Negative Affect, Attentional Flexibility, and the Development of Sensorimotor Intelligence

by

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A thesis submitted in conformity with the requirements for the degree of Master of Arts
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Master of Arts, 2001
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ABSTRACT

This study tests attentional flexibility (AF), a predictor of competence, as a mediator of individual differences in distress regulation and in the timing of sensorimotor means-end skills. This proposition was assessed through analysis of data from a study of 12 infants over 16 visits during their first year. Regulation and AF were assessed from videotaping infant responses to a frustrating procedure. Sensorimotor skills were also assessed.

Associations were found between distress regulation at 2-4 months, AF at 4-8 months, and means-end coordination at 8-10 months. Poor regulation predicted the co-occurrence of scanning and an agitated emotional state. Such co-occurrence predicted the timing of acquisition of means-end skills. These results suggest that the timing of skill acquisition was predicated on the infant’s developmental history. The implications of these findings for a model of cascading constraints on pathways to competence are discussed.
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TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>ii</td>
</tr>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>iii</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vi</td>
</tr>
<tr>
<td>1. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>1.1. Distress Regulation, Attention, and Pathways to Cognitive Competence</td>
<td>1</td>
</tr>
<tr>
<td>1.2 Distress Regulation and Flexible Attention</td>
<td>3</td>
</tr>
<tr>
<td>1.2.1 Reactive and Regulatory Components of Temperament and Distress</td>
<td>3</td>
</tr>
<tr>
<td>1.2.2 Distress Regulation and Developments in Attention Flexibility</td>
<td>5</td>
</tr>
<tr>
<td>1.2.3 Distress-Related Constraints on Attention Flexibility: Developmental Issues</td>
<td>9</td>
</tr>
<tr>
<td>1.2.4 Distress-Related Constraints on Attention: Real-Time Issues</td>
<td>11</td>
</tr>
<tr>
<td>1.2.5 Summary: Distress and Attention Interactions over Early Infant Development</td>
<td>13</td>
</tr>
<tr>
<td>1.3 Attentional Styles and Cognitive Competence</td>
<td>13</td>
</tr>
<tr>
<td>1.3.1 Attention and Cognitive Competence: Predictions over Development</td>
<td>13</td>
</tr>
<tr>
<td>1.3.2 The Neural Maturation Account of Fixation Duration</td>
<td>14</td>
</tr>
<tr>
<td>1.3.3 Attention as a Cascading Constraint on Subsequent Cognitive Development</td>
<td>16</td>
</tr>
<tr>
<td>1.3.4 Gaze Patterns in Short and Long Looking Infants</td>
<td>18</td>
</tr>
<tr>
<td>1.3.5 Scanning and Epistemic Activity</td>
<td>17</td>
</tr>
<tr>
<td>1.4 A Framework for Early Sensorimotor development</td>
<td>21</td>
</tr>
<tr>
<td>1.4.1 Stage Theories of Cognitive Development</td>
<td>21</td>
</tr>
<tr>
<td>1.4.2 Early Sensorimotor Development</td>
<td>21</td>
</tr>
<tr>
<td>1.5 Age-Specific Associations Between Distress and Cognitive Competence</td>
<td>24</td>
</tr>
<tr>
<td>1.6 Summary and Conclusion: Distress, Attention, and Developmental Pathways to Cognitive Competence</td>
<td>26</td>
</tr>
<tr>
<td>1.7 The Current Study</td>
<td>28</td>
</tr>
<tr>
<td>1.8 Research Questions and Hypotheses</td>
<td>31</td>
</tr>
<tr>
<td>2. METHOD</td>
<td>32</td>
</tr>
<tr>
<td>2.1 Overview</td>
<td>32</td>
</tr>
<tr>
<td>2.2 Subjects</td>
<td>32</td>
</tr>
<tr>
<td>2.3 Procedure</td>
<td>33</td>
</tr>
<tr>
<td>2.3.1 Measures of Sensorimotor Coordination</td>
<td>34</td>
</tr>
<tr>
<td>2.3.1.A Assessment of unifocal sensorimotor coordination</td>
<td>34</td>
</tr>
<tr>
<td>2.3.1.B Assessment of bifocal coordination</td>
<td>35</td>
</tr>
<tr>
<td>2.3.2 Frustrating Objects Interactions Procedure</td>
<td>36</td>
</tr>
<tr>
<td>2.4 Coding Procedures and Data Reduction</td>
<td>37</td>
</tr>
<tr>
<td>2.4.1 Coding of Infant Distress</td>
<td>38</td>
</tr>
<tr>
<td>2.4.2 Coding of Infant Attention Engagement</td>
<td>39</td>
</tr>
</tbody>
</table>
3. DATA ANALYSIS AND RESULTS

3.1 Sensorimotor Performance and the Demarcation of Stage Boundaries

3.2 Sensorimotor Coordination Scores as Cognitive Competency Outcome

3.3 Distress Measures
   3.3.1 Level of Distress During Withhold-Toy
   3.3.2 Distress Episodes and Distress Proportions
   3.3.3 Stability of Individual Differences in Distress Measures

3.4 Attention Allocation Indices
   3.4.1 Mean Fixation Duration and Attentional Flexibility

3.5 Real-Time Emotion-Scanning Co-occurrence

3.6 The Relationship between Distress and Means-end Coordination

3.7 The Relationship Between Distress and Attention Flexibility

3.8 The Relationship Between Attention Flexibility and Transition-Age

4. DISCUSSION

4.1 Early Distress Regulation and the Acquisition of Means-End Coordination

4.2 Distress and Attention Flexibility

4.3 Epistemic Activity and the Development of Means-End Behaviour

4.4 Limitations of the Present Study
   4.4.1 Limitations of the Distress Measures
   4.4.2 Limitations on the Measurement of Attention Flexibility
   4.4.3 Limitations on the Sensorimotor Measures
   4.4.4 General Limitations of this Study

4.5 Implications of this Study for a Model of Cascading Constraints on Infant Development

REFERENCES
LIST OF TABLES

Table 2.1  Summary of Variables  
Table 3.1  Sensorimotor Task Performance for All Visits and Demarcation of Stage Boundaries by Infant  
Table 3.2  Transition-Age (in weeks) by Infant  
Table 3.3  Distribution of Distress as a Proportion of Withhold-toy Segment by Sensorimotor Stage  
Table 3.4  Distress Episode Durations (in seconds) and Distress Proportions by Infant  
Table 3.5  Intercorrelations Between Distress Measures  
Table 3.6  Descriptive Statistics for Mean Bout Durations (in seconds) for Attentional Codes During Withhold-Toy  
Table 3.7  Scanning and Emotion Co-occurrence During Withhold-Toy by Stage  
Table 3.8  Intercorrelations Between Scan Variables Within Unifocal Stage  
Table 3.9  Zero-order Correlations Between Measures of Distress and Transition-Age  
Table 3.10  Zero-Order Correlations Between Measures of Distress and Measures of Mean Bout Duration for Unifocal Attention Codes  
Table 3.11  Zero-Order Correlations Between Measures of Distress and Unifocal Stage Scanning Variables  
Table 3.12  Partial Correlations Between Distress and Scan-Emotion Co-occurrence Controlling for Scan Duration  
Table 3.13  Partial Correlations Between Early Distress and Scan-Emotion Co-occurrence Controlling for Overall Agitation  
Table 3.14  Partial Correlations Between Distress and Scan-Emotion Co-occurrence Controlling for Scan Duration and Overall Agitation  
Table 3.15  Zero-Order Correlations Between Mean Bout Duration and Transition-Age  
Table 3.16  Zero-Order Correlations Between Scan Variables and Transition-Age
CHAPTER 1
INTRODUCTION

1.1. Distress Regulation, Attention, and Pathways to Cognitive Competence

In 1981, Piaget suggested that emotion could influence cognitive development. While in general psychological research has not addressed this idea, some recent studies have found support for Piaget’s intuition. Associations between individual differences in emotional characteristics, in particular distress, and later differences in sensorimotor and cognitive competence have been observed (Lewis, 1993a; 1993b; Lewis, Koroshegyi, Douglas, & Kampe, 1997). These longitudinal investigations of emotion-cognition associations suggest that early emotions might influence later competence. Keating and Miller (1999) have discussed how early interactions of regulatory systems may account for the findings of Lewis and colleagues. Specifically, these authors propose that systems which regulate emotion, attention, and social interaction modify and shape one another over development. While the systems may have distinct neurophysiological roots, their effects on behaviour are likely to be synergistic: interactions between systems may be more important than the main effects of a single system (Derryberry & Rothbart, 1997; Keating & Miller, 1999; Lewis, 2000).

Indeed, as new systems arise, it may be impossible to fully dissociate the action of the new systems from their interactions with preexisting systems. These interactive effects between regulatory systems may be best understood as reflecting processes of self-organization over development. Self-organization may provide a framework for understanding how interactions of regulatory systems can influence later developmental outcomes.
Self-organization—the tendency of some systems to evolve more complex and stable forms—represents a potentially powerful explanatory framework for developmentalists (Lewis, 2000). In self-organizing systems, repeated interactions between simple, lower-order, components result in more complex, higher-order, forms. Through these processes, novel forms can be said to emerge from complex interrelationships of system elements. Once a novel form has arisen in a system, that form becomes a part of the developmental history of that system. Thus, the emergent features of an increasingly complex system act as constraints on subsequent development of the system. As Lewis (1997) puts it, “a sequence of emergent constraints cascades down the developmental stream, each influencing the formation of the next, guiding and narrowing the flow through increasingly refined outcomes.” These cascading constraints are not to be confused with the constraints placed on a system by its initial structure or by the environment in which development occurs, though genetic and environmental constraints are indeed important, constituting the context in which the organism develops (Keating & Miller, 2000). In contrast, cascading constraints emerge through the process of development itself, and go on to become part of the context of the system.

Early emerging regulation systems may have cascading effects on subsequent systems, both constraining the range of possibilities available to those systems and increasing the idiosyncratic nature of the organism’s overall repertoire of behaviours (Derryberry & Reed, 1994; Derryberry & Rothbart, 1997; Lewis, 1997). This cascading process is particularly important because the regulatory systems and their interactions are likely to influence how the individual comes to sample her environment for specific learning opportunities (Keating
Although many studies have addressed aspects of these regulation systems and their interrelations, few have examined these systems in relation to later competence.

The purpose of this thesis is (i) to study the interactions of early emotion regulation and later attention flexibility, (ii) to address the influence that early regulatory capacities may have on later competence, and specifically (iii) to consider the role that emotion regulation and attention flexibility together may have on the infant’s opportunities to learn from her environment. In approaching these goals, I will review theoretical and empirical work on (i) the relationship of early distress tendencies and attention flexibility, (ii) associations between infant attention and later cognitive competence, and (iii) associations between distress and cognitive competence. I will then present a non-nativist framework for explaining variability in cognitive development based on interactions between emotion-regulation and attention flexibility. Specifically, I will argue that attention flexibility is a cascading constraint, itself organized in the context of earlier distress regulation capacities, that goes on to constrain early sensorimotor capabilities.

1.2 Distress Regulation and Flexible Attention

1.2.1 Reactive and Regulatory Components of Temperament and Distress

In recent years, substantial work has been done on interrelations between systems of emotion and attention in infancy. Many of these studies have been motivated by theories of temperament. Rothbart and Derryberry (e.g., Derryberry & Rothbart, 1997, 1988; Rothbart & Derryberry, 1981) define temperament as individual differences in reactivity and self-regulation. According to these authors, reactivity reflects sensitivity to environmental
changes and is based in systems implicated in emotional behaviours, including the endocrine and autonomic nervous systems (Rothbart & Derryberry, 1981) and specific neural systems (Derryberry & Rothbart, 1997; LeDoux, 1996). Self-regulation, by contrast, refers to any attentional or behavioural process that modulates reactivity. The development of temperament involves the interaction of regulatory and reactive systems, including systems that mature over development (Derryberry & Rothbart, 1997). With regard to distress, reactivity may be seen as the likelihood of the infant to respond with distress to environmental changes, and the characteristic intensity of these responses. Regulation may be seen in the capacity to self-soothe following the onset of distress, or to avoid intense distress.

Derryberry and Rothbart have noted that the first major developments in regulatory capacities occur around four months, with the onset of attentional capacities that enable distress regulation. However, it is important to note that individual differences in distress regulation may also be observed in very young infants (Demos, 1986; Thompson, 1990; Wolff, 1969). Infants as young as 2 months show individual differences in intensity and duration of distress (e.g., Lewis, 1993a). As well, parental reports indicate individual differences in infant soothability at this age (e.g., Johnson, Posner, & Rothbart, 1991). Capacities to avoid prolonged periods of intense distress and to return to a calm state following intense distress (Harmon, Rothbart & Posner, 1997) seem to reflect an early regulatory component of infant distress. Thus, prior to the development of attentional or behavioural processes that modulate reactivity, infants already show variability in capacities to regulate distress.
1.2.2 Distress Regulation and Developments in Attention Flexibility

Discussions of early development of temperament have emphasized the ways in which developments in attentional systems regulate emotional reactivity. This emphasis may serve to equate distress with reactivity and attention with regulation. Such a simplification of the concepts of reactivity and regulation may lead researchers to ignore important relationships between distress and attention. While attention may indeed serve the infant in regulating distress, there may be important ways in which, for example, distress regulates attention.

Nevertheless, the primary focus of recent investigations of early temperament has been how attention regulates distress. The impact of attentional control and flexibility on distress regulation has been much discussed (e.g., Cicchetti & Tucker, 1994; Derryberry & Rothbart, 1997; Johnson, et al., 1991; Rothbart, Ziaie, & O’Boyle, 1992). According to this framework, maturation of the Posterior Attentional System (PAS) of the brain allows increased attention flexibility. PAS maturation is believed to support disengagement of attention from one location and re-engagement at a new location (Posner & Peterson, 1990), as well as anticipation of upcoming events and contingency-learning (Johnson, et al., 1991). These capacities, which emerge between 3 and 6 months of age, have been argued to allow infants to regulate emotion more efficiently than before (Posner, Rothbart, & Thomas-Thrapp, 1997; Rothbart, et al., 1992).

From this perspective, individual differences in flexible attention are hypothesized to predict corresponding differences in capacities to avoid distress or regulate it once aroused. For example, disengagement of attention, as a self-regulatory behaviour, is expected to limit
distress and increase positive affect (Rothbart, et al., 1992). Such hypotheses have received much attention from developmental psychologists (e.g., Derryberry & Rothbart, 1997; Johnson, et al., 1991; Kopp, 1989; Posner, Rothbart, & Thomas-Thrapp, 1997; Rothbart & Derryberry, 1981; Rothbart, Ziaie, & O’Boyle, 1992). Indeed, attention flexibility and distress do appear to be related following the age of PAS development. Rothbart and colleagues (1992) found that high distress and low disengagement of attention were related at 13.5 months of age, such that infants less able to disengage attention from high-intensity stimulation were higher in distress.

However, the causal relationship between attention flexibility and distress remains unclear. Rothbart and her colleagues (1992) discuss research by MacLeod, Matthews, and Tata (1986) that suggests that, in adult subjects, anxiety can lead to difficulties in shifting attention. This suggests that the emotional context is preventing flexible attention. Furthermore, Rothbart and her colleagues found that early infant distress predicted later attention flexibility: 3-month-old infants who show short latencies to distress and high-intensity distress of long duration were less able to disengage from an intense visual stimuli at 13.5 months. Similarly, Johnson, Posner and Rothbart (1991), note that “four-month-olds who disengaged [attention] more easily were less susceptible to distress and more easily soothed” (p.342). However, the measures of distress and soothing may have been obtained when the infant was 2 months old. This finding suggests that early individual differences in distress regulation precede and predict later individual differences in disengagement capacities.

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1 It is unclear from the article when the measures of soothing and distress-susceptibility were obtained. The Method section of the article only refers to this measure under the procedures
Individual differences in attention flexibility may be best characterized, not as independent, biologically-specified, constraints on subsequent capacities to regulate distress, but as cascading constraints formed in the context of distress regulation.

Other research further complicates the relationship between attention flexibility and distress regulation, calling into question the role of PAS maturation around 4 months on capacities to regulate distress. Axia, Bonichini, and Benini (1999) found associations between duration of distress from pain and look durations at the ages of 3 and 11 months. Infants with inflexible attention, reflected in long look durations, were poorer at distress-regulation than were infants with short look durations. However, this relationship did not hold at 5 months, an age when PAS development would be expected to be underway and when attention flexibility should allow for reduced distress. Another study of 4 month olds found no relationship between maternal ratings of infant temperament and average peak look duration (Miceli, Whitman, Borkowski, Braungart-Rieker, & Mitchell, 1998). Also, at 5-months, infants with high rates of visual shifting--that is, high flexibility of attention--are given high ratings on the Distress to Limitations scale of Rothbart’s Infant Behaviour Questionnaire (IBQ) (Ruddy, 1993), a measure linked to displays of frustration and anger (Stifter & Grant, 1993). These studies suggest that the relationship between distress and attention flexibility may break down around the infant’s fourth and fifth month.

From the stance of the PAS maturation hypothesis outlined above, correlations between distress and attentional style would be expected to follow or to coincide with PAS for 2-month-old subjects, though if this is the case, it is not confirmed in the Results or Discussion sections.
maturation, and would ideally be reflected in high negative correlations between measures of attentional flexibility and subsequent measures of distress intensity and duration. From a developmental perspective, PAS maturation may improve infant abilities to shift attention (Johnson, et al., 1991; Rothbart et al., 1992). How well this increased flexibility assists the infant in regulating distress is less clear. The degree to which attention flexibility supports improved distress regulation may depend on prior capacities to regulate distress. There is evidence that attention flexibility may be strongly influenced by earlier capacities to regulate distress (Axia, et al., 1999; Rothbart et al., 1992). Indeed, distress regulation and attention flexibility appear related prior to PAS maturation, such that high distress already predicts inflexible attention at 3 months (Axia, et al., 1999). Curiously, this relationship appears to break down when PAS maturation should be showing its influence: attention flexibility is not consistently related to efficient distress regulation during the fourth and fifth month (Axia et al., 1999; Miceli et al., 1999; Ruddy, 1995; Wenckstern et al., 1984). Given these complications, it is difficult to conclude that innate individual differences in attention flexibility predict differences in regulation of distress. Rather, earlier individual differences in distress may have an important role in determining the degree to which attention flexibility facilitates distress regulation. In sum, “further research is required to clarify the direction of the causal relation between attention and negative affect” (Derryberry & Rothbart, 1988, p.964).
1.2.3 **Distress-Related Constraints on Attention Flexibility: Developmental Issues**

The emphasis of the causal role of neural maturation in developmental processes may suggest an (implicit) indebtedness to nativist assumptions about the processes of development. Postulating neural maturation to explain behavioural changes can lead to nativist arguments that “the structure of the nervous system prescribes the structure of development” (Lewis, 2000, p.37). In contrast, recent research in the field of developmental behavioural neuroscience (e.g., Gunnar & Nelson, 1992) presents an alternative to nativist conceptions of maturation. This framework, moreover, may help account for the associations between early distress and attention flexibility. According to this emerging framework, neural maturation is as much a result of the physical and social environment as of genetic determinants (Cynader & Frost, 1999; Greenough & Black, 1992). Rather than emphasizing the causal role of neural maturation, psychological inquiry may seek to explicate how different contexts for experience can differentially affect neural development.

Some developmental behavioural neuroscientists have argued that brain maturation is contingent on experience within specific environments during specific periods of development (Cicchetti & Tucker, 1994; Greenough & Black, 1992). According to these models of neural plasticity, the organism must be exposed to particular environmental inputs for neural maturation to occur, and for development to proceed within a normative range (Huttenlocher, 1994; Nelson, 2000). Two contrasting processes of experience-contingent maturation have been proposed: experience-expectant and experience-dependent maturation. Experience-expectant mechanisms hold when the maturation supports functions that are common to all
members of a species, and are likely to have been so throughout the history of the species. While experience-expectant maturation generally results in capacities common to members of the species, it may also support individual differences in the quality of those functions. For example, abnormal development in experience-expectant systems may be caused by insufficient experience to support the neural structure or by exposure to inappropriate information (Greenough & Black, 1992). These disruptions may result in individual differences in the functions supported by the affected neural structure. More commonly however, individual differences in performance are considered the result of experience-dependent maturation (e.g., Keating & Miller, 1999). In this process, the quality of experiences influences the developmental effects of the experience. Thus, minor variations in infant environments can result in individual differences on outcome measures. In any event, the two processes can be difficult to distinguish from one another (Derryberry & Reed, 1994; Greenough & Black, 1992). Most important, in both processes, neural maturation is contingent on the experiences of the developing organism, not on genetic pre-specification. In sum, "one's experiences become embedded in one's biology" (Keating and Miller, 1999, p. 220).

Rothbart and Derryberry (1981) have speculated that both the intensity and temporal characteristics of distress may influence the nature of the infant’s experience and development. Models of experience-contingent maturation might clarify why early distress predicts later differences in attention. Early distress regulation might act as a context for the infant’s experience, thereby modulating the basis for neural maturation. Moreover, early emotional differences may mediate both the quality and quantity of perception and action by
the organism. Furthermore, poor distress regulators may be less efficient in making use of
information from their environment. In this way, distress could affect how the infant
samples the environment, and thereby determine what experiences are available for
developing neural systems. Through this process, an early incapacity to regulate distress
could result in individual differences in later developing systems, including systems
supporting attention flexibility.

Thus, attentional qualities may both result from and be constrained by the infant’s
developmental history, including the infant’s emotional response to the world. As
Derryberry and Reed (1994) have speculated, the motivational processes that underlie
individual differences in emotion may contribute to cortical connectivity. Neural
developments such as the maturation of the posterior attentional system may represent a
case of self-organization—the coming-into-being of more complex patterns through feedback
processes characteristic to the systems involved. Considering neural maturation itself as a
case of self-organization avoids the argument for pre-specified programming of individual
differences in the function of systems supported by this neural maturation. A self-
organization perspective also allows us to consider how early distress, for example, may
contribute to subsequent system development. Early emotional characteristics may be
important factors in determining the quality of emergent attention systems.

1.2.4 Distress-Related Constraints on Attention: Real-Time Issues

Not only may early emotionality influence later attention, but emotion may also
interact with attention following PAS maturation. In reference to emotion and attention,
Rothbart and Derryberry (1982, p. 54) have argued that reactivity and self-regulation are “ongoing, simultaneously interacting, [and]...virtually inseparable”. Negative emotions have been shown to interact with attention developmentally in infants (see above) and in real time in adults (e.g., Derryberry & Tucker, 1994; MacLeod, Matthews & Tata, 1986). Distress, in particular, may interact with attention in real-time information processing.

One implication of real-time distress-attention interactions is for infant learning. Research suggests that infant learning is most efficient when the child is in a calm, neutral state (Bornstein & Lamb, 1992; Papousek & Bernstein, 1969), but only a small body of research has directly addressed associations of distress regulation and learning. As noted, Johnson and his colleagues (1991) found that easily soothed infants show greater abilities to use a central cue to predict the location of a target. Thus, early capacities to regulate distress may predict abilities to make use of contingency information. Similarly, Colombo, Mitchell, and Horowitz (1988) found that infants with better state control (i.e., those infants who were able to make the transition from sleep to alert states without distress) were better at discriminating between familiar and novel stimuli. As well, infants who cry during the learning phase show poor retention of conditioned responses, suggesting that distress interferes with memory consolidation and hence learning (Fagan, Ohr, Fleckstein, & Ribner, 1985). Distress seems to disrupt the attentional capacities necessary for infant learning.

This intuition may account for why infant visual attention researchers regularly exclude infants due to excess emotionality (e.g., Colombo, Mitchell, O’Brien, & Horowitz, 1987; Colombo, Mitchell, Coldren, & Freeseman, 1991). Emotions, and distress in particular, may
be important factors in determining how efficiently infants use the information available to them in their environment.

1.2.6 Summary: Distress and Attention Interactions over Early Infant Development

The work of examining the relationships between emotion and attention in early infancy has too often been carried out with a limiting emphasis on how attention (equated with regulation) impacts on negative emotionality (equated with reactivity). Yet young infant distress already shows both reactive and regulatory components. Focusing on the role of innate attention capacities on distress regulation has obscured important relationships. Infant distress appears to determine how well attention flexibility allows for improved distress regulation. It seems that individual differences in the quality of distress regulation set a context for variance in attention flexibility. Moreover, infant distress interacts with attention following the emergence of increased attention flexibility. Therefore, distress influences attention both over development and in real time. These routes of influence have important implications for infant learning and cognitive competence.

1.3 Attentional Styles and Cognitive Competence

1.3.1 Attention and Cognitive Competence: Predictions over Development

In contrast with the few studies predicting attention from earlier distress, many studies have shown that infant attention measures predict later cognitive competence (see Bornstein & Sigman, 1986; Bornstein, Slater, Brown, Roberts, & Barrett, 1997 for reviews). Whereas early tests of infant perceptual-motor ability (e.g., the Bayley Scale of Infant
Development) did not predict well to later intellectual competency, infant attentional measures predict substantially better (Bornstein & Sigman, 1986; Bornstein, et al., 1997; McCall & Carriger, 1993).

Most of this research has studied infant attention through a standardized laboratory procedure known as the habituation paradigm. This procedure involves showing the infant multiple repetitions of a single stimulus and measuring the decline in looking time to the stimulus. Once the infant reaches a certain minimum-duration looking time, the infant is said to have habituated to the stimulus. Following habituation, a new stimulus is presented. If the infant shows increased attention (i.e., longer look duration) to this new stimulus, it is assumed that the infant knows that the two stimuli are different. Habituating to a redundantly-presented stimulus and subsequently attending to a novel stimulus have been interpreted as implying capacities for encoding, storage, retrieval, and mental comparison of new and novel stimuli (McCall, 1994). Individual differences in infant attentional capacities, then, are taken as early indices of information-processing quality. Several measures derived from the habituation paradigm predict later intellectual competence. In particular, fixation duration has been argued to be the most stable, reliable, and central of the predictors, and has garnered wide interest amongst infant psychological researchers.

1.3.2 The Neural Maturation Account of Fixation Duration

Fixation duration reflects the characteristic duration of gaze which the infant allocates to the stimulus under examination. It is reported to be the most stable of the attentional indices, showing moderate test-retest reliability over both long and short intervals (Colombo,

Developmental differences in fixation duration have been observed, including a decrease in mean fixation duration over the first year. Mean fixation duration drops from 25 seconds to under 10 seconds between 3- and 7-months of age (Colombo & Mitchell, 1990). Thus, maturation may support normative decreases in fixation duration.

Moreover, individual differences in look duration relate to concurrent infant motor performance (Colombo et al., 1987) and later childhood cognitive performance (Rose, Slater, & Perry, 1986; Sigman, Cohen, Beckwith, & Parmalee, 1985). Generally, short lookers (i.e., those infants who gaze at stimuli in relatively short bouts) score higher on other tests of cognitive performance than do long lookers.

Colombo (1995) has put forth a nativist explanation of the association between individual differences in look duration and subsequent cognitive performance. Fixation duration may reflect the infant’s characteristic speed of processing due to an underlying general neural speed (Colombo & Mitchell, 1990). In Colombo’s words, “individual differences in the rapidity of encoding in infants [are] simply due to individual differences in the integrity or function of the nervous system” (Colombo, 1995, p. 101, emphasis added). Acknowledging that this hypothesis may lack specificity, Colombo (1995) discusses specific neural systems that may support attention capacities required to succeed in habituation tasks, including the posterior attentional system (PAS). Colombo notes that the schedule of maturation of the PAS coincides with that of developmental changes in fixation duration. Colombo suggests that the source of developmental and individual differences in fixation duration is the same -- neural immaturity. In particular, “long looking infants might appear to
be slower to encode visual information because of immature or depressed function of the posterior attention network” (1995, p. 119).

However, there is little reason to believe that individual differences in the timing of maturation need be pre-specified. As noted above (section 1.2.3), maturation of neural systems may itself be experience-contingent. Emotional characteristics may set a context for experience which constrains the development of attention, including individual differences in the timing of PAS maturation.

1.3.3 Attention as a Cascading Constraint on Subsequent Cognitive Development

Regardless of how individual differences in look duration evolve, these differences have been found to predict later cognitive capacities. In this section, I will examine experiential processes that might account for the predictive power of attention on cognitive outcomes. Associations between attention and cognitive competence may be explained without appeal to neural maturity. I will contend that the developmental history of the infant, constrained by her current attentional style, leads to particular habits of mind (Keating, 1990) that support advances in cognition. Individual differences in attention flexibility, themselves a function of earlier distress regulation capacities, limit the ways in which infants partake in and sample their environment, resulting in subsequent individual differences in cognitive skills.
1.3.4. **Gaze Patterns in Short and Long Looking Infants**

An alternative explanation for associations between attention and later cognitive capacity associations may be found in the different attentional habits of long and short looking infants. Colombo’s research shows that long and short lookers differ not only in the duration of their gaze, but in the nature of their scanning while fixating on a novel object. Colombo and his colleagues (Colombo, Freeseman, Coldren, & Frick, 1995) familiarized their infant subjects with a stimulus of a global configuration made up of individual local elements (micro-features). In this research, subsequent stimuli could have novel micro-features with the original global configuration, or a novel global configuration composed of the original micro-features. Long lookers tended to prefer stimuli consisting of novel local elements, suggesting that these infants focus their scanning on the micro-features of a stimulus. In contrast, short lookers initially preferred the novel global configuration, but with increased trials shifted to a preference for stimuli with novel micro-features. Short lookers initially scanned a wider area prior to focusing on details of interest. This difference between short and long lookers in the preferred range of visual inspection implies an epistemic bridge that could mediate between individual differences in attention and later cognitive capacities. Rather than explaining associations between infant attention and later cognition through appeal to pre-specified neural system maturation, this bridging model assumes that the infant’s active attention to the world is the source of associations with later cognition.
1.3.5. **Scanning and Epistemic Activity**

While the above discussion of scanning relates to the pattern of visual saccades to specific stimuli in the habituation paradigm, scanning outside the laboratory may represent a different and important type of attention flexibility. The scanning patterns of long- versus short-looking infants may have implications for how well the infant can attend to her physical and social world. Scanning outside the laboratory may allow infants to observe relationships between actors and actions and between one action and the next. Such epistemic activity may in turn have implications for sensorimotor and cognitive development.

A large body of research, largely habituation studies, suggests that, contrary to traditional Piagetian theory (Piaget, 1953), young infants have an early understanding of what is physically possible and what is not (see Baillargeon, 1993; Mandler, 1992; Spelke, Breinlinger, Macomber, & Jacobson, 1992 for reviews). Infants appear to have an early understanding of principles such as causality, object permanence, trajectory and solidity, but they cannot use this knowledge in action\(^2\).

Evidence for early perceptual sophistication calls into question the traditional Piagetian conception of cognitive development (Rutkowska, 1997; Bremner, Slater, & Butterworth, 1997). If objective awareness of their environment is possible for very young infants, such awareness may contribute to their cognitive development. Gibson’s theory of direct perception (1979) may help account for how early perceptual sophistication may

\(^2\) Indeed, not all developmentalists have accepted the case for early or innate understanding of physical reality in early infancy. See Fischer & Bidell, 1991 and Mueller & Overton, 1998.
allow cognitive advances. A fundamental principle of Gibson's theory is that the structure of the environment is directly available to the organism as perceptual information (Gibson, 1979). From this perspective, what develops over development is the organism's capacity (i) to recognize affordances, that is, to detect opportunities for action in the directly perceived environment and (ii) to differentiate among various perceptual affordances, that is, to understand that an action is possible in one context but not another.

If infants have an early capacity to perceive and discriminate events based on physical principles of causality, then they may be able to perceive connections between their own actions and results and between the actions of others and the results of those actions. Observation of such contingencies may represent a form of active experience that is a condition for cognitive development. Specifically, recognition of affordances might supplement active exploration of the physical world (Piaget, 1953; Case, 1985) as a prerequisite experience for the development of complex cognitive capacities, such as means-end problem-solving. Such epistemic activity may promote more effective action.

Scanning may indicate that infants are engaging in such epistemic activity. Through their tendency to show more frequent visual saccades, short lookers are more likely to scan frequently than are long lookers. Through their tendencies to scan first the global configuration of visual stimuli, then to examine the micro-details, short lookers are likely to attend to relationships at both macro- and micro-levels of detail than are long lookers. Infants who can attend to, and prefer attending to, novel global stimuli may be in a better position to encode contingencies between, for example, actions of agents and the results of those actions.
Thus short lookers may be more likely to attend to and come to understand what their environment affords them than are long lookers.

The variability of infant sensorimotor development may be, in part, due to earlier tendencies to attend to affordances. As Bremner, Slater, and Butterworth (1997) have noted, “although young infants cannot solve means-ends problems through their own efforts, maybe a necessary (but not sufficient) source of information about effective action on the world is gained through watching others act on objects” (p. 104). Thus, infants’ own epistemic activities may be privileged as a source of -- and a constraint on -- subsequent differences in cognitive capacities.

This perspective on scanning as indicating epistemic activity provides an alternative account of the predictive power of early attention measures on later competence. It is possible that neural maturity underlies associations between gaze fixation durations and later cognitive competence. However, individual differences in maturation may themselves be the result of differences in the organism’s active experiences, rather than genetically specified. Thus, individual differences in fixation duration and scanning behaviours (i.e., attention flexibility), which may develop in the context of earlier emotion regulation, may lead to differences in habits of mind that allow advances in cognitive competence. Attention flexibility may be seen as a cascading constraint on the developmental pathway to competence.
1.4 A Framework for Early Sensorimotor Development

1.4.1. Stage Theories of Cognitive Development

Stage models of human development capture the intuition that human intellectual capacities undergo qualitative changes over the course of infancy and childhood. Stages can be seen as transformations in the organization of a complex system that allow more elaborate capacities for action. These transformations affect the child’s capacity to make use of information from the environment to guide action. Stages can be thought of not as rungs on the ladder of development, but as re-organizations of capacities to understand (Fischer & Rose, 1995) that permit the child to grasp new and more complex relationships in the world, and enable more sophisticated action on the world.

1.4.2. Early Sensorimotor Development

Case, following Piaget, postulates that the first year and a half of the infant’s life is best characterized as involving the development of sensorimotor operations, which affects all areas of infant behaviour. During this time, the infant is seen as coordinating perceptual and motor skills into increasingly complex structures, thus allowing increasing sophistication of cognitive functioning. According to Case (1985), infants undergo two such re-organizations within their first year.

In the period from birth to approximately 4 months, the infant progresses through a substage that Case refers to as operational consolidation. During this period, the infant is acquiring the capacity to coordinate a perceptually-based goal with motor action to maintain the perceptual experience, resulting in simple action-result schemes (Case, 1985). For
example, the infant is increasingly able to track an interesting object across his visual field, or to reinsert a pleasing object into his mouth. Through these strategies, infants develop capacities for “preserving and modulating the pleasant stimulation to which they are recurrently exposed, and for avoiding or reducing the intensity of any recurrent stimulation that is aversive” (Case et al., 1988).

In the period from approximately 4 to 8 months, the infant, now capable of self-directed voluntary action, may begin to coordinate two sensorimotor actions together in service of an overarching goal. Case refers to this substage as unifocal coordination, wherein two previously independent sensorimotor actions are combined to enable more sophisticated behavior. With this transition, the infant seems to hold the consequences of her actions in mind in a qualitatively new manner. For example, after watching an adult play with a toy, the infant may actively repeat the actions of the adult to achieve a desired result from the toy. This requires the coordination of a goal of desiring the stimulation of the toy with a subordinated goal of acting in the manner observed to achieve the primary goal. The infant is able to maintain some sort of representation of her goals and of the actions by which she can achieve these goals.

It is important to note the parallels between the behavioural indices of unifocal coordination and the maturation of the posterior attentional system (PAS). Both PAS maturation and unifocal coordination are thought to occur around the 4th month. As well, many of the behaviours which mark unifocal coordination require the attentional capacities that are described by PAS maturation. For example, tasks used to assess unifocal coordination often require smooth visual tracking of objects in the infant’s visual field, a
development of the 2nd and 3rd months (Aslin, 1981). As well, both PAS maturation and the unifocal stage are behaviourally defined by the emergence of capacities for tracking the movement of an object by anticipating its movement (Haith, Hazan, & Goodman, 1988). It may be that PAS maturation is a prerequisite for unifocal coordination. Conversely, the coordination of sensorimotor abilities may be a prerequisite for experience-contingent PAS maturation. Unifocal coordination and PAS maturation may be two levels of description—specific and neural on the one hand, global and psychological on the other—of the same behavioural phenomena.

In the period between 8 and 12 months, infants begin to show the capacity to coordinate voluntary controlled action with attention to more than one object. Case terms this phase bifocal coordination, suggesting the capacity for dual foci of attention. In this period, infants acquire an understanding of how action on one object might affect another object. For example, removing a desired toy from the infant and placing it on a towel in front of the child elicits a novel response for an infant in this stage. Previously, the infant’s response may have consisted in focused reaches or lunges for the toy. In contrast, the bifocally-coordinated infant can solve the problem by pulling the towel, and consequently the toy, towards her. In this case, the infant coordinates strategies and goals for obtaining the toy with strategies and sub-goals of manipulating the towel on which the toy sits. This transition represents an increasingly elaborate understanding of the interrelations of objects and events in the world and of the infant’s capacities to manipulate those relationships.

The transition to bifocal sensorimotor coordination is marked by new competence in means-end reasoning. Means-end reasoning is elicited when an obstacle deters the infant
from achieving a goal. To meet the goal, the infant must use a strategy that will overcome the obstacle. While infants prior to bifocal coordination occasionally solve these problems, they do so in a haphazard, unfocused, and likely accidental way (Piaget, 1953; Willats, 1999). However, by 8-9 months, infants perform such means-end tasks with clear intent. Intentional means-end behaviours can be inferred when (i) the infant shows persistence in attempts to achieve a goal, (ii) the infant accomplishes a subgoal that sets the conditions to accomplish the primary goal, and (iii) the infant appears focused and organized in coordinating the goal and subgoal (Willats, 1999).

1.5 Age-Specific Associations Between Distress and Cognitive Competence

Case and his colleagues (1988) have argued that cognitive reorganizations result in changes in the types of emotions children can experience, in the contexts and settings which will elicit certain emotions in the child, and in their possible resources and capacities for regulating their emotions. However, as Piaget (1981) noted, emotions may also influence cognitive development. Studies have found that individual differences in emotion predict later differences in cognitive competence (Estrada, et al., 1987; Lewis, 1993a; 1993b; Lewis et al., 1997). Emotion and cognition may have reciprocal effects on one another, though the nature of these interactions may be age-specific and subject to change over development (Lewis et al., 1997; Lewis & Granic, 1999). Bornstein and colleagues (1997), in reviewing measures of

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3 Individual differences in such abilities may represent the third wave of intellectual predictors (Bornstein et al., 1997). Babies who, at 8 and 9 months, solve means-end tasks quickly, with little distraction, and seemingly with intent, tend to score higher on vocabulary and IQ measures at 3 years of age (range of rs from 0.42 to 0.64; Willats, 1992).
infant functioning that predict later intellectual functioning, have noted that there may be age-specific windows of opportunity for various measures. These windows may relate to critical or sensitive periods in the neural development underlying the predictor construct being measured. It is possible that age-specific windows of opportunity may parallel stages of development. A close examination of the relationship between emotion and cognition as it changes over development is required to analyze their interrelations.

In one such longitudinal study, Lewis (1993a) observed a qualitative shift in the relation of distress and sensorimotor scores in the infant’s first year. Examination of relations between distress to maternal separation/reunion and sensorimotor capacity revealed a shift in the nature of their relation around the onset of unifocal coordination. Prior to 4 months, reunion distress was negatively related to sensorimotor performance. Infants who fussed more in response to reunion with their mother scored lower on tests of sensorimotor coordination. Following 4 months, infants who fussed more performed better on sensorimotor tasks. Thus, the relationship between distress and sensorimotor performance may undergo reorganization around the 4-month mark, coinciding with unifocal coordination.

Perhaps the most robust of Lewis’ findings pertains to the predictive power of early negative affect on subsequent cognitive development. A follow-up study showed that reunion distress at 3 months predicted cognitive performance (particularly short term memory tasks) at 4 years of age (Lewis, 1993b). At no other age did tendencies toward high

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4 For purposes of this thesis, I will not be addressing this latter finding. Nevertheless, it is of interest that scores of distress relate to higher sensorimotor coordination at this stage. It is possible that the high scoring infants are using fussing to protest the absence of the mother, and in this way acting to accomplish a goal: maternal support.
distress predict later poor cognitive functioning. Further research with a different dataset found that other early measures of distress -- latency to distress and duration of distress -- predicted sensorimotor performance at later ages (Lewis et al., 1997). Infants who showed long distress durations at 2 months (during the operational consolidation stage) demonstrated poor bifocal sensorimotor performance at 8 months. As well, short latency to distress at 2 months predicted poor sensorimotor performance at 4, 8 and 12 months. Both early distress reactivity (latency) and distress regulation (duration) appear to predict poorer sensorimotor skills and, later, poor cognitive performance. More important, both distress reactivity and regulation predict best when measured before 4 months, that is, when the infants are consolidating sensorimotor operations.

1.6 Summary and Conclusion: Distress, Attention, and Developmental Pathways to Cognitive Competence

I have reviewed research that suggests that early individual differences in distress regulation could influence the development of attentional flexibility. Poor distress regulation in early infancy may contribute to later inflexibility of attention and potentially to long look durations. Differences in distress regulation may affect the quality of attention in real time and over development (Derryberry & Rothbart, 1997; Rothbart & Derryberry, 1982). In other words, individual differences in attention may be constrained by both prior and concurrent distress tendencies.

Furthermore, the style of attention allocation which results from this emotional influence may have effects on the development of habits of mind. In particular, emotionally-
derived differences in attention may influence what information infants obtain from their specific learning habitats (Keating & Miller, 1999). As noted above, individual differences in attention to affordances in the infant’s physical and social environment may result in later variability in means-end problem-solving skills. A flexible attention style may be conducive to developing an understanding of contingency relationships. Such epistemic activity may be an important condition for the emergence of early capacities to coordinate multiple steps to solve a problem. It is possible that these constraints on attention flexibility in general, and attention to contingency relations in particular, may mediate the finding of associations between early distress and later sensorimotor capacities.

Examination of the associations between distress regulation, attention flexibility and cognitive competence may help us understand the origins of variability in cognitive competence. Early emotional characteristics, including distress regulation, may influence the self-organization of emerging attentional systems and thereby limit the range of individual differences in attention flexibility. The consequent differences in attention flexibility, perhaps in interaction with the earlier capacities for distress regulation, may determine the way in which the individual is able to use her environment to learn strategies for more effective action. By constraining the epistemic activity of the infant, attention flexibility may cascade down the developmental path, delimiting variability in cognitive competence. Thus, early attention flexibility may act as a cascading constraint on a developmental path to competence.
1.7 The Current Study

The purpose of this study is to examine associations between distress regulation, attention flexibility, and means-end coordination over early infancy. The habits of mind framework proposed by Keating (1990) advocates longitudinal investigations which track the effects of regulatory systems on subsequent cognitive competency. Studying developmental pathways requires observing the same infants across their development, and attending to the organization within and across domains at key times in their development (Cicchetti, 1989; Keating & Miller, 1999). Given these considerations, I have used data that are part of a larger study conducted by Marc Lewis and colleagues. This dataset had been collected to examine emotion-regulation over time and over stages of development. Infant distress and attention were assessed through a standardized procedure designed to elicit frustration. Sensorimotor tasks were also administered at each visit. The present study used a subset of the full dataset based on the quality of the video data, and looked at 12 infants over 16 visits in the infants’ first year.

These data included a set of videotaped home-visits wherein infant-mother dyads engaged in a 6-cycle toy interaction procedure. In each cycle the mother gave, then withdrew, then returned a toy to her child. These data had been coded second-by-second for level of distress, focus of attention, and regulatory behaviours (see Cook, 2000). The regulatory behaviours were not addressed in the present study.

Unless otherwise noted, this study used data from the segments in which the toy was withdrawn. At these times, distress and distress regulation were most likely. Furthermore, during these segments, infant attention was less likely to be focused exclusively on the toy.
Hence, these segments provided the best opportunity for assessing attention flexibility. During these segments, attention flexibility could be derived in two ways. First, an averaged measure of fixation duration could be derived from real-time codes of looks to the mother, to the toy, and to other objects. While not as precise as look duration measured through habituation procedures, this technique allowed an approximation of attention flexibility given a potentially stressful situation. Secondly, mean durations of scanning episodes, overall proportion of scanning behaviour, and co-occurrence of scanning and different emotion levels could be derived. Given the potential epistemic role of individual differences in scanning, these measures provided another estimate of attention flexibility. From these data, a close examination of distress regulation and attention allocation in real time was possible, as distress episode dynamics, duration of attention bouts, and co-occurrences of distress and attention could be observed and compared over visits and stages.

The administration of sensorimotor tasks at each visit (also videotaped) allowed examination of associations between distress regulation, attention, and the timing of acquisition of means-end skills. As well, infant performance on unifocal and bifocal tasks was used to define developmental periods, which corresponded to presumed stage shifts. I was then able to create stage-specific variables by aggregating data across multiple visits within a developmental period. Thus, I could minimize the intra-individual variability of measures of infant behaviour (de Weerth & van Geert, 2000) by constructing variables based on multiple sampling points within windows of opportunity. My use of sensorimotor performance, rather than infant age, as the criteria by which multiple visits were aggregated reflects an assumption that the meaning of infant behaviour -- including social, emotional and
attentional components of behaviour -- may correspond to changes in stages of cognitive development (Case, et al, 1989; Lewis, et al., 1997).

Thus, emotion and attention characteristics were examined both within visits for real-time interactions and across stages for associations over development. This allowed the observation of associations between distress and attention flexibility. Specifically, I was able to examine the role of (i) distress regulation as a developmental constraint on fixation duration, (ii) distress regulation as a developmental constraint on scanning behaviours and (iii) distress as a real-time constraint on scanning. The relationships between emotion and attention, both real-time and developmental, were then examined in relation to variability in sensorimotor development. This allowed me to examine whether (i) early distress regulation would predict later sensorimotor competence, (ii) attention flexibility would predict later differences in sensorimotor competence, and (iii) distress would show a real-time effect on attention flexibility that influences predictions of later competence.
1.8 Research Questions and Hypotheses

**Hypothesis 1**

Individual differences in distress regulation during the operational consolidation stage, but not during unifocal coordination, were expected to relate to variability in the timing of bifocal sensorimotor skill acquisition.

**Hypothesis 2**

Individual differences in infant distress regulation were expected to relate to attention flexibility. It was expected that differences in distress characteristics during operational consolidation would relate to differences in look durations and in scanning during unifocal coordination.

**Research question 2a**

Would early poor distress regulation predict later tendencies for attention flexibility to co-occur with negative affect? Would this relationship be mediated by distress tendencies during unifocal coordination?

**Hypothesis 3**

Measures of attention flexibility during the unifocal stage were expected to associate with the timing of bifocal coordination. Fixation durations (hypothesis 3a) and scanning (hypothesis 3b) were expected to associate with variability in the timing of means-end coordination.

**Research Question 3a**

Would scanning during states of negative affect associate with means-end problem solving differently from scanning during calm states?
CHAPTER 2
METHOD

2.1 Overview

The data used for the present thesis come from a larger study conducted by Marc Lewis examining the development of individual pathways of emotion regulation from a self-organizing systems perspective. Infant-mother dyads were visited in their homes beginning in the infant’s third month and ending early in the infant’s second year. During each visit, a research assistant assessed the infant’s level of sensorimotor coordination using two tasks. As well, the dyads engaged in a procedure designed to frustrate the infant. The research assistant videotaped the infant during this procedure. The resulting tapes were later coded second-by-second for level of distress and for attention allocation. Variables for distress, average duration of attention fixation, scanning duration and scanning-distress concurrence were constructed from these tapes.

2.2 Subjects

This study made use of a sub-sample of 12 dyads who were part of the larger research project discussed above. Subjects were recruited from the Toronto area through posters at the university, notices at pediatric offices and in a local newspaper, and a radio bulletin. All mothers consented to the study on the understanding that they could withdraw from the research at any time. All infants were born within 2 weeks pre- or post-term. The 12 dyads were selected from a larger sample of 31 based on the completeness of their videotape...
records. A complete record required good quality video-data from 16 visits over a span of 43 weeks. Illness and other personal reasons forced some dyads to cancel visits, resulting in incomplete records. Incomplete records were not used in this study. Given the fine-grained and time-consuming coding procedures, some videotapes of poor quality could not be adequately coded and were also excluded.

2.3 Procedure

After the dyads were selected and consent was acquired, a research assistant was assigned to each dyad for the duration of the study. The same researcher visited dyads in their homes for all 16 visits. To account for the slowing rate of infant development (Lewis et al, 1997), the rate of visits changed with infant age. Visits were scheduled every two weeks from the infant's 12th week (~ month 3) to 24th week (~ month 6). After week 24, visits were spaced every three weeks until week 39 (~ month 10), after which visits occurred every 4 weeks until week 55 (~ month 12.5). Thus, dyads were visited at the following infant ages (in weeks): 12, 14, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 55. Prior to each visit, the researcher telephoned to assure that the infant was awake and alert. Visits were rescheduled if the infant was reported to be fussy due to illness, poor sleep, medical procedures, or household disruptions. All infants were fed no later than 10 minutes prior to the beginning of a session. All other family members and pets were excluded from the room to discourage interruptions during the procedure.

All visits were videotaped using a Sony Camcorder mounted on a tripod. For the sensorimotor assessment, babies were seated in an infant seat and the camera was set to
record the infant from the waist up, as to capture all arm movements. For the frustration-elicitation protocol, infants were seated in high-chairs, and the camera set to capture the infant’s head, torso, and the highchair tray.

2.3.1 Measures of Sensorimotor Coordination

For each visit, the researcher first assessed the infant’s capacities to coordinate sensory and motor goals. Tasks used for this assessment were developed based on Case’s stage model of cognitive development. The specific tasks used were developed by Piaget (1952), Case (1985), and Lewis & Ash (1992). Two pass-fail tasks were administered for each visit. These tasks were designed to assess unifocal coordinative capacities and were administered up to and including week 24. By week 24, infants generally pass these tasks with ease (Lewis, 1993a). New tasks, designed to assess bifocal coordinative skills, were used thereafter (weeks 27 to 55).

2.3.1.A Assessment of unifocal sensorimotor coordination

From weeks 12 through 24, the tasks Adjusted Reach and Reach and Grasp were administered. These tasks were designed to test the infant’s ability to coordinate two basic sensorimotor actions (Lewis & Ash, 1992). The first task, Adjusted Reach, required the coordination of visual tracking and manual reaching. In this task, the researcher slowly moved a squeaky dinosaur toy back and forth across the infant’s field of vision but just out of the infant’s reach. A pass was registered if the infant showed smooth adjustments to arm motion
in correspondence with the movement of the toy on two consecutive traverses. Two 30-second trials were permitted.

The second task, Reach and Grasp, assessed visually-guided reaching and grasping, and thus tapped both gross- and fine-motor capacities. In this task, the dinosaur toy was brought directly in front of the infant and within reach. If necessary, the toy was squeaked to capture the infant's attention and to stimulate reaching behaviour. A pass was registered if the infant reached his hand directly to the toy, with palm open and facing the toy, and immediately grasped the toy on initial contact for 2 of 4 trials per visit.

2.3.1.B Assessment of bifocal coordination

From weeks 27 through 55, the tasks Cloth Pull and Hidden Object were administered. These tasks were designed to assess the infant's ability to combine multiple sensorimotor actions into a means-end sequence.

The first bifocal task, Cloth Pull, requires that the infant manipulate one object (the cloth) as a means of acquiring the desired object (a toy). The infant was seated in a high-chair with a small table placed just in front of the high chair tray. In view of the infant, a cloth was placed over the tray and table. A toy was given to the infant for free-play, then taken away from the infant and, with the infant attending, placed on the far-end of the cloth. A pass was scored if the infant (i) retrieved the toy (ii) within 20 seconds of touching the cloth while (iii) attending to the movement of the toy. Two trials were allowed. The three criteria were designed to ensure that the infants were engaged in intentional problem-solving behaviours and were not producing accidental solutions (Willats, 1999).
The second bifocal task, Hidden Object, is a variant of Piaget’s classic object permanence task (Piaget, 1955). In this task, the infant must remove a container (means) under which is placed a desired toy (end). For this task, the infant was allowed 15 seconds to manipulate a plastic container. The research assistant then exchanged the container for a set of plastic keys. After 10 seconds of play, the research assistant then placed the keys under the container. During this time, the mother held the infant’s arms to prevent the infant from interfering in the procedure. A pass was registered if the infant (i) lifted the container, and (ii) touched the keys (iii) within 5 seconds of non-distracted attention (e.g., playing with the container, see Willats, 1984). Two trials were permitted.

2.3.2 Frustrating Objects Interaction Procedure

Following the assessment of sensorimotor coordination, mothers and infants engaged in a Frustrating Objects Interaction. In this procedure, the infant was seated in a high-chair with a tray. The mother had previously been instructed in the Frustrating Objects Interaction (FOI) procedure. The FOI consisted of six rounds each composed of three distinct segments. In the first round, the mother gave the first of the six toys to her baby for 20 seconds, then removed the toy from the infant’s grasp and placed it on the opposite side of the tray, out of the infant’s reach. After 30 seconds, the mother returned the toy to the infant for another 20 second segment. Toy 1 was then exchanged for toy 2 (i.e., simultaneous retrieving of toy 1 and offering of toy 2) and the cycle continued for the remainder of the six toys. All

5 See Appendix A for a schedule and descriptions of the toys used
transitions between the three segments (Give-toy, Withhold-toy, and Return-toy) were signaled by the researcher. The mother was to maintain a neutral expression during the FOI procedure and was not to speak to her baby. The mother was, however, allowed to look at her child and maintain normal eye contact. The researcher remained out of the infant’s sight during this procedure.

At the earliest ages the infant would not always immediately grasp the toy, and so the mother was advised to shake and rattle the toy and to touch the infant’s hand with the toy to stimulate grasping if necessary. Toys dropped during Give-toy or Return-toy were retrieved and returned to the infant prior to Withhold-toy segment.

It was expected that this procedure would elicit frustration and some distress. However, the FOI was discontinued if the infant cried for (a) 15 consecutive seconds or (b) 75% or more of two consecutive segments. This second criteria would be met if, for example, an infant showed intense distress for 15 seconds of a 20 second segment (e.g., Give-toy) and 23 seconds of the following 30 second segment (e.g., Withhold-toy). The mother could discontinue the FOI procedure at any point.

2.4 Coding Procedures and Data Reduction

As a part of the larger study referred to in 2.1, the videotapes of the Frustrating Objects Interaction procedure were coded by research assistants blind to the research hypotheses. All videotapes were coded second-by-second. Infant behaviour during the FOI was coded for intensity of negative affect, attentional engagement, and coping behaviours. These three criteria were coded on three separate passes conducted by independent teams of
research assistants. Only codes for negative affect and attentional engagement were used in the present study.

2.4.1 Coding of Infant Distress

Second-by-second coding of affect focused on three regions of the infant’s face: the eyebrows, the eyes and cheeks; and the mouth. The Maximally Discriminative Facial Movement Coding System (MAX), developed by Izard (1979), was used to identify the three regions. Distress was rated on a four-point scale. Facial expressions that were judged to show no distress in any of the three facial regions were assigned a value of zero (0) on the distress scale. Facial expressions that showed distress expressions in one or two of the focal regions and were judged as troubled, uncomfortable or mildly anxious were assigned a value of one (1). Facial expressions that showed fully articulated negative patterns in all three regions were assigned a value of two (2). If intense distress was evident in all three regions of the face, with eyes squinted or shut, or if the infant was crying, a value of three (3) was assigned. Time-lines of infant distress were derived from these second-by-second codes. These timelines mapped momentary changes in distress level. In reporting the results of this study, distress level zero will be referred to as “calm”, level 1 will be referred to as “irritated”, level 2 will be referred to as “disturbed” and level 3 will be referred to as “distressed”.

Teams of two independent raters were trained in coding negative affect. Inter-rater reliability was computed based on independent ratings of 16 percent of the videotaped visits. For these codes, reliability was calculated by comparing the sequence and duration of each change in level of distress. Any disagreements in the timing of changes (non-matching codes)
were isolated, and a dummy code created for the other raters’ corresponding time-segment. Using standard SPSS procedures, the Kappa calculation was weighted based on the event durations. The Kappa coefficient for affect codes was .70.

2.4.2 Coding of Infant Attention Engagement

As with negative affect, infant attentional focus was assessed for each second of each visit. First, raters went through the tapes and noted any occurrence of looks to the mother’s face (Mom). Looks to Mom of less than one second were rounded up. As Mom was coded independently of the other attention codes, it could overlap with the others. On a second pass through the tapes, the raters coded for three other attentional foci: Toy, Other, and Scan. Toy was coded when the infant gazed at, mouthed, or held the toy for at least two seconds. Other was coded for any gaze lasting two seconds or longer to anything other than the mother’s face or the Toy. Scan was coded any time the infant engaged in wide-range visual saccades between at least two distal visual locations for at least two seconds. Scan, Other, and Toy codes could not overlap with one another, but, as noted, could overlap with Mom.

Inter-rater reliability for attention codes was calculated from independent ratings of 15 percent of the videotaped procedures. As with the affect codes, the streams of codes for the two raters were inspected for disagreement, and the durations of disagreement were isolated and dummy-coded. The SPSS derived duration-weighted Kappa coefficient for attentional engagement codes was .84.
2.4.3 **Derivation of Basic Event Statistics.**

Attention and emotion event onset and offset times were formatted as Timed Event Sequential Data using the Sequential Data Interchange Standard (SDIS) for analysis with the Generalized Sequential Querier (GSEQ) (Bakeman & Quera, 1995). GSEQ allowed examination of co-occurrences of independently coded behavioural streams, as well as the derivation of simple descriptive statistics on the duration, frequency, and mean bout duration (duration divided by frequency) for all codes and combinations of overlapping codes. These derivations were used in calculating attention and emotion variables for each visit. As well, GSEQ was used to calculate overall durations of overlap of the scan code with the four distress levels for each visit.

To standardize the durations of attention and emotion variables, the total durations of these codes during withhold-toy segments were summed across all the rounds of each visit\(^6\). These summed totals were transformed to proportional durations by dividing by the total duration of withhold-toy segments for all rounds of the visit. This allowed comparison of infant data accounting for fluctuations in the lengths of withhold-toy segments and in the number of rounds completed per visit. These standardized durations were aggregated by stage for subsequent analyses.

**Distress Duration**

Following the standardization procedure described above, measures of the proportion of time infant spent at each level of distress during the Withhold-toy segments were derived.

---

\(^6\) The research design specified 6 rounds per visit. However, as noted, some visits were shortened due to excessive infant distress, or at the request of the mother.
distress level durations were calculated and aggregated by stage for each of the four levels of distress (Calm, Irritated, Disturbed, & Distressed).

_Scan Duration_

Following the standardization procedure described above, the proportion of the Withhold-toy segments spent scanning was calculated, and aggregated by stage.

_Mean Bout Durations of Attention Codes_

Measures of average fixation duration were calculated for the four attention codes (Mom, Toy, Other, & Scan). These measures were obtained through the GSEQ's simple statistics function. For each visit, mean bout duration was calculated as the overall summed duration of a code divided by its frequency of occurrence. These mean bout durations, or average episode lengths (Bakeman & Quera, 1995), were then aggregated by stage for further analyses.

_Co-occurrence of Attention and Emotion Codes_

As noted in Section 1.7, the design of this study, through the FOI procedure, permitted the analysis of co-occurring distress and attention. In particular, the Withhold-toy segments were expected to be distressing to the infants and to allow assessment of their capacities to regulate emotion and attention. For this reason, analyses of attention, co-occurrence of attention-distress, and distress (except for the peak distress proportion, see section 2.4.4 below) were computed for Withhold-toy segments only.

To assess the likelihood of attention flexibility given differing emotional states, two variables were constructed. _Calm scan_ was calculated as the sum total of scanning concurrent with level zero distress divided by the overall duration of level zero distress for all Withhold-
toy segments of a visit. Likewise, Agitated scan was calculated as the proportion of scanning concurrent with distress levels 1 to 3 to the overall summed duration of levels 1 through 3 distress for all Withhold-toy segments per visit.

2.4.4 Distress Episodes and Peak Distress Proportions

The measure of distress duration described above provided a metric of the overall tendency towards intense distress, but did not give any information on the dynamics of infant distress. Infant capacities to self-regulate were assessed through the construction of distress episodes and distress proportions. Distress episodes were defined as follows: the occurrence of level 2 or 3 distress at any point during a visit marked the onset of a distress episode. Distress episode offsets were based on: (a) a drop to distress level 1 for longer than 3 seconds; (b) a drop to distress level 0 for longer than 2 seconds; or (c) a mixture of level 1 and 0 for longer than 3 seconds. In the case of multiple distress episodes per visit, the distress episode of the greatest duration was selected as the representative episode for that visit.

From this distress episode, the peak distress proportion was derived. The number of seconds spent in level 3 distress during the distress episode was summed, and this number was divided by the total duration of the distress episode. Note that some distress episodes contained no level 3 distress, and thus resulted in a peak distress proportion of zero. Also, some visits had no distress at levels 2 or 3, and hence no distress episode occurred. These visits were treated as missing data in subsequent calculations.

Infants who have high distress proportions are those who, once they show distress, tend to maintain an intense pitch of distress for the duration of the distress episode. Infants
with low distress ratios, by contrast, may show some level 3 distress, but this distress alternates with drops in intensity to level 0, 1, or 2 distress. In sum, high distress proportions reflect distress episodes marked by steady intense distress; low distress proportions are obtained from distress episodes which show more variability in distress level.

Unlike other variables, mean distress proportions for each stage are not reported. Instead, one representative distress episode was selected per stage for each infant. The distress episode with the highest distress proportion within a stage was selected as the representative, and the distress proportion from this episode was used in analysis. The highest peak distress proportion was believed to represent the instance of the greatest challenge to the infant's regulatory capacities, and to reveal the infant's capacities for self-regulation given intense distress, as opposed to the infant's capacity to avoid intense distress in the first place.

2.4.5 Sensorimotor Tasks and Sensorimotor Stages Boundaries

Central to the hypotheses of this study is the idea that emotion and attention develop over infancy. In particular, developments in epistemic capacities and in abilities to coordinate sensorimotor actions imply that emotions may be elicited for different reasons and that attention may be differentially allocated in different stages of development (Case et al., 1988). In accordance with this framework, distress and attention variables were aggregated by sensorimotor stage.

The boundaries of sensorimotor stages were defined based on infant performance in the sensorimotor tasks described above. While the criteria for passing tasks were stringent, some
infants may have passed tasks accidentally. To protect against this, a conservative criterion for stage boundaries was adopted. An infant was considered to be operating at a new stage of sensorimotor coordination once (i) one of either of the two tasks had been passed on two consecutive visits; (ii) both tasks had been passed once, whether on the same visit or on consecutive visits. See Table 3.1 for stage demarcations for all infants.

Based on these boundaries, infant emotional and attentional data were aggregated by stage. Scores on variables of interest were summed within a stage and a mean score was derived for each infant. In this manner, stage-scores were derived for distress, for attention variables, and for distress-scanning co-occurrence.

2.4.6 Sensorimotor Task Performance as a Measure of Cognitive Competence

Performance on cloth pull and hidden object tasks was also used as a sensorimotor outcome measure. The week of bifocal coordination, defined according to criteria outlined above (section 2.4.5), was used as an index of the onset of means-end coordination.

Transition-age assesses individual differences in the precocity of means-end, or bifocal, coordination. Infants who pass these tasks earlier were thought to be more precocious in their sensorimotor development, and more able to demonstrate these skills in spontaneous unassisted problem-solving, than were infants who passed the tasks later.
<table>
<thead>
<tr>
<th>Variable type</th>
<th>Variable</th>
<th>Derivation (unit of measurement)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distress</td>
<td>Distress duration</td>
<td>Total level 3 distress duration divided by procedure duration</td>
</tr>
<tr>
<td></td>
<td>Peak distress episode</td>
<td>Longest single episode of distress within a stage</td>
</tr>
<tr>
<td></td>
<td>Peak distress proportion</td>
<td>Proportion of level 3 distress to other distress levels for peak distress episode</td>
</tr>
<tr>
<td>Attention</td>
<td>Mom mean bout duration</td>
<td>Duration of looks to mother divided by frequency of looks (s)</td>
</tr>
<tr>
<td></td>
<td>Toy mean bout duration</td>
<td>Duration of looks to toy divided by frequency of looks (s)</td>
</tr>
<tr>
<td></td>
<td>Other mean bout duration</td>
<td>Duration of looks to other locations divided by frequency of looks (s)</td>
</tr>
<tr>
<td></td>
<td>Scan mean bout duration</td>
<td>Duration of scanning divided by frequency of scanning (s)</td>
</tr>
<tr>
<td></td>
<td>Scan duration</td>
<td>Duration of scanning divided by overall duration of Withhold-toy segments</td>
</tr>
<tr>
<td>Emotion-attention</td>
<td>Calm scan</td>
<td>Duration of Scanning co-occurring with calm (level 0) affect</td>
</tr>
<tr>
<td></td>
<td>Agitated scan</td>
<td>Duration of scanning co-occurring with agitated (levels 1-3) affect</td>
</tr>
<tr>
<td>Sensorimotor Skills</td>
<td>Transition-age</td>
<td>Week of acquisition of bifocal skills (weeks) (see section 2.4.5)</td>
</tr>
</tbody>
</table>

**Note:** All variables were calculated only for Withhold-toy segments except Peak distress episode and Peak distress proportion. All variables are aggregated by stage except Transition-age, Peak distress episode, and Peak distress proportion.
Due to the small number of subjects used in this study and the exploratory nature of the analyses, a .10 alpha level was used for all statistical tests of significance.

3.1 Sensorimotor Performance and the Demarcation of Stage Boundaries

Table 3.1:
Sensorimotor Task Performance for All Visits and Demarcation of Stage Boundaries by Infant

<table>
<thead>
<tr>
<th>Infant</th>
<th>week</th>
<th>14</th>
<th>16</th>
<th>18</th>
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<th>22</th>
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<th>36</th>
<th>39</th>
<th>43</th>
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<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
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<td>0</td>
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<td>ar</td>
<td>0</td>
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<td>c</td>
<td>ch</td>
<td>ch</td>
<td>ch</td>
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<tr>
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<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
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<td>ar</td>
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<td>c</td>
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<td>ch</td>
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<td>0</td>
<td>0</td>
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<td>ar</td>
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<td>0</td>
<td>0</td>
<td>h</td>
<td>ch</td>
<td>ch</td>
<td>ch</td>
</tr>
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<td>11</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>r</td>
<td>ar</td>
<td>ar</td>
<td>ar</td>
<td>ar</td>
<td>ar</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>h</td>
<td>ch</td>
<td>ch</td>
</tr>
<tr>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>r</td>
<td>ar</td>
<td>ar</td>
<td>ar</td>
<td>ar</td>
<td>ar</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>c</td>
<td>h</td>
<td>c</td>
</tr>
</tbody>
</table>

Note: a = adjusted reach, r = reach and grasp, c = cloth pull, h = hidden object
* = beginning of subsequent stage
As shown in Table 3.1, infant sensorimotor performance largely corresponded with the stage model proposed by Case (1985; see also Lewis & Ash, 1992). Infants first passed unifocal tasks around week 20 (~4.6 months) (range = week 16 - week 24; mode = week 20; median = week 20). While successful performance of means-end tasks were observed as early as week 30 (~7 months), these may have been transitional (i.e., accidental) successes (Willats, 1984). Based on our criteria for stage boundaries, infants showed reliable bifocal skills around week 36 (~8.3 months) (median = week 36; mode = week 36; range = week 33 - week 39).

3.2 Sensorimotor Coordination Scores as Cognitive Competency Outcomes

Sensorimotor performance on the bifocal tasks was also used to derive Transition-age, the measure of onset of means-end coordination skills. The Transition-ages for all infants are presented in Table 3.2. The mean transition-age was 35.8 weeks (~8.3 months) (SD = 2.4)

<table>
<thead>
<tr>
<th>Table 3.2: Transition-Age (in weeks) by Infant</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>infant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transition-age</td>
<td>36</td>
<td>39</td>
<td>36</td>
<td>39</td>
<td>33</td>
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<td>33</td>
<td>39</td>
<td>33</td>
<td>36</td>
<td>36</td>
<td>33</td>
</tr>
</tbody>
</table>

It is very important to note that although the infants selected for this study were chosen based on criteria of a technical nature (e.g., missing visits, spoiled video data), an examination of the included and excluded groups revealed an important differences between the two. The mean Transition age of the group excluded from this study was 38.8 (~9 months) (SD = 5.1). Thus, both the mean and variability of the excluded group were higher
than for those infants who were included in the subsequent analyses. An univariate analysis of variance revealed a significant difference in transition-age between the groups (included and excluded infants), F (1, 29) = 3.72, p = .064. Inspection of the means for the two groups revealed that, on average, infants excluded from the analysis entered the bifocal stage later than those than those infants included in the study.

3.3 Distress Measures

3.3.1. Level of Distress During Withhold-Toy

Table 3.3: Distribution of Distress as a Proportion of Withhold-toy Segment by Sensorimotor Stage (n = 12)

<table>
<thead>
<tr>
<th>Distress level</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consolidation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calm</td>
<td>.77</td>
<td>.12</td>
<td>.60 -.94</td>
</tr>
<tr>
<td>Irritated</td>
<td>.13</td>
<td>.10</td>
<td>.04 -.35</td>
</tr>
<tr>
<td>Disturbed</td>
<td>.06</td>
<td>.05</td>
<td>.00 -.14</td>
</tr>
<tr>
<td>Distressed</td>
<td>.04</td>
<td>.05</td>
<td>.00 -.15</td>
</tr>
<tr>
<td>Unifocal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calm</td>
<td>.73</td>
<td>.16</td>
<td>.42 -.94</td>
</tr>
<tr>
<td>Irritated</td>
<td>.18</td>
<td>.15</td>
<td>.05 -.55</td>
</tr>
<tr>
<td>Disturbed</td>
<td>.05</td>
<td>.04</td>
<td>.00 -.15</td>
</tr>
<tr>
<td>Distressed</td>
<td>.03</td>
<td>.03</td>
<td>.00 -.08</td>
</tr>
<tr>
<td>Bifocal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calm</td>
<td>.69</td>
<td>.13</td>
<td>.53 -1.0</td>
</tr>
<tr>
<td>Irritated</td>
<td>.20</td>
<td>.11</td>
<td>.00 -.42</td>
</tr>
<tr>
<td>Disturbed</td>
<td>.08</td>
<td>.05</td>
<td>.00 -.15</td>
</tr>
<tr>
<td>Distressed</td>
<td>.03</td>
<td>.04</td>
<td>.00 -.13</td>
</tr>
</tbody>
</table>
Table 3.3 shows the descriptive statistics for the four distress levels during Withhold-toy segments for each stage of sensorimotor coordination. Despite the intended frustrating effect of toy-removal, calm responses were most common during Withhold-toy.

Nevertheless, there was a slight trend toward greater incidence and duration of Irritation over stages. Disturbed and Distressed responses as measured by overall duration showed no overall trend across stages.

3.3.2. Distress Episodes and Distress Proportions

Table 3.4: Distress Episode Durations (in seconds) and Distress Proportions by Infant

<table>
<thead>
<tr>
<th>Infant</th>
<th>Distress episode duration (mean (SD))</th>
<th>Distress peak episode duration (mean (SD))</th>
<th>Distress peak episode proportion</th>
<th>Distress peak episode duration (mean (SD))</th>
<th>Distress peak episode proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.0 (7.3)</td>
<td>15</td>
<td>.20</td>
<td>0.7 (0.8)</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>13.7 (14.6)</td>
<td>30</td>
<td>.73</td>
<td>6.0 (5.6)</td>
<td>.40</td>
</tr>
<tr>
<td>3</td>
<td>11.8 (12.8)</td>
<td>30</td>
<td>.57</td>
<td>10.1 (9.3)</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>9.8 (10.6)</td>
<td>21</td>
<td>.95</td>
<td>10.8 (9.3)</td>
<td>21</td>
</tr>
<tr>
<td>5</td>
<td>19.0 (16.5)</td>
<td>30</td>
<td>.7</td>
<td>10.8 (14.9)</td>
<td>.90</td>
</tr>
<tr>
<td>6</td>
<td>0.0 (--)</td>
<td>--</td>
<td>(n/a)*</td>
<td>0.8 (1.8)</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>2.8 (4.3)</td>
<td>9</td>
<td>.11</td>
<td>0.6 (1.3)</td>
<td>.00</td>
</tr>
<tr>
<td>8</td>
<td>12.8 (7.6)</td>
<td>9</td>
<td>.78</td>
<td>11.7 (11.4)</td>
<td>19</td>
</tr>
<tr>
<td>9</td>
<td>10.7 (12.2)</td>
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<td>.08</td>
<td>9.8 (7.8)</td>
<td>21</td>
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<tr>
<td>10</td>
<td>11.8 (14.1)</td>
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<td>.79</td>
<td>13.5 (13.9)</td>
<td>29</td>
</tr>
<tr>
<td>11</td>
<td>13.0 (14.4)</td>
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<td>.88</td>
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<td>3.0 (3.6)</td>
<td>7</td>
<td>.00</td>
<td>6.0 (8.9)</td>
<td>.60</td>
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</tbody>
</table>

* infant 6 showed no level 2 or 3 distress during operational consolidation
Table 3.4 shows the descriptive statistics for mean distress episodes, the peak distress episode durations and peak distress proportions for each infant for the first two stages. Distributions of real-time distress episodes showed both greater inter- and intra-individual variability than the distress duration measures. Note that there was no overall trend in either distress proportions or distress episode length over stages.

3.3.3. **Stability of Individual Differences in Distress Measures**

Table 3.5 shows the intercorrelations between distress measures both within and across the operational consolidation and unifocal stages. Strong associations were found

<table>
<thead>
<tr>
<th></th>
<th>Distress duration</th>
<th>Peak distress episode</th>
<th>Peak distress proportion</th>
<th>Distress duration</th>
<th>Peak distress episode</th>
<th>Peak distress proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>consolidation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distress duration</td>
<td>--</td>
<td>.34</td>
<td>.64*</td>
<td>.72**</td>
<td>.69*</td>
<td>.77**</td>
</tr>
<tr>
<td>Peak distress</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>episode*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak distress</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>proportion*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unifocal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>coordination</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distress duration</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak distress</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>episode</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak distress</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>proportion</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .10;  * p < .05; ** p < .01

* Infant 7 showed no level 2 or 3 distress during any visits prior to onset of unifocal coordination. No distress episodes were registered for her, reducing n to 11.
between measures both within stages and across stages. The weakest predictor of later distress was the duration of the peak distress episode.

3.4 **Attention Allocation Indices**

3.4.1. **Mean Fixation Duration and Attentional Flexibility**

In this study, mean bout durations were used as a measurement of individual differences in fixation duration. Mean bout duration—a composite measure of the summed duration of a code divided by the frequency of its occurrence—was derived for the four attentional codes during Withhold-toy segments. Table 3.6 shows mean bout durations for each attentional code for the three stages.

It is important to remember that the coding procedures for Mom were not the same as those for Toy, Scan and Other, in that no minimum duration for Mom was required. Thus, the large differences in mean bout durations for Mom compared with the other codes are ambiguous.

Only the mean bout durations of looks to Mom and to Other showed any developmental trend. Looks to Mom decreased over the first year, with average bout durations dropping from 2.5 seconds during operational consolidation to 1.9 and 1.7 seconds during unifocal and bifocal coordination stages respectively. Mean fixation duration of looks to Other also dropped from a mean of 8.0 seconds during operational consolidation to 6.6 and 6.1 seconds during unifocal and bifocal coordination respectively.

Although there was little change in means for bout duration, a developmental trend
was evident for the variability of infant fixations. Mom, Toy, and Other showed reductions in variance following the onset of unifocal coordination. Examination of the range of values for these codes revealed that the drop in variance came mostly from the upper end of the range: during operational consolidation, infants show a higher maximum value of mean fixation duration than during later stages. Mean duration of scanning showed no change either in

<table>
<thead>
<tr>
<th>Focus of attention</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operational Consolidation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mom</td>
<td>2.5</td>
<td>1.2</td>
<td>1.0 - 4.8</td>
</tr>
<tr>
<td>Toy</td>
<td>6.3</td>
<td>3.6</td>
<td>1.2 - 11.7</td>
</tr>
<tr>
<td>Scan</td>
<td>6.4</td>
<td>1.4</td>
<td>4.7 - 9.4</td>
</tr>
<tr>
<td>Other</td>
<td>8.0</td>
<td>3.5</td>
<td>3.8 - 16.9</td>
</tr>
<tr>
<td><strong>Unifocal Coordination</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mom</td>
<td>1.9</td>
<td>0.5</td>
<td>1.2 - 2.7</td>
</tr>
<tr>
<td>Toy</td>
<td>6.2</td>
<td>1.5</td>
<td>4.7 - 8.6</td>
</tr>
<tr>
<td>Scan</td>
<td>6.6</td>
<td>1.4</td>
<td>5.1 - 10.2</td>
</tr>
<tr>
<td>Other</td>
<td>6.6</td>
<td>1.8</td>
<td>3.9 - 9.8</td>
</tr>
<tr>
<td><strong>Bifocal Coordination</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mom</td>
<td>1.7</td>
<td>0.3</td>
<td>1.4 - 2.4</td>
</tr>
<tr>
<td>Toy</td>
<td>6.2</td>
<td>1.5</td>
<td>4.8 - 9.3</td>
</tr>
<tr>
<td>Scan</td>
<td>5.3</td>
<td>0.7</td>
<td>4.1 - 6.2</td>
</tr>
<tr>
<td>Other</td>
<td>6.1</td>
<td>1.8</td>
<td>3.5 - 9.5</td>
</tr>
</tbody>
</table>
central tendency or in variance across the operational consolidation and unifocal stages. In contrast with the other attention codes, the range of bouts of scanning slides slightly up across the two stages, from 4.7 - 9.4 to 5.1 - 10.2 seconds. It was not until bifocal coordination that the mean episode length of scanning dropped (from a mean of 6.6 to 5.3), accompanied by an overall reduction in variance.

3.5 Real-Time Emotion-Scanning Co-occurrence

Table 3.7:
Scanning and Emotion Co-occurrence
During Withhold-Toy by Stage (n = 12)

<table>
<thead>
<tr>
<th>Scan Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scan Duration</td>
<td>.33</td>
<td>.14</td>
<td>.08 - .60</td>
</tr>
<tr>
<td>CalmScan</td>
<td>.35</td>
<td>.15</td>
<td>.09 - .62</td>
</tr>
<tr>
<td>Agitated Scan</td>
<td>.27</td>
<td>.17</td>
<td>.00 - .57</td>
</tr>
</tbody>
</table>

Unifocal Coordination

| Scan Duration   | .35  | .10 | .18 - .51 |
| CalmScan        | .34  | .10 | .18 - .48 |
| Agitated Scan   | .40  | .17 | .07 - .67 |

Bifocal Coordination

| Scan Duration   | .27  | .11 | .07 - .43 |
| CalmScan        | .25  | .10 | .07 - .35 |
| Agitated Scan   | .31  | .17 | .05 - .52 |

*infant 8 did not show any co-occurrence of scanning and agitation during the bifocal stage. Thus the number of subjects for the final two measures listed is 11.
Table 3.7 lists the descriptive statistics for Scan, Calm-scan and Agitated-scan variables by stage. There was no trend over development in the overall proportion of scanning. Similarly, the incidence of co-occurrence of scanning and calm affect did not change until the bifocal stage. Agitated scanning peaked during the unifocal stage. As well, during this stage, infants appeared more likely to scan while agitated that while calm.

As shown in Table 3.8, Calm-scan and Agitated-scan were highly correlated with both overall Scan Duration and with each other. Infants who scanned while calm were more likely to scan while agitated, and were more likely to scan in general.

Table 3.8: 
Intercorrelations Between Scan Variables 
Within Unifocal Stage (n = 12)

<table>
<thead>
<tr>
<th></th>
<th>Scan duration</th>
<th>Calm scan</th>
<th>Agitated scan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scan duration</td>
<td>--</td>
<td>.97**</td>
<td>.89**</td>
</tr>
<tr>
<td>Calm scan</td>
<td>--</td>
<td>--</td>
<td>.78**</td>
</tr>
<tr>
<td>Agitated scan</td>
<td></td>
<td></td>
<td>--</td>
</tr>
</tbody>
</table>

** p < .01

3.6 The Relationship between Distress and Means-end Coordination.

The first hypothesis was that early individual differences in distress regulation would predict means-end skills. Specifically, high distress during operational consolidation, but not thereafter, was expected to predict a lag in bifocal coordination. Correlations between distress measures and the Transition-age of bifocal coordination are presented in Table 9. In general, infant distress measures during operational consolidation were more strongly related to Transition-age than were unifocal measures. Nevertheless, at neither stage did overall duration of level 3 distress or the peak distress episode predict Transition-age. A significant association
was found between the peak distress proportion during operational consolidation and the age of bifocal coordination ($r = .70, p = .015$). Infants whose longest distress episodes were marked by a high proportion of level 3 distress did not demonstrate means-end coordination until later than infants with low distress proportions. However, this relationship did not hold for the peak distress proportion during unifocal coordination.

Table 3.9:
Zero-order Correlations Between Measures of Distress and Transition-Age ($n = 12$)

<table>
<thead>
<tr>
<th>Distress Measure</th>
<th>Transition-age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational Consolidation</td>
<td></td>
</tr>
<tr>
<td>Distress duration</td>
<td>.34</td>
</tr>
<tr>
<td>Peak distress episode</td>
<td>.27</td>
</tr>
<tr>
<td>Peak distress proportion$^a$</td>
<td>.70 *</td>
</tr>
<tr>
<td>Unifocal Coordination</td>
<td></td>
</tr>
<tr>
<td>Distress duration</td>
<td>.17</td>
</tr>
<tr>
<td>Peak distress episode</td>
<td>-.03</td>
</tr>
<tr>
<td>Peak distress proportion</td>
<td>.38</td>
</tr>
</tbody>
</table>

* $p < .05$

$^a$ $n = 11$, see note for Table 5.

3.7 The Relationship Between Distress and Attention Flexibility

According to the second hypothesis, early distress was also expected to predict flexibility of attention during the unifocal stage. It was expected that this relationship might be found either for fixation durations or for scanning during Withhold-toy segments.
As shown in Table 3.10, only overall distress duration during operational consolidation was significantly correlated with mean bout duration for scanning. Infants who spent a large proportion of Withhold-toy segments distressed tended to have long scanning episodes during unifocal coordination. However, this correlation may have been overly dependent on outliers. In this case, two infants (infant 8 & infant 10) had high overall levels of distress during operational consolidation and high mean bout durations for scanning during the unifocal stage. Removal of these two infants reduced the correlation to non-significance ($r = -.19, p = .60$). In sum, there were no reliable correlations between distress and mean bout durations.

<table>
<thead>
<tr>
<th>Distress measures</th>
<th>Mom</th>
<th>Toy</th>
<th>Scan</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operational Consolidation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distress duration</td>
<td>-.17</td>
<td>.22</td>
<td>.75**</td>
<td>.12</td>
</tr>
<tr>
<td>Peak distress episode$^a$</td>
<td>.30</td>
<td>.19</td>
<td>-.20</td>
<td>.30</td>
</tr>
<tr>
<td>Peak distress proportion$^a$</td>
<td>.26</td>
<td>.03</td>
<td>.37</td>
<td>.09</td>
</tr>
<tr>
<td><strong>Unifocal Coordination</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distress duration</td>
<td>.24</td>
<td>-.06</td>
<td>.38</td>
<td>.13</td>
</tr>
<tr>
<td>Peak distress episode</td>
<td>.29</td>
<td>-.19</td>
<td>.21</td>
<td>.03</td>
</tr>
<tr>
<td>Peak distress proportion</td>
<td>.45</td>
<td>-.20</td>
<td>.36</td>
<td>.02</td>
</tr>
</tbody>
</table>

$^{**} p < .01$

$^a n = 11$, see note for table 5
The second hypothesis also predicted that early distress would relate to scanning during the unifocal stage. As well, the first research question asked whether early distress regulation would relate to later real-time co-occurrence of attention flexibility and negative affect. Table 3.11 shows the correlations between scanning variables and distress measures (for both operational consolidation and unifocal stages). Early distress showed no significant relations with scan duration during the unifocal stage. There was a moderate trend between the overall duration of distress and later tendencies to scan while agitated. However, examination of the scatterplot of this relationship revealed two outliers (infants 8 & 10).

Table 3.11:
Zero-Order Correlations Between Measures of Distress and Unifocal Stage Scanning Variables (n=12)

<table>
<thead>
<tr>
<th>Distress measures</th>
<th>Scan duration</th>
<th>Calm scan</th>
<th>Agitated scan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational Consolidation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distress duration</td>
<td>.36</td>
<td>.32</td>
<td>.51\textsuperscript{+}</td>
</tr>
<tr>
<td>Peak distress episode\textsuperscript{a}</td>
<td>-.14</td>
<td>-.15</td>
<td>.15</td>
</tr>
<tr>
<td>Peak distress proportion\textsuperscript{a}</td>
<td>.14</td>
<td>.08</td>
<td>.38</td>
</tr>
<tr>
<td>Unifocal Coordination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distress duration</td>
<td>.05</td>
<td>.05</td>
<td>.15</td>
</tr>
<tr>
<td>Peak distress episode</td>
<td>.14</td>
<td>.16</td>
<td>.20</td>
</tr>
<tr>
<td>Peak distress proportion</td>
<td>.10</td>
<td>.09</td>
<td>.25</td>
</tr>
</tbody>
</table>

\( + \ p < .10 \)
\( \text{\textsuperscript{a}} \ n = 11, \text{see note for table 5} \)

Removal of these infants greatly reduced the correlation (\( r = .03; p = .93 \)). However, the small sample size of this study makes it difficult to conclude whether these infants
represent a sub-group of frequently distressed infants or whether they are in fact anomalous. Distress during the unifocal stage did not relate to scanning or to scan-emotion co-occurrence.

Due to the strong intercorrelations between Scanning duration, Calm scan and Agitated scan during the unifocal stage (see Table 8), the relationship between early distress and later scanning while calm or agitated may have been obscured by overall scanning. To test further whether distress during operational consolidation related to distress-scanning co-occurrence, it was necessary to partial out individual differences in scan duration. Table 3.12 shows the results of partial correlation analysis controlling for scan duration during the unifocal stage.

Table 3.12:

**Partial Correlations Between Distress and Scan-Emotion**

**Co-occurrence Controlling for Scan Duration (d.f. = 8).**

<table>
<thead>
<tr>
<th>Distress measures</th>
<th>Calm scan</th>
<th>Agitated scan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distress duration</td>
<td>0.08</td>
<td>0.26</td>
</tr>
<tr>
<td>Peak distress episode</td>
<td>-0.09</td>
<td>0.70*</td>
</tr>
<tr>
<td>Peak distress ratio</td>
<td>-0.32</td>
<td>0.62*</td>
</tr>
</tbody>
</table>

* p < .10; * p < .05

Controlling for scan duration resulted in a significant correlation between the peak distress episode and agitated scan. Infants who had long distress episodes were more likely to scan while distressed than were infants who had short distress episodes. As well, high peak distress proportions predicted tendencies to scan while agitated. With regard to the
second research question, early distress predicted individual differences in the co-occurrence of scanning and negative affect, but only once overall scanning tendencies had been controlled.

Because the Calm-scan and Agitated-Scan measures were both dependent on the overall amount of negative affect during unifocal coordination, it was possible that their relationships to early distress were based on their common association with agitation. To further clarify the relationship, partial correlations were performed controlling for overall negative affect during the unifocal stage (see Table 3.13). Controlling for general agitation (duration of level 1-3 distress) increased the strength of many of the associations between early distress and scanning. Distress duration during operational consolidation now predicted overall Scan duration, Calm-scan, and Agitated-scan.

Table 3.13:
Partial Correlations Between Early Distress and Scan-Emotion

<table>
<thead>
<tr>
<th>Co-occurrence Controlling for Overall Agitation (d.f. = 8)</th>
<th>Scan duration</th>
<th>Calm-scan</th>
<th>Agitated scan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distress duration</td>
<td>.55*</td>
<td>.61*</td>
<td>.56*</td>
</tr>
<tr>
<td>Peak distress episode</td>
<td>-.08</td>
<td>-.10</td>
<td>.25</td>
</tr>
<tr>
<td>Peak distress proportion</td>
<td>.36</td>
<td>.32</td>
<td>.56*</td>
</tr>
</tbody>
</table>

+ p < .10

Controlling for overall agitation also strengthened the relationship between individual differences in the peak distress proportion and Agitated scan (partial r = .56, p = .096).

Thus, the distress proportion of the single longest episode of distress during operational
consolidation was associated with agitation-scanning co-occurrence independent of later distress. With regard to research question 3a, early distress predicted later tendencies for scanning and distress to co-occur, regardless of distress tendencies during the unifocal stage.

Note again, however, that Scan duration, Calm scan and Agitated scan were all highly associated during unifocal coordination. Thus, these correlations may have been a result of overall scanning, not scanning-emotion co-occurrence. A final, second-order partial correlation was performed, controlling simultaneously for Scan duration and overall agitation during the unifocal stage. As shown in Table 3.14, when both scan and agitation were controlled for, only the peak distress episode and agitated scan were significantly correlated.

Table 3.14: Partial Correlations Between Distress and Scan-Emotion Co-occurrence Controlling for Scan Duration and Overall Agitation (d.f. = 7).

<table>
<thead>
<tr>
<th>Distress measures</th>
<th>Calm scan</th>
<th>Agitated scan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distress duration</td>
<td>.35</td>
<td>.17</td>
</tr>
<tr>
<td>Peak distress episode</td>
<td>-.08</td>
<td>.74*</td>
</tr>
<tr>
<td>Peak distress proportion</td>
<td>-.11</td>
<td>.57</td>
</tr>
</tbody>
</table>

* p < .05

3.8 The Relationship Between Attention Flexibility and Transition-Age

The final hypothesis predicted that fixation durations (hypothesis 3a) and scanning (hypothesis 3b) would predict variability in the timing of bifocal skills. Research question 3a asked if the relation between scanning and transition-age would be different for infants who scanned while distressed than for infants who scanned while calm.
As shown in Table 3.15, there were no significant relationships between the Transition-age and mean bout duration for Mom, Toy, or Scan for either stage. There was a modest association between mean bout duration to Other during operational consolidation and Transition-age. Examination of scatterplots for this correlation revealed one infant (7) as an outlier. Elimination of this infant from analysis reduced the correlation to non-significance ($r = -.37$, ns).

Duration of scanning and tendencies to scan while calm or while distressed did not show any significant correlations (see Table 3.16). There was, however, a moderate but non-significant correlation between Transition-age and Agitated-scan during the unifocal stage ($r = .48$, $p = .12$, ns).

<table>
<thead>
<tr>
<th>Attention focus</th>
<th>Transition-age</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operational Consolidation</strong></td>
<td></td>
</tr>
<tr>
<td>Mom</td>
<td>.00</td>
</tr>
<tr>
<td>Toy</td>
<td>.36</td>
</tr>
<tr>
<td>Scan</td>
<td>.37</td>
</tr>
<tr>
<td>Other</td>
<td>-.50*</td>
</tr>
<tr>
<td><strong>Unifocal Coordination</strong></td>
<td></td>
</tr>
<tr>
<td>Mom</td>
<td>.14</td>
</tr>
<tr>
<td>Toy</td>
<td>.02</td>
</tr>
<tr>
<td>Scan</td>
<td>.41</td>
</tr>
<tr>
<td>Other</td>
<td>-.01</td>
</tr>
</tbody>
</table>

* + p < .10
Table 3.16:  
Zero-Order Correlations Between Scan Variables and Transition-Age (n=12)  

<table>
<thead>
<tr>
<th>Scan Variable</th>
<th>Transition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational Consolidation</td>
<td></td>
</tr>
<tr>
<td>Scan Duration</td>
<td>.26</td>
</tr>
<tr>
<td>Calm Scan</td>
<td>.17</td>
</tr>
<tr>
<td>Agitated Scan</td>
<td>.20</td>
</tr>
<tr>
<td>Unifocal Coordination</td>
<td></td>
</tr>
<tr>
<td>Scan Duration</td>
<td>.19</td>
</tr>
<tr>
<td>Calm Scan</td>
<td>.06</td>
</tr>
<tr>
<td>Agitated Scan</td>
<td>.48</td>
</tr>
</tbody>
</table>

As noted in the previous sections, Scan, Calm-Scan and Agitated Scan were all highly correlated. While overall Scan-duration showed no relationship to bifocal coordination, overall tendencies to scan may have obscured relationships between scan-emotion co-occurrence and transition-age. To further examine this possibility, partial correlations (d.f. = 9) were computed, controlling for overall scanning during the unifocal stage. Both Calm scan (partial r = -.61, p = .048) and Agitated scan (partial r = .67, p = .025) were related to the timing bifocal coordination. With overall tendencies to scan held constant, infants who scanned when calm showed early transitions to bifocal coordination, and infants who scanned when agitated showed late transitions. Thus, as predicted, individual differences in the timing of bifocal coordination—that is, in the timing of acquisition of means-end problem-
solving—were related to scanning during the unifocal stage. However, this relationship was only evident once the emotional context of the scanning was accounted for.
CHAPTER 4

DISCUSSION

The present study sought to examine associations between individual differences in distress regulation, attention flexibility, and early cognitive skills. This study also addressed how distress and attention might interact to promote or delay means-end coordination. Three general associations were expected. As Lewis and colleagues had previously found, early distress was anticipated to predict the timing of bifocal skill acquisition (hypothesis 1). This relationship was argued to be mediated by attentional flexibility. It was expected that poor distress regulation in the first months of life would lead to inflexible attention (hypothesis 2). This inflexibility of attention was argued to constrain the infant’s opportunities to learn about contingency relations. Thus, attention flexibility was taken to be indicative of epistemic activity by the infant, and flexible attention was hypothesized to predict earlier acquisition of bifocal sensorimotor skills (hypothesis 3).

There was some support for these three hypotheses. However, the associations were strongest when the emotional context of attention flexibility was taken into account. With regard to research questions 1 and 2, it appears that real-time co-occurrence of attention and distress may be an important mediator of distress-cognition associations in infancy.

I will discuss the three hypotheses in separate sections. Research question 2a will be discussed in conjunction with hypothesis 2, and research question 3a in conjunction with hypothesis 3. In each of these sections, I will summarize and discuss the results, and then relate the findings to the literature reviewed in the first chapter. Following these, I will
present some general limitations on this study, and suggest possible directions for future research. Finally, I will relate the findings to a framework of cascading emergent constraints on developmental pathways leading to habits of mind.

4.1 Early Distress Regulation and the Acquisition of Means-End Coordination

This study found modest support for the hypothesis that individual differences in distress reactivity would predict differences in timing of bifocal strategies which support means-end problem-solving. The findings suggested that poor distress regulation predicts a lag in bifocal coordination. As expected, this relationship held only for distress during operational consolidation but not during later sensorimotor stages.

This finding is consistent with the small body of research that has found similar emotion-cognition associations. As found by Lewis (1993a; Lewis et al., 1997), infant distress during operational consolidation predicted differences in sensorimotor performance, including scores on means-end tasks such as those used in this study. This is an important replication because of differences in the context for distress elicitation. In Lewis’ studies, distress was elicited by separation from the mother; in this study, distress occurred during the Frustrating Object Interaction—a procedure administered by the mother. This difference suggests that the association between distress and later sensorimotor capacities is not specific to distress elicited by the mother’s absence.

Nevertheless, in both this study and those of Lewis, the mother is instructed not to engage in normal soothing behaviours. In both cases, the infant’s distress regulation is unassisted by the caretaker; the infant is left to her own devices for regulating distress. Lewis
and colleagues (1997) have speculated that infants during operational consolidation may not have developed capacities for self-soothing, and that the onset of unifocal coordination may allow new capacities for emotional regulation. From a normative standpoint, this may be the case. However, the overall levels of negative affect during Withhold-toy do not change dramatically over stages of development (see Table 3.3). In fact, the proportion of time spent agitated appears to rise slightly following the operational consolidation stage. It would not appear that infants become more efficient at distress regulation. Furthermore, individual differences in distress appeared quite stable over time (see Table 3.5). Based on these observations, it appears difficult to conclude that unifocal coordination brings new capacities for self-soothing.

An alternative explanation suggests that, even though relative distressfulness may not change greatly over early infancy, the contexts which elicit distress do (Case, et al., 1989; Lewis, et al., 1997; Sroufe, 1996). As the child develops more complex capacities to coordinate actions, the meaning of events for the infant may become more elaborate. As suggested by both the habits of mind and cascading constraints frameworks, such new understanding may be increasingly idiosyncratic. A given situation may come to elicit distress for one infant but not for another. The Frustrating Object Interaction may be such a situation. For one infant, having toys taken away by her mother may be a common occurrence, and may not be adequately stressful to elicit any distress. For another infant, this situation may occur only when the researcher comes to visit. For the latter infant, the procedure may elicit distress more reliably, or the FOI may remove the social scaffolds (i.e., maternal soothing) that the infant requires to regulate her distress. Before the unifocal stage,
the FOI may not be subject to such expectations. In fact, earlier research using this dataset suggested that the withhold-toy segment of the FOI did not reliably elicit more distress than other segments until infants were 18 weeks old (Cook, 2000). Thus toy-withdrawal did not appear to stress infants particularly until one visit prior to the average age of unifocal coordination. This suggests that distress during the early visits is less affected by elaborated expectations than distress during more cognitively complex stages.

It is important to note that, of the distress measures, only the peak distress proportion reached significance in its relationship with later means-end coordination. The most reliable distress-cognition relationship is that between the infant’s peak distress proportion and the timing of their demonstrations of bifocal sensorimotor coordination. The peak distress proportion of a stage reflects the instance when the infant’s ability to regulate intense distress was poorest. Infants who scored high on distress duration may show frequent distress (high reactivity) but may be efficient regulators. Similarly, the duration of the distress episode alone does not tell us how efficiently the infant regulates distress. For example, during a long distress episode, the distress may never escalate to an intense level. Such an episode, which would generate a low peak distress proportion, would not be considered a sample of poor distress regulation. On the contrary, it may represent efficient regulation, as the infant manages to avoid intense distress. Thus, the peak distress proportion remains the best indicator in this study of regulatory capacities. The relationship with later means-end coordination suggests that it is the regulatory capacities, as opposed to reactive aspects, of infant distress that predict later competence.
Nevertheless, this replication of stage-specific emotion-cognition associations does little to advance our understanding of processes that might relate the temporally distant measures of distress reactivity and bifocal sensorimotor coordination. The second and third hypotheses were proposed to address potential mediating processes.

4.2 Distress and Attention Flexibility

The second hypothesis of this study predicted a relationship between early distress regulation and later attention flexibility. There was no reliable support in this study for associations between individual differences in early distress and mean gaze fixations to the toy, to mother, to other visual locations, or to the mean duration of scanning bouts. As well, there were no significant correlations between early distress and the overall duration of scanning during the unifocal stage.

The second research question addressed the possibility that poor distress regulation would relate to later co-occurrence of distress and attention flexibility. No reliable correlations were observed between the distress measures and emotion-scanning co-occurrence variables. However, it appears that individual differences in the infants’ overall tendency to scan may have obscured an important relationship: once scan duration was held constant, significant correlations were revealed between the peak distress measures and Agitated scan. This suggests that poor distress regulators are more likely to have agitation coincide with disorganized attention. Infants who do not develop efficient means of regulating distress during operational consolidation may later have difficulty regulating attention when upset. Poor regulation in one domain may go on to limit regulatory capacities in other domains. In
other words, attention regulation may build on distress regulation. If the foundational regulatory capacities are insufficient, subsequent regulatory skills may not develop adequately, particularly in contexts where the initial capacities are challenged.

Research question 2a asked whether individual differences in negative affect during the unifocal stage would account for the relationship between early regulation and later distress-attention co-occurrence. It could be argued that the relationship between early distress regulation and later Agitated scan was an artifact of continued overall poor distress regulation. However, rather than revealing the relationship to be spurious, the second-order partial correlation, with both scanning and agitation controlled for, revealed that the peak distress episode was strongly associated with Agitated scan. Those infants who had long distress episodes were more likely to scan while agitated. This effect was not due to overall tendencies to scan or to show agitation during the Frustrating Objects Interaction procedure.

Also of interest, controlling for individual differences in agitation (but not for scanning) during the unifocal stage revealed an important relationship between the peak distress proportion and Agitated scan. Infants with intense peak distress episodes were more likely to scan while agitated once individual differences in overall agitated were controlled for. Moreover, once individual differences in agitation were partialed, infants who showed high distress durations during operational consolidation were later more likely to scan during Withhold-toy than less distressed infants. This suggests that, once later tendencies to show agitated behaviours are controlled for, early distress may predict overall scanning during the unifocal stage.
Distress during unifocal coordination related neither to attentional flexibility nor to real-time emotion-attention co-occurrence. Only distress tendencies during the operational consolidation stage predicted later attentional flexibility measures. This finding agree with previous research showing that infant distress at 2 months (Johnson, Posner, & Rothbart, 1991) and 3 months (Axia, Bonichini, & Benini, 1999; Rothbart, Ziaie, & O’Boyle, 1992) predicts attentional flexibility better than does distress at 5 months (Axia, et al., 1999; Ruddy, 1993). If, during the fourth and fifth months, capacities to coordinate action and sensory information reorganize (Case, 1985), then this reorganization may be accompanied by reorganization in other systems, including systems linking distress and attention.

In conclusion, there is reason to believe that early distress regulation does influence the development of attention flexibility. As Derryberry and Rothbart (1997) have observed, "...the motivational system [e.g., frustrative/ anger systems]...also play[s] an adaptive role in regulating attention and perceptual processing"(p. 637). The results from this study most strongly suggest that successful distress regulation in early infancy allows flexible attentional orienting to occur in conjunction with calm affect. Poor distress regulation during early infancy may limit such opportunities and may promote scanning during more distressed emotional states.

This distressed scanning may represent a disorganization of attention due to poor regulatory skills. In particular, poor distress regulation in early infancy may have influenced the self-organization of attentional styles, creating an attractor state of scanning and agitation. An attractor represents a stable recurring state that evolves over the development of a system due to real-time interaction of elements of the system. Future research may address the
developmental conjunction of distress and disorganized attention. For example, does agitated scanning evolve incrementally, or are there qualitative shifts in the infant’s proclivity to scan while agitated? Furthermore, the infant’s social context may promote or deter distress regulation and attention control. So future research may address whether these habits of mind develop in relation to the social environment, or whether they appear to evolve regardless of caretaker qualities.

4.3. **Epistemic Activity and the Development of Means-End Behaviour**

The final hypothesis was that attentional flexibility during the unifocal coordination stage would modulate the infant’s epistemic activities, and thereby influence the timing of early bifocal sensorimotor coordination. The characteristic scanning patterns of short- versus long-looking infants were argued to allow an experiential process that can account for corresponding differences in the timing of means-end coordination. In particular, scanning was suggested as a prime indicator of a type of epistemic activity that might allow the infant to achieve early bifocal coordination. However, it was argued that this epistemic function might only in conjunction with calm affective states.

None of the measures of fixation duration during unifocal coordination were significantly related to the timing of bifocal coordination (hypothesis 3a). There was no support for the prediction that measures of mean bout duration would predict variability in means-end coordination.

Neither were there significant relations found between overall scanning duration or scanning bout duration and transition-age (hypothesis 3b). However, once the emotional
context of scanning was accounted for, and overall scanning was controlled for, significant relations were found. Thus, in response to research question 3a, the relationship between scanning and transition-age did appear to differ depending on the emotional state in which scanning occurred.

In particular, once overall scanning was partialed, agitated scanning predicted the timing of sensorimotor coordination differently from calm scanning. Scanning while calm may support precocious means-end skills. Scanning while distressed may not. These results lend initial support to a model of epistemic activity predicated on active attention and attention flexibility, even if they do not directly address the mechanism.

The finding that the emotional context of scanning predicted cognitive capacities suggests that it is essential to account for the affective quality of infant information-processing. Demos (1986) argues that the contexts of different affective states support different types of learning. Even arousal level influences attentional processing: infant arousal level has been found to predict preferences for complex or simple visual stimuli (Gardner & Karmel, 1983). The unsatisfactory level of predictive power from infant information processing measures (McCall, 1994) may be in part due to the general failure to account for emotional influences on attention. Rather than excluding agitated infants, habituation research might benefit from incorporating and accounting for individual differences in infant distress. Moreover, the finding that co-occurences of attention flexibility and affective state predict cognitive competence supports a model of the importance of the interactions of systems on the course of development. Only once emotion and attention were examined together was their impact on later developments in competence observed.
As noted, it is unclear from this study whether scanning provides infants with opportunities to attend to affordance relationships. So the question of whether affordance recognition is important in furthering infants' understanding of causal relationships remains open. As well, the relationship between such learning and bifocal coordination skills remains to be directly assessed. Nevertheless, the finding that the emotional context of scanning predicts the onset of success in such tasks suggests that calm-scanning infants may be more able to make use of information from their environment than their poor regulating peers. This finding is of interest particularly in light of Isen's (1990) account of the cognitive implications of positive and negative affect. In her review of differential effects of positive and negative affect on cognitive organization, Isen concludes that, over development, positive affective experiences might lead to cognitive flexibility and creativity. By contrast, frequent and prevalent negative affect might lead to limited and constricted cognitive organization. Isen, following Easterbrook (1959), suggests that restrictions on attention account for such effects. The emotional context of scanning during early infancy may be a particular case of differential effects of emotional state on attention and cognitive organization.

4.4 Limitations of the Present Study

There are several areas of weakness in the design of this study with respect to the present analysis. This discussion will address three main weaknesses: limitations on the distress measures; limitations regarding the measurement of attentional flexibility; and limitations on the sensorimotor outcomes.
4.4.1 Limitations of the Distress Measures

The procedure used in this study elicited distress unreliably. For some infants, the procedure failed to elicit distress on multiple occasions. It is not clear that toy-removal is the most efficient method of obtaining frustration and distress in early infancy. In their research on infant distress regulation, Stifter and Braungart (1995; see also Braungart-Ricker & Stifter, 1996; Stifter & Grant, 1993; Stifter & Jain, 1996) made use of toy-removal procedures, but not until the tenth month. For their fifth-month measure, they employed arm-restraint, a procedure that produces angry facial expression in infants at 4 and 7 months of age, but not in neonates of 1 month (Stenberg & Campos, 1990). Thus, the challenge is to design a procedure that reliably provokes distress over the broad age-range that this study sought to examine, within the boundaries of ethically-defensible research.

Other research using the same data-set showed that the Withhold-toy segments did result in significantly higher distress levels than the Give-toy segments (Cook, 2000) suggesting that infant distress was greater when the toy was withheld. Inspection of developmental timelines of mean distress levels for the three segment types suggests that, by the 18th week, distress is notably greater during Withhold-toy segments. In any event, the distress measure which proved to be the most powerful predictor in this study (i.e., the peak distress proportion) was neither limited to distress resulting from the withholding the toy nor to Withhold-toy segments.
4.4.2 Limitations on the Measurement of Attention Flexibility

Another limitation of this study was the manner in which attention flexibility was operationalized. The predictive power of look duration has not been demonstrated to hold for naturalistic procedures. As well, this study was not able to measure attention with the same degree of control as is possible with habituation research. The mean bout duration calculation used in this study is very different from that procedure used to derive look duration in habituation research. This study used measures which were averaged both across Withhold-toy segments within a visit and across visits within a stage. Colombo, in contrast, argues that the best infant attention measure for predictive purposes is the single longest “peak” fixation during a single habituation session (Colombo, Mitchell, O’Brien, & Horowitz, 1987). This important differences suggests that the findings of this study require cautious interpretation. However, it is interesting to note that Miceli and colleagues (1998) found no significant relationships between habituation-derived measures of look duration and maternal-rated distress to limitations or soothability.

Nevertheless, the method used, which allows emotional interference with attention allocation, permitted the derivation of variables which could not be derived in strict habituation research. Research on the cascading effects of emotion-regulation and emotional-constraints on attention flexibility may provide a new avenue of exploration in the search for predictors of later cognitive capacities.
4.4.3. **Limitations on the Sensorimotor Measures**

Means-end problem solving skills, such as are required to pass the bifocal coordination tasks presented to infants in this study, reflect fledgling skills in understanding causal relationships (Bornstein, et al, 1997; Piaget, 1953; Willats, 1999). Such skills may represent a "third-wave" of intelligence prediction measures, albeit with no greater predictive power than the "second wave" of visual information processing measures (Bornstein, et al, 1997).

Unfortunately, failures of sensorimotor performance can be difficult to interpret. For example, if infants have precocious understanding of causal relationships, and can demonstrate this knowledge in habituation-based studies, why do they continue to fail to demonstrate that knowledge in their actions for so many months? Are these failures due to inadequate knowledge, underdeveloped motor skills, or some other factor? Too often researchers have focused on the (precocious) successful performance and downplayed the failures, relegating the failures to "factors considered to be outside the theoretical domain of interest" (Munakata, McClelland, Johnson, & Siegler, 1997, p. 686). Despite some early understanding of physical principles, infant knowledge may still evolve through gradual processes (Bremner, 1997; 1998; Fischer & Bidell, 1991; Willats, 1997). Future research could address which factors act as contextual limitations and which as supports for successes and failures in demonstrations of knowledge through action.

Affect may represent one internal contextual factor on variability in bifocal skill use. The coding procedures for sensorimotor tasks did not allow the examination of interference of emotional or attentional (or their interactive) processes on problem-solving in real-time.
Further research could address this through a closer examination of real-time behaviour during means-end problem-solving.

4.4.4 General Limitations of this Study

A preliminary cause for concern lies in the finding of significantly different mean Transition-ages between the infants used in this study and those whose video data were not selected for further analysis. It is important to note, however, that the criteria for inclusion in this phase of the research were not based on infant sensorimotor performance. Rather, the infants were selected due to completeness and quality of video records.

Nevertheless, there may be systematic reasons why the infants who missed visits were later in acquiring bifocal skills. Visits were occasionally canceled by the mothers due to infants’ irritability. The infants selected for this study may have been less irritable than those excluded. Thus, it is possible that many of the infants who were excluded were both more irritable and later in acquiring bifocal skills. A stronger test of the hypotheses of this study may require coding more infant data, even for infants with missing visits.

Another general area of concern for this research is the interpretation of correlations based on a small numbers of subjects but aggregated across multiple sampling points. It was hoped that such stage-specific measurements would minimize intra-infant variability and allow the construction of reliable measures of the infant’s behaviour during stages cognitive development. However, the use of correlations based on aggregated visits is rare in the literature, and may be subject to criticism.
Furthermore, as with correlational analyses in general, inferences of causality based on the results of this study are to be considered speculative. The developmental nature of these associations does not avoid this problem. For example, the associations between early distress regulation, attention, and early means-end coordination found in this study may not be the result of cascading effects of constraint, but of their common relationship to some unknown factor or factors. It is hoped that further fine-grained longitudinal research will allow stronger demonstrations of the paths of influence and causal relations between disparate but inter-related psychological constructs.

A final potential criticism is that this study examined the infant removed from her standard social environment. Although the mother was present, and data were collected in the infant’s home, the mother was asked not to engage in normal soothing behaviours. These aspects of the procedure may have rendered the social environment strange to the infant. Nevertheless, the restricting of external sources of soothing was important to this study, as it allowed a test of the infant’s own abilities to regulate distress. This study did not address the history of infant–mother interaction and its potential effect on distress-regulation, attentional flexibility, or means-end coordination. Future research may seek to examine the child’s home environment in terms of, for example, distress regulation and caretaker emotional availability, attentional flexibility and dyadic reciprocity, or means-end problem solving and the quality of object-oriented play by the caretaker. This future research may contribute to the understanding of how the infant’s psychological capacities and habits evolve out of social relationships.
4.5 Implications of this Study for a Model of Cascading Constraints on Infant Development

This study provides support for a model of infant development that seeks to integrate our understanding of emotion regulation, attention, and the development of habits of mind which support adaptive cognitive activities (Keating, 1990). It lends support to the idea that early individual differences in emotion regulation influence the quality of developments in other systems often regarded as distinct. Not only do attention and emotion act upon one another, but individual differences in attention-emotion co-occurrence appear to influence the timing of normative cognitive milestones. These findings provide initial support for a model of cascading constraints on the path of ontogenetic development, as attention-emotion co-occurrences, which developed in relation to earlier distress regulation, went on to delimit the range of individual differences in later sensorimotor performance.

In this study, early capacities to regulate intense distress (whether considered as a part of the innate structure of the newborn’s psychology or as a developmental product of earlier interactions of lower-level components) were seen as setting a constraint on subsequent system development. Specifically, high distress interacted with the infant’s capacities to calmly attend to a wide range of environmental events. Negative emotion states and unfocused visual scanning may come to co-occur regularly, such that the occurrence of one may come to elicit the other. Such self-organized coupling of agitation and visual scanning may influence the underlying structures that give rise to both phenomena, such that the coincidence of agitation and scanning is more likely in future.
This reinforcement of complementarities--an increased likelihood of elements of a system to act in conjunction due to a history of co-occurrence--may then go on to constrain subsequent developments (Lewis, 1997). A complementarity that elicits agitation from scanning, or scanning from agitation, could result in preventing the infant from benefiting from the positive epistemic effects of calm, flexible, visual exploration of her environment. In addition, agitated-scanning may make it hard for the infant to find a focal point for subsequent regulation of affect and attention. Thus, the complementary arising from a coupling of agitation and scanning could constrain the pace at which infants come to understand and use means-end strategies. Based on the self-organization framework, capacities for emotion regulation constrain the quality of emergent attentional styles, which cascade on to constrain the timing of bifocal skill acquisition.

A model of cascading constraints, informed by an understanding of the processes of self-organization, can explicate how emotion and emotion regulation influence cognitive development. Competence arises not simply from innate maturational factors, but from the infant’s history of emotion and attention regulation. From the self-organization perspective, the analysis of patterns of individual differences across psychological domains holds promise for an integrated understanding of infant development (Lewis, 2000). The idea of self-organization may offer a way of integrating a great range of phenomena within a cogent theoretical framework (Keating & Miller, 2000). Further research is needed to address both the interwoven nature of infant regulation and competence during the first year and the self-organizing processes of their dynamic inter-relationships.
REFERENCES


Appendix A

Schedule of Toy Presentation for Frustrating Object Interaction Procedure

<table>
<thead>
<tr>
<th>12 WEEKS</th>
<th>14 WEEKS</th>
<th>16 WEEKS</th>
<th>18 WEEKS</th>
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APPENDIX B

B-1: Procedures and Administration

STUDY #3 ADMINISTRATION GUIDELINES

Pre-visit Suggestions:

A) FOR THE FIRST VISIT: Call the Mother at least one week before the first visit (12 weeks). Introduce yourself as the researcher from OISE who will be making the home visits for the next few months. Your goal during this first phone call should be to get a sense of the Mother’s comfort in having agreed to be in the study. If required, review the rationale behind the study, i.e., that we wish to follow your infant across time to see how his/her reaction to certain emotion-eliciting situations will change as they begin to develop cognitively....more specifically Mom will be giving and taking away from her infant a variety of stimulating and interesting toys... the hardest thing she will be asked to do will be to not talk to her infant during this time...etc...

B) FOR ALL VISITS: Set-up a time for the visit(s) that is convenient to the both of you. Certain questions to ask Mom when scheduling the visit: Is the infant on any particular schedule...are the afternoons or mornings better...when does the infant tend to wake-up and/or nap....Make sure you book visits BEFORE and NOT AFTER the infant has received any of his/her shots, given that some infants have bad reactions to them....In general, it would be best to schedule appointments after naps. However, each Mom should know when her infant is the most alert. End by telling her that on the day of the visit, just before you come you will call her just to make sure that everything is in order with the baby.

C) FOR ALL VISITS: On the day of the visit, call Mom before you leave (half hour before you leave). Ask her these questions to determine if a visit is appropriate for that day:

    i) How is ****’s MOOD today? If normal=5, what is today?
       Is **** more fussy than usual?
       What is the atmosphere at home?
       Any recent disruptions?

Do NOT make a visit if:
    - the infant is ill and/or on medication
    - if Mom says the infant is more fussy than usual
Guidelines for the Visit:

1) SET-UP YOUR CAMERA
   i) use manual focus; ii) set the code; iii) set the time to On

   Phase I (12-24 Weeks) infants will be in infant seats on the floor (tripod legs need not be extended).

   Phase II (27-55 Weeks) infants will be in high chairs place against a table; the camera will be placed at the opposite end of the table

*** The infant seat or high chair should not be facing any windows or distractions if possible.

N.B. During this time the infant should NOT be placed into his/her infant seat or high chair; Mom may hold the infant.

2) GIVE MOM HER INSTRUCTIONS

   On your first visit with the Mom you may give a video presentation of what she can expect. Regardless if this is done, it would be a good idea to book the start of the first visit about a half-hour before the infant is anticipated to wake-up from a nap. This way you can go through the instructions without interruptions, and you can have her read and sign the consent form.

   Explain to the Mom that there will be a series of conditions where she will give and take-away toys from her infant. Our interest is to record how the infant behaves/reacts within each condition...what does the infant do when she/he has the toy...what does the infant do when the toy is taken away and placed just out of his/her reach.

   Now take three toys (that you will not be using on that visit); explain what you want Mom to do as you actually go through the sequence of events yourself. Then have her role play what she is to do to make sure she understands the sequence of events. Continue to do this before each visit until you are sure Mom understands what she is to do. After you go through the Routine, explain to the Mom the rules she herself is to follow. N.B. DO NOT have the baby in the infant seat or high chair during this time.
3) PUT INFANT INTO INFANT SEAT OR HIGH CHAIR

4) GIVE THE COGNITIVE TASKS

Tell mothers that you will be assessing their infants sensorimotor abilities at the start of each visit to help us follow each infant's development with respect to the coordination of certain basic sensorimotor abilities. Also, remind mom NOT to practise any of these tasks.

a) Phase I Infants: Will be given two tasks designed to assess infant’s capacity to coordinate 2 elementary sensorimotor operations:

i) Adjusted Reach: Assess visual tracking and reaching. Hold the dinosaur and move it slowly back and forth in front of the infant’s hand...touch the infant's hand with toy if necessary to stimulate reaching, but keep it just out of reach to observe adjustments in arm movement. Do this for 30 seconds. A pass is scored if continuous lateral adjustment in reach, corresponding to the movement of the toy, for at least two consecutive traverses is done.

ii) Reach and Grasp: Assess visually-guided reaching and grasping. Hold the dinosaur directly in front of the baby's hand and squeak to stimulate reaching...touch the infant's hand with toy (either left or right, but alternate between the two) with toy, if necessary, to stimulate reaching, but keep it just out of reach to observe the baby's open-handed grasp. Do this for 30 seconds. A pass is scored if the baby reaches its hand directly to the toy, with the palm open and facing the toy, and then grasps the toy at once with the palm making the initial contact.

*** When doing the Phase I cognitive measures the camera should be at a 15 degree angle from the center of the chair so that the examiner's hand does not block the face of the infant during the administration of the tasks (the examiner will be seated on the opposite side of the camera angle) After you do the cognitive measures put the camera at mid-line, i.e., so that the infant is in the centre of the viewfinder, and with just the top edge of the tray visible in the bottom of the viewfinder.

b) Phase II Infants will be given tasks designed to assess ability to combine two coordinated actions into a means-end production.

i) Cloth Pull: One object (cloth) is manipulated (pulled) as a means to access a desired toy. Allow the infant to play with the wobbling toy while you lay the cloth half on the table, half on the high-chair tray. Take the toy from the infant, and while ensuring the infant's attention is on the toy, move it to the far end of the cloth. Direct the infant's attention back to the toy only if he/she is looking elsewhere for at least 5 continuous seconds. Do not talk to the infant.
during this time. A pass is scored if the infant retrieves the toy within 20 seconds of touching the cloth, by pulling on the cloth while attending to the movement of the toy.

ii) Hidden Object: A classic object permanence task, requires removing a container to reach a hidden toy. Allow the infant 15 seconds to manipulate the container, then present the plastic keys to him/her. After 10 seconds of play with the keys, ask the Mom to hold the infant’s arms as you take the keys, place them on the tray, (ensure that the infant's attention is on the keys, e.g., by tapping your hand on them) and cover them with the plastic container. A Pass is scored if the infant removes the cup and immediately attends to the keys, and then within 5 seconds touches the keys (with no intervening activity).

5) MOM, INFANT, & SELF-ORGANIZING ROUTINE

- Since you have already explained to Mom her role, you should be ready to start the routine as soon as you have finished administering your last cognitive tasks

- Make sure camera is set up appropriately (you will only have to readjust the camera position during Phase I)

- Phase I infants: Place the tray in front of the baby, just over the infant seat. Mom will sit to one side of the infant and beside the tray (versus directly beside the infant chair)

- Examiner moves to a place where she will not be seen by the baby...have Mom begin by giving the first toy.

EXAMINERREMININDERS

1) Once you have arrived, if you judge the baby to be in a less than desirable mood, if Mom says that the baby is suddenly fussy, you should consider rescheduling for later that day or for the next day.

2) If the home you visit has any of the toys anticipated to be used for that visit, replace it with one that this home does not have.

3) Remember that you are to discontinue the SO procedure if the DISTRESS CRITERION is met:

A) If the infant is INTENSELY upset in any one episode for 15 continuous seconds.

OR
B) If the infant is fussy for 75% or more seconds across two consecutive episodes; i.e.,
   For a 30 Second episode = 23 seconds of distress
   For a 20 Second episode = 15 seconds of distress

It would be easier to keep track of the minimum non-fussiness i.e.,
   For a 30 Second episode= total of 8 seconds of nonfussiness...continue
   For a 20 Second episode= total of 6 seconds of nonfussiness...continue

4) For Phase I infants, make sure Mom is not sitting right beside the infant seat. She should sit more beside the tray so that eye contact between infant and mother can be made with greater ease.
MOMS’ RULES & REMINDERS

1) Moms are NOT to talk or smile:
   Keep the face as neutral as possible (tell the Moms: Just like you are doing now as you listen to me talking....). They may look at the baby and respond with their eyes. If they find they are about to smile or laugh they may avert their gaze from the infant to recompose themselves. Warn the moms that this is the most difficult thing they will have to do, (some studies have Moms practice in front of a mirror how to keep a neutral face!!) and that for that reason you will initially monitor their ability to do so. That is, tell/warn them ahead of time that you will whisper "FACE" if and/or when they begin to smile at their infant during the actual routine.

2) Presentation of the Toy:
   For Phase I infants, especially early on (12-18 weeks), Mom may have to touch the toy to the infant's hand to stimulate the grasping reflex. If this does not work Moms may have to open the infant's hand and place it in the hand. Otherwise, once the infant is able to reach and grasp the toy, Moms may shake the toys when presenting them. If the toy should fall out of the infant's hand Moms should pick it up and present it to the infant again.

3) Five (5) Second Rule:
   If Mom should hear the beep to signal the removal of the toy, and at that precise moment the infant tosses or drops the toy, then the Mom should give the toy BACK to the infant for another 5 seconds...the goal is to take the toy when the infant is interacting with it. For Phase II infants, if the toy is on the tray when the beep is heard, Mom is to take the toy even though it is not in the infant's hands; at this phase, only if the toy is not accessible to the infant should it be returned to him/her (e.g., if it is tossed over the edge of the tray).

4) Position of the Displaced Toy:
   Phase I Infants: The toy will be placed on the opposite side of the tray from Mom at about 15 degrees from the center of the tray, and 3 inches out from the infant's grasp. Some infants may begin to move the tray around by kicking it or moving it with their hands; therefore, it will be up to the Mom to ensure that the displaced toy is in its required location.

   Phase II Infants: The toy will always be place on the edge of the table (just in front of the edge of the tray of the high chair, at about 15 degrees from the center of the camera's line of sight.

NB When taking toys away Moms should NOT shake them.
5) **Exchange of two toys:**

When Mom is giving a new toy and taking away the old toy, the exchange should be done **SIMULTANEOUSLY**. As soon as the infant is holding the new toy the old one should be removed to its appropriate place.

6) **Removal of two toys:**

Likewise, when Mom is taking the new toy away and/or out of her infant's hands, the old toy should be removed from its out-of-reach position at the same time; i.e., Mom should use her left hand to take away the old toy from the tray, and her right hand to take away the new toy from her infant's hand(s).
APPENDIX C

Coding Procedures

C-1: Attention Codes

Order of Coding:

1. Code mom in the second pass through the tape. Both onsets and offsets are coded for mom, no minimum time.

2. In the third pass, code only the onsets of Toy, Other, and Scan. Code each behavior until a new code starts. If a behavior does not meet time criteria, include it in the previous code, until you come to a new behavior that does meet criteria. Toy, Scan, and Other codes are butted up against one another. When you check the offset times, each code will end one frame before the new one begins.

3. If there is a subthreshold gap (x) between end of one code and start of Mom:

   - if Mom is 2 secs. or more, then butt up last threshold code against Mom and end it. (note that Toy continues to be coded as long as the toy is held, even during a long Mom code).

   /Toy/......x....../Mom/

   would look like: /Toy.........../Mom/.

   - if Mom is under 2 secs.:

     if pre-Mom sub-threshold code (x) is same as post-Mom code, then code x from when it begins (ie. prior to Mom, and extending through Mom until it ends.) Even if the post-Mom code (x) is subthreshold, the total will usually be at least 2 secs. because it will include duration of Mom.

     /...x../Mom/...x.../

     would be coded as: /Mom/

     /.................x................./
3. (cont'd.)
   - if pre-Mom subthreshold code (x) is different from post-Mom code (y), then
     subsume x under last complete code prior to Mom, (which then gets extended right
     through Mom). When y is subthreshold, continue this (previous) code until some other
     code (not y, eg. z) begins. When y reaches 2-sec threshold, code it from when it starts.

   \[ /\text{Toy}/...x.../\text{Mom}/...y.../ \]
   would be coded as: \[ /\text{Mom}/ \]
   \[ /\ldots\ldots/\text{Toy}.../\ldots z \]

1. **Baseline.** (b). Coded as one second (sixty frames on the computer, thirty frames on the
   VCR) in duration. Begin code on the first frame in which either the toy, or the mother's hand
   holding it, is clearly visible (any part of the toy or hand).

2. **Separation.** (s). Also coded as one second in duration. Begin code at point when toy leaves
   child's hand. If the toy is on the tray, code from the point toy clearly leaves tray.

3. **Reunion.** (r). Also, one second duration. As toy is already visible, code from the frame
   mother's hand (holding the toy) lifts up from the tray.

4. **Toy.** Child must: gaze at, mouth, or hold toy for two seconds or more. Look for infant's
   fingers curled in grasp. If grasp isn't visible, consider context clues (e.g. hand raising, toy
   moving, etc.) When uncertain, look for interest brows or brow flash, cocking head, quick glance.
   Can engage two toys at once (code as one Engage Toy, rather than two discrete engagements) or
   Toy and mom simultaneously. If baby is dangling (or banging) toy out of sight and/or drops it
   but remains looking at it (or seems to be) then code Engage Toy until gaze is broken for two
   seconds. If child is engaged with a toy, do not code Scan or Other. Mom may be co-coded. See
   below for blocking and gaze criteria.

5. **Mom.** Child must: gaze at mother's face. Look for brow flash, eyes widening, or glint in
   the eye. Sometimes the baby will lift the chin in order to look mother in the eye. Head-lifting is
   not a surefire signal to code Mom, so be cautious about using this cue. When in doubt,
   concentrate on the eyes or brows. **No minimum time.** (note: in the event that a mother
   should blink and that a blink should last for more than 15 frames, the coder should "break up" the
   mom code).

6. **Other** Gaze (at least 2 sec) or behaviour directed toward objects other than toy, including:
   manipulate tray, part of highchair or infant seat, clothes, or mother's body (as well as when baby
   is rubbing eyes or sneezing). If 'Other' behavior appears to also fit the criteria of Repmotor, it's
   okay. It will be coded separately by the Engage and Motor groups. So long as it fits the criteria,
code it. Note: other codes can co-code with (1) Mom codes that are under 2 seconds, (2) other focal points that are under 2 seconds if the baby returns to the original other.

7. Scan. Wide-range scanning is coded when the eyes focus on two or more different points which are not in a localized area. Code scan from point where baby focuses first. Wide-range scanning must last for two full seconds. Can co-code with Mom, but not with Toy or Other.

*Gaze.* Is considered to exist when the eyes stare at an object for at least two seconds. Gaze begins at point when eyes fix, and ends at the beginning of the next code. If the baby breaks gaze for less than two seconds and returns to the object, this will be considered as continuous gaze. For mom, breaks in gaze have no minimum. All looks at mom are coded separately.

*Blocking:* Code through block until you can see a new codable behavior. It is not necessary to have evidence that the current code is ongoing, just look for a new behavior.

Note: Very young babies sometimes seem to be looking at the periphery of a toy, rather than the toy itself. Code such looks as engagement with Toy.
C-2: Coding Distress

Code facial distress only, second-by-second. Code peak distress within one-second bin.

Begin coding at frame in which any part of toy, or mother's hand holding the toy, first appears. Check for slippage at subsequent baselines.

The three regions of the face to consider are: 1. eyebrows, 2. eyes/cheeks, and 3. mouth
(Refer to MAX and AFFEX codes for examples of facial distress in these regions, and fully articulated distress expressions)

Distress Scale

Code on a 4-point scale as follows:

0 Content: Facial expression shows contentment, happiness, interest, puzzlement; neutral expression

1 Agitated: Facial expression is troubled, uncomfortable, or mildly anxious; generally, negative expression is in one or two regions only

2 Disturbed: Fully articulated negative facial expression: sad, angry, anxious or fearful, etc; expression must be in all regions

3 Distressed: Intense negative facial expression; pre-cry face, eyes squinted or shut

Procedure for coding distress

Insert tape, find beginning of episode, turn volume down.

Open: 1. Sprouts, 2. macShapa folder, and then 3. either macShapa application, or document to be coded

If opening new document (application): 1. File to Save As (Subject name, session, initials, distress) 2. Spreadsheet to Variables (name: distress, type: nominal) 3. Windows to VCR Control (check name, highlight end cell) 4. Make window smaller, move VCR control to right.

If opening existing document, go to step 3. and 4.
Calibrate: Counter reset to 0 at first frame in which toy, or mother's hand holding the toy, appears.

Stamp new cell.

Begin coding, press PLAY, and view at normal speed until facial distress is evident.

When distress first appears, jog back to point just prior to its onset.

Code previous cell (0)

Stamp new cell.

Click "jog" once, ascertain level of distress, enter code, and stamp new cell.

Repeat "jog", code, and stamp new cell sequence until distress is no longer evident, then resume coding at normal speed (PLAY) until distress once again appears.