Temperament Differences in Fear Reactivity in Infancy:

Frontal EEG Asymmetry and Recognition Memory

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Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

Master of Science

In

Psychology

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May 5th, 2009
Blacksburg, Virginia

Keywords: Temperament, Recognition Memory, Physiology, Development

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ABSTRACT

Findings that relate cognition and negative affect are not very consistent. However, according to Lazarus (1982) cognitive processes are key to the development and expression of emotions. This study examined the relations between temperament fear reactivity and visual recognition memory at ten months of age. Both behavioral and physiological measurements of fear reactivity and recognition memory were examined in order to further the understanding of temperamental fear in infancy, the relationship temperamental fear reactivity holds with visual recognition memory, and the development of prefrontal and medial temporal areas in the brain. Though both social and non-social fear tasks were examined, only infants who were fearful during stranger approach demonstrated greater novelty preference during the visual paired comparison task. Reactively fearful infants also demonstrated greater left frontal activation during familiarization and recognition memory indicative of better feature discrimination.

ACKNOWLEDGEMENTS

The author wishes to thank the mothers and their infants for their participation and CAP LAB members for their help with data collection. But most of all, Martha Ann Bell for her guidance and patience.

GRANT INFORMATION

The author was supported by the NIH Biomedical and Behavioral Sciences Research Training Grant R25 GM072767 -Virginia Tech Initiative to Maximize Student Diversity

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Chapter 1

Introduction

An individual's life is immersed in emotions. These emotions can manifest themselves as feelings, behaviors, and also physical reactions. What is most interesting about emotion however, is that its reactivity can be shown so early in life. As children mature, they transition from passive demonstration of emotion at around three months, to more active methods at one and two years of age (11). Specifically, knowing when and where to exhibit emotion such as fear is crucial in situations when an infant is confronted with the unfamiliar, whether it is novel objects, new environments or even unknown individuals. Individual infants may display different levels or intensities of fear reactivity to attain a specific goal. This means that some infants may be unable to discern what level of fear reactivity would be more appropriate or adaptable in similar situations. According to Lazarus (49) cognitive processes are key to the development and expression of emotions; thus, an infant's cognitive skills may be a source of these differences in emotion reactivity, especially that in which fear is involved. Therefore, the purpose of this study is to examine the relations between temperamental fear reactivity and recognition memory, both behaviorally and physiologically.

1.1 Temperamental Fear

Temperament represents the biological basis of individual differences in emotion reactivity and its regulation (65-66) and is the foundation from which personality develops (64). Reactivity refers to the arousability, responsiveness and excitability of physiological and behavioral systems and regulation refers to the neural and behavioral processes functioning to modulate this reactivity (47, 65, 66). Negative reactivity in infancy is a temperamental characteristic (45). Goldsmith and Rothbart (38) have suggested that fear is one of several very basic emotions that has been differentiated from other emotions and exhibited in infants as early as 6 months of age. Fear is the expression of negative affectivity that includes unease, worry or nervousness. Fear reactivity behaviorally manifests itself with distressed facial expressions, vocalizations and even physical display of bodily fear such as escape behaviors. Thus, fear serves as a major survival mechanism as it mobilizes a child's resources in the face of threat or imaginary threat.

The appearance of temperamental fear reactivity can be observed gradually in early life as an infant's responsiveness to different stimuli becomes apparent. Children exhibit an inherent bias towards the detection and rapid recognition of evolutionarily relevant threatening stimuli (51). At first, infants become fearful of stimuli in their immediate environment that display load noises or from a loss of support (75), as these stimuli may reveal impending danger. Infants may whimper or cry and become overly tense when in such circumstances. With age, infant fears mature to include anticipatory events and stimuli of an imaginary or abstract nature (14). This is supported by empirical visual search studies that demonstrate faster detection of fear-relevant compared to fear-irrelevant stimuli in young children (51). When infants approach their first birthday, previous fears become somewhat subdued; however, this fear does not vanish. Behaviors such as freezing, trembling and vigorously trying to escape occur when presented with frightening stimuli.

Fear in turn can occur in different circumstances. Researchers have commonly utilized a social fear inducing task based on Dawson and colleagues' (18) stranger approach to assess infant's fearful temperament behavior. In this procedure the child is observed playing while a stranger enters the room creating a scene of unfamiliarity. Starting at around 6 months and peaking in intensity between 10 and 18 months, many infants undergo a period of fear and anxiety around anyone except their caregiver and even more so when their caregiver is absent (74). However, fear can occur in non-social contexts as well, with relatively mild and non-intrusive stimulation. Previous studies have used objects, such a mask, to examine fear in infants and children (43). Maternal ratings of infant temperament have also been used to assess temperamental fear behaviors outside of a laboratory setting. Temperament questionnaires such as the IBQ have showed good internal consistency and converge with other similar scales (53).

Negative reactivity associated with temperamental traits refers to the arousability and excitability of not only behavioral but also physiological systems. Fox and colleagues propose that patterns of frontal EEG asymmetry may serve as a marker of an underlining disposition, as well as an indication of a current emotional state. EEG differences in emotion have been noted as early as the first year of life, suggesting that different levels of emotion may be associated with frontal lobe activation (28). Moreover, resting EEG may reflect an individual's bias to respond with negative affect to certain stressful situations (33). Fox's (28) model of differential activation of the left and right frontal cortices has postulated that differential frontal EEG asymmetry patterns are indices of individual differences in emotion reactivity. For example, infants who cried during maternal separation showed significant right frontal EEG asymmetry at baseline before their mothers even left the room (4, 29, 31). In addition, infants who displayed negative affect and high motor activity at five months of age were reported to display right frontal EEG activation at nine months (13). Negative emotion reactivity seems to be exhibited in the right frontal cortex. Therefore behavioral and maternal-rated measures of temperamental fear should be correlated with frontal EEG asymmetry scores during baseline and during the fear tasks.

1.2 Recognition Memory

Fear is an innate response that usually occurs in response to novelty (43). Visual recognition memory is categorized by the differential attention paid to novel and familiar stimuli following a period of familiarization. If familiarization time is sufficient, visual attention to the novel stimulus should predominate (69). Visual recognition memory plays a substantial role during infancy as a child begins to develop the capability to recognize aspects of the surrounding environment. This can include the recognition of faces, like family and loved ones.

Colombo and colleagues (17) have demonstrated the existence of a preference to novel facial stimuli from three to eight months of age. The recognition of locations also emerges during this time period and soon after how to orient oneself within a given setting (15).

As visual recognition memory matures, an infant's detection of something new in the environment grows and a distinction between novel and familiar appears. Better recognition memory in infancy of visual stimuli (i.e., greater novelty detection) has been associated with higher IQ scores at later ages (69). This might be a consequence of the considerable change visual recognition memory undergoes from 5 to 7 months of age (24) as the ability to disengage and inhibit attention is rapidly developing in infancy (69). Studies have shown a distinct novelty preference in early infancy by assessing shift gaze, look duration and speed of encoding (34, 69). Rose and colleagues have documented improvements in processing speed from 5 to 12 months of age that correspond to increases in novelty detection, as well as a higher shift rates associated with faster stimulus learning at both 7 and 12 months (70). The ability to detect common features in a visual recognition memory task before 12 months may reflect an infant's advanced cognitive abilities (46). Ten month olds are an ideal population as they fit this time period where shifts in gaze and encoding speed have been related to cognitive performance.

Posner has gone one step further and suggested that the vigilance attentional network of the brain, which comprises inputs to the frontal cortex, is involved in maintaining and sustaining ones alertness (61) and Rose and colleagues (69) have reported correlations between attention and recognition memory. Thus, individual differences in the functioning of the vigilance attention network, as well as the ability to encode the stimuli during the familiarization phase, may be associated with individual differences in infant novelty scores. Infants with a novelty preference may display different EEG patterns in frontal scalp locations specifically corresponding to areas implicated in Posner's vigilance system as compared to infants who do not demonstrate a novelty preference (57).

However, recognition memory is thought to be localized in a different area in the brain; the medial temporal cortex. The medial temporal cortex's development might share a role in infancy novelty preference. Infants tend to have a higher novelty preference if they have the cognitive capacity to attend to the familiarized stimulus and then later on to remember that initial stimulus. Electrical activity patterns at temporal scalp sites for infants who are successful in novelty recognition should consequently have greater temporal activity during the retrieval test phase (57). Infants who show novelty preference should then exhibit higher right frontal EEG activity during familiarization relative to their baseline EEG values. These infants should also demonstrate an increase in right temporal EEG activity during familiarization and test, whereas infants who do not demonstrate a novelty preference might display no task-related changes in brain electrical activity from any frontal or temporal scalp sites.

1.3 Recognition Memory and Temperament Fear

Temperament has also been found to play a substantial role in cognitive functioning (83,84). Novelty preference may serve as a biologically driven survival mechanism for the recognition of danger and thus the reactivity of temperamental fear. However, findings relating cognition and negative affect are not very consistent (46). Some researchers have found that infants who exhibit more negative reactivity show less advanced mental development and lower IQ scores in preschool (53). On the other hand, other researchers show that distress to novelty at 10 months was positively correlated with language development (23). Karrass and Braugart-Rieker (46) showed that early distress to novelty, not distress to limitations, was linked to higher IQ at 36 months.

Robinson & Acevedo (63) claim that both negative and positive emotions develop during the second half of the first year of life and serve to enhance an infant's responsiveness and engaging capacities with objects and the surroundings. Fear evokes a preemptory response from adults to protect their infants, thus infants who haven't shown lively reactivity of their negative emotion by their first year of life may receive fewer preemptory responses and in turn may elicit less response from the environment as children (63). According to Karrass and Braugart-Rieker (46), an infant's limited communicative and motoric abilities heighten negative emotions to bring caregiver closers. This is turn impacts cognitive growth. The emergence of distinct fears in infancy (i.e., fear of strange persons, objects, and situations) must require some cognitive maturation in order to remember and also be able to distinguish between the novel and the familiar (39). In order to truly assess temperamental fear in infancy, multiple assessments of fear in social and non-social circumstances are needed.

Infants who present higher fear reactivity may rely on sustaining heightened levels of attention to their environment, as is seen in studies of temperamental attention in infancy and relations with language and growth into early childhood (63, 23, 53). Infant reactivity and early efforts to regulate emotion is supplemented by the ability and the capacity for voluntary forms of control, including individual differences in inhibitory control and attentional mechanisms (65, 67). This is complemented by the findings that highly fearful toddlers and preschoolers are characterized as displaying vigilant behaviors (13). The developmental changes that occurs around 10 months (67), coincide with the developmental time period when advances in attentional control (72, 81), cognitive control (22), and emotion regulation (12, 72) are taking place. Early displays of distress to novelty may reflect a higher cognitive level as infants can recognize that a stimulus is discrepant from those encoded before (46).

Fear then is an integral and adaptive aspect of development. If one is not able to discriminate the novelty of a certain stimuli or event, one is not able to experience emotion or the same kind of intensity of emotion (78). Underlying patterns of general fearfulness expression may enhance the information processing that is required for the encoding and retrieval associated with recognition memory positively correlating with novelty preference during recognition memory tasks.

1.4 Recognition Memory & Temperament Fear Physiology

Since infants seem to be physiologically disposed to express negative affect in response to novelty (33), it may be that similar brain systems for fear reactivity and novelty recognition exist. Though fear reactivity is associated with the amygdala (43) and visual recognition memory to the hippocampus (77), functioning might overlap at the right frontal cortex. Infants who demonstrate greater right frontal EEG asymmetry at baseline and during fear tasks should then show increased right frontal EEG activity during familiarization as well as an increased right temporal activity during familiarization and test on the recognition memory task.

Cognitive processes are key to the development and expression of emotions (49). Because substantial advancements in attention control (72, 81) cognitive control (22), and emotion control (12, 72) take place around 10-months of age, 10-month olds will be examined to see the relation between temperamental fear reactivity and recognition memory, both behaviorally and physiologically. An infant's fearful temperament is characterized by motivational aspects, various communicative behaviors and reactive responses that may have unique associations with physiology (9). Investigating infant's physiology, specifically the central nervous system's activity, while an infant is experiencing fear may divulge further information on the cognitive abilities that could be influencing individual differences in fear reactivity.

1.5 Hypotheses

There were four hypotheses for this study. First, behavioral and maternal-rated measures of temperamental fear will be correlated with frontal EEG asymmetry scores during baseline and during fear tasks. Second, there will be a positive relation between the level of temperamental fear reactivity and novelty score on the recognition memory task. Third, infants who demonstrate greater right frontal EEG asymmetry at baseline and during fear tasks also will show greater right frontal EEG activation during familiarization as well as greater right temporal activation during familiarization and test on the recognition memory task compared to infants without greater right frontal EEG asymmetry at baseline and during the fear tasks. Finally, infants who show novelty preference during the visual recognition memory task will exhibit greater right frontal

EEG activation during familiarization (encoding) phase relative to their baseline EEG values compared to infants without novelty preference. These infants will also demonstrate an increase right temporal EEG activation during both familiarization and test.

Chapter 2

Method

2.1 Participants

Participants included 50 10-month-old infants (24 male, 26 female; 38 Caucasian, 4 African American, 4 Asian American, 4 Hispanic) and their mothers from the New River Valley area of southwest Virginia. Infants were born within 2 weeks of their expected due dates, experienced no prenatal or birth complications and no neurological diagnoses. Infants were seen in the research lab within two weeks after their 10 month birth date. All infants were born to parents with a high school diploma and college degrees or higher were held by 89% of the mothers and 73% of the fathers. Mothers were approximately 29 years of age at birth (range 17–38) and fathers were approximately 31-years-old (range 18–45).

2.2 Procedures

Infants were recruited through the use of the Developmental Sciences Database of mother names and addresses, advertisements on the Virginia Tech website, e-mails to the Virginia Tech Working Moms listserve, and flyers to the community. After parents indicated interest in participating in the study, mothers were asked to fill out two questionnaires [General Information Questionnaire (Appendix A), the Infant Behavior Questionnaire-Revised (IBQ-R)] (36) and a Consent Form (Appendix B). Forty-six out of the fifty mothers returned the two questionnaires.

On the day of the visit, the infant sat on mother's lap and was distracted with toys in order to situate the Electro-cap for the EEG on the infant’s head. Electrodes remained on the scalp during the entire procedure and the EEG record was event marked by a research assistant in an adjacent room. The session was digitally recorded for later behavioral coding purposes. The infant also sat on mother’s lap while the familiarization and test phases of the recognition memory task were administered. After recognition memory task, the infant was moved to a highchair where all subsequent temperamental fear tasks took place.

The temperamental fear tasks were adapted from the Laboratory Temperament Assessment Battery Lab-TAB, Version 3.1 (37). A social fear task of stranger approach, as well as two non-social fear tasks of mask presentation and toy spider, was counterbalanced during each infant’s visit to control for order effects. After each temperamental fear task, a two minute free play session occurred were mother interacted with and played with her infant as she would normally do at home. The free play session was utilized to return the infant back to a baseline state and limit any carryover effects. Infants were only assessed if they were calm and display no distress before starting the second and third temperamental fear tasks. If an infant protested by crying continuously for more than 15 seconds during a temperamental fear task, the task was stopped and the mother was asked to comfort her child to help the infant settle back down to baseline. The entire procedure lasted approximately 45 minutes

2.2.1 EEG Recordings

Upon arrival to the research laboratory, the EEG electrodes were placed on the infant’s head and one minute of baseline physiology was recorded. Recordings were made from

16 left and right scalp sites [frontal pole (Fp1, Fp2); medial frontal (F3, F4); lateral frontal (F7, F8); central (C3,C4); anterior temporal (T3, T4); posterior temporal (T7,T8); parietal (P3, P4); and occipital (O1, O2)]. All electrode sites were referenced to Cz during recording.

Baseline EEG was recorded while the infant sat on the mother's lap and watched a research assistant manipulate a toy containing brightly colored balls on top of the testing table, 1.1 m in front of the infant. This procedure quieted the infant and yielded minimal eye movements and gross motor movements, thus allowing the infant to tolerate the EEG cap (2,3). Mothers were asked not talk to infants during the EEG recordings and tasks until asked otherwise.

EEG was recorded using a stretch cap (Electro-Cap, Inc.) with electrodes in the 10/20 pattern (41). After the cap was placed on the head, the recommended procedures regarding EEG data collecting with infants was followed (60). Specifically, a small amount of abrasive gel was placed into each recording site and the scalp gently rubbed. Next, conductive gel was placed in each site and the scalp gently rubbed. Electrode impedances were measured and accepted if they were below 10K ohms.

The electrical activity from each lead was amplified using separate SA Instrumentation Bioamps and bandpassed from 1 to 100 Hz. Activity for each lead was displayed on a monitor of an acquisition computer. The EEG signal was digitized on-line at 512 samples per second for each channel so that the data were not affected by aliasing. The acquisition software was Snapshot-Snapstream (HEM Data Corp.) and the raw data were stored for later analyses. EEG data were examined and analyzed using EEG Analysis System software developed by James Long Company. First, the data was re-

referenced via software to an average reference configuration. Average referencing, in effect, it weighed all the electrode sites equally and eliminated the need for a noncephalic reference. Active (Fp1, Fp2, F3, F4, F7, F8 etc.) to reference (Cz) electrode distances vary across the scalp. Without the re-referencing, power values at each active site may reflect interelectrode distance as much as electrical potential.

The average reference EEG data were artifact scored for eye movements using a peak-to-peak criterion of 100 uV or greater. Artifact associated with gross motor movements over 200 uV peak-to-peak were also scored. These artifacts scored epochs were eliminated from all subsequent analyses. The data was then analyzed with a discrete Fourier transform (DFT) using a Hanning window of 1-second width and 50% overlap. Power was computed for the 6 to 9 Hz frequency band as infants at this age have a dominant frequency between 6 and 9 Hz (4, 54). This particular frequency band discriminates baseline EEG from task EEG during infant working memory (2,3) and long-term recall tasks (55). For the current study, the power was expressed as mean square microvolts and the data transformed using the natural log (ln) to normalize the distribution. F3 and F4 asymmetry has been utilized to provide evidence of the associations between frontal scalp regions and observed cognitive and emotion behaviors (55, 28). However, Buss and collogues (10) have provided evidence of the associations between not only F3 and F4 asymmetric regions but Fp1 & Fp2 and F7 & F8 as well. In their study, greater frequency of withdrawal-related behaviors and right frontal activation was strongest for the most anterior site of Fp1 & Fp2. Therefore, frontal asymmetry scores were calculated at each pair of frontal electrodes (e.g., Fp1 & Fp2, F3 & F4, F7 & F8) by subtracting ln left frontal power from ln right frontal power (ln right – ln left =

frontal asymmetry). In the affective neuroscience literature, brain activation is indicated by lower EEG power values (4). Thus, negative asymmetry scores reflect greater activation on the right hemisphere compared to the left. Asymmetric labels refer to scalp, not brain, locations. Utilizing more than one asymmetric region can provide more information of localization in the absence of source localization methods that permit topographic localization of the intracerebral sources of brain electrical signals (10).

2.2.2 Recognition memory task

A modified visual paired comparison task was used to test recognition memory (Diamond et al., 1997). This type of task has long been used to assess recognition memory (Fagan, 1970) and involves infants examining a stimulus briefly followed by a delay. After the specified delay, the infant is given a choice between looking at that same stimulus further or a novel one.

The first part of the visual paired comparison task consisted of familiarizing the infant with a stimulus during which an object is presented to the infant. Because the infant is 10 months of age, infants were shown the object for a set period of time, 30 seconds (Diamond et al., 1997; Frick, Colombo & Allen, 2000; Colombo, Freesman, Coldren & Frick, 1995). If an infant looked away from the object before the allotted presentation time was expired, his or her attention was immediately brought back to the object. As soon as the infant had accumulated 30 second of actual looking time to the object, the object was removed and then a five minute delay period ensued. After the five minutes had elapsed, the test portion of the visual paired comparison followed. The recognition memory test phase involved the novel object and the familiarized object presented simultaneously. The experimenter presented the familiarized and novel objects side by side at the infant's midline. The objects were moved apart and back together to ensure that the infant had seen both of them. After the infant had clearly seen both objects, he/she was allowed to look at them for 30 seconds of total looking time.

2.2.3 Social temperamental fear task: Stranger Approach

Mothers were instructed to keep her seat slightly behind her infant and refrain from speaking for the duration of this task. The experimenter exited the room and a new female research assistant entered saying nothing for 10 seconds and standing at the far corner of the room. The stranger then approach the infant until she positioned herself half way across from the infant and remained there for 10 seconds. Then, the stranger approached the infant one last time until she was directly in front of the infant and standing over the highchair for another 10 second interval. The stranger then exhibited the hand and arm motions as if to pick up the infant and stayed in the position for the last 10 second interval. Throughout the stranger approach, the stranger looked directly at the infant but refrained from smiling and speaking. Since the stranger approach incorporates both proximal and distal fear inducing tasks, stranger approach was divided into the approach component as well as the reach component for some analyses.

2.2.4 Non-social temperamental fear task: Masks Presentation

While the infant was in the highchair, the experimenter positioned a table covered by a black cloth in front of the infant. Five masks on a wig stands (evil queen, old man, vampire, gas mask, and gorilla) were placed under the table out of sight of the infant.

Mother was asked to move her chair slightly behind the highchair and refrain from interacting with her infant. The experimenter sat on the floor behind the table out of sight of the infant. The task began when the infant's attention was focused on the table. The experimenter then placed one mask at a time on top of the table 25 inches away from the infant. Each mask was shown for 10 seconds with five seconds intervals in between.

2.2.5 Non-social temperamental fear task: Toy Spider

This task involved presenting the infant with a small jumping spider toy. The experimenter sat on the floor behind a cloth-draped table and out of sight of the infant. The task began when the infant's attention was focused on the table. The experimenter then placed the spider on top of the table 25 inches away from the infant. The experimenter manipulated the toy spider, making it jump and move for 60 seconds.

2.2.6 Temperamental fear task: Maternal report

The Infant Behavioral Questionnaire - Revised (IBQ-R) was utilized to measure maternal observation of infant fearful temperament outside of a laboratory setting. This 191-item questionnaire assessed infant's emotional and behavioral responses across a number of situations. This instrument measures 14 domains of infant temperament. The focus however is only on the temperamental fear score.

2.2.7 Behavioral Measures

Three types of measures were derived from the assessment: recognition memory measure, three temperamental fear measures (masks presentation, stranger approach, and spider) and maternal report of temperamental fear measure. Standardized summery and individual scores of each measure were used for data analysis.

Recognition memory measures

Novelty preference were calculated according to Fagan's criteria (1971) in which infants who spend more than 53% of the time in the test phase looking at the novel object are labeled as novelty preferring. Infants in the test phase who spend less than 53% of the time looking at the novel object were categorized as having no novelty preference. Novelty preference percentage was also used as a continuous variable for some analyses Using this criteria, 28 infants were novelty-preferring and 23 infants were non-novelty preferring (Novelty preferring: M = .687, R = .54-1.00, SE =.020; Non-Novelty preferring: M = .416, R =.21-.53, SE= .020).

Temperamental fear tasks measures

Lab-TAB was used to code all three temperamental fear tasks; mask presentations, stranger approach, and spider. Temperamental fear tasks were divided into five to ten second epochs depending on the length of the task and coded on a four point scale indicating the level and/or occurrence of seven specified behaviors (Please see Appendices D & E for further coding details). Four coders trained on 10% of the videotaped sessions and independently coded another 10% for reliability. The average adjusted kappas between each pair of coders were all above .70. The parameter estimates had adequate reliability for all emotion reactivity tasks, Stranger approach (.89), masks presentation (.76) and toy spider (.79), as well as for look duration during the visual recognition task (.80).

Temperamental fear variables were chosen based on previous research measuring infant fearful temperament (Goldsmith & Rothbart, 1999). Table 2.1-2.3 provide summery scores for each temperamental fear variable by fear task composite.

The variables of interest included:

1) Latency to first fear response: The interval, in seconds, from the start of the trial to the first definite fear response including facial, vocalic, and postural (bodily fear or escape behaviors).

2) Intensity of facial fear: The presence of raised brows drawn together and faint horizontal furrows. Raised eyelids that make eyes appear wide with a tense appearance and also lip corners drawn straight back with the mouth less than wide open.

3) Intensity of distressed vocalizations: Ranging from no distress to long whining or low-intensity cry with extended or rhythmic quality.

4) Intensity of bodily fear: Degree, if any, of freezing or trembling.

5) Intensity of escape: Degree of mild fleeting behavior to full-body movements.

6) Startle: Present of startle at first presentation.

Chapter 3

Results

3.1 Frontal EEG Asymmetry and Temperament-fear

Temperamental fear tasks measures

The first hypothesis was that behavioral and maternal-rated measures of temperamental fear will be correlated with frontal EEG asymmetry scores during baseline and during fear tasks. Fear behavior variables were Z-scored in order to create a composite score of fear for the stranger approach, mask presentation, and toy spider tasks. Startle was not included in any composite score of fear due to its lack of appearance and variance. Fear composites were not correlated with one another (see Table 3.1). Pearson correlations were utilized to determine whether behavioral fear scores in the stranger approach, mask presentation, toy spider and maternal ratings of fear on the IBQ were negatively correlated with the frontal EEG asymmetry scores at baseline and during each respective fear task. Because EEG asymmetry scores are calculated by subtracting left ln power from right ln power, negative scores reflect greater relative right frontal asymmetry.

As seen in Table 3.2, mask presentation fear behavioral composite score was negatively correlated with frontal EEG asymmetry at Fp1/Fp2 during the baseline EEG recording. Toy spider behavioral fear composite was negatively correlated with frontal EEG asymmetry at Fp1/Fp2 during the spider task EEG recording. However, mother rated report of fear was positively correlated with baseline frontal EEG asymmetry at F3/F4.

A median split was used to determine higher and lower levels of behavioral fear in the stranger approach, masks presentation, and toy spider. These three individual fear groups (high and low fear during stranger approach, during masks, during toy) were compared on baseline and task-related frontal EEG asymmetries. Membership in high versus low fear groups varied across the three fear tasks ($\chi^2 < 2.06$, all p's >.07). Eleven infants, however, were classified high fear across all three temperamental fear tasks and ten infants were classified low fear across all three temperamental fear tasks. Different analyses were performed on the three temperamental fear tasks; masks presentation, stranger approach, and toy spider. To test for differences in baseline and task-related EEG asymmetries during individual fear tasks, a repeated-measures MANOVA with condition (baseline, fear task) as the within-subjects factor and performance group (high, low fear group) as the between-subjects factor. Frontal EEG asymmetry was the dependent variable (Table 3.3). Of interest were main effects for group and group by condition interactions.

Group by condition interactions were found for frontal EEG asymmetry at Fp1/ Fp2 trend for masks presentation and toy spider (see Figure 3.1 & Figure 3.2). Infants with greater behavioral fear during the two tasks demonstrated a change from left frontal EEG asymmetry during baseline to right frontal EEG asymmetry during the task. Infants with lower behavioral fear during the two tasks demonstrated left frontal EEG asymmetry during both baseline and fear tasks.

High and low fear groups during stranger approach showed no differences in their baseline and task-related frontal EEG asymmetries. Because stranger approach is composed of distal and proximal interactions, analyses were performed to determine whether or not distance from stranger played a role in baseline and task-related EEG activity (Table 3.4). Stranger approach was broken into two components: the approach and the reach. There was a group by condition interaction for reach at Fp1/ Fp2 (Figure 3.3). Infants with greater behavioral fear during the stranger reach demonstrated a change from left frontal EEG asymmetry during baseline to right frontal EEG asymmetry during the task. Infants with lower behavioral fear during the stranger demonstrated EEG hemispheric symmetry during both baseline and stranger reach.

A fourth repeated-measures MANOVA was performed with condition (baseline, fear task) as the within-subjects factor and maternal-report fear group (high, low IBQ fear) as the between-subjects factor (see Table 3.5 and Table 3.6). Internal consistency for the IBQ fear scale was .85 which is akin to cronbach alphas found in other studies of .87 for the temperamental fear at 10-months of age (Garstein & Rothbart, 2003). A group by condition interaction was found for spider at frontal pair Fp1 & Fp2 signifying that the high IBQ fear group showed significantly more right frontal asymmetry from baseline to task compared to low fear groups (Figure 3.4). Infants with greater behavioral fear according to maternal reports during the toy spider demonstrated a change from left frontal EEG asymmetry during baseline to right frontal EEG asymmetry during the task. Infants with lower behavioral fear demonstrated no differences in EEG asymmetry from baseline to task.

3.2 Behavior association of recognition memory and temperament-fear

Hypothesis two was that will be a positive relation between the level of temperamental fear behavior and novelty score on the recognition memory task. In order to determine the relationship between behavioral demonstrations of temperamental fear and recognition memory test performance, Pearson correlations were used to examine whether novelty preference positively correlated with behavioral temperamental fear composite scores during each fear task. There was a positive correlation between temperamental fear during stranger approach composite and novelty preference score (r = .32, p = .02). A breakdown of the stranger approach into two components, the approach and the reach, demonstrated a positive correlation between temperamental fear during the reaching portion of the stranger task and novelty preference (r = .34, p = .01) and no correlation between temperamental fear during the approach phase of the task (r = -.03, p = .84).

Individual stranger approach fear variables then were examined to see which specific fear behaviors were associated with novelty preference. Facial and vocal reactions were different between novelty preferring infants (see Table 3.7). A breakdown of the stranger approach composite into two components again revealed novelty preference group behavioral differences only during the reach subportion of the stranger approach task.. Groups demonstrated differences between temperamental fear during the reaching portion of the stranger task specifically with facial and vocal reactions (see Table 3.7).

Pearson correlations revealed no association between novelty preference and behavioral temperamental fear scores during mask presentations (r = .08, p=.59) or during toy spider (r= .09, p=.51). Pearson correlations revealed no association between novelty preference and IBQ temperamental fear scores (r= .09, p=.55).

3.3 Physiology association of recognition memory and temperamental fear

Hypothesis three was that infants who demonstrate greater right frontal EEG asymmetry at baseline and during fear tasks also will show greater right frontal EEG activation during familiarization as well as greater right temporal activation during familiarization and test on the recognition memory task compared to infants without greater right frontal EEG asymmetry at baseline and during the fear tasks. In order to determine the relations between physiological demonstrations of temperamental fear (higher right frontal asymmetry) and physiological demonstrations of recognition memory, Pearson correlations were used to analyze whether frontal asymmetry during familiarization and temporal asymmetry during familiarization and retrieval were positively correlated with frontal asymmetry during baseline and frontal asymmetry during stranger approach, mask presentation, toy spider and IBQ. As seen in Table 3.8, frontal asymmetry scores during stranger approach were negatively correlated with all three frontal asymmetry scores at both familiarization and during the recognition memory task. This same pattern was also evident for frontal asymmetry scores during mask and toy spider.

As seen in Table 3.9, temporal asymmetry scores during the fear tasks were negatively correlated with temporal asymmetry scores at both familiarization and during the recognition memory task.

3.4 Baseline and recognition memory related EEG

Hypothesis four was that infants who show novelty preference during the visual recognition memory task will exhibit greater right frontal EEG activation during familiarization (encoding) phase relative to their baseline EEG values compared to infants without novelty preference. These infants will also demonstrate an increase right temporal EEG activation during both familiarization and test.

To test for differences in baseline and task-related EEG power during recognition memory task performance, a repeated-measures MANOVA was conducted with condition (baseline, recognition memory familiarization), and hemisphere (left, right) as the within-subjects factors and performance group (high, low novelty preference) as the between-subjects factor. Frontal and Temporal ln EEG power at 6-9 Hz was the dependent variables. No Group x Condition x Hemisphere interaction was found (Table 10). Identical analyses were conducted substituting recognition memory test for recognition memory familiarization in the condition factor. Frontal and temporal ln EEG power at 6-9 Hz was the dependent variables. The hypothesis for a Group x Condition x Hemisphere interaction was not found (Table 3.11).

3.5 Summary

Results indicated that behavioral fear scores during mask presentation were correlated with frontal EEG asymmetry scores during baseline, whereas behavioral fear during toy spider was correlated with frontal EEG asymmetry during the toy spider task.

Infants with greater behavioral fear demonstrated a change from left frontal EEG asymmetry during baseline to right frontal EEG asymmetry during the task.

Temperamental fear composite score during stranger approach and stranger reach was positively correlated with novelty preference. Individual fear variables, facial and vocal fear scores, were also positively correlated with novelty preference during stranger approach and stranger reach.

Frontal EEG asymmetry scores during stranger approach, mask, and toy spider composites were negatively correlated with frontal asymmetry scores at familiarization and recognition memory tasks. The same was true for temporal asymmetry scores.

There were no novelty preference group differences in frontal or temporal EEG activity during baseline, familiarization, or test phases of the recognition memory task.

Chapter 4

Discussion

The current study investigated individual differences in temperamental fear reactivity and its association with recognition memory. Given the discrepancies relating cognition and negative affect in infancy (Karass & Braugart-Rieker, 2004), it is vital to recall that fear can occur in various situations and that visual recognition memory plays a substantial role in the development and capability to recognize aspects of the surrounding environment. Accordingly, social and non-social fear tasks were utilized to observe not only behavioral observations of fear reactivity but also infant physiological responses.

4.1 Baseline and task-related Temperament-fear

It was predicted that fear-related behaviors during tasks would be associated with greater right frontal baseline EEG asymmetry. This was not substantiated during the stranger approach or toy spider. However, temperamental fear during mask presentation was associated with greater right frontal baseline EEG asymmetry at Fp1/ Fp2. This right frontal pattern is typically associated with negative emotions (Fox, 1994) and also has been taken to indicate activation of the motivational system associated with withdrawal behaviors coupled with the experience and expression of moderately high levels of fear (Fox, Henderson, Marshall, Nichols & Ghera, 2005). This pattern of frontal EEG asymmetry during baseline may serve as a marker of an underlining disposition for temperamental fearful infants to display temperamental fear behaviors during a novel non-social situation such as the masks.

Fear-related behaviors were also predicted to be associated with greater right frontal task-related EEG asymmetry during toy spider. This suggests that infants with higher fear reactivity during the task demonstrated greater right frontal asymmetry values when the infant experienced the fear inducing situation. This is indicative of not only a current emotional state but also perhaps an index of individual differences in emotion reactivity.

No differences in baseline and task-related EEG asymmetries were found for infants with greater fear reactivity during stranger approach. Fear reactivity manifests itself through changes in arousal states and physiological reactivity. The most proximal portion of the stranger approach task (i.e., when the stranger reached to pick up the infant), however, did demonstrate an association with frontal EEG. Fear has been preserved over the course of human evolution because of its contribution to survival especially in social situations. The moment that could be presumed as the most dangerous by evolutionary standards appeared to arouse a physiological respond concurrent with negative affect.

What was unexpected was a positive correlation between baseline frontal asymmetry and maternal ratings. A positive correlation couples higher maternal ratings of negative emotion with greater left frontal asymmetry values. Greater left frontal asymmetry values are usually associated with approach-directed emotional responses (Fox, 1994). However, further analyses found that infants with greater maternal-rated temperamental fear scores on the IBQ exhibited a change in frontal EEG asymmetry from left frontal to frontal asymmetry during the toy spider task. These results correspond with previous research that state that higher maternal rating on negative emotions are correlated with greater right frontal asymmetry (Fox, Schmidt, Henderson & Marshall, 2007; Fox, et al., 2001).

4.2 Behavior association of recognition memory temperament-fear

In accordance to earlier predictions, novelty preference positively correlated with temperamental fear reactivity, but only in the social fear task. This was especially evident during the most proximal component of the stranger approach task where the stranger acted as if she were going to pick up the infant. This study was not designed for emotion and cognitive tasks to conflict with one another. The infant's temperament-related ability to better perceive and react to an unknown individual in one task may have helped the infant during the recognition memory task at separate point in time. Fear's adaptive function is to increase vigilance and orienting to environmental cues that could be indicative of threat (LeDoux, 2000). Higher-order cortical processes are closely involved in fear acquisition in both animals and humans (Delgado, Olsson, & Phelps, 2006; Lovibond, 2004). Perhaps these infants' temperamentally heightened arousal aided their attentional abilities during the recognition memory task, giving them an advantage to better distinguish novelty from the familiar. These novelty preferring infants also had higher scores of facial and vocal fear reactions during the stranger approach task. Though infants are unable to verbally articulate their distress, use of other salient means such as facial and vocal reactions are strategic means to make caregivers aware of the infants' current plight but, more importantly, bring caregiver closer and perhaps increasing infants' opportunities for cognitive interactions.

4.3 Physiology association of recognition memory and temperamental fear

Infants who had greater right frontal asymmetries at baseline and during the temperamental fear tasks had greater left frontal asymmetry scores at familiarization as well as during the recognition memory task at frontal and temporal regions, contrary to predictions. Greater activity in the left prefrontal cortex may have helped contain negative reactions (Gunnar & Davis, 2003) in these temperamental fearfully prone infants during the visual paired comparison task. The visual paired comparison task is not an emotion eliciting task. It is a task formulated to tap into the ability to differentiate between previously seen stimuli and novel stimuli. Interest and exploration are thought to reflect tendencies of left frontal brain function, however.. The left hemisphere has also been linked with various cognitive abilities including attending to local cues and visual-spatial analyses on local features (Vallortigara & Rogers, 2005) as well as feature based encoding (Farah, 1990). It appears that fearful infants relied more on their left hemispheres in order to attend and encode object features during familiarization. These temperamentally fearful infants also demonstrated greater left activation during the recognition memory test. Perhaps they utilized their left hemisphere to help them discriminate local feature differences between objects. Given these results, it was not unexpected then that infants who showed a novelty preference did not exhibit higher right frontal EEG activity during familiarization and recognition memory relative to their baseline EEG values.

Non-social fear tasks generally demonstrated more anterior frontal asymmetry activity at the frontal pole area while the social fear task had a mixture both frontal pole and lateral frontal asymmetry. However, most research has focus on solely medial frontal asymmetry site F3/F4 when exploring physiological correlates of temperament behaviors. The first year of life is comprised of rapid EEG development that continues into early childhood and is then followed by a more gradual change in EEG to perhaps more coherent patterns at asymmetry site F3/F4 as they mature. Buss and colleagues (2003) have explored frontal asymmetries other than medial frontal areas when investigating emotion reactivity in infancy. These current results give support to the notion that infants' brains and electrical activity are quite dynamic and not yet specialized especially when investigating temperament and cognitive processing during the first year of life (Bell & Wolfe, 2007).

4.4 Caveats and Future Studies

This study is not without its limitations. Infants were predominately Caucasian and from highly educated families. Future studies should examine ethnic and culture differences between temperamental fear and recognition memory as well as social economical status as moderators of these relations. Studies have indicated differences in temperament across distinct ethnic group in various Eastern and Western cultures (Ahadi et al., 1993; Windle, Iwawaki, & Lerner, 1988). Culture is an important factor in understanding individual differences, as it may influence the development or maintenance of certain behaviors.

This group of infants was also not selected on any specific behavioral or physiological criteria and is generally a low fear sample given their mean scores.

Subsequent studies should specifically select infants based on high or low reactivity to fearful stimulus. This method would allow for the investigation of extreme groups within high and low fearful infants. In turn, these extreme groups may provide more evidence regarding the relation between fear reactivity and recognition memory.

Evidence shows that emotional reactivity and emotional regulation (rapid or slow response dampening following reactivity), are functioning systems in infant temperament (Rothbart & Bates, 1998). These data support a linkage between emotional reactivity and recognition memory in young infants, but do not address emotion regulation associations with recognition memory. One viable and interesting next step would be to extend this experimental paradigm to investigate emotional regulation processes to social and non-social novel events. Since temperament represents both individual differences in emotion reactivity and regulation (Rothbart & Bates, 1998; 2006), incorporating emotion regulation might provide an even more complete picture of how temperamental fear relates to recognition memory.

4.5 Conclusion

The findings from this study illustrate the association between temperamental fear reactivity and recognition memory in infancy. Both social and non-social fear tasks were examined and infants who were fearful during stranger approach demonstrated greater novelty preference during the visual paired comparison task. Reactively fearful infants also demonstrated greater left frontal activation during familiarization and recognition memory indicative of better feature discrimination. These findings add additional weight to the use of frontal asymmetries as central variables in the examination of temperament and cognitive capabilities in infancy.

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Table 2.1

Summary Scores for Stranger Approach Temperamental Fear Variables

	Mean	SE	Range
Facial	.78	.11	0 - 2.25
Vocal	.36	.17	0 - 5
Startle	.03	.01	0 - .5
Bodily	.28	.06	0 - 1.75
Escape	.96	.12	0 - 2.50
Latency	3.32	.28	0 - 7.25

Note: *n* = 50 for each variable

Table 2.2

Summary Scores for Mask Presentation Temperamental Fear Variables

	Mean	SE	Range
Facial	.66	.06	0 - 2.3
Vocal	.29	.06	0 - 1.75
Startle	.04	.01	0 - .5
Bodily	.19	.05	0 - 1.80
Escape	.43	.05	0 - 1.63
Latency	3.81	.31	0 - 9

Note: *n* = 50 for each variable

Table 2.3

Summary Scores for Toy Spider Temperamental Fear Variables

	Mean	SE	Range
Facial	.73	.089	0 - 2.33
Vocal	1.01	.178	0 - 4.33
Startle	.01	.006	0 - .33
Bodily	.15	.049	0 - 2
Escape	.84	.119	0 - 3
Latency	19.88	2.159	0 - 60

Note: *n* = 50 for each variable

Table 3.1

Correlations among Temperamental Fear Composite Scores

Fear Composites	Mask	Stranger	Approach	Reach	Spider	IBQ
Mask Composite	n/a					
Stranger Composite	.07	n/a				
Stranger Approach	-.14	.82**	n/a			
Stranger Reach	.24	.64**	.28*	n/a		
Spider Composite	.04	.13	.16	.29*	n/a	
IBQ	-.39**	.09	.13	.12	.07	n/a

**$p \leq .01$; *$p \leq .05$
Note: n = 50 for each variable

Table 3.2

Correlations between Task-related Temperamental Fear Behaviors and Frontal Asymmetries during Baseline and Corresponding Task

Fear Task	Baseline EEG	Task-related EEG
Fp1 / Fp2 Asymmetry		
Stranger Approach	-.19	-.14
Approach	.25	-.05
Reach	.00	-.28
Masks	-.39**	-.21
Spider	.04	-.30*
IBQ	.04	n/a
F3 / F4 Asymmetry		
Stranger Approach	.08	-.25
Approach	.02	-.07
Reach	-.18	-.29
Masks	.23	-.08
Spider	-.02	-.11
IBQ	.37*	n/a
F7 / F8 Asymmetry		
Stranger Approach	-.08	-.34+
Approach	.11	-.09
Reach	-.08	-.34+
Masks	.12	-.12
Spider	.14	-.03
IBQ	-.03	n/a

*$p \leq .05$; +$p \leq .06$

Table 3.3

Summary of MANOVA F values for Baseline and Task-related Frontal EEG Asymmetries During Individual Fear Tasks using Fear Groups from Each Task

	Task	Condition	Condition x Group
df		1, 31	1, 31
Fp1/2 Asymmetry	Stranger	.67	1.13
F3/4 Asymmetry	Stranger	1.32	.15
F7/8 Asymmetry	Stranger	1 .33	.16
df		1, 47	1, 47
Fp1/2 Asymmetry	Masks	7.32**	2.91+
F3/4 Asymmetry	Masks	1.13	.07
F7/8 Asymmetry	Masks	.06	3.67+
df		1, 47	1, 47
Fp1/2 Asymmetry	Spider	3.51+	4.98*
F3/4 Asymmetry	Spider	1.13	.04
F7/8 Asymmetry	Spider	.04	.50

**$p \leq .01$; *$p \leq .05$; +$p \leq .09$

Table 3.4

Summary of MANOVA F values for Baseline and Task-related Frontal EEG Asymmetries During Stranger Approach Subdivisions using Strange Approach Fear Groups

	Task	Condition	Condition x Strange
df		1, 42	1, 42
Fp1/2 Asymmetry	Approach	.11	.00
F3/4 Asymmetry	Approach	.01	.15
F7/8 Asymmetry	Approach	1 .53	.07
df		1, 31	1, 31
Fp1/2 Asymmetry	Reach	.03	5.94*
F3/4 Asymmetry	Reach	.47	3.27+
F7/8 Asymmetry	Reach	.60	3.03+

*$p \leq .05$; +$p \leq .09$.

Table 3.5

Summary of MANOVA F values for Baseline and Task-related Frontal EEG Asymmetries during Individual Fear Tasks using IBQ Fear Groups

	Task	Condition	Condition x Strange
df		1, 31	1, 31
Fp1/2 Asymmetry	Stranger	.69	2.27
F3/4 Asymmetry	Stranger	1.22	.313
F7/8 Asymmetry	Stranger	1 .83	2.11
df		1, 47	1, 47
Fp1/2 Asymmetry	Masks	6.26**	.39
F3/4 Asymmetry	Masks	1.38	.06
F7/8 Asymmetry	Masks	.00	1.38
df		1, 43	1, 43
Fp1/2 Asymmetry	Spider	.94	5.07*
F3/4 Asymmetry	Spider	1.19	2.98+
F7/8 Asymmetry	Spider	.21	1.90

**$p \leq .01$; *$p \leq .05$; +$p \leq .09$.

Table 3.6

Summary of MANOVA F values for Baseline and Task-related Frontal EEG Asymmetries during Stranger Approach Subdivisions using IBQ Fear Groups

	Task	Condition	Condition x Strange
df		1, 42	1, 42
Fp1/2 Asymmetry	Approach	.13	3.01+
F3/4 Asymmetry	Approach	.03	.51
F7/8 Asymmetry	Approach	.63	.25
df		1, 31	1, 31
Fp1/2 Asymmetry	Reach	.07	1.15
F3/4 Asymmetry	Reach	.58	1.24
F7/8 Asymmetry	Reach	1.68	1.48

+$p \leq .07$.

Table 3.7

Group Differences for Individual Temperamental Fear Variables for Stranger Approach Composite, Stranger Approach and Stranger Reach

Stranger Approach Composite	Mean	SE	*t*	*p*
Facial				
Novelty Preferring	.91	.13	2.16	.04*
Non-Novelty Preferring	.63	.10		
Vocal				
Novelty Preferring	.57	.22	2.58	.01*
Non-Novelty Preferring	.09	.06		
Escape				
Novelty Preferring	1.09	.13	1.92	.06+
Non-Novelty Preferring	.78	.13		

Stranger Reach	Mean	SE	*t*	*p*
Facial				
Novelty Preferring	1.62	.20	2.61	.01*
Non-Novelty Preferring	.82	.23		
Vocal				
Novelty Preferring	1.45	.38	2.68	.01*
Non-Novelty Preferring	.23	.16		
Escape				
Novelty Preferring	1.79	.21	1.81	.08+
Non-Novelty Preferring	1.18	.27		

Stranger Approach		Mean	SE	*t*	*p*
Facial					
	Novelty Preferring	.66	.20	.50	.60
	Non-Novelty Preferring	.57	.23		
Vocal					
	Novelty Preferring	.49	.38	1.65	.07+
	Non-Novelty Preferring	.06	.16		
Escape					
	Novelty Preferring	.89	.21	1.65	.09+
	Non-Novelty Preferring	.63	.27		

Note: n=50 for each variable

*$p \leq .05$; +$p \leq .09$.

Table 3.8

Correlations between Frontal Asymmetry Scores during Baseline and Temperamental Fear Tasks and Frontal Asymmetry Scores during Familiarization and Recognition Memory Test

Fear Task	Familiarization	Test
	Fp1/Fp2 Asymmetry	
Baseline	-.36**	-.39**
Stranger Approach	-.52*	-.53**
Masks	-.33*	-.46**
Spider	-.45**	-.51**
IBQ	-.03	-.05
	F3/F4 Asymmetry	
Baseline	-.44**	-.26
Stranger Approach	-.39*	-.44*
Masks	-.54***	-.27+
Spider	-.61**	-.48**
IBQ	.17	-.07
	F7/F8 Asymmetry	
Baseline	-.22	-.17
Stranger Approach	-.42*	-.37*
Masks	-.56**	-.49**
Spider	-.51***	-.24
IBQ	-.04	.09

*** $p \leq .001$; ** $p \leq .01$; * $p \leq .05$; + $p \leq .08$.

Table 3.9

Correlations between Temporal Asymmetry Scores during Baseline and Temperamental Fear Tasks and Temporal Asymmetry Scores during Familiarization and Recognition Memory Test

Fear Task	Familiarization	Test
	T3/T4 Asymmetry	
Baseline	-.44**	-.10
Stranger	.26+	-.36*
Masks	-.47***	-.49***
Spider	-.23	-.27+

Fear Task	Familiarization	Test
	T7/T8 Asymmetry	
Baseline	-.36*	- .01
Stranger	-.19	-.31*
Masks	-.39**	-.49***
Spider	-.27+	-.41**

***$p \leq .001$; **$p \leq .01$; *$p \leq .05$; +$p \leq .09$.

Table 3.10

Summary of MANOVA F Values for Baseline and Task-Related Frontal and Temporal EEG Power During Recognition Memory Familiarization using Novelty Preference Groups

	Cond	Hemi	Cond x Novelty	Cond x Hemi	Hem x Novelty	Con x Hemi x Novelty
			Familiarization Fp1/Fp2			
df 1, 48						
Fp1/2	2.58	.05	2.39	1.39	.45	1.45
			Familiarization F3/F4			
df 1,47						
F3/4	.30	.04	.00	.70	.61	.25.
			Familiarization F7/F8			
df 1, 47						
F7/8	9.04**	.04	1.29	2.81+	.05	.20
			Familiarization T3/T4			
df 1,48						
T3/4	8.69**	.43	.55	2.33	.12	1.37
			Familiarization T7/T8			
df 1,47						
F7/8	17.70***	1.41	.79	.12	.81	1.89

***p≤.001; **p≤.01

Table 3.11

Summary of MANOVA F Values for Baseline and Task-Related Frontal and Temporal EEG Power During Recognition Memory Test using Novelty Preference Groups

	Cond	Hemi	Cond x Novelty	Cond x Hemi	Hem x Novelty	Con x Hemi x Novelty
				Test Fp1/Fp2		
df 1, 46						
Fp1/2	.49	.46	.51	.75	1.71	.23
				Test F3/F4		
df 1, 45						
F3/4	.30	.04	.00	.70	.61	.25
				Test F7/F8		
df 1, 45						
F7/8	12.72**	.79	.03	.28	.11	.89
				Test T3/T4		
df 1,45						
T3/4	3.37+	.01	.63	.12	.16	.84
				Test T7/T8		
df 1, 48						
T7/8	12.10***	1.15	.15	.12	.94	.24

***$p \leq .001$; **$p \leq .01$; *$p \leq .05$; +$p \leq .07$.

Figure 3.1

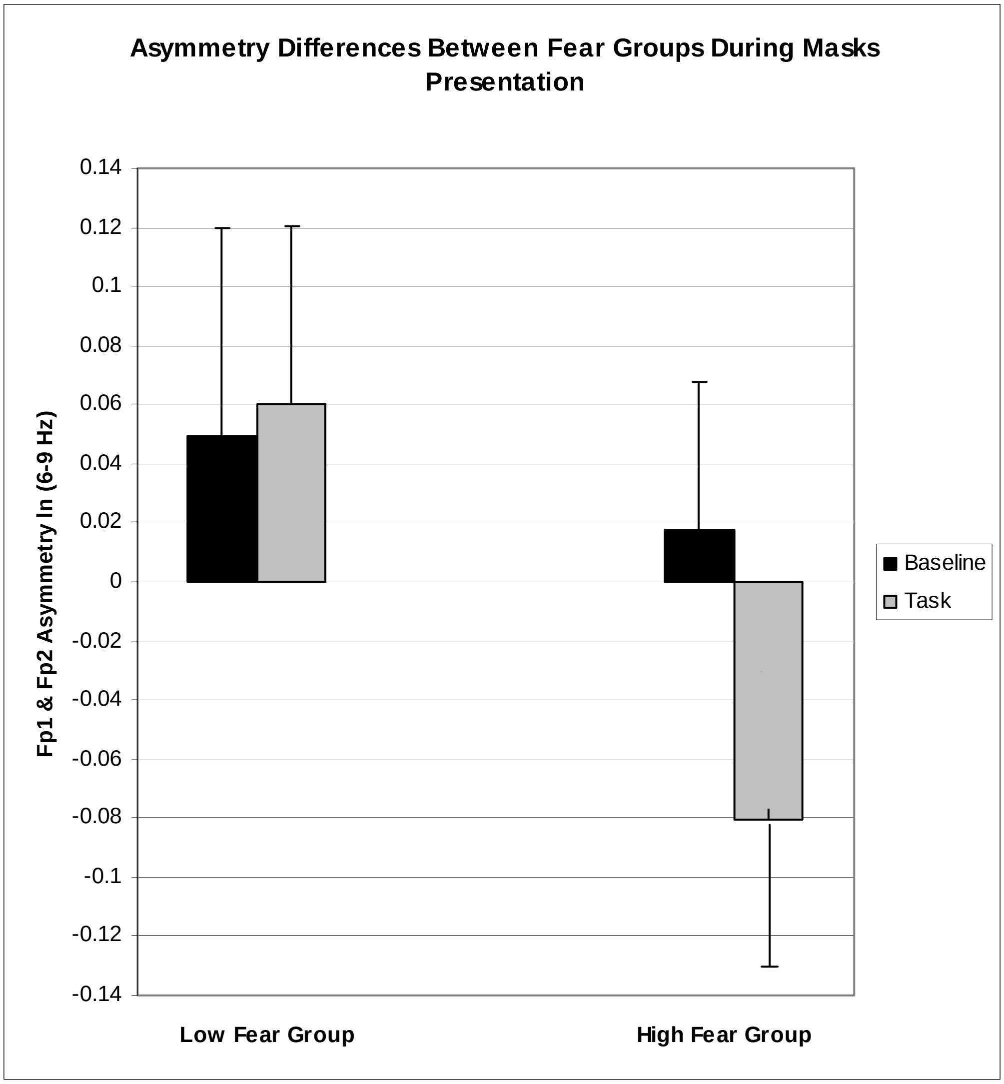
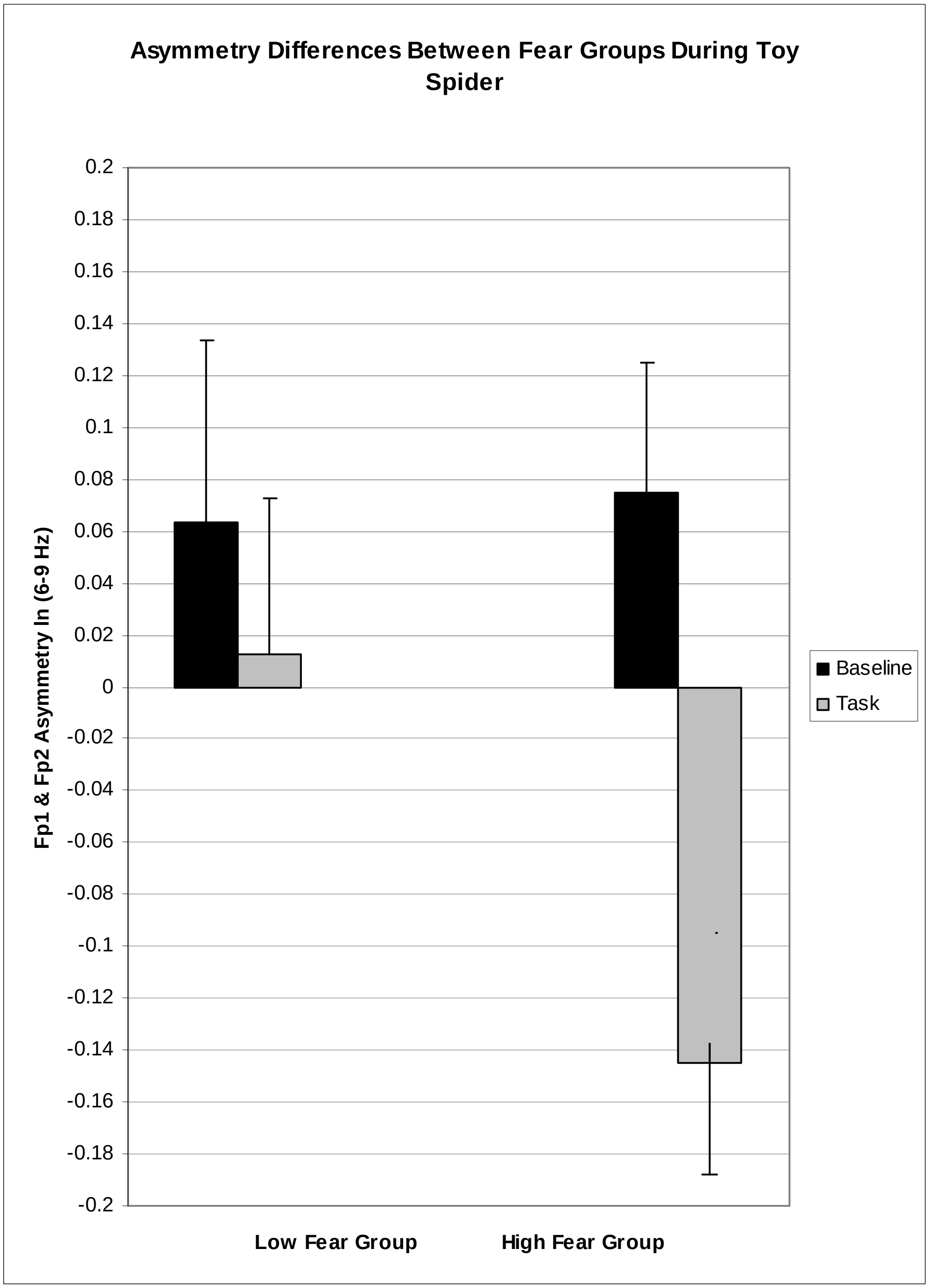

Asymmetry Differences Between Fear Groups During Masks Presentation
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
Fp1 & Fp2 Asymmetry ln (6-9 Hz)
Low Fear Group
High Fear Group
Baseline
Task

Figure 3.2



Asymmetry Differences Between Fear Groups During Toy Spider
Fp1 & Fp2 Asymmetry ln (6-9 Hz)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
-0.18
-0.2
Low Fear Group
High Fear Group
Baseline
Task

Figure 3.3

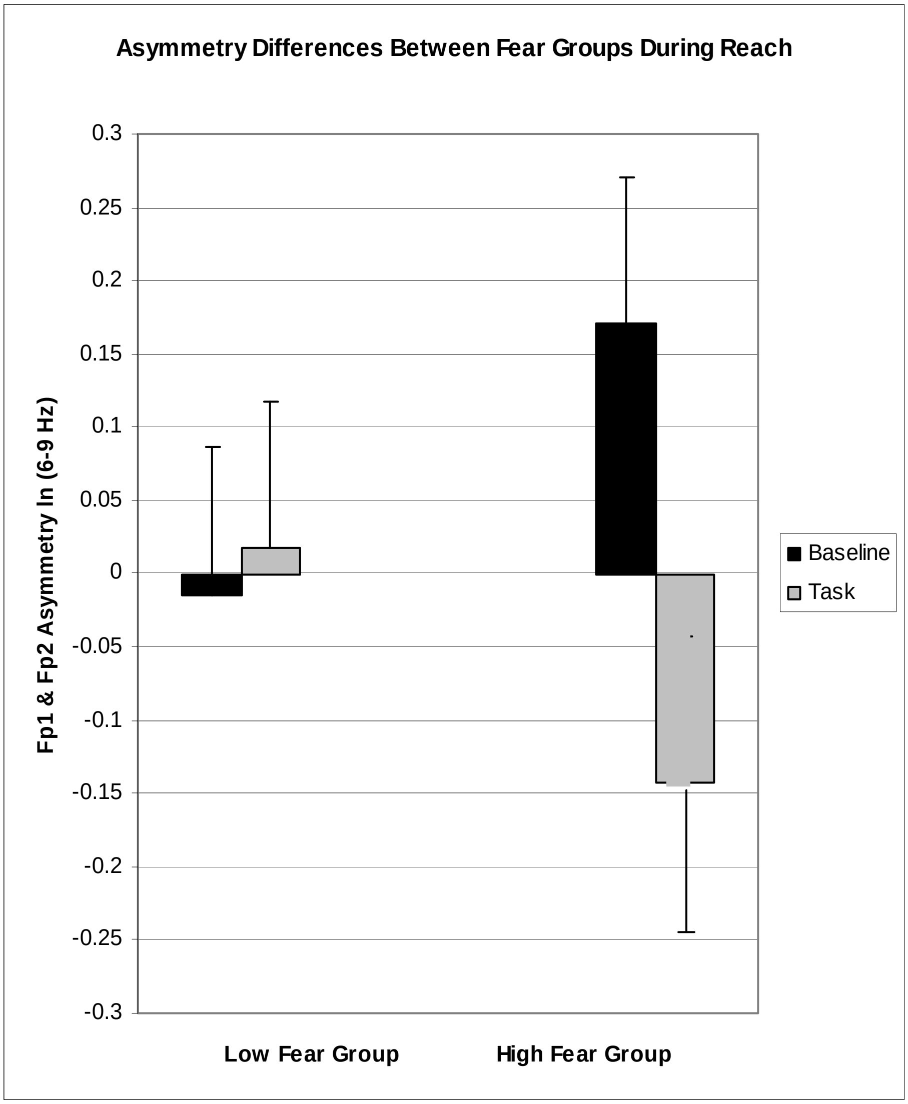
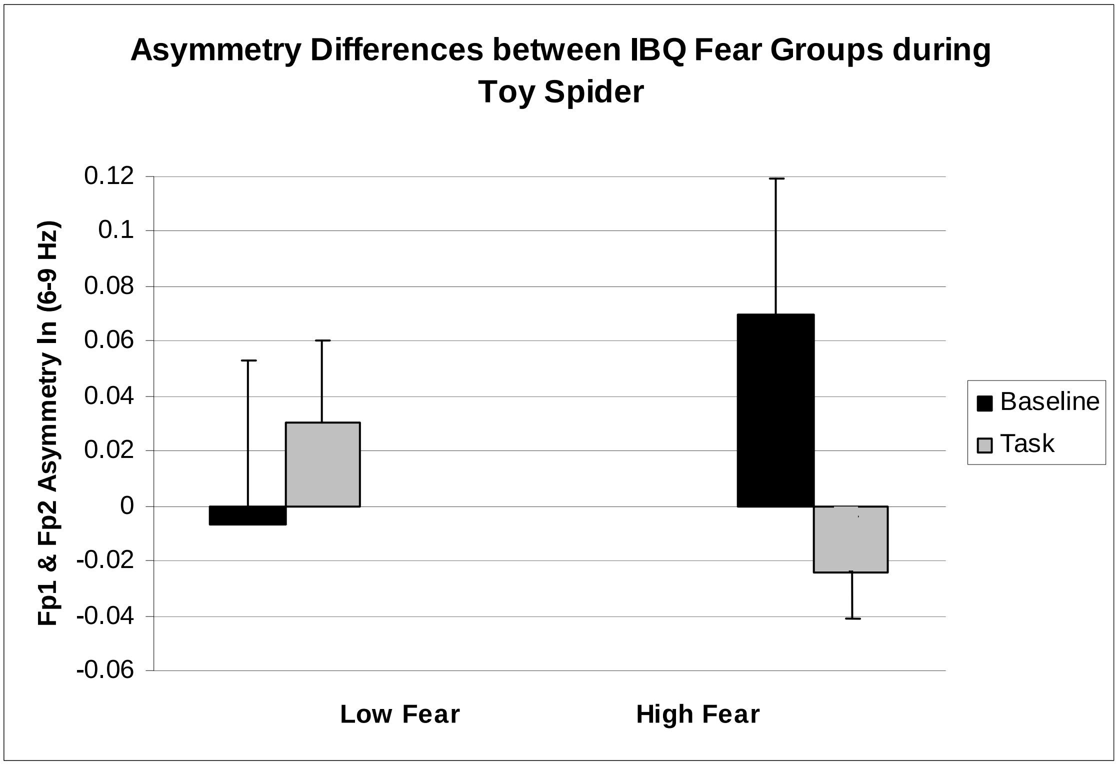

Asymmetry Differences Between Fear Groups During Reach
Fp1 & Fp2 Asymmetry ln (6-9 Hz)
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
Low Fear Group
High Fear Group
Baseline
Task

Figure 3.4


Asymmetry Differences between IBQ Fear Groups during Toy Spider
Fp1 & Fp2 Asymmetry ln (6-9 Hz)
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
Low Fear
High Fear
Baseline
Task

Appendix A

Infant Development Project

General Information Questionnaire

Child ID number _____________

Date of visit ________________

1. Sex of Child: M F

2. Date of birth __________________

3. Has your child experienced any serious illness or problems in development?
   _________ No
   _________ Yes-----brief explanation___________________________________

4. Has your child ever had any neurological problems, such as epilepsy, or seizures of any kind?
   _________ No
   _________ Yes-----brief explanation___________________________________

5. Has your child received any long term medication?
   _________ No
   _________ Yes-----brief explanation___________________________________

6. Is your child ill or on any medications now?
   _________ No
   _________ Yes-----brief explanation___________________________________

7. Has your child shown an allergic reaction to anything?
   _________ No
   _________ Yes-----brief explanation___________________________________

8. Has your child ever had any skin irritations?
   _________ No
   _________ Yes-----brief explanation___________________________________

9. Age of parents:

   Mother_______
   Father ________

10. Ethnic group of parents:

    A. **Mother-** *I consider myself*
    _______ Hispanic or Latino
    _______ Not Hispanic or Latino

    B. **Father-** *I consider myself*
    _______ Hispanic or Latino
    _______ Not Hispanic or Latino

11. Racial group of parents:

A. **Mother-** *I describe myself as*
_______ American Indian / Alaska Native
_______ Asian
_______ Native Hawaiian or Other Pacific Islander
_______ Black or African American
_______ White

A. **Father-** *I describe myself as*
_______ American Indian / Alaska Native
_______ Asian
_______ Native Hawaiian or Other Pacific Islander
_______ Black or African American
_______ White

12. Highest level of education completed: (please note any "in progress")

Mother _______	High school	**Father** _______	High school
_______	Technical school	_______	Technical school
_______	College	_______	College
_______	Graduate school	_______	Graduate school

13. Which hand do you prefer to use for each of these activities?
Please put **R** (right hand), **L** (left hand), or **E** (either hand).

	Mother	**Father**
a. Writing	_______	_______
b. Drawing	_______	_______
c. Throwing	_______	_______
d. Scissors	_______	_______
e. Toothbrush	_______	_______
f. Knife (without fork)	_______	_______
g. Spoon	_______	_______
h. Broom (upper hand)	_______	_______
i. Striking match (to hold match)	_______	_______
j. Opening jar (hand on lid)	_______	_______
* * * * * * *		
k. Which foot do you prefer to kick with?	_______	_______
l. Which eye do you use when using only one?	_______	_______

Appendix B

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY Parent Consent Form

Title of Thesis Project: **"Temperament Differences in Fear Reactivity in Infancy: Frontal EEG Asymmetry and Memory"**

Researchers: Martha Ann Bell, PhD. and Anjolii Diaz

I. Purpose of this Research

You and your infant are invited to be a part of a research study investigating memory and emotion regulation at 10 months. Specifically, we are examining how brainwave activity and heart rate activity associated with infant temperament relate to the strategies infants have for searching for hidden toys, remembering previously seen toys, and interacting with a stranger. What we learn from this study will help us better understand how these important skills emerge and begin to develop during infancy. A total of 50 10-month-old infants will be participating in this study.

II. Procedures

You and your infant will be asked to visit The C.A.P. Lab (350 Williams Hall) at Virginia Tech for approximately 45 minutes. Your infant will sit on your lap for part of the visit and then in an infant highchair with you sitting nearby. The entire session will be video taped. This study also involves three questionnaires (General Information Questionnaire, Infant Behavior Questionnaire, and the McArthur-Bates: Words & Gestures).We would asked you to try to complete these forms at home prior to your infant's visit to our research lab.

A little green cap that helps us to collect brainwave activity will be placed on your infant's head. This cap looks and fits like a little swim cap. In order to collect brain-wave activity, gels will be applied to your infant's hair through little holes in the cap. Two small stickers will be placed on your infant's back to help us collect heart rate activity. These procedures are similar to those used in a doctor's office and are not harmful to your infant. Brain-wave activity and heart rate activity will be recorded during the entire research session.

We will play two memory games with your infant. First we will show your infant a novel object and measure your infant's interest in looking at that novel object. Next, we will observe how your infant searches for a hidden toy that is out of reach. We will be making note of where your infant looks to determine the strategy your infant uses in searching for a toy that is beyond grasp. After this toy-hiding game, we will present the original novel object your infant saw prior to the toy-hiding game with a second novel object to see which your infant prefers.

The emotion regulation games come next. First a female research assistant that you and your infant have not yet seen will enter the room and successively move closer to your infant until she is standing directly in front of the child. Next we will ask you to play with your infant with a toy for 2 minutes. Then, we will show your infant five masks individually (not worn by a human, but mounted on wig stands) for a total of 70 seconds. We will then ask you to play peek-a- boo for 2 minutes. The last task will involve presenting the infant with a small toy jumping spider for 60 seconds. If your infant protests by crying continuously for 15 seconds during any of these emotion tasks, we will stop the task and ask you to comfort your child.

After these recordings, the cap and sticky patches will be removed and the gel will be washed from your infant's hair with warm water and a clean washcloth.

III. Risks

There is minimal risk associated with this research project. The brainwave and heart rate procedures are similar to that done in a doctor's office and are not harmful. All brain-wave equipment is disinfected after each use. The heart rate equipment is disposable. If your infant has an allergy to skin lotions, please inform us so that we can discuss the allergy and determine if any procedural changes need to be made. Our EEG gels are water based, but do not contain the same preservatives that are used in everyday skin lotions.

IV. Benefits of This Research

There are no tangible benefits for you or your infant. No promise or guarantee of benefits has been made to encourage you and your infant to participate in this study. In a scientific sense, however, this research study will give psychologists more information about the development of source memory during early infanthood.

V. Extent of Confidentiality

Information gathered for this study will be confidential and the information from each individual infant will be identified by code number only. Information linking infant's name and code number will be kept in a file and locked in a file drawer. Only my professor Dr. Bell and I will have access to the file. Your infant will be videotaped during the lab procedure. This allows us to go back at a later date and code your infant's behaviors. Videotapes will identify infants only by code number. Tapes will be stored in the research lab and will not be accessible to anyone else. Dr. Bell will supervise the confidentiality of the videotapes. Tapes will be erased 5 years after final publications of the results of this study.

If the Investigator (Dr. Bell) should ever become concerned that your infant has a developmental delay, you will be told of the concerns. You will be given a list of referrals who will provide your family with a developmental screening of your infant. If at any time during the study you request help in dealing with a infant, Dr. Bell will provide referrals of both private and public agencies that offer assistance.

Also, if at any time there is a concern that your infant is in danger due to abuse or neglect, the Investigator (Dr. Bell) will, after informing you, be obligated to contact the Department of Social Services and report the concern. This is in compliance with the mandatory reporting laws of the state of Virginia.

VI. Compensation

At the end of the session, your infant will be given a small toy. Also, your name will be entered into a drawing for a $50.00 gift certificate to a local store of your choice.

VII. Freedom to Withdraw

You may also elect to withdraw your infant from participation at any time without penalty. Your infant will still be given the toys, and your name will still be entered into the drawing for the gift certificate.

VIII. Approval of Research

This research project has been approved, as required, by the Institutional Review Board for Research Involving Human Subjects at VPI&SU and by the Department of Psychology at Virginia Tech.

IX. Parent's Responsibilities

You will be asked to transport and accompany your infant to the research laboratory for this visit. We also ask that you complete the questionnaires.

X. Parent's Permission

I have read and understand the Informed Consent and conditions of this research study. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent for my infant to participate in this project. I understand that I may withdraw my infant from participation at any time without penalty. I understand that I will be given a copy of this consent form.

_______________________________________ _____________________

Parent's signature Date

Should I have any questions about this study, I may contact:

1) Anjolii Diaz
   Co-Investigator, Graduate student, 540-604-4406, adiaz07@vt.edu
1) Martha Ann Bell, Ph.D.
   Principal Investigator, Associate Professor of Psychology, 231-2546, mabell@vt.edu
2) David W. Harrison, Ph.D.
   Chair, Psychology Department Human Subjects Committee, 231-4422, dwh@vt.edu
3) David Moore, Ph.D.
   IRB Chair, 1880 Pratt Drive, Suite 2006, Blacksburg, VA 24060, 231-4991, moored@vt.edu

Photographer's Release (optional)

I understand that the photographs taken of my infant are the property of Virginia Tech. These photographs will be used to illustrate Department of Psychology research at professional conferences, in professional publications, and/or in university/departmental literature (print and internet).

_____________________________________ _______________________

Parent's signature Date