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# Anger and Approach Motivation in Infancy: Relations to Early Childhood Inhibitory Control and Behavior Problems

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The relations among infant anger reactivity, approach behavior, and frontal electroencephalogram (EEG) asymmetry, and their relations to inhibitory control and behavior problems in early childhood were examined within the context of a longitudinal study of temperament. Two hundred nine infants' anger expressions to arm restraint were observed at 4 months of age. Infants' approach behaviors during play with an unpredictable toy and baseline frontal EEG asymmetry were assessed at 9 months of age. Inhibitory control during a Go/No-Go task and parent report of behavior problems were evaluated at 4 years of age. High anger-prone infants with left, but not right, frontal EEG asymmetry showed significantly more approach behaviors and less inhibitory control relative to less anger-prone infants. Although a link between anger proneness in infancy and behavior problems in early childhood was not found, a combination of low approach behaviors and poor inhibitory control was predictive of internalizing behaviors.

Approach-withdrawal motivational systems underlie temperamental reactivity and influence behaviors across infancy, childhood, and adolescence (Fox, Henderson, Rubin, Calkins, & Schmidt, 2001; Hane, Fox, Henderson, & Marshall, 2008; Perez-Edgar & Fox, 2006). Approach motivation facilitates movement toward potential rewards, whereas withdrawal motivation functions to distance an individual from potential punishment (Gray, 1987). Individual differences in the relative strength of these motivational systems relate to patterns of social behavior such that high levels of withdrawal motivation are associated with inhibited, shy behavior, and high levels of approach motivation are related to aspects of extraversion, surgency, exuberance, and approach behavior (Fox et al., 2001; Rothbart, 1988). Moreover, approach behaviors, which are a manifestation of an underlying approach motivation, promote exploratory activity and are believed to have developed by 6 months of age (Putnam & Stifter, 2002). In addition, infants who displayed high levels of positive affect and motor activity in response to novel stimuli at 4 months of age were more likely to exhibit exuberance in early childhood (Fox et al., 2001). These children were quick to approach novel stimuli including strangers and novel toys, and were generally enthusiastic and sociable with peers. Similarly, Stifter, Putnam, and Jahromi (2008) showed that a sample of exuberant toddlers were more socially responsive and less shy with unfamiliar people as preschoolers. Indeed, approach motivation has been linked to early positive affect and motor activity, as well as later exuberance, approach behavior, and sociability. However, along with a strong motivation for approach comes the chance for negative affect and disruptive behavior when one's goals are blocked. Therefore, the current study focuses on anger as an approach-related emotion and examines how both anger and approach relate to later social developmental outcomes, such as inhibitory control and behavior problems.

## Anger and approach behaviors

Anger is a basic emotion observed in both animals and humans, reflects the potential to overcome obstacles in the anticipation of desired goals, and is thought to be an approach-motivated emotion (Ekman, 1998; Lewis, Sullivan, Ramsay, & Alessandri, 1992). Infants' proneness to anger is a major dimension of temperament (Rothbart, 2007), and has important implications for the later development of social behavior (Fox, 1989; Rothbart, 1994). Previous research has shown that anger-prone infants showed greater approach behavior throughout infancy and childhood (Derryberry & Rothbart, 1997; Fox, 1989; Kochanska, Coy, Tjebkes, & Husarek, 1998; Rothbart & Bates, 2006). For example, at 8 and 10 months of age, anger-prone infants were quicker to grasp novel objects (Kochanska et al., 1998). Furthermore, Fox (1989) reported that anger expressions during an arm restraint procedure at 5 months were positively related to approach to strangers and novel events at 14 months. Anger could be a predecessor of approach behavior. It could also be the case that higher approach leads to higher anger. In fact, children who showed strong approach tendency at 6.5, 10, and 13.5 months, displayed high anger frustration at age 7 (Rothbart & Bates, 2006).

A functionalist theory of emotion views anger as providing individuals the "energy" to remove barriers and orient toward goals (Campos, Campos, & Barrett, 1989). Consistent with this view, Kearney (2004) found that 7- and 9-month-old infants displaying high anger, in response to being blocked from a desired toy, exhibited more approach behaviors and were more likely to complete a frustrating task than low anger infants. These high anger infants were also more frequently described by their mothers as "knowing what he/she wants and getting it." In a recent study, toddlers who displayed anger in response to toy removal exhibited greater behavioral approach (i.e., reaching or leaning toward the toy) and verbal protests to get the toy back than those who did not manifest anger (He, Xu, & Li, 2009). Similarly, Lewis et al. reported that infants' anger was associated with increased instrumental activity during goal blockage situations, increased positive emotion after obstacle removal, and greater persistence in obtaining a blocked object in later childhood (Lewis & Ramsay, 2005; Lewis, Ramsay, & Sullivan, 2006). Therefore, the current study views anger as an approach-related emotion, and examines the relation between anger and approach behavior, as well as their longitudinal relations to socioemotional outcomes.

## Anger and frontal EEG asymmetry

A motivational model of frontal brain activity suggests that electroencephalogram (EEG) asymmetry may reflect an individual bias to respond with approach or withdrawal under conditions of environmental challenge. Left frontal activation is related to approach (Coan & Allen, 2003; Pizzagalli, Sherwood, Henriques, & Davidson, 2005) and right frontal activation is related to withdrawal (Davidson, Ekman, & Saron, 1990; Fox, 1991; Harmon-Jones, 2004). In addition, frontal EEG asymmetry has been shown to be a key factor associated with continuity in temperament (Fox et al., 2001). From the infant literature, extreme right frontal EEG asymmetry during a withdrawal-negative affect task is linked to more fear and sadness than average levels of asymmetry (Buss, Schumacher, & Dolske, 2003; Dawson, Panagiotides, Klinger, & Hill, 1992). Moreover, research with adults (Harmon-Jones, 2004, 2007) and adolescents (Harmon-Jones & Allen, 1998) has consistently found a connection between anger and left frontal asymmetry, and approach-related anger in particular (Harmon-Jones & Sigelman, 2001; Harmon-Jones, Sigelman, Bohlig, & Harmon-Jones, 2003). However, it remains unknown if this association is also evident in anger-prone infants, or whether frontal EEG asymmetry moderates the relation between anger proneness and approach behaviors in infancy, such that approach-driven infants with left frontal EEG asymmetry are those who are most prone to anger. The current study examines these direct and indirect associations in infancy. In addition, we examine how these factors, independently and in concert, contribute to specific early childhood behaviors that require the regulation of approach tendencies, including inhibitory control and internalizing/externalizing behavior problems.

## Anger and inhibitory control

Inhibitory control is defined as the capacity to suppress inappropriate approach responses (Rothbart & Bates, 2006) and is a primary component of executive functioning (Diamond, Barnett, Thomas, & Munro, 2007; Martel et al., 2007; Welsh & Pennington, 1988). It is different from reactive overcontrol or behavioral inhibition which includes rigid and constrained behavior in response to novel and stressful situations (Eisenberg et al., 2007). Inhibitory control has also been inversely associated with anger (Derryberry & Rothbart, 1997; Kochanska, 2003). For example, a lower intensity of anger and joy in children at 22 months was related to higher inhibitory control at 45 months (Kochanska, 2003). In addition, children who had greater inhibitory control were less prone to frustration (Derryberry & Rothbart, 1997). These links between emotional response patterns (i.e., anger) and inhibition suggests an adaptive combination of these processes. Given that there are various assessments of inhibitory control and approach throughout the literature, it is important to clarify the nature of these associations. Overall, the notion of enhanced emotional control (i.e., anger or frustration) in the context of stronger cognitive inhibition warrants further investigation, especially in the context of predicting children's behavioral outcomes.

## Anger and behavior problems

A number of studies suggest that anger-prone children are at risk of development of behavior problems, especially externalizing behaviors (i.e., Eisenberg et al., 2007; Smeekens, Riksen-Walraven, & van Bakel, 2007). For instance, children prone to externalizing problems are found to be high in parental report of anger (Muris, Meesters, & Blijlevens, 2007). By contrast, higher levels of fear and sadness are often linked to internalizing problems (Eisenberg, Fabes, Nyman, Bernzweig, & Pinuelas, 1994), but researchers suggest that anger also may contribute to internalizing problems. For instance, anxious and depressed children may display anger in response to being rejected by peers (Dodge, Coie, Pettit, & Price, 1990). In addition, a sample of Chinese children prone to internalizing problems were reported to be high in anger (Eisenberg et al., 2007). Overall, anger has been linked to externalizing and internalizing behavior problems in childhood, however, other factors, such as approach behavior or inhibitory control, seem to influence the nature of these associations (Eisenberg et al., 2007; Muris et al., 2007).

## Approach, inhibitory control, and behavior problems

While anger may be directly related to behavior problems, as the current study views anger as an approach-related emotion, it is also important to examine the relations between approach and problem behavior. Hirshfeld-Becker et al. (2007) have found approach to be directly related to externalizing disorders, such as oppositional disorder. However, combinations of approach and inhibitory control have also been linked to problem behavior. Several reports have suggested that a combination of high approach and low inhibitory control are related to externalizing problems (Martel et al., 2007; Muris et al., 2007). Both approach and inhibitory control have also been related to internalizing problems, but the patterns of results are not as consistent as they are with externalizing problems. For instance, Martel et al. (2007) reported a combination of high approach and low inhibitory control predicted internalizing problems, whereas Eisenberg et al. (2007) reported that low approach and low inhibitory control predicted internalizing problems. Moreover, these studies have only examined young children and adolescents and few studies have examined anger reactivity and approach behaviors in infancy in relation to later behavior problems. Therefore, in an attempt to clarify these discrepant findings, the current study explores the unique and joint effects of infant anger and approach on inhibitory control and the joint effects of anger, approach, and inhibitory control on behavior problems in early childhood.

### The current study

The current study examined the relations among infants' anger reactivity, approach behaviors, and frontal EEG asymmetry and the relations between these factors and inhibitory control and behavior problems assessed in early childhood. Infants who displayed high anger in a frustrating situation at 4 months of age were hypothesized to exhibit more approach behaviors to a novel stimulus and greater left frontal EEG asymmetry during a baseline task at 9 months of age than infants who displayed low anger. These high anger-prone infants were also expected to demonstrate lower inhibitory control and higher behavior problems at 4 years of age. In addition to these direct effects, we also explored frontal EEG asymmetry as a moderator of the associations between infant anger and subsequent approach behavior, and inhibitory control and behavior problems. As frontal EEG asymmetry has been found to moderate the relations between early distress and later social wariness (Henderson, Fox, & Rubin, 2001), we hypothesized that the associations between anger and approach behaviors, inhibitory control, or behavior problems would be moderated by frontal EEG asymmetry such that the associations would be stronger for infants with left frontal asymmetry.

Furthermore, we examined inhibitory control as a moderator between anger/approach behaviors and behavior problems. We predicted that infants' anger/approach behaviors would be associated with externalizing and internalizing behavior problems at 4 years of age. Specifically, high anger/approach was expected to predict more behavior problems. In addition, we hypothesized that poor inhibitory control would strengthen the positive relation between anger/approach and behavior problems, such that these relations would be stronger in children with low inhibitory control.

## METHOD

### Participants

This study was part of a longitudinal study examining the role of infant temperament in the development of social competence. Details of sample recruitment may be found in Hane et al. (2008). Briefly, a large number of families were contacted by mail and those who were interested were screened to ensure that infants were full-term and healthy. Seven hundred seventy-nine infants who met these criteria were brought into the laboratory at 4 months of age for the temperament screening, during which emotional (positive and negative) and motor reactivity during the presentation of novel visual and auditory stimuli were observed. Informed consent was obtained from the mothers prior to running the temperament screening. Two hundred ninety-one infants (135 boys and 156 girls), who were selected based on their classification into one of three different temperament groups, were followed in the longitudinal study: high negative/high motor reactive ($n = 105$); high positive/high motor reactive ($n = 103$); and control group ($n = 83$). Therefore, the current sample was selected to display a wide range of infant temperamental reactivity to novelty. Of these infants, 187 (64.3%) were Caucasian, 41 (14.1%) were African American, and 63 (21.6%) were of other ethnicity. In addition, most mothers were at least college educated (84.4%) and the others (15.6%) had a high school education.

## Procedure

In addition to the temperament screening procedure at 4 months of age, infants' responses to mild arm restraint were observed. Subsequently, families were invited to the laboratory when their infants were 9 months and 4 years of age. When the infants were 9 months, their approach behaviors were observed during an unpredictable toy task and brain activity was recorded via EEG during a baseline task. When the children were 4 years of age, they took part in an inhibitory control task (Go/No-Go (GNG)) and mothers reported on children's behavior problems using the Child Behavior Checklist (CBCL 1.5–5; Achenbach & Rescorla, 2000).

## Measures

### *Arm restraint task*

An arm restraint task, adapted from the Laboratory Temperament Assessment Battery Pre-locomotor version (Lab-TAB; Goldsmith & Rothbart, 1999), was used to measure infant anger at 4 months of age. Infants were placed in a car seat and mothers were instructed to sit behind the infants and gently restrain their infants by holding their arms down to their sides. Mothers were also instructed to refrain from verbally or behaviorally interacting with their infants during the procedure. After 1 min of arm restraint or 20 sec of intense infant crying, mothers were cued to release their infants' arms. Then mothers were allowed to soothe their infants using any method they deemed appropriate.

Frequency of anger was coded from videotapes in 5-sec epochs for a maximum of 12 epochs based on the facial action coding system (FACS; Ekman, Friesen, & Hager, 2002). The main action units of anger prototypes are brow lower (AU4), upper lid raiser (AU5), lid tighten (AU7), lip tighten (AU23), or lips part (AU25)/jaw drop (AU26). As suggested by Ekman et al. (2002), only one facial region (such as a lower brow) may or may not reflect anger. We considered anger to be displayed if two of the three main facial regions (brow, eye, and mouth) exhibited anger during an epoch. Reliability for this coding, calculated across two coders on 20% of the data was .90 (kappa).

### *Unpredictable toy task*

In order to assess approach behaviors, at 9 months of age, infants were presented with an unpredictable toy task, adapted from the Lab-TAB (Goldsmith & Rothbart, 1999). During the task, a remote controlled dog moved toward the infant until it was 15 cm directly in front of the infant. Then it was placed on the back of the table and the procedure was repeated two more times for a total of three trials. At the end of the last trial, the dog barked and sat up for an additional 10 sec. During the procedure, both mother and experimenter were asked to remain as uninvolved as possible.

The frequency of approach behaviors was coded for each trial. Approach behaviors included actions, such as leaning forward or reaching for the dog. Reliability for this coding, calculated across two coders on 20% of the data was .98 (kappa).

### *Electroencephalogram*

At 9 months of age, frontal EEG asymmetry was assessed during a baseline task for a total of 3 min. During EEG collection, the infant sat on the mother's lap to minimize fussing and movement. A metal bingo wheel with 1, 3, or 7 brightly colored balls was placed in front of the infant and was spun for six 20-sec trials by the experimenter. These trials were separated by 10-sec intervals when the experimenter tapped the balls on the outside of the metal wheel to keep the attention of the infant between trials. EEG was recorded for the total 3-min period.

Prior to EEG collection, the infant was fitted with a Lycra stretch cap (Electro-Cap International Inc., Eaton, OH) containing electrodes according to the 10–20 system of electrode placement (Jasper, 1958). EEG was recorded from 14 scalp sites (F3, F4, F7, F8, Fz, C3, C4, P3, P4, Pz, O1, O2, T7, and T8) and the reference site (Cz). Electrooculogram (EOG) was recorded from the left eye using two silver-chloride BioPotential mini-electrodes (Rochester Electro-Medical, Lutz, FL), with one placed at the supra orbit and the other at the outer canthus. All sites were gently abraded to ensure impedances were at or below 10 KΩ. EEG and EOG were amplified with filter settings of .1-Hz high-pass and 100 Hz low-pass on custom bio-amplifiers made by SA Instrumentation (Encinitas, CA). The EEG data were digitized at a rate of 512 Hz and re-referenced with the average reference configuration. The digitized data were displayed graphically for artifact scoring and the portions of EEG marked by motor artifact were removed from all channels of the EEG record and blink artifact was regressed before further analysis.

The re-referenced, artifact-removed EEG was analyzed by discrete Fourier transform analysis used a Hanning window with 50% overlap. The power in picowatt ohms (or microvolts squared) was computed for each site. Spectral power data in single Hz frequency bands from 1 to 30 Hz were computed for each trial at each site. As suggested by Marshall, Bar-Haim, and Fox (2002), power in the 6–9 Hz alpha-range band for 9-month-old infants was calculated at each site by summing the power in the single hertz bands of these four frequencies across trials. The power data in the 6–9 Hz band were then log-transformed at frontal and parietal regions (F3 and F4, P3 and P4). As the alpha power is negatively related to brain activation (Fox et al., 2001), the asymmetry score was computed as power in the right hemisphere minus power in the left hemisphere. Therefore, positive scores reflected left asymmetry, and negative scores reflected right asymmetry. Infants who had sufficient EEG data (more than 45 DFT windows) were included in the analysis.

### *Inhibitory control task: Go/No-Go*

For this study, children's inhibitory control at 4 years of age was assessed with the Zoo Game, a computer-based GNG task designed for use in young children (McDermott, 2005). During this task, children were presented pictures of animals on a computer screen and were told to help the zookeeper catch all the animals who escaped from their cages. Children were instructed to press the button for all of the animals (go trials), except for the monkey who helped the zookeeper catch the animals (no-go trials). Children were given 12 practice trials and a total of 120 test trials, presented in two blocks of 60 trials each. Response accuracy was calculated on both go and no-go trials. Children who had correct scores on at least half of the go trials were included in the analysis. In the current study, the percent correct on the no-go trials served as the index of inhibitory control.

### *Behavior problems*

During the 4-year laboratory visit, mothers completed the 100-item CBCL (Achenbach & Rescorla, 2000) and rated how often their children displayed certain behavior problems using a three-point scale from not true (0) to very true (2). The CBCL provides both narrow- and broad-band indices of childhood behavior problems. In this study, the broad-band externalizing (e.g., aggression and defiance) and internalizing (e.g., anxiety and depression) scores were examined. These scores have shown internal consistency, internalizing $\alpha = .89$ and externalizing $\alpha = .92$, and moderate stability across a 12-month period of time, internalizing $r = .76$ and externalizing $r = .66$ (Achenbach & Rescorla, 2000). As Achenbach and Rescorla (2000) suggested that raw scores are more appropriate than *T*-scores in a developmental analysis, the raw externalizing and internalizing scores of the CBCL were used in the present study.

## Participant attrition

Of the 291 infants selected to continue participation based on temperament screening at 4 months of age, 209 completed the arm restraint task. Thus, the current study focused on these 209 infants. Arm restraint episodes were terminated if the infant became too upset or if the mother indicated that she thought the infant was becoming too upset to continue. This termination due to infant protest or mother's ineffective arm restraint (i.e., soothing infants, not putting infants' hands at sides) was responsible for all of the missing arm restraint data. Of the 209 infants who had valid data during 4-month arm restraint, 185 infants finished the unpredictable toy task and 164 infants' EEG data were collected at 9 months of age. Missing EEG data were due to 29 infants who had significant amounts of artifact contaminated EEG and 14 infants whose EEG data were outliers (exceeding $\pm$ 3 *SD*). Missing unpredictable toy data were due to infants being too distressed to complete the entire Lab-TAB battery at 9 months of age. At 4 years of age, 135 children had valid scores on the GNG task and parent ratings on the CBCL were collected for 169 children. Missing data at 4 years of age were due to children's refusal, not having enough correct go-trials on the GNG task, and unsuccessful return of parental report on the CBCL. Comparisons between the children who were missing versus not missing data on each measure (frequency of anger, frequency of approach behaviors, frontal EEG asymmetry, accuracy on GNG, externalizing, and internalizing behavior problems) did not indicate differences on any of the other key variables (all *p*s $> .10$). In addition, missing data were evenly distributed across the 4-month temperament groups (all *p*s $> .10$) and a missing data analysis determined that data were missing completely at random (MCAR), Little's MCAR,

$\chi^2(48) = 57.45$, $p = .17$. Therefore, in order to maintain maximum power to detect interaction effects, all available data were used throughout the analyses.

# RESULTS

## Preliminary analyses

Descriptive statistics for the variables are presented in Table 1. First, all the variables were inspected to ensure normality of distributions. The skewness values of all the measures ranged from −.75 to .96, which suggested that the variables were relatively normally distributed (West, Finch, & Curran, 1995). However, a visual inspection of the frequency of anger ($M = .46$, $SD = .35$) showed that the data were nominally distributed. Therefore, anger was median spit into two groups (median value = .43): low anger-prone (0) and high anger-prone (1). Second, parents' education and ethnicity, children's ethnicity and gender, and children's temperament group from the screening paradigm were examined to determine whether they should be included in subsequent analyses as covariates. There were no differences of anger group on any of the sociodemographic variables (all *p*s > .05). In addition, one-way analyses of variance (ANOVAs) revealed that none of the key variables in Table 1 were significantly related to parent education, parent ethnicity, child ethnicity, or 4-month temperament group (all *p*s > .05). An independent samples *t*-test showed that girls were more accurate on no-go trials during the GNG task ($n = 73$, $M = 38.68$, $SD = 34.44$) than boys ($n = 62$, $M = 24.15$, $SD = 26.34$), $t(133) = 2.71$, $p < .01$. Hence, gender was included in subsequent analyses that included GNG scores as the dependent variable.

## Relation between anger and approach

In order to examine whether early anger-prone groups were significantly different in terms of 9-month frontal EEG asymmetry, a chi-squared analysis

TABLE 1
Descriptive Statistics for the Key Variables

| *Variables* | *N* | *Min* | *Max* | *M* | *SD* |
|---|---|---|---|---|---|
| Frequency of approach behaviors at 9 months | 140 | .00 | 1.00 | .22 | .18 |
| Frontal EEG asymmetry at 9 months | 121 | −.89 | .59 | .01 | .27 |
| Inhibitory control (GNG accuracy) at 48 months | 135 | .00 | 100.00 | 32.00 | 31.72 |
| Externalizing behaviors at 48 months | 169 | .00 | 31.00 | 10.95 | 6.69 |
| Internalizing behaviors at 48 months | 169 | .00 | 25.00 | 6.86 | 5.15 |

was conducted. Frontal asymmetry was dichotomized into left and right asymmetry groups (a positive value reflects greater activity in the left hemisphere, and a negative value reflects greater activity in the right hemisphere). Analyses showed that anger groups and asymmetry groups were not significantly related, with 34 (28.10%) high anger-prone infants and 33 (27.27%) low anger-prone infants in the left asymmetry group, and 24 (19.83%) high anger-prone infants and 30 (24.79%) low anger-prone infants in the right asymmetry group, $\chi^2(1, 121) = .48$, $p = .58$. Using frontal EEG asymmetry as a continuous variable, a *t*-test between the two anger groups was also nonsignificant. In addition, there were no significant relations between frontal EEG asymmetry and measures of approach, inhibitory control, or behavior problems.

### Moderation of the relation between anger and approach by frontal EEG asymmetry

As anger, left EEG asymmetry, and approach behavior were hypothesized to be linked to an underlying approach system (Harmon-Jones, 2007), a hierarchical multiple regression analysis was computed to examine whether anger group (high anger-prone versus low anger-prone) at 4 months, frontal EEG asymmetry at 9 months, and their interaction predicted frequency of approach behaviors to the unpredictable toy at 9 months. In the first step, anger group and the continuous and mean-centered frontal EEG asymmetry scores were entered. In the second step, the two-way interaction term for anger group by frontal EEG asymmetry was entered. Frontal EEG asymmetry moderated the relation between anger group and frequency of approach behaviors, $\beta = .32$, $t = 2.50$, $p < .05$ (Table 2).

To interpret this interaction, the moderator variable (frontal asymmetry) was dichotomized into left and right asymmetry groups (a positive value reflects greater activity on left hemisphere, and a negative value reflects greater activity on right hemisphere). As seen in Figure 1, within the left asymmetry group, high anger-prone children had more approach behaviors ($n = 28$, $M = .30$, $SD = .20$) than low anger-prone children ($n = 26$, $M = .17$, $SD = .16$), $t(52) = 2.65$, $p < .05$. This relation between anger and approach behaviors was nonsignificant for children in the right asymmetry group as shown in Figure 1. A similar analysis of EEG asymmetry in the parietal region yielded no significant results, confirming the specificity of the EEG asymmetry effect to the frontal sites.

TABLE 2
Anger and Frontal EEG Asymmetry Predicting Approach Behaviors ($n$ = 97)

| *Variable* | *B* | *β* | *t* |
|---|---|---|---|
| Step 1 ($\Delta R^2 = .03$) | | | |
| Anger group at 4 months | .06 | .16 | 1.60 |
| Frontal EEG asymmetry at 9 months | .02 | .03 | .26 |
| Step 2 ($\Delta R^2 = .06^*$) | | | |
| Anger group at 4 months | .05 | .14 | 1.51 |
| Frontal EEG asymmetry at 9 months | −.12 | −.18 | −1.41 |
| Anger group at 4 months × Frontal EEG asymmetry at 9 months | .32 | .32 | 2.50* |

*Note*. *$p < .05$.

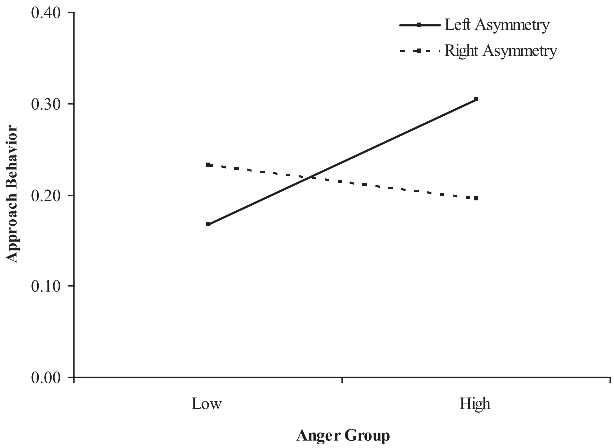


**Figure 1** The moderating effect of frontal electroencephalogram asymmetry on the association between anger and approach behaviors.

## Moderation of the relation between anger and inhibitory control by frontal EEG asymmetry

As the anger–approach relation was moderated by frontal EEG asymmetry, a hierarchical multiple regression analysis was computed to examine whether the relation between anger and inhibitory control (i.e., GNG scores at 48 months) was also moderated by 9-month frontal EEG asymmetry. As gender influenced inhibitory control, gender, anger group, and frontal EEG asymmetry were entered in the first step, followed by the two-way interaction term for anger group by frontal EEG asymmetry in the second step.

There was a main effect of anger group predicting inhibitory control, $\beta = -.28$, $t = -2.70$, $p < .01$, such that the high anger group had lower

TABLE 3
Anger and Frontal EEG Asymmetry Predicting Inhibitory Control (GNG Accuracy) ($n$ = 84)

| *Variable* | *B* | *β* | *t* |
|---|---|---|---|
| Step 1 ($\Delta R^2 = .15^{**}$) | | | |
| Gender | 14.32 | .23 | 2.14* |
| Anger group at 4 months | −17.31 | −.27 | −2.62* |
| Frontal EEG asymmetry at 9 months | .11 | .00 | .01 |
| Step 2 ($\Delta R^2 = .04^{**}$) | | | |
| Gender | 12.61 | .20 | 1.90 |
| Anger group at 4 months | −17.60 | −.28 | −2.70** |
| Frontal EEG asymmetry at 9 months | 16.04 | .15 | 1.15 |
| Anger group at 4 months × Frontal EEG asymmetry at 9 months | −43.98 | −.25 | $-1.91^{+}$ |

*Note.* $^{+}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

inhibitory control. Results also indicated that frontal EEG asymmetry marginally moderated the relation between anger group and inhibitory control, $\beta = -.25$, $t = -1.91$, $p = .06$ (Table 3). In the left asymmetry group, children with high anger had lower inhibitory control ($n = 21$, $M = 14.92$, $SD = 17.72$) compared with children with low anger ($n = 24$, $M = 46.81$, $SD = 34.59$), $t$ (43) = −3.81, $p < .01$. However, the relation between anger and inhibitory control was nonsignificant for children in the right asymmetry group as shown in Figure 2. A similar analysis of EEG asymmetry in parietal region yielded no significant results, confirming the specificity of the EEG asymmetry effect to the frontal sites.

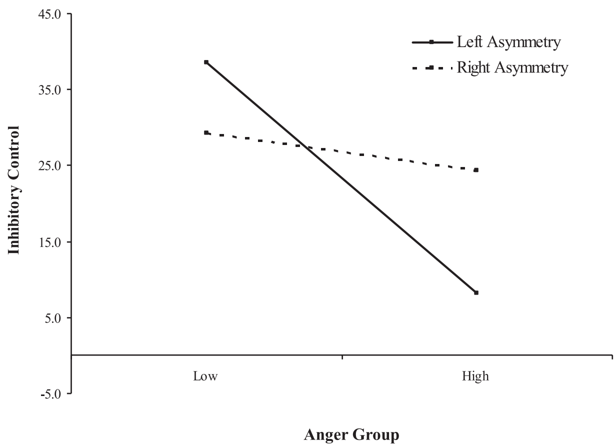


**Figure 2** The moderating effect of frontal electroencephalogram asymmetry on the association between anger and inhibitory control.

## Moderation of the relation between anger and behavior problems by frontal EEG asymmetry or inhibitory control

In order to explore whether anger would show an effect on behavior problems, several hierarchical multiple regression analyses were computed to examine whether 4-month anger group was related to 4-year internalizing or externalizing behavior problems. In addition, 9-month frontal EEG asymmetry and 4-year inhibitory control were examined separately as potential moderators of the anger–behavior problem relations. For each analysis, anger group and frontal EEG asymmetry (or inhibitory control) were entered in the first step, followed by the two-way interaction term for anger group by frontal EEG asymmetry (or inhibitory control) in the second step. There were no significant main or interaction effects associated with externalizing and internalizing behavior problems.

## Moderation of the relation between approach behaviors and behavior problems by inhibitory control

Despite the fact that anger did not predict 4-year behavior problems, the relations between approach behavior and behavior problems were explored in order to investigate whether the nonsignificant results were specific to anger as a predictor or the entire approach motivational system. Thus, two hierarchical multiple regression analyses were calculated to examine whether frequency of approach behaviors to the unpredictable toy at 9 months predicted externalizing or internalizing behavior problems at 4 years of age. In addition, inhibitory control at 4 years was examined as a potential moderator of the approach-behavior problem relations. In the first step, mean-centered measures of approach behavior and inhibitory control were entered. The two-way interaction term for approach behavior by inhibitory control was entered on the second step.

There was a main effect of approach behavior associated with internalizing behavior problems, $\beta = -.21$, $t = -1.95$, $p = .05$, such that lower approach predicted higher internalizing problems. However, inhibitory control moderated this association, $\beta = .22$, $t = 2.08$, $p < .05$ (Table 4). To interpret this interaction, the relation between approach behavior and internalizing was determined for children with high (+1 *SD*), mean (0), and low (−1 *SD*) levels of inhibitory control (Aiken & West, 1991). The regression lines for high, mean, and low GNG groups were plotted in Figure 3. The effect of approach behavior was significant at low levels, $\beta = -.43$, $t = 2.65$, $p < .01$, and mean levels of inhibitory control, $\beta = -.21$, $t = -1.95$, $p = .05$, but not at high levels of inhibitory control, $\beta = .02$,

TABLE 4
Approach Behaviors and Inhibitory Control (GNG Accuracy) Predicting Internalizing Behaviors ($n$ = 89)

| *Variable* | *B* | *β* | *t* |
|---|---|---|---|
| Step 1 ($\Delta R^2$ = .03) | | | |
| Frequency of approach behaviors at 9 months | −5.36 | −.17 | −1.61 |
| GNG accuracy at 48 months | −.00 | −.01 | −.11 |
| Step 2 ($\Delta R^2$ = .05$^+$) | | | |
| Frequency of approach behaviors at 9 months | −6.47 | −.21 | −1.95* |
| GNG scores at 48 months | .00 | .01 | .10 |
| Frequency of approach behaviors at 9 months × GNG accuracy at 48 months | .22 | .22 | 2.08* |

*Note.* $^+p$ < .10. $^*p$ < .05.

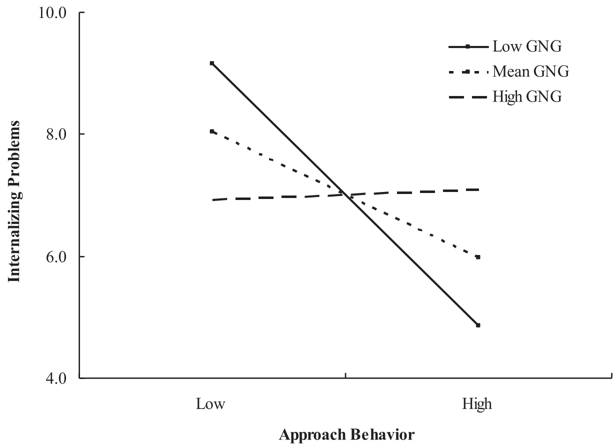


**Figure 3** The moderating effect of inhibitory control on the association between approach behaviors and internalizing behaviors.

$t$ = .13, *ns*. Thus, low approach was associated with more internalizing behaviors for children with low to medium, but not high, inhibitory control. No significant results were found in relation to externalizing behavior problems.

## DISCUSSION

In this study, we sought to elucidate the factors associated with anger and approach motivation in infancy. Specifically, the current study examined the relations among infants' anger reactivity, approach behaviors, and frontal EEG asymmetry and the associations between these factors and inhibitory control and behavior problems assessed in early childhood. In addition to the direct relations among these factors, the role of baseline frontal EEG asymmetry was examined as a moderator of the relation between early anger and later approach behaviors, inhibitory control, and behavior problems. Furthermore, the role of inhibitory control was examined as a moderator of the relation between early anger or approach behaviors and later behavior problems.

The findings indicate that infants' anger reactivity in response to arm restraint at 4 months of age predicted greater approach responses to an unpredictable toy at 9 months, specifically among infants with greater relative left frontal EEG activation at 9 months. In essence, frontal EEG asymmetry moderated the relation between anger and approach behaviors. Functionalists suggest that the expression of emotions, even anger or distress, is adaptive (Campos et al., 1989). Thus, this result supports the view that anger is an approach-related emotion that functions to elicit action facilitating the attainment of a difficult goal (Campos et al., 1989). It also extended He et al.'s (2009) finding that toddlers who expressed high levels of anger during a toy removal task showed more approach behaviors to get the toy back from mothers than toddlers without anger and the results of Lewis and Ramsay (2005) who found that infants' anger during goal blockage was related to increased instrumental activity to remove obstacles. Moreover, the results support the idea that left frontal EEG asymmetry reflects a bias to approach novel stimuli (Fox, 1991; Harmon-Jones, 2004), reflecting the activation of motor and affective responses that facilitate reward-seeking behaviors.

Contrary to what was hypothesized, the direct relation between anger and frontal asymmetry was not found. Although some studies find greater left asymmetry in angry adolescents and adults (Harmon-Jones, 2004, 2007; Harmon-Jones & Allen, 1998), this relation has not been found in young infants (Davidson & Fox, 1989). One possibility is that state anger at one time point (i.e., 4 months) is not related to baseline frontal EEG asymmetry at a different time point (i.e., 9 months). Another possibility is that the underlying approach system is not completely integrated yet and as such, emotional expressivity and physiological processes do not directly relate to one another until later on in development. Studies are needed that examine anger expression and baseline frontal EEG asymmetry at the same time point in infancy and continue to follow these associations longitudinally to determine when in development they begin to relate to one another.

As noted above, anger is an approach-related emotion that is associated with an approach motivational system. However, excessive anger or approach in infancy seems to interfere with the development of inhibitory control in early childhood. Consistent with previous studies (Derryberry & Rothbart, 1997; Kochanska, 2003), the current findings revealed that high anger at 4 months of age predicted poor inhibitory control on a GNG task at 4 years of age, but especially for infants with left frontal EEG asymmetry. Hence, anger-prone infants who showed a corresponding physiological profile consistent with an approach bias were those who showed poor inhibitory control. The inverse relation found between anger and inhibitory control may reflect that anger-prone children find it hard to inhibit their responses due to heightened approach motivation.

Inconsistent with our hypotheses, and contrary to other reports (i.e., Eisenberg et al., 2007; Smeekens et al., 2007), neither main effects of 4-month anger nor possible moderation effects by frontal EEG asymmetry and inhibitory control were found to predict externalizing or internalizing problems at age 4. It may be that the measure of anger proneness in the current study, infant response to arm restraint, is an adaptive display of infant anger. Thus, anger in certain contexts could be a positive and optimal emotional response and may not increase children's risk of behavior problems. Another possibility is that the strong link between anger and problem behaviors has only been found in later childhood, as opposed to early infancy, due to increasing exposure to negative social experiences (Olson, Sameroff, Kerr, Lopez, & Wellman, 2005). When anger-prone children become older, they may have more negative interactions with family members and peers. Therefore, this continued link between anger and interpersonal problems may increase their risk of externalizing problems. Furthermore, a lot of infants expressed anger during the arm restraint procedure (79% of infants expressed facial anger at least in one 5-sec epoch). Other tasks, which are not so emotionally arousing, might show more variability in anger reactivity, and might be related to behavior problems.

Although an association between anger and behavior problems was not found, the current results revealed that 9-month approach interacted with 4-year inhibitory control in relation to children's internalizing behaviors at 4 years of age. As anger is suggested to be an approach-motivated emotion, it follows that approach behavior displayed in infancy might be more strongly related to behavior problems later on in early childhood. In addition, unlike the measure of anger, which showed less variability, the current measure of approach was in response to a potentially fear-inducing stimulus (although fear and approach during this task were not related to each other in this sample) and thus, the infants may have shown more variability in their approach behaviors. Perhaps more extreme levels of approach behavior are more likely to relate to behavior problems in early childhood.

Specifically, the current findings showed that children who were low on both approach and inhibitory control were most at risk of internalizing behavior problems. While one previous study found high approach and low inhibitory control predicted internalizing problems (Martel et al., 2007), the current finding is consistent with other results showing that low approach and low inhibitory control were associated with internalizing problems in school-aged children (Eisenberg et al., 2007). One reason for this result may be that GNG tasks are widely used to test inhibitory control (Rubia, Oosterlaan, Sergeant, Brandeis, & Leeuwen, 1998), which is different from reactive overcontrol (or behavioral inhibition). Inhibitory control is the capacity to plan and effortfully suppress inappropriate responses, whereas reactive overcontrol includes behaviors that are overly inhibited and inflexible. Children prone to internalizing problems are high in reactive overcontrol but not necessarily high in inhibitory control (Eisenberg et al., 2007). Thus, the connection of low inhibitory control with high internalizing problems in this study seems plausible in that children with internalizing behaviors may find themselves unable to inhibit a dominant response because of performance-related anxiety or depressive-like preoccupations that interfere with task performance (Degnan & Fox, 2007). In addition, the fact that this relation existed for children with low levels of approach to a potential fearful stimulus corresponds with the literature on behavioral inhibition and inhibitory control (Kooijmans, Scheres, & Oosterlaan, 2000).

## Strengths and limitations

The current work was based on a longitudinal study, which related early anger and approach motivation to later socioemotional outcomes. Few studies can provide such rich longitudinal data with which to address these research questions from early infancy to early childhood. In addition, measures of anger expression, approach behavior, and inhibitory control were assessed using detailed and reliable systems (FACS, Ekman et al., 2002; Lab-TAB, Goldsmith & Rothbart, 1999; McDermott, 2005). Moreover, data were collected across multiple informants (parent and observer) and systems of analysis (physiological and behavioral), limiting possible reporter bias. While there are additional studies that have examined these same constructs, measures of inhibitory control, approach, and anger vary significantly across this literature. Thus, further investigation into these associations is warranted until there is a more firm understanding of how these factors influence each other over time.

Nevertheless, there were limitations to the current study as well. First, the results may be affected by the large amount of missing data. Missing data analyses on the measures of approach behavior, frontal EEG asymmetry, inhibitory control, and behavior problems revealed no significant group differences on these variables. However, the reduction in sample size may decrease the power to detect results, especially when examining interaction effects (Jaccard, Wan, & Turrisi, 1990). Second, anger expression was only assessed once at 4 months of age via administration of an arm restraint procedure. Although this measure is reported to elicit anger more frequently and reliably in infants than other tasks, such as pacifier withdrawal (Stenberg & Campos, 1990), it would be preferable to measure anger repeatedly across several frustrating tasks. Third, the approach behavior measured during an unpredictable toy task reflects the response to high-intensity stimuli. It might also confound with fear, the dominant negative emotion in this task (although we did not find a relation between fear and approach behavior). As well, approach was assessed at 9 months and anger at 4 months. Hence, the lack of evidence for prediction from anger to behavior problems at 4 years, despite the fact that approach was predictive of such behavior problems, may be a function of the fact that approach was measured later in infancy, closer to the time that behavior problems were reported. Future work should examine anger and approach behaviors to both high- and low-intensity stimuli (for example, see Putnam & Stifter, 2002) and explore the concurrent and predictive relations between them across infancy. Fourth, we found the physiological influences on early negativity to later behavior through EEG, an indirect assessment of brain functioning. Fifth, this study focused primarily on individual, child-level effects; however, future work should include an analysis of the environmental factors (e.g., maternal psychopathology, mother–child relationship, and child care) that undoubtedly influence the approach motivation system and the emotional, physiological, and behavioral correlates of that system over time.

## Summary and conclusions

In summary, the findings in this study provide more insights into the relations between early components of the approach motivation system (i.e., anger reactivity, approach behavior, and frontal EEG asymmetry), and later inhibitory control and behavior problems. Specifically, physiological processes (e.g., left frontal EEG asymmetry) were implicated in the relations between anger and approach behavior or inhibitory control. Moreover, approach behaviors and inhibitory control were shown to jointly influence internalizing behaviors. Future research that models the contributions of endogenous (e.g., emotionality and frontal EEG asymmetry) and exogenous (e.g., quality of child rearing environment) factors over time should help to account for the variability in behavioral and social outcomes of approach-driven children. Studies that include all of these factors from multiple levels of analysis and examine their differential relations to the underlying approach motivation system in one structural model would greatly enhance our understanding of these mechanisms over the course of development.

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