The Relations of Stress and Parental Sensitivity to Deferred Imitation in Infants

by

Jennifer Ann Cordick

A thesis submitted in conformity with the requirements for the degree of Master of Arts
Department of Psychology
University of Toronto

© Copyright by Jennifer Ann Cordick 2009
The Relations of Stress and Parental Sensitivity to Deferred Imitation in Infants

Jennifer Ann Cordick

Master of Arts

Department of Psychology
University of Toronto

2009

Abstract

The current study compared infant cortisol responses during the still-face procedure with those shown during other parent-infant interactions. It also examined how stress hormones can affect memory retention. Six-month-old infants (n = 38) were exposed to either a repeated still-face procedure, normal face-to-face interaction, or a divided-attention task. Salivary cortisol was collected at multiple time points. Infants were assigned to a memory demonstration (n = 30) or a no-demonstration (n = 8) group. Infants in the demonstration group were shown 3 target actions with a puppet, and subsequently given a chance to repeat the target actions. Infants in the no demonstration group were not shown the target actions. Only the infants who experienced the still-face procedure showed a significant change in salivary cortisol throughout the procedure. Cortisol values did not significantly predict memory performance. There are still many questions regarding how stress induction during memory consolidation affects memory performance.
Acknowledgments

This research was supported by funding received from the Ministry of Training, Colleges, and Universities of Ontario; the Natural Sciences and Engineering Research Council of Canada; the Social Sciences and Humanities Research Council of Canada; and the Canada Foundation for Innovation.

The researcher would like to thank Sarah Mackrell, Taskeen Mansur, and Maireanne Ryan, who provided invaluable support by recruiting participants, assisting participants through the study protocol, and completing video coding.
# Table of Contents

## Contents

Acknowledgments ..................................................................................................................... iii

List of Tables ........................................................................................................................... vi

List of Figures .......................................................................................................................... vii

1 The Effects of Stress and Parental Sensitivity on Deferred Imitation in Infants ............. 1
   1.1 Memory ............................................................................................................................ 1
   1.2 Stress Induction: The Still-Face Procedure ................................................................. 2
   1.3 The Stress Response in Infants ..................................................................................... 3
   1.4 Stress and Memory ......................................................................................................... 4
   1.5 Maternal Sensitivity ....................................................................................................... 5
   1.6 Sensitivity and Memory ................................................................................................. 6

2 Study 1: Examining Infant Stress Responses to the Still-Face Procedure and Chair
   Restraint ............................................................................................................................... 7
   2.1 Method ............................................................................................................................. 8
      2.1.1 Participants ............................................................................................................... 8
      2.1.2 Materials .................................................................................................................. 9
      2.1.3 Procedure ................................................................................................................. 10
   2.2 Results ............................................................................................................................ 12
   2.3 Discussion ....................................................................................................................... 16

3 Study 2: Examining Infant Stress Responses to Laboratory Visit ................................. 17
   3.1 Method ............................................................................................................................. 17
      3.1.1 Participants ............................................................................................................... 17
      3.1.2 Materials .................................................................................................................. 18
      3.1.3 Procedure ............................................................................................................... 18
3.2 Results

3.3 Discussion

4 Study 3: Examining Memory Ability in Infants

4.1 Method

4.1.1 Participants

4.1.2 Materials

4.1.3 Procedure

4.2 Results

4.3 Discussion

5 Study 4: Examining Stress, Memory, and Maternal Sensitivity

5.1 Method

5.1.1 Participants

5.1.2 Materials

5.1.3 Procedure

5.2 Results

5.2.1 Stress and Memory

5.2.2 Maternal Sensitivity and Stress

5.2.3 Maternal Sensitivity, Stress, and Memory

5.3 Discussion

6 Conclusions

References
List of Tables

Table 1. Demographic Variables for Stress and Control I Groups

Table 2. Demographic Variables for Control II Group

Table 3. Target Memory Behaviours for Infants in Demonstration and No-Demonstration Groups
List of Figures

Figure 1. Comparison of Stress and Control I group protocol during the 10-min still-face or free-play procedure.

Figure 2. Infant salivary cortisol for the Stress and Control I groups, collected at baseline, 20-min, and 30-min post-test.

Figure 3. Mean infant affect for the Stress and Control I groups for each episode of the still-face or free-play procedure.

Figure 4. Infant salivary cortisol for the Stress, Control I, and Control II groups, collected at baseline, 20-min, and 30-min post-test.

Figure 5. Probability of target memory behaviours for the memory demonstration and no demonstration groups.

Figure 6. Infants in the memory demonstration group were split into three groups based on peak cortisol reactivity. Probability of target memory behaviours for these three groups and the no demonstration group.
1 The Effects of Stress and Parental Sensitivity on Deferred Imitation in Infants

The relationships between maternal sensitivity, stress, and infant memory have only begun to be investigated by the academic community. Evidence exists which argues that stress hormones have differential impacts on the processes of encoding, consolidation, and retrieval (e.g., Beckner, Tucker, Delville, & Mohr, 2006). However, research has not yet studied these processes in very young infants. This study is one of the first attempts to experimentally produce stress in infants to determine its effects on memory. Because there is evidence that maternal sensitivity moderates stress reactivity (e.g., Liu et al., 1997; Weaver et al., 2004) and memory in children (e.g., Downer & Pianta, 2006), measures of maternal sensitivity will be included to determine if this will significantly interact with stress to influence memory.

1.1 Memory

Research has made it abundantly clear that very young infants have the ability to remember previously demonstrated information. This is consistent with Bandura’s social learning theory (e.g., Bandura & Walters, 1963). Social learning is the process in which infants and children learn novel behaviours by observing others perform them. According to Bandura and Walters, this process can explain the development of a number of behaviours, including pro-social and antisocial behaviour.

Recent research has shown that infants as young as 6 months can replicate previously viewed behaviour. For example, in a series of experiments by Barr, Dowden, and Hayne (1996), researchers measured immediate and deferred imitation in infants ranging in age from 6- to 24-months-old. For the first study, 24 infants in each of four age groups (6 months, 12 months, 18 months, and 24 months) were shown a novel action on an unfamiliar object and then tested for imitation 24 hours later. In an important divergence from prior research, Barr et al. (1996) included a control group who were exposed to the object but were not shown the target action. This allowed the researchers to measure how often the target action was spontaneously produced without previous demonstration. The results indicated that imitation was highest for 18- and 24-month-old infants, moderate for 12-month-olds, and lowest for 6-month-olds. In two later experimental variations, researchers attempted to bring imitation levels in 6-month-olds up to the
level in 24-month-olds. They found that measuring imitation immediately after the target demonstration or doubling the number of demonstrations caused the 6-month-olds to imitate at the same rate as the 24-month-olds.

These studies point to a strong memory system in infants. While not comparable to an adult level, infants can clearly remember select information for up to 24 hours after demonstration.

1.2 Stress Induction: The Still-Face Procedure

Stress can be defined as a threat to one’s well-being (Gunnar & Quevedo, 2007). Through the processes of natural selection, the stress response was developed to deal with challenges in an organism’s environment. In this sense, the stress response can be adaptive: it mobilizes the body’s resources to cope with environmental challenge. Prolonged or chronic stress, however, can be detrimental (Gunnar & Quevedo, 2007). The stress response in humans is incredibly complex, involving two distinct systems, the sympathetic-adrenomedullary (SAM) system and the hypothalamic-pituitary-adrenocortical (HPA) system. In the event of a stressor, these two systems release a multitude of hormones including epinephrine (adrenalin) and glucocorticoids. Past research has shown that these hormones can have various long-lasting consequences on human cognition and behaviour. In early work on stress hormones and memory consolidation, Gold and van Buskirk (1975) found that injections of epinephrine immediately after a training phase increased retention in male rats. It is possible that stress hormones will have the same effect on human infants. For this reason, a stressor will be administered immediately after the learning phase to determine if stress will affect infant learning.

Providing infants with a stressor is significantly more difficult than doing so with rats. For ethical and moral reasons, it is impossible to use some of the more common methods of stress induction from animal research. One of the methods which have been accepted in prior research to produce stress in infants in an experimental situation is the still-face procedure. Originally described by Tronick, Als, Adamson, Wise, and Brazelton (1978), the still-face effect occurs when an infant is confronted with a non-responsive mother and shows a typical pattern of emotional reaction. This includes a strong attempt to restart contingent responding, followed by increased frustration, anger, and general distress when attempts fail. Eventually, the infant becomes withdrawn and will avoid eye contact with the mother. When the mother begins acting in a normal fashion again, the infant is often wary and slower to warm up. The infant may
approach normal behaviour later, but rarely achieves the same level of positive affect as during the free-play.

The infant’s reaction to the still-face differs considerably from normal face-to-face interaction. Tronick et al. (1978) and others have described the negative affect experienced during this experience. Haley and Stansbury (2003) note that infants showed increased production of stress hormones during and after the still-face procedure. Their results showed a significant difference in salivary cortisol over time: infants produced more cortisol after experiencing the still-face. On a physiological level, the still-face does seem to be an effective stressor. Tronick (2006) also reviews some of the research on respiratory sinus arrhythmia (RSA) measured by vagal tone (VT). He describes RSA as an index of neural regulation of the heart. According to Tronick, decreases in RSA (or VT) indicate an effort to cope with stressors. Prior research has shown that infants experience a decrease in VT during the still-face episode. Individual differences also indicate that infants whose VT did not decrease (indicating coping with stress) showed less positive affect and higher reactivity during the still-face.

1.3 The Stress Response in Infants

Some of the earliest research on infants’ stress responses show that certain procedures will produce both behavioural and adrenocortical responses to stress (e.g., Gunnar, Hertsgaard, Larson, Rigatuso, 1990). Gunnar, Porter, Wolf, Rigatuso, and Larson (1995) extended prior work by measuring infant vagal tone (VT), heart period, cortisol level, and behavioural state both before and after the heelstick (pricking the infant’s foot with a lancet). They determined that all four measures of stress reactivity correlated significantly with infants’ temperament 6 months later. They note, however, the importance of using multiple measures of stress reactivity, as VT and cortisol measures were not significantly correlated.

Lewis and Ramsay (1995a, 1995b) have attempted to describe the developmental trend in infants’ stress response by studying infants longitudinally. In Lewis and Ramsey (1995a), they attempted to track infants’ stress responses across three periods: 2, 4, and 6 months of age. They note that the general trend was for an increase in cortisol in response to a well-baby examination and inoculation. They also state that infant baseline cortisol level and cortical response to stress both decrease with age. They argue that their results provide support for the hypothesis that stress reactivity experiences a developmental shift between 2 and 6 months of age. Lewis and
Ramsay (1995b) also tracked infants across 2, 4, 6, and 18 months of age to determine longer-term stability. Their results indicated that infants’ stress response at 6 and 18 months of age were not significantly different, although 2 and 4 months of age differed significantly from 18 months. This provides even more support for the idea that the stress response undergoes a shift at 6 months of age.

1.4 Stress and Memory

Research has provided conflicting results on how stress affects memory. For example, research with stressful events sometimes indicates that there is a curvilinear relationship between stress and memory. In order to determine the relationship between stress and memory, Bahrick, Parker, Fivush, and Levitt (1998) interviewed 100 children between 3 and 4 years of age about their recall of Hurricane Andrew. The sample consisted of children who experienced a range of storm severity from low to severe hurricane exposure. The children were asked about the general storm experience, pre-hurricane preparations, the storm itself, and post-hurricane recovery. Parents were also questioned about their memory for the storm. The results showed an inverted-U relationship between stress and memory. The number of facts recalled was greatest for children in the moderate storm severity group. Those in the low or severe storm severity groups showed the least recall. This provides evidence that moderate levels of stress may be beneficial to memory, while too little or too much stress may be detrimental to memory.

Research on memory consolidation argues for a different pattern. According to McGaugh (2003), most research on memory consolidation has been performed on animals. However, he also argues that the findings from animal and human studies on memory and stress have shown the same basic patterns: when stress hormones are produced by the brain, memory consolidation is benefited. Thus, hormones such as epinephrine have shown to produce better event recall. According to this view, some types of stress may have a positive impact on memory. However, McGaugh does not cite the specifics of this research. It is possible that different amounts of stress would have differential impacts on memory, as in the study by Bahrick et al. (1998).

A more specific breakdown in terms of memory processes sheds some light on the conflicting findings of previous research. It has become clear that different memory processes are affected differently by stress. Beckner et al. (2006) note that stress hormones may affect memory differently depending on the stage of memory processing. They separate memory into learning,
consolidation, and retrieval. When stress hormones are produced during the learning and consolidation phases, moderate levels of hormones usually produce a facilitative effect on memory. When hormones are high for all phases, however, or when stress occurs close to retrieval, this often causes conflicting findings.

Abercrombie, Kalin, Thurow, Rosenkranz, and Davidson (2003) received similar results in their test of cortisol’s influence on memory for neutral or emotionally arousing stimuli. They note, however, that the results were significantly different depending on the time of the memory test. On a test 1 hr after learning, when cortisol levels were still elevated, there was a positive linear relationship between stress and memory. However, on a test 24 hr later, the results were consistent with Bahrick et al. (1998) inverted-U-shaped pattern. Moderate levels of stress hormones during consolidation produce better retention, while levels at the extreme ends of the scale are detrimental to memory.

1.5 Maternal Sensitivity

Like stress and memory, maternal sensitivity is of interest for the present study. Maternal sensitivity is most relevant to work with attachment; it is sometimes defined in terms of attachment. For example, Ijzendoorn and Bakermans-Kranenburg (2004) define sensitivity as the ability to perceive and respond quickly to the infant’s attachment signals. Parent-infant attachment has been described most thoroughly by Ainsworth, Blehar, Waters, and Wall (1978). They discuss the process of parent-infant attachment, whereby infants hold a perception of their caregivers as being responsive to their needs or nonresponsive. According to Ainsworth et al., attachment is primarily the product of maternal sensitivity to infant attachment behaviours.

Maternal sensitivity has been related to a variety of other characteristics and outcomes besides attachment. A number of studies have looked at the relationship between sensitivity and infant affect and infant regulation. Braungart-Rieker, Garwood, Powers, and Notaro (1998) administered a modified still-face procedure to mother-infant and father-infant dyads. The investigators were attempting to identify relations among parental sensitivity, infant affect during the still-face, and infant regulation during the still-face. Results showed that infants who had mothers with higher levels of mutual engagement showed greater positive affect and those who had mothers with higher sensitivity showed less negative affect.
Other studies have attempted to link maternal sensitivity to stress responses. The first attempts to tie maternal behaviour to stress responses were in the animal research field. For example, Liu et al. (1997) established that differences in maternal licking, grooming, and nursing behaviours in the rat can cause differences in the neurology of stress.

A study by Blair, Granger, Willoughby, Kivlighan, and the Family Life Project Investigators (2006) attempted to identify the relationship between maternal sensitivity, challenge, and stress reactivity. Results showed that infants with more sensitive mothers had a lower baseline level of cortisol, and their cortisol levels increased between pre-test and 20 min post arousal and decreased between 20 min and 40 min post arousal. Infants with less sensitive mothers, on the other hand, showed higher levels of pre-test cortisol and experienced a decrease in cortisol across all time points. These results provide evidence that maternal sensitivity correlates with stress reactivity in infants.

Haley and Stansbury (2003) examined the relationship between parental responsiveness or contingency and infant stress regulation during the still-face procedure. The authors hypothesize that parents who show more responsiveness to their infant’s social cues will have infants with better stress regulation. The results indicated that high parental responsiveness was related to infants who looked more at their parents, were less upset during the final episode, and showed larger decreases in heart rate from the second still-face to the final reunion. The authors cite this as evidence that infants of parents with higher responsiveness show more stress regulation.

It is readily apparent that maternal sensitivity is correlated with a vast number of behaviours and outcomes, including attachment, infant affect, infant regulation, and stress reactivity. Based on the previous literature, a tentative conclusion may be that maternal sensitivity decreases negative affect and stress reactions, including those caused by the still-face procedure.

1.6 Sensitivity and Memory

Although not as much research has been completed on how maternal sensitivity relates to infant or child memory, there have been some preliminary findings. Downer and Pianta (2006) looked at the relationship between a variety of home factors and cognitive outcomes during first grade. Children were tested on reading, mathematics, and phoneme knowledge using measures of long-term retrieval, short-term memory, auditory processing, and verbal comprehension. The results
indicated that maternal sensitivity showed a significant relationship with all four measures. Of most interest for the current study, maternal sensitivity was positively correlated with long-term retrieval and short-term memory. This provides evidence that maternal sensitivity may significant predict children’s memory abilities.

Research has indicated that stress can have an effect on children’s memory. Although the findings in this area vary, those on memory consolidation seem to indicate that stress hormones benefit memory. Evidence has also been provided that maternal sensitivity can influence the stress reactions of infants during the still-face. Maternal sensitivity seems to correlate negatively with stress reactivity. Finally, increased maternal sensitivity seems to show a positive effect on event recall. While past research efforts have done an exceptional job of discovering some of the links between maternal sensitivity, stress, and memory, there has yet to be a project devoted to examining these concepts in unison. Also, a significant portion of the research on stress hormones has examined these processes in animals. Very little work has been done on stress and memory in humans, and virtually none on infants. It is very clear that infant can remember previously learned stimuli; what is less clear is how retention will be affected by an experimentally induced stressor, and how maternal sensitivity will impact this process. This study will attempt to further research in this area by producing stress in infants during memory consolidation, and measuring maternal sensitivity to determine its influence.

2 Study 1: Examining Infant Stress Responses to the Still-Face Procedure and Chair Restraint

The first study attempts to further prior research on the still-face paradigm by examining cortisol reactivity to a modified still-face procedure. Using the same still-face procedure as in Haley and Stansbury (2003), the study attempts to determine the pattern of cortisol change. Mothers and infants experienced a five-episode still-face procedure with the following sequence of episodes: play, still-face 1, reunion 1, still-face 2, reunion 2. Cortisol samples were obtained at multiple time points during the procedure, and both absolute and relative change scores were computed in order to track cortisol reactivity.

Both absolute and relative change scores were used in order to determine if baseline cortisol production has a significant impact on measures of cortisol reactivity.
The final goal of the first study is to determine if infant affect can be used with cortisol reactivity as a method of measuring infant stress.

Consistent with prior research on the still-face procedure, we expected to find that infants exposed to a still-face procedure would show significant evidence of stress reactivity, including increased salivary cortisol and increased negative affect.

2.1 Method

2.1.1 Participants

Mothers were recruited for the current study from a combination of commercial mailing lists and sign-ups at infant conventions. Mothers were phoned by lab personnel and given a detailed description of the study protocol. If they expressed interest in participating, an appointment was scheduled for them to come into the lab. Appointments ranged from early morning to early evening. The appointment was scheduled at a time of day which was not usually a dedicated feeding or sleeping time. The mean time of day for the beginning of the study was 11:55 a.m., and was not significantly different for the still-face and free-play groups.

There were at total of 30 mother-infant dyads included in the present study, with 15 dyads experiencing the still-face procedure (Stress Group) and 15 dyads experiencing a control free-play procedure (Control Group I). Assignment to the Stress and Control I groups was done randomly, with participants being assigned to alternate conditions. Mothers ranged in age from 21 to 39 years old, with a mean age of 26.63 years. Infants were only eligible to participate in the study if they were 6 months of age. The 30 infants included in the present sample ranged in age from 24 to 29 weeks (approximately 5.5 to 6.6 months) of age. The majority of mothers (70%, n=21) had graduated from college or university. Most were also currently married (83.3%, n=25). Of those reporting a partner’s education level (90%, n=27), 55.6% (n=15) reported their partner’s education as college/university graduate.

Religion was highly variable across the sample, with the largest proportion of mothers identifying themselves as following “Other” religion (40%, n=12). The majority reported relatively high income levels, with 46.7% (n=14) of mothers and 50% (n=15) of partner’s reported income exceeding 50000 dollars per year. For a detailed report of demographic
characteristics in each group, see Table 1. There were no significant differences in demographics between the Stress and Control I groups.

Table 1

**Demographic Variables for Stress and Control I Groups**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Stress Group</th>
<th>Control Group I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant age (weeks)</td>
<td>26.53</td>
<td>26.73</td>
</tr>
<tr>
<td>S.D.</td>
<td>1.55</td>
<td>1.33</td>
</tr>
<tr>
<td>Mother's age (years)</td>
<td>32.33</td>
<td>32.6</td>
</tr>
<tr>
<td>S.D.</td>
<td>3.87</td>
<td>4.43</td>
</tr>
<tr>
<td>Median</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother's education</td>
<td>College/university graduate</td>
<td>College/university graduate</td>
</tr>
<tr>
<td>Partner's education</td>
<td>College/university graduate</td>
<td>College/university graduate</td>
</tr>
<tr>
<td>Marital status</td>
<td>Married</td>
<td>Married</td>
</tr>
<tr>
<td>Religion</td>
<td>Other</td>
<td>Other</td>
</tr>
<tr>
<td>Mother’s income</td>
<td>30,000-49,999</td>
<td>&gt; 50,000</td>
</tr>
<tr>
<td>Partner’s income</td>
<td>&gt; 50,000</td>
<td>&gt; 50,000</td>
</tr>
</tbody>
</table>

2.1.2 Materials

Saliva samples were collected at the start of the study and then 20 and 30 minutes after the first still-face episode in the Stress group or second free-play episode in the Control I group. Salivary samples were collected using sorbettes obtained from Salimetrics LLC. (2007). Experimenters placed the sorbettes under the infant’s tongue for 45-60 s or until the sorbette had collected sufficient volume, as shown by sorbette expansion. Only 1 of 90 samples did not have sufficient quantity to be analyzed. This participants’ other samples were within normal range, however.

In order to ensure adequate volume, two sorbettes were used at each sampling session. The Salimetrics Oral Swab (SOS; Salimetrics LLC, 2007) was used to collect samples from the
mothers. Once saturated, SOS and sorbette samples were stored in the investigating lab at -40°C.

2.1.3 Procedure

Upon arrival at the campus, participants were met by lab personnel in the parking lot and escorted into the lab. A detailed description of the study protocol was given both verbally and on paper. Mothers read and signed a consent form. Once the procedure had been explained and consent had been obtained, a baseline sample of cortisol was collected from both the mother and the infant. Immediately following the baseline cortisol sample, the experimenter demonstrated the memory task, which will be discussed in detail in Study 3. Once the demonstration was completed, the still-face or free-play procedure began. Infants were placed into a feeding chair and safety straps were fastened. Mothers were seated directly facing their infants. Mother-infant dyads assigned to the Stress group then experienced a repeated still-face procedure. This procedure, described in Haley and Stansbury (2004), involves three play episodes and two still-face episodes, each lasting 2 minutes. Mothers were instructed to look slightly above their infant’s head and maintain a neutral or blank expression during the still-face episodes. They were requested not to speak or react to their infants in any way. These instructions were given at the beginning of the experiment and again immediately before the still-face procedure, and mothers were free to ask questions if they needed clarification. Dyads assigned to the Control I group experienced a 10-min play session seated opposite one another (see Figure 1 for a comparison of the two groups).
Mothers in both groups were asked to refrain from touching their infants. Mothers were also encouraged to play without any toys. In order to minimize any significant negative impact of the still-face episodes on the infant, the procedure stopped if an infant cried hard for 30 seconds. A short break was provided, and then the procedure was resumed. In some cases, a toy was provided at this point to assist the mother during the procedure. The experimenter was out of sight of both the mother and the infant, but remained close by in order to cue the mother when to switch episodes or to assist in the event that the infant became significantly distressed.

Once the still-face or free-play procedure was completed, mothers were asked to complete several questionnaires during a divided-attention procedure which was used to measure maternal sensitivity. Saliva samples were collected 20 and 30 min after the beginning of the first still-face episode for the still-face group. In order to collect samples at the same time for the free-play group, samples were collected 22 and 32 minutes from the beginning of the free-play procedure.

Video cameras were placed to record the mother and infant’s facial expressions. Videos were then transferred onto an external hard drive and backed up on DVD. Infant affect was scored by trained observers throughout the still-face and free-play sessions. Affect was coded by two independent observers using a system adapted from Lowe, Handbaker, and Aragon (2006). Raters coded each 10-second interval on a scale from -3 to 3, with a rating of -3 indicating rhythmic crying for > 3 seconds, and a rating of 3 indicating laughing > 2 seconds. A score of 0 indicated neutral affect. The scores for 10-second bins were averaged for each episode, giving a mean affect score between -3 to 3 for each 2-min episode. A lower average score indicates more negative and less positive affect than a higher average score. The principle researcher scored all 30 participants. A second coder scored 20% of the videos. Inter-rater reliability for average affect scores in each episode was calculated, with Cohen’s kappa = .945.

Infant cortisol was reported in nmoles/L. As infant baseline cortisol levels were positively skewed, all cortisol values were winsorized to correct for skewness and reduce outliers. This method allows values which fall outside a given distribution to be replaced by a constant (Dixon, 1960). Indices of reactivity were calculated with absolute change scores: Reactivity 1 = Time 2 – Time 1; Reactivity 2 = Time 3 – Time 1; and Recovery = Time 3 – Time 2, in the hopes of providing a measure of how infants react to, and recover from, significant stressors. Simple change scores can have some limitations, however. Baseline values can influence reactivity
scores, and absolute differences in change scores might not be as sensitive to important individual differences as relative change in scores. In order to determine if this was the case, correlations were computed between baseline cortisol and all three indices of cortisol reactivity. None of the correlations were significant. However, analyses were also computed using relative change scores: Change 1 = (Time 2 – Time 1)/Time 1 and Change 2 = (Time 3 – Time 1)/Time 1.

2.2 Results

As there is significant evidence that cortisol production shows a significant change throughout the day, time of day must be analyzed as a possible covariate. Correlations were computed between time of day of the experiment and baseline cortisol, the three indices of cortisol reactivity, and measures of affect during the five episodes/play segments. None of these correlations were significant, indicating that further analyses need not correct for time of day.

Cortisol values changed throughout the procedure. All values reported are measured in nmoles/L. Baseline winsorized cortisol for the entire sample was M = 4.357, SD = 2.889 (Stress group: M = 3.873, SD = 1.837; Control I group: M = 4.841, SD = 3.66). Time 2 winsorized cortisol had a mean value of 7.441, SD = 5.19 (Stress group: M = 8.292, SD = 5.477; Control I group: M = 6.591, SD = 4.932), and Time 3 winsorized cortisol had a mean value of 6.672, SD = 5.320 (Stress group: M = 7.260, SD = 5.690; Control I group: M = 6.043, SD = 5.028). The two groups did not differ significantly on any of the cortisol measures. Using relative change scores, the mean percentage change in cortisol from Time 1 to Time 2 was equal to an 86.7% increase (SD = 132.9%; Stress group: M = 151.01%, SD = 168.32%; Control I group: M = 62.64%, SD = 94.945). The mean percentage change in cortisol from Time 1 to Time 3 was equal to a 60.7% increase (SD = 129.291%; Stress group: M = 118.38%, SD = 176.264%; Control I group: M = 36.38%, SD = 71.435%). Neither of the percentage change scores were significantly different between the Stress and Control I groups, although the relative change between Time 1 and Time 2 showed a trend towards significance, t(22.090) = 1.771, p = .09.

In order to examine the infants’ stress response to the Stress and Control I procedures, repeated-measures ANOVAs were computed for infant cortisol over time. Using stress group as a between-subjects variable, repeated-measures ANOVAs showed that infant winsorized cortisol showed a significant change over time throughout the procedure, F(1.423, 38.42) = 8.442, p <
.005. However, stress group was not a significant between-subjects factor, $F(1, 27) = .093, n.s.$, nor was there a significant interaction between group and time, $F(1423, 38.42) = 1.751, n.s.$, indicating that the entire sample as a group showed different levels of salivary cortisol over time, but this change in cortisol was not significantly different for the Stress and Control I groups (see Figure 2).

In order to determine if the significant changes in cortisol over time were present for both the stress and control groups, separate repeated-measures ANOVAs were completed. These analyses showed that, for the stress group only, cortisol changed significantly over time (stress group, $F[1.393, 19.5] = 6.706, p < .05$; and control group, $F[2, 26] = 2.181, n.s.$), indicating that infants in the Control I group did not experience significant changes in cortisol throughout the procedure.

Because infant baseline cortisol has a strong influence on absolute change scores, the repeated-measures ANOVAs were also run on relative change scores. Using baseline, Change 1, and Change 2 measures of reactivity, the results indicated that there were no significant between-
group differences between the Stress and Control I groups in percentage change in cortisol \((F[1, 27] = .168, n.s.)\). There was also no significant interaction between group and time, \(F(1.125, 30.386) = 2.374, n.s.\).

Ratings of infant affect were also used to determine infants’ stress responses to the still-face and free-play procedures. Repeated-measures ANOVAs analyzing infant affect with stress group as a between-subjects factor indicated that infants in the sample experienced significant changes in affect throughout the 10-min interaction with their mother, \(F(4, 72) = 14.691, p < .001\). While stress group was not a significant between-subjects factor, \(F(1, 18) = .722, n.s.\), there was a significant interaction between stress group and time, \(F(4, 72) = 2.965, p < .05\), indicating that infants in the different groups showed significantly different patterns of affect change over time.

In order to determine the type of affect change shown by each group, repeated-measures ANOVAs examining infant affect were computed on each group separately. Infants in the Stress group showed significant changes in affect over time, \(F(4, 36) = 8.634, p < .001\). Post-hoc contrasts showed that the significant changes in affect occurred between each pair of adjacent episodes in the still-face procedure (that is, infant affect changed significantly between one episode and the next). A visual inspection of the data led to the conclusion that infants exhibited higher affect during free-play episodes and lower affect during still-face episodes. This pattern can be seen graphically in Figure 3.

Infant affect was also examined in the control group. A repeated-measures ANOVA showed a significant pattern of affect change over time, \(F(4, 36) = 9.091, p < .001\). Post-hoc contrasts showed, however, that the only significant changes in affect occurred between the first 2-min and the second 2-min of the free-play episode. Visual inspection of the data showed a roughly linear decline in infant affect throughout the 10-min play period, with the largest drop occurring after the first 2 minutes. This pattern can be seen graphically in Figure 3.

In order to determine if changes in infant affect and cortisol showed significant correlations, and can be used together to demonstrate levels of infant stress, correlations were calculated between indices of infant stress reactivity and infant affect. Change scores for affect were also computed, with average affect scores in each episode being subtracted from those of the previous episode, indicating either a positive or negative shift in affect from one episode to the next. If the score is positive, average affect increased after the episode. If it is negative, average affect decreased.
For the sample as a whole, there was a strong negative correlation between change in affect between still-face episode 2 and play episode 3 (SF2-P3) and cortisol recovery ($r = -.541, p < .05$). Therefore, only 1 of a possible 12 correlations was significant. There were no other significant relationships between changes in affect and changes in cortisol.

However, splitting the sample into stress groups showed that only the Stress group contributes to this relationship. The correlation between SF2-P3 and recovery for the Stress group only was $r = -.965, p < .001$, while that for the Control I group was $r = -.245, n.s$. A negative correlation between these two measures indicates that as change from SF2 to P3 decreases, an infant’s cortisol recovery increases. As well, only for the Stress group, change in affect between play episode 2 and still-face episode 2 (P2-SF2) was positively correlated with cortisol recovery ($r = .854, p < .01$), indicating that as change from P2 to SF2 increases, cortisol recovery increases.
2.3 Discussion

The results showed that infants exposed to the still-face procedure experienced significant indicators of stress, including elevated cortisol levels at 20 min from the onset of the first still-face episode. As well, infants in the Stress group showed a significant change in affect as they proceeded through the still-face procedure. There were significant decreases in affect during the two still-face episodes, as would be expected from descriptions of the “still-face effect” described in Adamson and Frick (2006) and elsewhere.

Also as expected, infants in the Control I group did not show a significant increase in cortisol during the procedure. However, this pattern was only visible when the Control I group was analysed alone; when the groups were analysed together, there was no significant effect of group, nor was there a significant time X group interaction. This was not predicted by previous research, and calls into question the idea that the physiological response observed during the still-face procedure is produced solely through the mother’s non-responsiveness. It is possible that there are other reasons for this physiological arousal, such as the stress inherent to a laboratory visit. Another possible cause is the physical restraint necessary to complete the procedure. Infants must be strapped into a feeding chair – it is possible that this is distressing enough to the infant to produce the cortisol response seen during the still-face.

Visual inspection of the data confirms that infants in the Control I group experienced an increase in cortisol from baseline to 20 min post-test, this pattern was not significant. So, it is possible that the lack of a significant interaction between time and group for the entire sample was simply due to a lack of statistical power. As well, the infants in the Control I group experienced a significantly different pattern of affect throughout the procedure from those in the Stress group. This confirms previous work which has cited the still-face procedure as producing significant infant distress (Tronick et al., 1978).

In order to examine the possibility that it is simple chair-restraint or other aspects of the laboratory visit which produce the cortisol response seen in the Stress group, a second study needed to be completed examining a group of infants who did not experience chair restraint during their free-play session.
3 Study 2: Examining Infant Stress Responses to Laboratory Visit

As the results from the previous study did not provide strong evidence that the still-face procedure produces a significantly different stress response from simple chair restraint, the second study was designed to examine infant stress responses to a simple laboratory visit. For the current study, infants were allowed to sit beside their mothers, move around, be placed on the floor, or in their mother’s arms. There were no restrictions placed on the infant’s behaviour by the procedure. As such, it was hoped that this procedure would provide a more naturalistic control than the previous free-play control.

For 10 minutes, mothers completed questionnaires while also being the primary caretaker for their infant. This procedure has been used many times to score maternal sensitivity (see Study 4). For the current study, it will also be used as a rough control for the earlier still-face and free-play groups. It is expected that infants experiencing the new control procedure will show a much smaller cortisol response than both the infants in the Stress group and the Control I group.

3.1 Method

3.1.1 Participants

An additional 15 mother-infant dyads were recruited to the Control Group II, although only 8 dyads were included for the present analysis. Mothers were recruited using identical procedures to Study 1. Mothers in the new group ranged in age from 25 to 35 years of age, with a mean age of 31.8 years. Infants were 26 to 28 weeks of age (approximately 6.0 to 6.4 months), with a mean of age of 26.75 weeks. As with the participants in Study 1, the majority of mothers (50%, n=4) had completed college or university, as had their partners (37.5%, n = 3). Most were married (62.5%, n=5). The majority reported their religion as “None” (50%, n = 4). There were equal number of mothers reporting income between 30000 and 49999 and over 50000 (37.5%, n = 3 each). The majority of mothers reported partners earning more than 50000 per year (50%, n = 4). The mean appointment time for the new group was 12:42 p.m., and was not significantly different from the participants in the Stress or Control I groups. None of the demographic variables were significantly different from dyads in the Stress or Control I groups.
3.1.2 Materials

Salivary cortisol was collected using the same equipment as in Study 1. No other apparatus was required.

3.1.3 Procedure

Mother-infant dyads visited the lab and were asked to read and sign a consent form. Immediately following, a baseline saliva sample was taken. Following the baseline cortisol sample, the experimenter demonstrated the memory task, which will be discussed in detail in Study 4. Once the demonstration was completed, the infants were asked to sit with their mothers, in a relaxed environment, while mothers completed questionnaires. Dyads were videotaped by one camera recording the scene. This procedure, often referred to as the Divided-Attention Task, will be explained in detail in Study 4.

Saliva samples were collected at baseline and then 20 and 30 minutes from the beginning of the Divided-Attention Task. In this way, saliva samples were taken at the same point during the procedure for all participants in the three groups. To correct for skewness in the saliva sample values, all saliva measurements were winsorized identically to Study 1. Percentage change scores were also computed to measure relative change from baseline levels.

3.2 Results

The Control II group of participants had a mean baseline cortisol level of 6.825, SD = 3.400. Time 2 cortisol had a mean value of 8.126, SD = 6.260, while Time 3 cortisol had a mean value of 6.975, SD = 5.522. Only baseline cortisol was significantly different between participants in Study 1 and Study 2, with infants in Study 1 reporting a mean 2.468 nmoles/L less in baseline cortisol than those in Study 2 ($t[36] = 2.072$, $p < .05$). Cortisol levels at Time 2 and Time 3 were not significantly different from those in Study 1 (Time 2: $t[36] = 0.318$, n.s., Time 3: $t[35] = 0.141$, n.s.). Mean percentage change in cortisol between Time 1 and Time 2 was equal to 11.03%, SD = 39.697%, while mean change in cortisol between Time 1 and Time 3 was equal to a decrease of 4.86%, SD = 33.619. Both percentage change scores were significantly different from the mean values in the Stress and Control I groups (Change 1: $t[35.748] = 3.257$, $p < .005$, Change 2: $t[34.836] = -2.924$, $p < .01$), with infants in the Control II group showing an average
of 95.799% less of an increase between Time 1 and Time 2 and 83.654% less of an increase between Time 1 and Time 3.

In order to examine how all infants from all three groups reacted throughout the procedure, a repeated-measures ANOVA was completed. The results indicated a significant change in winsorized cortisol over time, $F(1.404, 47.727) = 7.055, p < .01$, but no significant between-subjects factor of group, $F(2, 34) = .240, n.s.$, nor a significant group by time interaction, $F(2.807, 47.727) = 1.511, n.s.$ This pattern can be seen in Figure 4. However, a repeated-measures ANOVA run on just the new control participants showed no significant change in cortisol over time, $F(1.142, 7.995) = 1.058, n.s.$

A repeated-measures ANOVA completed using the percentage change scores instead of absolute cortisol levels showed a significant main effect of time, $F(1.097, 38.378) = 50.667, p < .001$, but no significant effect of group when comparing the Stress and Control I groups to the Control II groups ($F[1, 35] = .184, n.s.$). There was a significant interaction between time and group, $F(1.097, 38.378) = 5.059, p < .05$. Further ANOVAs comparing the Stress and Control II groups
and the Control I and Control II groups indicated that the significant interaction between group and time was present only for the comparison between the Stress and Control II groups ($F[1.185, 24.877] = 9.35, p < .005$). While it would be ideal for affect to be used additionally to examine the infants’ stress reactions to the new procedure, it was impossible to code facial affect during the Divided-Attention Task.

### 3.3 Discussion

Infants in the Control II group showed significantly different cortisol levels than those in the Stress and Control I groups. Control II group infants started with higher baseline cortisol than those in the other groups, and showed much smaller percentage change scores between baseline and Time 2 and Time 3. As expected, this indicates that infants in the new Control II group showed less of a cortisol increase to the procedure than those in the other groups. Like infants in the Control I group, when analysed alone, infants in the Control II group did not experience a significant increase in cortisol secretion over time when using winsorized values.

Infants who were free to play with their mothers without being physically restrained showed a significantly different pattern of cortisol change from infants who were restrained, although this difference was only visible when using percentage change scores. This was most likely due to the higher baseline cortisol values in the Control II group. By taking baseline values into account in the percentage change scores, the pattern of cortisol change was shown to be much smaller than for infants in Study 1. Further analyses were able to determine that infants in the new Control II group showed a pattern of cortisol change which was significantly different only from the Stress group, not the Control I group. This result provides stronger evidence that there is something inherent to the still-face procedure which is producing a stress response, as opposed to simple chair restraint.

### 4 Study 3: Examining Memory Ability in Infants

The current study attempts to confirm work by Barr and colleagues at Georgetown University that the puppet task paradigm is a valid measure of infant memory. As detailed in Barr’s (Barr et al., 1996) work, it was expected that infants who were shown the memory demonstration would show significantly more target behaviours than infants who did not see the demonstration.
4.1 Method

4.1.1 Participants

The present analysis examined data from all 38 participants in the sample. For demographic information for the entire sample, see Table 2. The infants from Study 1 (n=30) experienced a 2-day experimental session, with infants viewing the puppet demonstration on the first day and being tested on the puppet task on the second day. In order to confirm previous work indicating that infants will not spontaneously produce the target behaviours at significant levels if they do not view the puppet demonstration, the infants from Study 2 (n=8) experienced a 1-day experimental session. These infants were given a chance to show the target behaviours without any previous exposure to the puppet.

Table 2

_Demographic Variables for Entire Sample_

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant age (weeks)</td>
<td>25.658</td>
<td>1.321</td>
</tr>
<tr>
<td>Mother’s age (years)</td>
<td>32.371</td>
<td>4.037</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td></td>
</tr>
<tr>
<td>Mother’s education</td>
<td>College/university graduate</td>
<td></td>
</tr>
<tr>
<td>Partner’s education</td>
<td>College/university graduate</td>
<td></td>
</tr>
<tr>
<td>Marital status</td>
<td>Married</td>
<td></td>
</tr>
<tr>
<td>Mother’s religion</td>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Mother’s income ($/year)</td>
<td>30000-49999</td>
<td></td>
</tr>
<tr>
<td>Partner’s income ($/year)</td>
<td>50000+</td>
<td></td>
</tr>
</tbody>
</table>

4.1.2 Materials

Two hand puppets were made specifically for the study. These include one grey rabbit and one pink mouse. They are covered with soft acrylic fur, and a same-colour felt mitten is placed over
the right hand. During the demonstration, a small bell was pinned inside the felt mitten. This was removed during the test.

One video-camera will be set up to record the demonstration of the puppet task. This camera will record the experimenter and infant at a 90 degree angle.

4.1.3 Procedure

For infants from Study 1, the procedure involves two separate visits, with the second visit occurring approximately 24 hr after the first. On the first day, the infant comes in to view the puppet task demonstration. On the second day, the infant returns to the lab and is tested for memory of the puppet task.

Study 1 infants first had the puppet task demonstrated to them. The infant sat on the mother’s lap while the experimenter kneeled on the floor in front of them. With the infant attending, the experimenter removed the mitten from the puppet, shook it three times, causing the bell inside to ring, and then replaced the mitten on the puppet. The experimenter repeated this sequence of events six times. The experimenter then put the puppet away without having allowed the infant to touch the puppet. This is consistent with Barr et al.’s (1996) procedure using the puppet task.

The mother and infant returned the following day (24 hr later ± 1 hr) to be tested on the deferred imitation task. The infant was presented with the puppet and allowed to interact with it for several minutes. Coders recorded three behaviours to test for memory: removing the mitten, shaking the mitten, and replacing the mitten. Because 6-month-olds have limited motor control, a visible attempt to produce the behaviour, even if unsuccessful, counted towards their memory score. The principle investigator had been trained by Rachel Barr’s staff at Georgetown University in performing the puppet task and scoring the behaviours during the memory task. Satisfactory inter-rater reliability (.80 kappa) was obtained following training.

Infants from Study 2 were not provided with the puppet demonstration. They came in for a 1-day visit, and were immediately given a chance to play freely with the puppet. The procedure was identical to infants in Study 1 experiencing the puppet test. They were presented with the puppet and given 2 min to interact with it. The target behaviours were scored by the same investigator.
4.2 Results

Infants varied in how long they took to first touch the puppet. For the entire sample, infants took from .8 to 183.4 sec to first touch the puppet, with a mean time to touch of 11.669 sec. A total of 17 infants (44.7%) infants removed the mitten from the puppet, while 7 (18.4%) shook the mitten, and 6 (15.8%) attempted to replace the mitten. The number of infants to perform at least one of the target behaviours was 17 (44.7%). Only 2 of 38 (5.3%) infants completed the entire sequence of target behaviours in order (mitten taken off, mitten shaken, mitten replaced).

Detailed information on each target behavior for the Study 1 (demonstration) and Study 2 (no demonstration) groups can be seen in Table 3 and Figure 5.

Table 3

| Target Memory Behaviours for Infants in Demonstration and No-Demonstration Groups |
|-----------------------------------------------|----------------|----------------|
| Demonstration Group | No Demonstration Group |
| Time to first touch (s) | 13.578 | 5.225 |
| Mitten taken off | 46.7% | 37.5% |
| Mitten shaken | 20.0% | 12.5% |
| Mitten replaced (or attempt) | 20% | 0% |
| Total number of memory behaviours | 0.867 | 0.500 |
| Memory sequence | 6.7% | 0% |

The only memory behaviour that was significantly more likely in the demonstration group than in no demonstration group was the attempt to replace the mitten. This is not consistent with other research by Barr (Barr et al., 1996) indicating that the behaviours were shown at a significantly higher rate for infants who viewed the demonstration. A further examination of the probability of each memory behaviour in each group using a chi-square analysis produced no significant differences between the groups with or without a memory demonstration. In this case, at least some of the infants in the group without the puppet demonstration spontaneously produced one or more target behaviours.
**Discussion**

The results of Study 3 were inconsistent with previous research. As has been cited in Barr et al. (1996), as well as in other work, the puppet task has been validated in numerous studies. In order to argue that any target behaviours shown are indeed an index of infant memory, the researchers at Georgetown University have often included control groups which experienced no memory demonstration. If there are significant differences in target behaviours between infants in the control and demonstration groups, it is arguable that the only explanation for the target behaviours occurring is memory retention. However, if infants who are not exposed to a demonstration are spontaneously producing the target behaviours, it calls into question whether any of the infants producing the behaviours are indeed showing evidence of memory.

This study failed to find a significant difference in target behaviours between infants in the demonstration and no demonstration groups. While some might argue this as a sign that the
puppet task paradigm is not a reliable measure of memory, it is far more likely that the present lack of significance can be attributed to the small sample size of the no demonstration group. This small number of participants in the control group has limited the power of the statistical analyses. Further research needs to be undertaken in order to confirm previous findings on the puppet task paradigm.

5 Study 4: Examining Stress, Memory, and Maternal Sensitivity

The final study was directed towards answering the question of how stress and maternal sensitivity interact to affect infant memory. Several analyses were proposed to examine these relationships. The following hypotheses were the focus of the study and were based on previous research discussed above:

- Infants exposed to a stressor (the still-face procedure) will show an inverted-U shaped quadratic relationship between their cortisol levels and memory retention.

- Infants exposed to a stressor who produce moderate levels of cortisol will perform better on measures of retention than those not exposed to a stressor.

- Infants exposed to a stressor who produce extremely low or extremely high levels of cortisol will perform worse on measures of retention than those not exposed to a stressor.

- Infants with more sensitive mothers will show decreased physiological stress responses to the still-face.

- Overall, infants of more sensitive mothers will show a similar U-shaped relationship between stress and memory to that shown by infants of less sensitive mothers. However, infants of more sensitive mothers will show better memory at a lower level of stress than those of less sensitive mothers.

- At equivalent levels of stress, measured by cortisol response, infants of more sensitive mothers will show better memory than those of less sensitive mothers. This is due to the facilitative impact of maternal sensitivity on memory.
5.1 Method

5.1.1 Participants

All mother-infant dyads in the Stress, Control I, and Control II groups were included for the present analysis. For demographic information, see Table 2 from Study 3.

5.1.2 Materials

Because there is evidence that maternal sensitivity and infant temperament can interact to produce infant cortisol levels (Kertes, 2005), a measure of infant temperament will be used, and temperament will be statistically controlled during the analysis to remove the influence of infant temperament. Rothbart’s (1981) Infant Behavior Questionnaire (IBQ) will be used to measure infant temperament, which rates infants on activity level, soothability, fear, distress to limitations, smiling and laughing, and duration of orientation. An index of Negative Temperament was created by using the following formula: (Activity Level + Distress + Fear of Novelty) minus (Smiling + Soothability) as used in Haley and Stansbury (2003).

5.1.3 Procedure

See Studies 1-3 for details on the still-face/free-play procedures and the memory test. All infants also experienced the Divided-Attention Task, which occurred immediately following the still-face or free-play session for infants in Stress and Control I groups, respectively. For infants in the Control II group, the Divided-Attention Task was used in lieu of the still-face or free-play session as a control play session and occurred following the puppet test.

During the Divided-Attention Task, mothers were seated in a play area with their infants and asked to complete the IBQ while also caring for their infant. Infants were free to move about and play with toys while mothers worked on the questionnaire. This protocol is often used to score maternal sensitivity using Ainsworth’s Maternal Sensitivity Scales (Ainsworth, 1969). Maternal sensitivity was coded by one individual for all tapes.
5.2 Results

Infant negative temperament was correlated with infant cortisol measures, infant affect, and maternal sensitivity. As there were no significant relationships between temperament and any of the other variables, further analyses did not control for infant temperament.

5.2.1 Stress and Memory

In order to determine if cortisol reactivity was related to infant memory, maternal income, maternal education, maternal sensitivity, parity, and infant gender were entered into a regression model predicting peak cortisol reactivity. Standardized residual scores were computed to remove the influence of these confounding variables. In this way, an index of cortisol reactivity independent of income, education, sensitivity, parity, and gender can be used to attempt to predict infant memory. Linear and quadratic regression analyses were then computed using the standardized residual score of reactivity to predict the mitten being taken off, mitten shaken, and mitten replaced behaviours, as well as the total number of memory behaviours. None of the regression equations were significant.

Infants who were shown the memory demonstration were then split into three groups based on their peak cortisol change: low, moderate, and high based on the following ranges: Low peak percentage change (scores ≤ .21), Moderate peak percentage change (.21 < scores ≤ 1.32), and High peak percentage change (scores > 1.32). These three groups were compared to infants who had not viewed the memory demonstration on each of the four memory behaviours using one-way ANOVAs. None of the memory behaviours showed significant differences between groups, (mitten taken off: \( F[3, 33] = .361, n.s. \); mitten shaken: \( F[3, 33] = .426, n.s. \); mitten replaced: \( F[3, 33] = .628, n.s. \); total number of memory behaviours: \( F[3, 33] = .494, n.s. \)). See Figure 6 for a graphical comparison of the groups.

5.2.2 Maternal Sensitivity and Stress

A median split was computed on maternal sensitivity for all infants. Infants in the high-sensitivity group were compared to the low-sensitivity group on cortisol levels. There were no significant differences in baseline cortisol, winsorized levels, or absolute changes in cortisol levels. There was, however, a significant difference between groups in percentage change in cortisol between Time 2 and Time 3 (\( t[24] = -2.161, p < .05 \)). Visual inspection of the data
indicates that infants with mothers in the low-sensitivity group showed an increase in cortisol between Time 2 and Time 3 relative to their Time 2 levels, while infants with mothers in the high-sensitivity group maintained the same levels of cortisol between Time 2 and Time 3.

5.2.3 Maternal Sensitivity, Stress, and Memory

Linear and quadratic regression models for cortisol and memory were calculated for mothers in the low-sensitivity and high-sensitivity groups in order to examine the interaction of sensitivity and stress and how these variables influence memory. These models also used the standardized residual scores of peak cortisol reactivity. None of the models were significant for mothers with either low or high sensitivity ratings. As well, a standardized memory score independent of cortisol response was calculated. Low-sensitive mothers and high-sensitive mothers were compared by an independent samples t-test. This memory score was not significantly different between groups, \( t(33) = -0.344, \, n.s. \)
5.3 Discussion

There were no significant relationships between stress as indicated by cortisol reactivity and memory for any of the groups. As this is the first attempt to trace how physiological indicators of stress can have an impact on infant memory, the lack of significant results does not prove that there are no relationships between stress and memory. The small sample size, as well as the need to control for demographic variables, resulted in a lack of statistical power for the majority of analyses.

The examination of maternal sensitivity and stress provided more promising results. While baseline and absolute cortisol change values were not significantly different for mothers with low or high sensitivity levels, there was a significant difference between groups in percentage change in cortisol. This finding provides strong support for the idea that baseline cortisol values should always be taken into account when measuring cortisol reactivity. Infants with mothers showing low sensitivity showed an average increase in cortisol between Time 2 and Time 3, a pattern not shown for infants with mothers showing high sensitivity. In contrast to infants with more sensitive mothers, infants with less sensitive mothers actually show a continual increase in cortisol secretion throughout the procedure, rather than the slight decrease expected from previous work (see Study 2).

6 Conclusions

The present studies attempted to draw together several different paradigms to examine the relationships between infant stress reactivity, maternal sensitivity, and measures of infant memory. The first study examined infant stress reactivity to the still-face procedure in detail. While previous research has shown a strong cortisol response to this procedure (e.g., Haley & Stansbury, 2003), and others have noted the suitability of this protocol for infant stress research (Gunnar, Talge, and Herrera, 2009), the findings in the present study were somewhat conflicting.

There is clear evidence that infants experiencing the still-face procedure show a cortisol response. However, infants in the present study experiencing a control free-play procedure could not be distinguished from infants experiencing the still-face procedure when analyzed together. This calls into question the precise causes of infant stress reactions to the still-face: Is it possible that it is simply physical restraint, or the pressure of a laboratory visit, which causes the increase
in cortisol production observed during the procedure? Further analyses examining each group in isolation provided more support for the idea that it is the mother’s non-responsiveness during the still-face episodes that causes cortisol reactivity. Infants who experienced vastly different control procedures did not show a significant cortisol change over time, although these results were only visible when the groups were analyzed alone.

A more clear indication of stress induction during the still-face procedure was provided by analyses of infant affect. Infants experiencing the still-face exhibited a clear pattern of affect change in response to the procedure, with mean affect scores dropping during each still-face episode and then rising again during each reunion. Infants who experienced a control 10-min play session also showed interesting changes in mean affect. Average affect computed for each 2-min segment showed a clear decline across the play session, although only the first two segments were significantly different. Although their mothers were sitting directly across from them, and there were no interruptions in their interaction, infants in this group showed decreases in affect throughout the session. What is less clear is the cause of such a decline. As mentioned above, it is feasible that infants are responding negatively to the necessary physical restraint. In Gunnar et al.’s (2009) review of different methods of stress-induction, they note that arm restraint may not be sufficiently stressful to produce a cortisol response. However, that does not necessarily mean that it is not sufficiently stressful to produce a behavioural stress response.

Analyses examining the correlations between cortisol change and affect change indicated the relatively weak relationship these two indicators of stress share. While there were some significant correlations between changes in affect and changes in cortisol for the Stress group, the Control I group showed no such significant relationships. For infants experiencing the free-play, these two separate indicators of stress reactions were not significantly interrelated. This finding highlights the need to use multiple indicators of stress reactivity. As others have noted, there is not always a significant overlap between physiological and behavioural indicators of stress (see Tronick, 2006).

An additional control condition was added to examine infant stress responses to a laboratory visit which did not involve any aspects of physical restraint or reduced mobility. In contrast to the previous two groups, infants in the Control II group were free to move about during their play session with their mothers. They were also free to play with available toys. As expected, these
infants did not show a significant change in cortisol throughout the procedure. However, when the three participant groups were analyzed together, the patterns of cortisol change were not significantly different between groups. This pattern of results is identical to the one seen in the first study: while the control groups both fail to show a significant cortisol change throughout the procedure, they were also not significantly different from the Stress group, which did show a significant change in cortisol over time.

Maternal sensitivity showed some significant effect on infant stress reactivity. While there were no differences in baseline cortisol or absolute change scores, the percentage change between 20 min and 30 min post-test was significantly higher for infants with less sensitive mothers, indicating that maternal sensitivity can have a significant impact on how infants respond to, and recover from, stressful events. This coincides nicely with Haley and Stansbury’s (2003) finding of larger decreases in heart rate at the end of the still-face procedure for infants with more sensitive mothers. Both physiological indicators of stress show a better recovery from the still-face procedure for infants with more sensitive mothers. This pattern should be examined in more detail, as there is also conflicting evidence (Blair et al., 2006) suggesting that infant cortisol should show the opposite pattern for infants with less sensitive mothers; that is, it should decrease across all time points.

There were no significant findings when examining the relationship between stress and memory. Contrary to prior research establishing an inverted-U-shaped function between stress level and retention (e.g., Bahrick et al., 1998), cortisol secretion did not predict memory in either a linear or quadratic fashion. Nor were there significant between-group differences on memory behaviours when infants were split into groups based on their peak percentage change in cortisol. One possible explanation for this finding is the relative infrequency of the target memory behaviours. In a sample with more variability, a clear stress-memory interaction might have emerged. Another limitation of the present sample was the relatively small number of participants. The stress-memory relationship might be sufficiently small that a larger group of infants needed to be tested.

Another significant limitation of the sample was the occurrence of target behaviours in infants not exposed to the memory demonstration. This finding came as a great surprise. The protocol developed by Barr et al. (1996) has been validated in numerous studies. The present study was
limited by the small number of participants used in the no-demonstration group. It is possible that those infants showing target behaviours simply occurred at random, and that a larger sample size would correct for this.

Further research efforts in this area should focus on examining the precise causes of infant distress during the still-face procedure. As well, future studies should continue to examine the relations of stress and sensitivity and their influence on infant memory. While this study did not find any significant results in this area, it is still a strong possibility that maternal behaviour and infant stress reactivity can have a significant impact on infant cognition, and, more specifically, infant memory.
References


