. E., Chen, H. N., . . . Jaffe, J. (2012). On the Origins of Disorganized Attachment and Internal Working Models: Paper II. An Empirical Microanalysis of 4-Month Mother-Infant Interaction. *Psychoanalytic Dialogues*, 22(3), 352-374. doi: 10.1080/10481885.2012.679606

- Biringen, Z., Emde, R. N., Campos, J. J., & Appelbaum, M. I. (1995). Affective Reorganization in the Infant, the Mother and the Dyad - the Role of Upright Locomotion and Its Timing (Vol 66, Pg 499, 1995). *Child Development*, 66(4), Cp2-Cp2.
- Birmingham, E., & Kingstone, A. (2009). Human social attention. *Attention*, 176, 309-320. doi: Doi 10.1016/S0079-6123(09)17618-5
- Bodnarchuk, J. L., & Eaton, W. O. (2004). Can parent reports be trusted?: Validity of daily checklists of gross motor milestone attainment. *Journal of Applied Developmental Psychology*, 25(4), 481-490.
- Bolger, N., Davis, A., & Rafaeli, E. (2003). Diary methods: Capturing life as it is lived. *Annual Review of Psychology*, 54(1), 579-616.
- Bornstein, M. H. (1985). How infant and mother jointly contribute to developing cognitive competence in the child. *Proceedings of the National Academy of Sciences of the United States of America*, 82(21), 7470-7473.
- Brody, S., Axelrad, S., Horn, E., Moroh, M., & Taylor, M. (1978). *Mothers, fathers, and children: Explorations in the formation of character in the first seven years*: International Universities Press New York.
- Brooks, R., & Meltzoff, A. N. (2008). Infant gaze following and pointing predict accelerated vocabulary growth through two years of age: a longitudinal, growth curve modeling study. *Journal of Child Language*, 35(01), 207-220.
- Bruner, J. S. (1975). From communication to language—a psychological perspective. *Cognition*, 3(3), 255-287.
- Bushnell, E. W., & Boudreau, J. P. (1993). Motor development and the mind: the potential role of motor abilities as a determinant of aspects of perceptual development. *Child Development*, 64(4), 1005-1021.

- Butterworth, G., Verweij, E., & Hopkins, B. (2011). The development of prehension in infants: Halverson revisited. *British Journal of Developmental Psychology*, *15*(2), 223-236.
- Campos, J. J., Anderson, D. I., Barbu-Roth, M. A., Hubbard, E. M., Hertenstein, M. J., & Witherington, D. (2000). Travel Broadens the Mind. *Infancy*, *1*(2), 149-219. doi: Doi 10.1207/S15327078in0102\_1
- Carpendale, J. I. M., & Carpendale, A. B. (2010). The Development of Pointing: From Personal Directedness to Interpersonal Direction. *Human Development*, *53*(3), 110-126. doi: 10.1159/000315168
- Carpenter, M., Nagell, K., & Tomasello, M. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development*, *63*(4), V-143.
- Chevallier, C., Kohls, G., Troiani, V., Brodtkin, E. S., & Schultz, R. T. (2012). The social motivation theory of autism. *Trends in Cognitive Sciences*.
- Clearfield, M. W. (2004). The role of crawling and walking experience in infant spatial memory. *Journal of Experimental Child Psychology*, *89*(3), 214-241. doi: S0022-0965(04)00109-2 [pii] 10.1016/j.jecp.2004.07.003
- Clifford, S. M., & Dissanayake, C. (2008). The early development of joint attention in infants with autistic disorder using home video observations and parental interview. *Journal of Autism and Developmental Disorders*, *38*(5), 791-805. doi: 10.1007/s10803-007-0444-7
- Cobo-Lewis, A. B., Oller, D. K., Lynch, M. P., & Levine, S. L. (1996). Relations of motor and vocal milestones in typically developing infants and infants with

- Down syndrome. *American journal of mental retardation : AJMR*, 100(5), 456-467.
- Collins, W. A., Maccoby, E. E., Steinberg, L., Hetherington, E. M., & Bornstein, M. H. (2000). Contemporary research on parenting. The case for nature and nurture. *The American psychologist*, 55(2), 218-232.
- Collins, W. A., Maccoby, E. E., Steinberg, L., Hetherington, E. M., & Bornstein, M. H. (2001). Toward nature with nurture. *The American psychologist*, 56(2), 171-173.
- Conner, T. S. (2008). Ambulatory assessment at the interface of psychology and genetics: An illustration with the serotonin transporter gene. *International Journal of Psychology*, 43(3-4), 194-194.
- Cronbach, L. J. (1957). The 2 Disciplines of Scientific Psychology. *American Psychologist*, 12(5), 671-684.
- Danis, A., Bourdais, C., & Ruel, J. (2000). The co-construction of joint action between mothers and 2-4-month-old infants: The mother's role. *Infant and Child Development*, 9(4), 181-198.
- Danziger, K. (2000). Psychological knowledge: A social history and philosophy. *Journal of the History of the Behavioral Sciences*, 36(3), 269-270.
- Davoli, C. C., Brockmole, J. R., Du, F., & Abrams, R. A. (2012). Switching between global and local scopes of attention is resisted near the hands. *Visual Cognition*, 20(6), 659-668.
- Davoli, C. C., Brockmole, J. R., & Goujon, A. (2012). A bias to detail: How hand position modulates visual learning and visual memory. *Memory & Cognition*, 1-8.

- Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., & Liaw, J. (2004). Early social attention impairments in autism: Social orienting, joint attention, and attention to distress. *Developmental Psychology, 40*(2), 271-283. doi: Doi 10.1037/0012-1649.40.2.271
- De Schuymer, L., De Groote, I., Beyers, W., Striano, T., & Roeyers, H. (2011). Preverbal skills as mediators for language outcome in preterm and full term children. *Early Human Development, 87*(4), 265-272.
- Dekker, Marielle C., Nunn, Russell J., Einfeld, Stewart E., Tonge, Bruce J., & Koot, Hans M. (2002). Assessing Emotional and Behavioral Problems in Children with Intellectual Disability: Revisiting the Factor Structure of the Developmental Behavior Checklist. *Journal of Autism and Developmental Disorders, 32*(6), 601-610. doi: 10.1023/a:1021263216093
- Depue, R. A., & Collins, P. F. (1999). Neurobiology of the structure of personality: Dopamine, facilitation of incentive motivation, and extraversion. *Behavioral and Brain Sciences, 22*(3), 491-517.
- Diamond, A. (2000). Close interrelation of motor development and cognitive development and of the cerebellum and prefrontal cortex. *Child Development, 71*(1), 44-56.
- Dunn, W. (1990). Establishing inter-rater reliability on a criterion-referenced developmental checklist. *Occupational Therapy Journal of Research, 10*(6), 377-380.
- Ebner-Priemer, U. W., & Sawitzki, G. (2007). Ambulatory assessment of affective instability in borderline personality disorder - The effect of the sampling frequency. *European Journal of Psychological Assessment, 23*(4), 238-247. doi: Doi 10.1027/1015-5759.23.4.238

- Ebner-Priemer, U. W., & Trull, T. J. (2009). Ambulatory Assessment An Innovative and Promising Approach for Clinical Psychology. *European Psychologist, 14*(2), 109-119. doi: Doi 10.1027/1016-9040.14.2.109
- Emde, R. N., Gaensbauer, T. J., & Harmon, R. J. (1976). Emotional expression in infancy; a biobehavioral study. *Psychological Issues, 10*(01), 1.
- Emery, N. J. (2000). The eyes have it: the neuroethology, function and evolution of social gaze. *Neuroscience and Biobehavioral Reviews, 24*(6), 581-604. doi: 10.1016/s0149-7634(00)00025-7
- Fais, L., Werker, J., Cass, B., Leibowich, J., Barbosa, A., & Vatikiotis-Bateson, E. . (2012). Here's looking at you, baby: What gaze and movement reveal about minimal pair word-object association at 14 months *Laboratory Phonology, 3*(1), 91–124.
- Falck-Ytter, T., Fernell, E., Hedvall, Å L., von Hofsten, C., & Gillberg, C. (2012). Gaze Performance in Children with Autism Spectrum Disorder when Observing Communicative Actions. *Journal of Autism and Developmental Disorders, 1-10*.
- Fantz, R. L. (1964). Visual experience in infants: Decreased attention to familiar patterns relative to novel ones. *Science, 146*(3644), 668-670.
- Farroni, T., Csibra, G., Simion, G., & Johnson, M. H. (2002). Eye contact detection in humans from birth. *Proceedings of the National Academy of Sciences of the United States of America, 99*(14), 9602-9605. doi: DOI 10.1073/pnas.152159999
- Feldman, R. (2012). Bio-behavioral synchrony: A model for integrating biological and microsocial behavioral processes in the study of parenting. *Parenting, 12*(2-3), 154-164.

- Fenson, L., Pethick, S., Renda, C., Cox, J. L., Dale, P. S., & Reznick, J. S. (2000). Short-form versions of the MacArthur Communicative Development Inventories. *Applied Psycholinguistics*, *21*(1), 95-115.
- Fischer, M. H., & Zwaan, R. A. (2008). Embodied language: A review of the role of the motor system in language comprehension. *Quarterly Journal of Experimental Psychology*, *61*(6), 825-850. doi: Doi 10.1080/17470210701623605
- Fogel, A. (1995). Development and Relationships - a Dynamic-Model of Communication. *Advances in the Study of Behavior*, *Vol 24*, *24*, 259-290. doi: Doi 10.1016/S0065-3454(08)60396-4
- Fogel, A., de Koeper, I., Secrist, C., & Nagy, R. (2002). Dynamic systems theory places the scientist in the system. *Behavioral and Brain Sciences*, *25*(5), 623-+.
- Fogel, A., & Thelen, E. (1987). Development of Early Expressive and Communicative Action - Reinterpreting the Evidence from a Dynamic-Systems Perspective. *Developmental Psychology*, *23*(6), 747-761. doi: Doi 10.1037//0012-1649.23.6.747
- Forssberg, H. (1999). Neural control of human motor development. *Current Opinion in Neurobiology*, *9*(6), 676-682.
- Fox, R., & McDaniel, C. (1982). The Perception of Biological Motion by Human Infants. *Science*, *218*(4571), 486-487.
- Frischen, A., Bayliss, A. P., & Tipper, S. P. (2007). Gaze cueing of attention: visual attention, social cognition, and individual differences. *Psychological Bulletin*, *133*(4), 694-724. doi: 2007-09203-007 [pii] 10.1037/0033-2909.133.4.694



- Gartstein, M. A., & Rothbart, M. K. (2003). Studying infant temperament via the Revised Infant Behavior Questionnaire. *Infant Behavior & Development*, 26(1), 64-86. doi: Pii S0163-6383(02)00169-8
- Gentilucci, M., & Corballis, M. C. (2006). From manual gesture to speech: A gradual transition. *Neuroscience and biobehavioral reviews*, 30(7), 949-960. doi: 10.1016/j.neubiorev.2006.02.004
- Gernsbacher, M. A., Sauer, E. A., Geye, H. M., Schweigert, E. K., & Hill Goldsmith, H. (2008). Infant and toddler oral- and manual-motor skills predict later speech fluency in autism. *Journal of child psychology and psychiatry, and allied disciplines*, 49(1), 43-50. doi: JCPP1820 [pii] 10.1111/j.1469-7610.2007.01820.x
- Gewirtz, J. L., & Pelaez-Nogueras, M. (2000). Infant emotions under the positive-reinforcer control of caregiver attention and touch. *Issues in Experimental and Applied Analyses of Human Behavior*, 271-291.
- Goldin-Meadow, S. (2006). Talking and thinking with our hands. *Current Directions in Psychological Science*, 15(1), 34-39.
- Golombok, S., Tasker, F., & Murray, C. (2006). Children raised in fatherless families from infancy: Family relationships and the socioemotional development of children of lesbian and single heterosexual mothers. *Journal of Child Psychology and Psychiatry*, 38(7), 783-791.
- Goodwyn, S. W., Acredolo, L. P., & Brown, C. A. (2000). Impact of symbolic gesturing on early language development. *Journal of Nonverbal Behavior*, 24(2), 81-103.
- Graziano, M. S. A., & Gross, C. G. (1998). Spatial maps for the control of movement. *Current Opinion in Neurobiology*, 8(2), 195-201.

- Green, A. S., Rafaeli, E., Bolger, N., ShROUT, P. E., & Reis, H. T. (2006). Paper or plastic? Data equivalence in paper and electronic diaries. *Psychological methods*, *11*(1), 87-105. doi: 10.1037/1082-989X.11.1.87
- Grossberg, S., & Vladusich, T. (2010). How do children learn to follow gaze, share joint attention, imitate their teachers, and use tools during social interactions? *Neural Networks*, *23*(8-9), 940-965. doi: 10.1016/j.neunet.2010.07.011
- Hicks, T. P., & Onodera, S. (2012). The mammalian red nucleus and its role in motor systems, including the emergence of bipedalism and language. *Progress in neurobiology*, *96*(2), 165-175. doi: S0301-0082(11)00225-5 [pii]  
10.1016/j.pneurobio.2011.12.002
- Hill, E. L. (1998). A dyspraxic deficit in specific language impairment and developmental coordination disorder? Evidence from hand and arm movements. *Developmental Medicine and Child Neurology*, *40*(6), 388-395.
- Hill, E. L. (2001). Non-specific nature of specific language impairment: a review of the literature with regard to concomitant motor impairments. *International journal of language & communication disorders / Royal College of Speech & Language Therapists*, *36*(2), 149-171.
- Hill, E. L. (2010a). The importance of motor skill in general development. *Developmental Medicine and Child Neurology*, *52*(10), 888. doi: 10.1111/j.1469-8749.2010.03700.x  
DMCN3700 [pii]
- Hill, E. L. (2010b). Motor difficulties in specific language impairment: evidence for the Iverson account? - a commentary on Iverson's 'Developing language in a developing body: the relationship between motor development and language

- development'. *Journal of Child Language*, 37(2), 287-292. doi:  
S0305000909990444 [pii]  
10.1017/S0305000909990444
- Holmes, Allison, & Teti, Douglas M. (2008). Developmental Science and the  
Experimental Method *Handbook of Research Methods in Developmental  
Science* (pp. 15-80): Blackwell Publishing Ltd.
- Hsu, Hui-Chin, & Fogel, Alan. (2001). Infant Vocal Development in a Dynamic  
Mother-Infant Communication System. *Infancy*, 2(1), 87-109. doi:  
10.1207/s15327078in0201\_6
- Hufford, M. R., & Shields, A. L. (2002). Electronic diaries. *Applied Clinical Trials*,  
11(4), 46-52.
- Hufford, M. R., Stone, A. A., & Shiffman, S. (2002). Patient compliance with paper  
diaries. *Gastroenterology*, 122(4), A466-A466.
- Iriki, A., & Taoka, M. (2012). Triadic (ecological, neural, cognitive) niche  
construction: a scenario of human brain evolution extrapolating tool use and  
language from the control of reaching actions. *Philosophical Transactions of  
the Royal Society B-Biological Sciences*, 367(1585), 10-23. doi: DOI  
10.1098/rstb.2011.0190
- Itier, Roxane J., & Batty, Magali. (2009). Neural bases of eye and gaze processing:  
The core of social cognition. *Neuroscience & Biobehavioral Reviews*,  
33(6), 843-863. doi: 10.1016/j.neubiorev.2009.02.004
- Iverson, J. M. (2010a). Developing language in a developing body: the relationship  
between motor development and language development. *Journal of Child  
Language*, 37(2), 229-261. doi: S0305000909990432 [pii]  
10.1017/S0305000909990432

- Iverson, J. M. (2010b). Multimodality in infancy: vocal-motor and speech-gesture coordinations in typical and atypical development. *Enfance; psychologie, pedagogie, neuropsychiatrie, sociologie*, 2010(3), 257-274. doi: 10.4074/S0013754510003046
- Iverson, J. M., & Braddock, B. A. (2011). Gesture and motor skill in relation to language in children with language impairment. *Journal of speech, language, and hearing research : JSLHR*, 54(1), 72-86. doi: 1092-4388\_2010\_08-0197 [pii]  
10.1044/1092-4388(2010/08-0197)
- Iverson, J. M., & Goldin-Meadow, S. (2005). Gesture paves the way for language development. *Psychological science : a journal of the American Psychological Society / APS*, 16(5), 367-371. doi: PSCI1542 [pii]  
10.1111/j.0956-7976.2005.01542.x
- Iverson, J. M., & Wozniak, R. H. (2007). Variation in vocal-motor development in infant siblings of children with autism. *Journal of Autism and Developmental Disorders*, 37(1), 158-170. doi: 10.1007/s10803-006-0339-z
- Johansson, Gunnar. (1973). Visual perception of biological motion and a model for its analysis. *Attention, Perception, & Psychophysics*, 14(2), 201-211. doi: 10.3758/bf03212378
- Johnson, Mark H., Dziurawiec, Suzanne, Ellis, Hadyn, & Morton, John. (1991). Newborns' preferential tracking of face-like stimuli and its subsequent decline. *Cognition*, 40(1-2), 1-19. doi: 10.1016/0010-0277(91)90045-6
- Kamm, K., Thelen, E., & Jensen, J. L. (1990). A dynamical systems approach to motor development. *Physical therapy*, 70(12), 763-775.

- Karasik, L. B., Adolph, K. E., Tamis-LeMonda, C. S., & Zuckerman, A. L. (2011). Carry on: Spontaneous object carrying in 13-month-old crawling and walking infants. *Developmental Psychology*. doi: 2011-25888-001 [pii] 10.1037/a0026040
- Karasik, L. B., Tamis-LeMonda, C. S., & Adolph, K. E. (2011). Transition from crawling to walking and infants' actions with objects and people. *Child Development*, 82(4), 1199-1209. doi: 10.1111/j.1467-8624.2011.01595.x
- Kaye, K. (1982). *The mental and social life of babies: how parents create persons*. Cambridge: The Harvester Press.
- Kaye, K., & Fogel, A. (1980). The Temporal Structure of Face-to-Face Communication between Mothers and Infants. *Developmental Psychology*, 16(5), 454-464.
- Keller, H. (2003). Socialization for competence: Cultural models of infancy. *Human Development*, 46(5), 288-311.
- Kobayashi, H., & Kohshima, S. (2001). Evolution of the human eye as a device for communication. *Primate origins of human cognition and behavior*. Springer, Tokyo, 383-401.
- Kopp, Claire B. (2002). Commentary: The Codevelopments of Attention and Emotion Regulation. *Infancy*, 3(2), 199-208. doi: 10.1207/s15327078in0302\_5
- Kuhlmeier, Valerie A., Troje, Nikolaus F., & Lee, Vivian. (2010). Young Infants Detect the Direction of Biological Motion in Point-Light Displays. *Infancy*, 15(1), 83-93. doi: 10.1111/j.1532-7078.2009.00003.x
- Kuhn, D. (1995). Microgenetic Study of Change What Has It Told Us. *Psychological Science*, 6(3), 133-139.

- Laing, E., Butterworth, G., Ansari, D., Gsödl, M., Longhi, E., Panagiotaki, G., . . . Karmiloff - Smith, A. (2002). Atypical development of language and social communication in toddlers with Williams syndrome. *Developmental Science*, 5(2), 233-246.
- Lam, J., Barr, R. G., Catherine, N., Tsui, H., Hahnhaussen, C. L., Pauwels, J., & Brant, R. (2010). Electronic and paper diary recording of infant and caregiver behaviors. *Journal of Developmental & Behavioral Pediatrics*, 31(9), 685.
- Lamb, M. E., Frodi, A. M., Hwang, C. P., Frodi, M., & Steinberg, J. (1982). Mother-Infant and Father-Infant Interaction Involving Play and Holding in Traditional and Non-Traditional Swedish Families. *Developmental Psychology*, 18(2), 215-221. doi: Doi 10.1037/0012-1649.18.2.215
- Langton, Stephen R. H., Watt, Roger J., & Bruce, Vicki. (2000). Do the eyes have it? Cues to the direction of social attention. *Trends in Cognitive Sciences*, 4(2), 50-59. doi: 10.1016/s1364-6613(99)01436-9
- Lee, N., Mikesell, L., Joaquin, A. D. L., Mates, A. W., & Schumann, J. H. (2009). *The interactional instinct: The evolution and acquisition of language*: Oxford University Press, USA.
- Leekam, S., Baron - Cohen, S., Perrett, D., Milders, M., & Brown, S. (2011). Eye - direction detection: a dissociation between geometric and joint attention skills in autism. *British Journal of Developmental Psychology*, 15(1), 77-95.
- Leekam, S. R., López, B., & Moore, C. (2000). Attention and joint attention in preschool children with autism. *Developmental Psychology*, 36(2), 261.
- Lenneberg, E. H. (1967). Biological foundations of language.
- Liberman, A. M., & Mattingly, I. G. (1985). The motor theory of speech perception revised. *Cognition*, 21(1), 1-36. doi: 0010-0277(85)90021-6 [pii]

- Malatesta, C. Z., Grigoryev, P., Lamb, C., Albin, M., & Culver, C. (1986). Emotion Socialization and Expressive Development in Preterm and Full-Term Infants. *Child Development, 57*(2), 316-330. doi: DOI 10.1111/j.1467-8624.1986.tb00031.x
- McCall, R. B. (1981). Nature-Nurture and the 2 Realms of Development - a Proposed Integration with Respect to Mental-Development. *Child Development, 52*(1), 1-12.
- Meins, E., Fernyhough, C., Arnott, B., Vittorini, L., Turner, M., Leekam, S. R., & Parkinson, K. (2011). Individual differences in infants' joint attention behaviors with mother and a new social partner. *Infancy, 16*(6), 587-610.
- Messinger, D., & Fogel, A. (2007). The interactive development of social smiling. *Advances in Child Development and Behaviour, 35*, 328-366.
- Messinger, Daniel S., Ekas, Naomi V., Ruvolo, Paul, & Fogel, Alan D. (2012). "Are You Interested, Baby?" Young Infants Exhibit Stable Patterns of Attention During Interaction. *Infancy, 17*(2), 233-244. doi: 10.1111/j.1532-7078.2011.00074.x
- Miller, P. H., Coyle, T. R., Scholnick, E. K., Nelson, K., Gelman, S. A., & Miller, P. H. (1999). Developmental change: Lessons from microgenesis. *Conceptual development: Piaget's legacy*, 209-239.
- Mills, Debra L., Alvarez, Twyla D., George, Marie St., Appelbaum, Lawrence G., Bellugi, Ursula, & Neville, Helen. (2000). III. Electrophysiological Studies of Face Processing in Williams Syndrome. *J. Cognitive Neuroscience, 12*(Supplement 1), 47-64. doi: 10.1162/089892900561977

- Mirenda, Patricia L., Donnellan, Anne M., & Yoder, David E. (1983). Gaze behavior: A new look at an old problem. *Journal of Autism and Developmental Disorders*, 13(4), 397-409. doi: 10.1007/bf01531588
- Mitchell, S.K. (1979). Interobserver agreement, reliability, and generalizability of data collected in observational studies. *Psychological Bulletin*, 86(2), 376-390.
- Moore, G. A., Powers, C. J., Bass, A. J., Cohn, J. F., Propper, C. B., Allen, N. B., & Lewinsohn, P. M. (2012). Dyadic Interaction: Greater than the Sum of its Parts? *Infancy*.
- Mullen, E. M. (1995). *Mullen scales of early learning*: Pearson.
- Muller, U., & Giesbrecht, G. (2008). Methodological and Epistemological Issues in the Interpretation of Infant Cognitive Development. *Child Development*, 79(6), 1654-1658. doi: 10.1111/j.1467-8624.2008.01216.x
- Napier, J. (1993). *Hands*: Princeton University Press.
- Nummenmaa, L., & Calder, A. J. (2009). Neural mechanisms of social attention. *Trends in Cognitive Sciences*, 13(3), 135-143. doi: DOI 10.1016/j.tics.2008.12.006
- Oller, D. K. (2010). Vocal motoric foundations of spoken language - a commentary on Iverson's 'Developing language in a developing body: the relationship between motor development and language development'. *Journal of Child Language*, 37(2), 275-279. doi: Doi 10.1017/S0305000909990456
- Olzak, M., Laskowska, I., Jelonek, J., Michalak, M., Szolna, A., Gryz, J., . . . Gorzelanczyk, E. J. (2006). Psychomotor and executive functioning after unilateral posteroventral pallidotomy in patients with Parkinson's disease. *Journal of the neurological sciences*, 248(1-2), 97-103. doi: S0022-510X(06)00208-5 [pii]



10.1016/j.jns.2006.05.046

Papoušek, M., Papoušek, H., & Symmes, D. (1991). The meanings of melodies in motherese in tone and stress languages. *Infant Behavior and Development*, 14(4), 415-440.

Parlade, M. V., & Iverson, J. M. (2011). The interplay between language, gesture, and affect during communicative transition: A dynamic systems approach.

*Developmental Psychology*, 47(3), 820-833. doi: 2011-00162-001 [pii]

10.1037/a0021811

Perra, O., & Gattis, M. (2010). The control of social attention from 1 to 4 months.

*British Journal of Developmental Psychology*, 28(4), 891-908. doi:

10.1348/026151010x487014

Perra, O., & Gattis, M. (in press). Attention Engagement in Early Infancy. *Infant Behavior and Development*.

Piek, J. P., Dyck, M. J., Nieman, A., Anderson, M., Hay, D., Smith, L. M., . . .

Hallmayer, J. (2004). The relationship between motor coordination, executive functioning and attention in school aged children. *Archives of clinical neuropsychology : the official journal of the National Academy of Neuropsychologists*, 19(8), 1063-1076. doi: S0887617704000083 [pii]

10.1016/j.acn.2003.12.007

Piek, Jan P., Dawson, Lisa, Smith, Leigh M., & Gasson, Natalie. (2008). The role of early fine and gross motor development on later motor and cognitive ability.

*Human Movement Science*, 27(5), 668-681.

Pinker, S. (2010). The cognitive niche: Coevolution of intelligence, sociality, and language. *Proceedings of the National Academy of Sciences of the United*

*States of America*, 107, 8993-8999. doi: DOI 10.1073/pnas.0914630107

- Rakoczy, H., Tomasello, M., & Striano, T. (2005). On tools and toys: how children learn to act on and pretend with 'virgin objects'. *Developmental Science*, 8(1), 57-73. doi: 10.1111/j.1467-7687.2005.00393.x
- Rechetnikov, R. P., & Maitra, K. (2009). Motor impairments in children associated with impairments of speech or language: a meta-analytic review of research literature. *The American journal of occupational therapy. : official publication of the American Occupational Therapy Association*, 63(3), 255-263.
- Reznick, J. S., & Goldfield, B. A. (1992). Rapid change in lexical development in comprehension and production. *Developmental Psychology*, 28(3), 406-413. doi: 10.1037/0012-1649.28.3.406
- Reznick, J. S., & Goldfield, B. A. (1994). Diary Vs Representative Checklist Assessment of Productive Vocabulary. *Journal of Child Language*, 21(2), 465-472.
- Rizzolatti, G., & Arbib, M. A. (1998). Language within our grasp. *Trends in neurosciences*, 21(5), 188-194. doi: S0166-2236(98)01260-0 [pii]
- Robinson, Byron F., & Mervis, Carolyn B. (1999). Comparing productive vocabulary measures from the CDI and a systematic diary study. *Journal of Child Language*, 26(01), 177-185. doi: doi:null
- Ruff, H. A., & Lawson, K. R. (1990). Development of sustained, focused attention in young children during free play. *Developmental Psychology*, 26(1), 85.
- Ruff, H.A., & Rothbart, M.K. . (1996). *Attention in Early Development: Themes and Variations*. Oxford, UK: Oxford University Press.
- Saxe, R., Tenenbaum, J. B., & Carey, S. (2005). Secret agents: Inferences about hidden causes by 10-and 12-month-old infants. *Psychological Science*, 16(12), 995-1001.

- Scaife, M., & Bruner, J. S. (1975). The capacity for joint visual attention in the infant. *Nature*, 253(5489), 265-266.
- Sebeok, T. A. (1965a). Animal Communication . A Communication Network Model for Languages Is Applied to Signaling Behavior in Animals. *Science*, 147(3661), 1006-&. doi: DOI 10.1126/science.147.3661.1006
- Sebeok, T. A. (1965b). New Directions in the Study of Language - Lenneberg, Eh. *American Anthropologist*, 67(3), 818-820. doi: DOI 10.1525/aa.1965.67.3.02a00430
- Seifer, R. (2005). Who should collect our data: parents or trained observers? In D. M. Teti (Ed.), *Handbook of research methods in developmental science* (pp. 123-137). Malden, MA: Balckwell.
- Shi, Jinfu, Weng, Xuchu, He, Sheng, & Jiang, Yi. (2010). Biological motion cues trigger reflexive attentional orienting. *Cognition*, 117(3), 348-354. doi: 10.1016/j.cognition.2010.09.001
- Simion, F., Regolin, L., & Bulf, H. (2008). A predisposition for biological motion in the newborn baby. *Proceedings of the National Academy of Sciences of the United States of America*, 105(2), 809-813. doi: DOI 10.1073/pnas.0707021105
- Slaughter, V., & Neary, P. (2011). Do young infants respond socially to human hands? *Infant Behavior & Development*, 34(2), 374-377. doi: DOI 10.1016/j.infbeh.2011.01.004
- Smith, L. B., & Thelen, E. (2003). Development as a dynamic system. *Trends in Cognitive Sciences*, 7(8), 343-348. doi: 10.1016/S1364-6613(03)00156-6

- Sommerville, J. A., & Woodward, A. L. (2005). Pulling out the intentional structure of action: the relation between action processing and action production in infancy. *Cognition*, *95*(1), 1-30. doi: DOI 10.1016/j.cognition.2003.12.004
- Sommerville, J. A., Woodward, A. L., & Needham, A. (2005). Action experience alters 3-month-old infants' perception of others' actions. *Cognition*, *96*(1), B1-B11. doi: DOI 10.1016/j.cognition.2004.07.004
- Sorce, J. F., Emde, R. N., Campos, J., & Klinnert, M. D. (1985). Maternal Emotional Signaling - Its Effect on the Visual-Cliff Behavior of 1-Year-Olds. *Developmental Psychology*, *21*(1), 195-200.
- Soska, K. C., Adolph, K. E., & Johnson, S. P. (2010). Systems in development: motor skill acquisition facilitates three-dimensional object completion. *Developmental Psychology*, *46*(1), 129-138. doi: 2009-24671-004 [pii] 10.1037/a0014618
- Spencer, J. P., Perone, S., & Buss, A. T. (2011). Twenty Years and Going Strong: A Dynamic Systems Revolution in Motor and Cognitive Development. *Child Development Perspectives*, *5*(4), 260-266. doi: 10.1111/j.1750-8606.2011.00194.x
- Steele, J., Ferrari, P. F., & Fogassi, L. (2012). From action to language: comparative perspectives on primate tool use, gesture and the evolution of human language. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, *367*(1585), 4-9. doi: 367/1585/4 [pii] 10.1098/rstb.2011.0295
- Stone, A. A., Broderick, J. E., Kaell, A. T., DelesPaul, P. A. E. G., & Porter, L. E. (2000). Does the peak-end phenomenon observed in laboratory pain studies

- apply to real-world pain in rheumatoid arthritis? *Journal of Pain*, 1(3), 212-217.
- Stout, D., & Chaminade, T. (2012). Stone tools, language and the brain in human evolution. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, 367(1585), 75-87. doi: 367/1585/75 [pii] 10.1098/rstb.2011.0099
- Striano, T., & Rochat, P. (1999). Developmental link between dyadic and triadic social competence in infancy. *British Journal of Developmental Psychology*, 17(4), 551-562.
- Symons, Lawrence A., Hains, Sylvia M. J., & Muir, Darwin W. (1998). Look at me: five-month-old infants' sensitivity to very small deviations in eye-gaze during social interactions. *Infant Behavior and Development*, 21(3), 531-536. doi: 10.1016/s0163-6383(98)90026-1
- Thal, D., & Tobias, S. (1994). Relationships between language and gesture in normally developing and late-talking toddlers. *Journal of Speech and Hearing Research*, 37(1), 157-170.
- Thelen, E. (1995). Motor development. A new synthesis. *The American psychologist*, 50(2), 79-95.
- Thelen, E. (2005). Dynamic systems theory and the complexity of change. *Psychoanalytic Dialogues*, 15(2), 255-283.
- Thelen, E., & Bates, E. (2003). Connectionism and dynamic systems: are they really different? *Developmental Science*, 6(4), 378-391. doi: 10.1111/1467-7687.00294

- Thelen, E., Corbetta, D., Kamm, K., Spencer, J. P., Schneider, K., & Zernicke, R. F. (1993). The transition to reaching: mapping intention and intrinsic dynamics. *Child Development, 64*(4), 1058-1098.
- Tomasello, M., Carpenter, M., & Liszkowski, U. (2007). A new look at infant pointing. *Child Development, 78*(3), 705-722.
- Tomasello, M., & Farrar, M. J. (1986). Joint attention and early language. *Child Development, 57*(6), 1454-1463.
- Tseng, P., & Bridgeman, B. (2011). Improved change detection with nearby hands. *Experimental brain research, 209*(2), 257-269.
- Tuttle, R. H. (1981). Evolution of Hominid Bipedalism and Prehensile Capabilities. *Philosophical Transactions of the Royal Society of London Series B-Biological Sciences, 292*(1057), 89-94.
- Tuttle, R. H. (2005). Knuckle - walking and the evolution of hominoid hands. *American Journal of Physical Anthropology, 26*(2), 171-206.
- van Geert, P. (1998). We almost had a great future behind us: The contribution of non-linear dynamics to developmental-science-in-the-making. *Developmental Science, 1*(1), 143-159. doi: 10.1111/1467-7687.00020
- Vandell, D. L. (1980). Sociability with Peer and Mother during the 1st Year. *Developmental Psychology, 16*(4), 355-361.
- Vandell, D. L., Wilson, K. S., & Buchanan, N. R. (1980). Peer Interaction in the 1st Year of Life - an Examination of Its Structure, Content, and Sensitivity to Toys. *Child Development, 51*(2), 481-488.
- Viholainen, H., Ahonen, T., Lyytinen, P., Cantell, M., Tolvanen, A., & Lyytinen, H. (2006). Early motor development and later language and reading skills in

children at risk of familial dyslexia. *Developmental Medicine and Child Neurology*, 48(5), 367-373. doi: S001216220600079X [pii]

10.1017/S001216220600079X

Vukovic, M., Vukovic, I., & Stojanovic, V. (2010). Investigation of language and motor skills in Serbian speaking children with specific language impairment and in typically developing children. *Research in Developmental Disabilities*, 31(6), 1633-1644. doi: DOI 10.1016/j.ridd.2010.04.020

Vygotsky, L. (1978). Interaction between learning and development. *Readings on the development of children*, 34-41.

Wan, M. W., Green, J., Elsabbagh, M., Johnson, M., Charman, T., & Plummer, F. (2012). Parent-infant interaction in infant siblings at risk of autism. *Research in Developmental Disabilities*, 33(3), 924-932. doi: S0891-4222(11)00442-2 [pii]

10.1016/j.ridd.2011.12.011

Webster, R. I., Majnemer, A., Platt, R. W., & Shevell, M. I. (2005). Motor function at school age in children with a preschool diagnosis of developmental language impairment. *The Journal of pediatrics*, 146(1), 80-85. doi: S0022347604008753 [pii]

10.1016/j.jpeds.2004.09.005

West, R., & Turner, L. H. (2007). *Understanding Interpersonal Communication: Making Choices in Changing Times*.

Wijnhoven, T. M. A., de Onis, M., Onyango, A., Wang, T., Bjoerneboe, G. E. A., Bhandari, N., & Al Rashidi, B. (2004). Assessment of gross motor development in the WHO Multicentre Growth Reference Study. *Food and Nutrition Bulletin*, 25(1), 537-545.

- Wilson, S. M., Saygin, A. P., Sereno, M. I., & Iacoboni, M. (2004). Listening to speech activates motor areas involved in speech production. *Nature neuroscience*, 7(7), 701-702. doi: 10.1038/nn1263  
nn1263 [pii]
- Wolff, P. H. (1965). The development of attention in young infants. *Annals of the New York Academy of Sciences*, 118(21), 815-830.
- Wolfson, Amy, Lacks, Patricia, & Futterman, Andrew. (1992). Effects of parent training on infant sleeping patterns, parents' stress, and perceived parental competence. *Journal of Consulting and Clinical Psychology*, 60(1), 41-48. doi: 10.1037/0022-006x.60.1.41
- Woodward, A. L. (1998). Infants selectively encode the goal object of an actor's reach. *Cognition*, 69(1), 1-34. doi: S0010-0277(98)00058-4 [pii]
- Woodward, A. L. (2003). Infants' developing understanding of the link between looker and object. *Developmental Science*, 6(3), 297-311.
- Yoon, Jennifer M. D., & Johnson, Susan C. (2009). Biological Motion Displays Elicit Social Behavior in 12-Month-Olds. *Child Development*, 80(4), 1069-1075. doi: 10.1111/j.1467-8624.2009.01317.x
- Yu, C., Smith, L. B., Shen, H., Pereira, A. F., & Smith, T. (2009). Active Information Selection: Visual Attention Through the Hands. *IEEE transactions on autonomous mental development*, 1(2), 141-151. doi: 10.1109/TAMD.2009.2031513