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Continuity and Discontinuity of Behavioral Inhibition and Exuberance: Psychophysiological and Behavioral Influences across the First Four Years of Life

Nathan A. Fox, Heather A. Henderson, Kenneth H. Rubin, Susan D. Calkins, and Louis A. Schmidt

Four-month-old infants were screened ($N = 433$) for temperamental patterns thought to predict behavioral inhibition, including motor reactivity and the expression of negative affect. Those selected ($N = 153$) were assessed at multiple age points across the first 4 years of life for behavioral signs of inhibition as well as psychophysiological markers of frontal electroencephalogram (EEG) asymmetry. Four-month temperament was modestly predictive of behavioral inhibition over the first 2 years of life and of behavioral reticence at age 4. Those infants who remained continuously inhibited displayed right frontal EEG asymmetry as early as 9 months of age while those who changed from inhibited to noninhibited did not. Change in behavioral inhibition was related to experience of nonparental care. A second group of infants, selected at 4 months of age for patterns of behavior thought to predict temperamental exuberance, displayed a high degree of continuity over time in these behaviors.

INTRODUCTION

There are multiple reports in the research literature of the behavioral and physiological correlates of the temperamental pattern known as behavioral inhibition. Inhibited toddlers and preschool children are characterized as displaying vigilant behaviors and motor quieting when confronted with novelty. They are unlikely to approach unfamiliar adults (Calkins, Fox, & Marshall, 1996), show little spontaneous positive social initiation when placed with unfamiliar peers (Rubin, Hastings, Stewart, Henderson, & Chen, 1997), and are thought of by parents and peers as anxious and fearful (Garcia-Coll, Kagan, & Reznick, 1984; Rubin, Nelson, Hastings, & Asendorpf, 1999). In addition, there appears to be a unique pattern of physiology associated with this group. Reports indicate that they display high and stable heart rate, elevated home baseline cortisol, amplified EMG amplitude to a startle stimulus, and right frontal EEG activation (Calkins et al., 1996; Fox, Schmidt, Calkins, Rubin, & Coplan, 1995; Kagan, Reznick, & Snidman, 1987; Schmidt, Fox, & Schulkin, 1999).

In addition, there have been a number of studies that have described the antecedents and developmental trajectories of behaviorally inhibited children. For example, Kagan, Reznick, Clarke, Snidman, and Garcia-Coll (1984) reported on 43 4-year-old children, 22 of whom were identified as inhibited at 21 months of age. At age 4, the 22 inhibited children were more socially inhibited with unfamiliar peers and more vigilant and hesitant during cognitive testing compared to the 21 children identified as uninhibited. At 5½ years of age, the same 22 children were more inhibited with peers in both laboratory and school settings (Reznick et al., 1986). Kagan et al. (1987) subsequently reported on the original and a second cohort of children who were selected in either the second or third year of life as being behaviorally inhibited or uninhibited. At 6 years of age, the inhibited children continued to be more cautious and vigilant during their interactions with peers and with an experimenter and they exhibited signs of physiological stress. Yet it was the case that 40% of the inhibited children from these original groups became less inhibited by 5½ years of age, while fewer than 10% of the children originally identified as uninhibited became more inhibited with age. They further noted that boys were more likely than girls to become less inhibited over time. In summary, among the two original cohorts from Kagan's studies (Kagan et al., 1987) there appears to be some continuity as well as a good deal of discontinuity in the extreme forms of temperamental inhibition across the preschool and elementary school years.

In an attempt to examine infant predictors of behavioral inhibition, Kagan and colleagues selected infants at 4 months of age who displayed either high or low levels of motor arousal and negative affect in response to a series of novel visual and auditory stimuli (Kagan & Snidman, 1991). One-third of the high reactive infants were inhibited at either 14 or 21 months of age. In contrast, very few infants who were selected based on their low levels of reactivity were inhibited at later ages. High reactive infants also showed greater sympathetic reactivity than did low reactive infants (Snidman, Kagan, Riordan, & Shannon, 1995). In a follow-up of these selected infants, 46% of the children who had been high reactive at 4 months of age were classified as inhibited at 4½ years of age (Kagan, Snidman, & Arcus, 1998). In contrast, only 10% of children who had been low reactive as infants were classified as inhibited. Thirteen percent of the high reactive infants seen at 4½ years of age had been consistently inhibited at each of the assessment points over the 4-year period. Sixty-seven percent of the low reactive children, but only 27% of the high reactive children, were classified as uninhibited with peers. Kagan et al. (1998) argued that this pattern of data supports the notion that negative reactivity is a temperamental trait and an antecedent in the development of behavioral inhibition.

One of the issues in the study of the continuity of inhibition is the characterization of its form across development. In his Handbook chapter, Caspi (1998) describes five different types of continuity of personality to be considered in the study of developmental change. Four of these (differential, absolute, structural, ipsative) refer to homotypic continuity, which is continuity of similar behaviors or phenotypic attributes over time. The fifth, heterotypic continuity, refers to continuity of an inferred genotypic attribute presumed to underlie diverse phenotypic behaviors. It is this latter type of continuity that characterizes developmental change in behavioral inhibition. The term behavioral inhibition is used to describe temperamental differences in infants' and young children's initial reactions to a range of novel stimuli including people, objects, contexts, and challenging situations (Kagan et al., 1987). Inhibition is assessed in young children by recording their latencies to approach various novel stimuli. It has been measured in older children by examining their latency to spontaneously interact with an experimenter during cognitive testing, and with unfamiliar peers in laboratory play sessions. Measures of reluctance to interact with unfamiliar adults and/or peers reflect a specific aspect of behavioral inhibition, that is, reactivity to unfamiliar people. The change in emphasis from assessment of reactivity to novel stimuli to assessment of the child's social response to unfamiliar peers reflects the type of stimulus situation expected to elicit behavioral inhibition in older children. Older children are unlikely to display inhibition to novel objects but are likely to exhibit inhibition to novel social situations. This may reflect the child's increasing perceived control over the nonsocial environment. Unfamiliar objects may elicit inhibition in infants and young children because of their novelty and the child's lack of control over their actions (e.g., Gunnar, 1978, 1980). As children enter preschool they have more experience with a range of novel and unfamiliar toys and their perceived control over these objects may increase as well. In contrast, peers and adults may continue to elicit inhibition due to the level of their unpredictability in social situations. The change in the nature of the eliciting stimulus conditions from inanimate *and* social situations to social situations specifically warrants the introduction of different terminology for the behaviors in older children.

Fox and Rubin have used the term social reticence to reflect behavioral inhibition in social situations. They and their colleagues have conducted detailed observations of children's behaviors during free play, speech-making, and cooperative tasks with unfamiliar peers in order to study social reticence (e.g., Fox et al., 1996; Rubin, Coplan, Fox, & Calkins, 1995). Using a variety of observational taxonomies, including the Play Observation Scale (Rubin, 1989), these researchers have derived a measure of socially wary, anxious, and reticent behaviors in the preschool play group. This measure, comprising observed reticence and anxiety during free play and an inclination to avoid making a speech in the presence of unfamiliar peers, has been found to be contemporaneously associated with maternal reports of both dispositional shyness and internalizing behavior problems (e.g., Coplan, Rubin, Fox, & Calkins, 1994). In contrast, other forms of nonsocial play have been described in which children are simply more focused on objects than on people, and this form of solitary play does not show contemporaneous relations with measures of distress or anxiety. Thus, reticence is conceptually related to behavioral inhibition based on the common underlying motivation to avoid novelty due to the negative affect elicited by novel stimuli. Reticence reflects a specific form of nonsocial behavior, one that is accompanied by signs of anxiety and wariness (Asendorpf, 1990; Coplan et al., 1994). Despite variation in the specific behaviors across different ages, reticence and behavioral inhibition provide age-appropriate measures of a common psychological state.

A number of studies using parent report measures of temperament to identify inhibited children have also found moderate continuity in this trait. Sanson, Pedlow, Cann, Prior, and Oberklaid (1996) reported findings from the Australian Temperament Project in which they assessed 501 children longitudinally, beginning at 4 to 8 months of age and continuing through 5 to 6 years of age. The authors found few relations among the measures of inhibition from the infancy period to later ages. However, the magnitude of the correlations increased significantly when continuity was examined between the second year of life and 5 to 6 years of age. Rubin et al. (1999) reported moderate continuity in both mothers' and fathers' ratings of shyness among Canadian children from 2 to 4 years of age. Broberg (1993) also reported modest continuity in maternal reports of behavioral inhibition in a sample of Swedish first-born children assessed at 16, 28, and 40 months of age. Scarpa, Raine, Venables, and Mednick (1995) reported modest continuity in behavioral inhibition based on a longitudinal study of 1,800 Mauritian children assessed at 3, 8, and 11 years of age. The children were classified as high, middle, or low in inhibition at each of the three ages based on a combination of parental reports and behavioral observations. Children who were highly inhibited at 3 years of age displayed greater inhibition at 8 years of age, and those who were highly inhibited at 8 years of age were more inhibited than were other children at 11 years of age.

In each of the aforementioned studies of inhibition, the emphasis has been on continuity. Yet given the modest correlations reported, there are clearly many children who do not remain inhibited across the early years of life. We know little about these children or the factors that may contribute to the changes in their behavior over time.

One factor that may contribute to the continuity of inhibition over time is the physiological disposition of infants to express negative affect and withdrawal in response to novelty. A variety of data suggests that the pattern of the resting electroencephalogram (EEG) may reflect an individual bias to respond with positive or negative affect to stressful situations. Davidson and colleagues (Tomarken, Davidson, & Henriques, 1990) reported that increased resting right frontal EEG activation was associated with adults' self-reports of higher levels of global negative affect (fear, disgust, sadness, and anger) while watching film clips selected to elicit negative emotions (disgust, sadness, and anger). The relation between resting frontal asymmetry and self-reported negative affect was particularly strong for the subjects' ratings of fear. In contrast, resting frontal asymmetry was not related to the adults' ratings of global positive affect (happiness, amusement, and interest) when viewing film clips selected to elicit positive emotion. Davidson and Fox (1989) found that 10-month-old infants who cried during a 1-minute period of maternal separation showed significant right frontal asymmetry during a baseline recording that took place before the mother left the room. In contrast, infants who did not cry during the separation period displayed significant left frontal asymmetry during the baseline recordings. In a separate study, Fox, Bell, and Jones (1992) replicated this finding and found the frontal EEG pattern to be stable across the second half of the first year of life. Henriques and Davidson (1990, 1991) reported that adults with clinical depression, as well as adults who were depressed and currently in remission, displayed this pattern of right frontal EEG asymmetry. Together, these findings suggest that patterns of right frontal EEG asymmetry may serve as a marker of an underlying disposition rather than simply reflecting current affective state. For example, Davidson (1992) has argued that this EEG pattern reflects a diathesis around which stressful events may trigger the expression of negative affect or depressive symptomatology.

In addition to being related to specific affective states, Fox and his colleagues have found relations between EEG asymmetry and shyness in adults and reticence in children. Specifically, adults who rated themselves as high in shyness displayed right frontal EEG asymmetry (Schmidt & Fox, 1994). Preschool and elementary school age children who displayed social reticence in a peer situation were more likely to display right frontal EEG asymmetry as well (Fox et al., 1995; Fox et al., 1996). And Calkins et al. (1996) reported that infants displaying high motor arousal and negative affect at four months of age were more likely to display right frontal EEG activity at nine months of age and behavioral inhibition at 14 months of age. A recent study by Schmidt et al. (1999) illustrates these relations. Seven-year-old children, observed to be shy in a peer situation, exhibited right frontal EEG asymmetry during baseline conditions compared to their nonshy counterparts. When placed in an emotionally evocative situation, the shy children displayed signs of anxiety that were accompanied by increases in the magnitude of their right frontal asymmetry scores.

The following study reports on two cohorts of infants, some of whom were selected at four months of age for characteristics thought to predict behavioral inhibition. These infants were high in negative reactivity. A second group of infants who were high in positive reactivity, as well as a low reactive group, were also recruited. All infants were seen at 9, 14, 24, and 48 months of age in the laboratory. Measures of brain electrical activity were recorded at each of these ages and behavioral observations were made at 14, 24, and 48 months. At 14 and 24 months, children were seen in a standard behavioral inhibition paradigm. At 48 months of age, children were observed in same-gender, unfamiliar peer quartets, and measures of reticence and social play were coded. In this paper, we examined the degree to which infant reactivity patterns predicted later behavioral inhibition and reticence. We also compared the degree of continuity in inhibition based on patterns of infant reactivity. In addition, we examined relations among observed behavior and EEG to determine if frontal EEG asymmetry was related to patterns of continuity in behavioral inhibition. The group of infants displaying high motor reactivity and high positive affect in response to novel stimuli were unlike Kagan's low reactive group in that these infants displayed high motor reactivity but positive affect in their responses. We predicted that this group would present with its own unique developmental trajectory and pattern of physiological response including lack of fear or inhibition, high sociability, and left frontal EEG asymmetry. It is important to distinguish this group from noninhibited children who may simply show less fear or inhibition in response to challenge. Indeed, we expected that exuberant, uninhibited children would be different from noninhibited controls.

The data in the current paper reflect two cohorts of children. Children in each cohort were selected at 4 months of age and each cohort was seen at the identical age points through age 4. Data on the patterns of EEG activity at 9 months and behavioral inhibition at 14 months of age for the first cohort have previously been reported in Calkins et al. (1996). Data on the combined two cohorts and a follow-up to 4 years of age have not been reported elsewhere. Combining these two cohorts allowed the subgroup analyses found in the current paper.

METHOD

Participants

To select infants thought likely to display behavioral inhibition later in infancy and early childhood, a total of 433 4-month-old infants were screened for motor reactivity and emotional reactivity in response to novel sights and sounds. The infants recruited came from two separate cohorts with identical screening procedures. Details of the screening procedure have been described previously (Calkins et al., 1996; Kagan & Snidman, 1991).

Families with young infants were initially contacted by mail using commercially available lists of names and addresses compiled from the birth records of area hospitals. Interested parents were asked to complete a brief background survey. Families were excluded from further participation if any of the following were true: (1) the infant was preterm (less than 36 weeks gestation), (2) the infant had experienced any serious illnesses or problems in development since birth, (3) the infant was on any long-term medication, or (4) either of the parents were left-handed. Families who did not meet any of these exclusion criteria were contacted by phone and given more information regarding the study. Home visits were scheduled for interested families ($N = 433$).

Home visits took place when the infant was 4 months of age (±14 days). While in an infant seat and in a quiet and alert state, the infant was presented with two sets of novel visual (brightly colored mobiles) and auditory (taped sentences and nonsense syllables) stimuli. Each set of stimuli consisted of a series of visual presentations followed by a series of auditory presentations. The first series of visual stimuli consisted of three mobiles differing in the number of hanging characters (1, 3, or 6 characters). Each mobile was presented for 20 s, and the presentations were separated by a 10-s intertrial interval. The series of three mobiles was repeated three times for a total of nine trials. Each mobile was displayed at the infant's eye level and approximately 12 inches from the face. The first series of auditory stimuli consisted of 8 short sentences. Each sentence was approximately 6 s in duration, followed by a 2-s intertrial interval. The sentences were presented in pairs. The pairs differed in the number of voices speaking and, as a result, the volume of the presentation. The first pair was spoken by a single voice, the second pair by two voices, the third pair by three voices, and the fourth pair by four voices.

The second set of novel stimuli was similar to the first except that the characters on the mobiles were different, and the auditory stimuli were nonsense syllables (ma, ga, pa) rather than sentences. The series of three mobiles was presented in exactly the same fashion as in the first set, for a total of nine trials. Each nonsense syllable was presented in three consecutive 10-s trials, with 5-s intertrial intervals.

The stimuli were presented to the infants in an identical order (mobiles 1, auditory 1, mobiles 2, auditory 2). Infants who began to cry during an episode were allowed to cry for a continuous period of no more than 20 s after which the mother was asked to intervene and calm her infant. Once sufficient calm was restored, the session was continued. If an infant was unable to continue with a session, scores were prorated for the amount of time (number of episodes) that the infant missed. All sessions were videotaped, allowing for the later coding of infant reactivity.

Infants from both cohorts were selected based on the amount of motor reactivity as well as positive and negative affect expressed during the presentation of the novel sights and sounds. The methods of coding and quantifying reactivity varied slightly between the two cohorts. In the first cohort, coding was based on the procedures described previously by Calkins et al. (1996) and Kagan and Snidman (1991). Specifically, the frequencies of the following behaviors were coded during stimulus presentation: (1) Motor Activity (arm and leg movements greater than 45° from resting position, burst of two or more arm and leg movements, back arches, hyperextension of arms and legs); (2) Positive Affect (smiling and neutral or positive vocalizations); and (3) Negative Affect (fussing, fretting, and crying). Interrater reliability was computed on approximately 20% of the sample. Pearson correlations between pairs of raters ranged from .78 to .86.

Infants who were extreme on the dimensions of motor activity and affect were selected for participation in the study. The criteria for selection were established based on the reactions of the first 25% of the screened sample. Three groups were selected: (1) those above the mean on motor activity and negative affect (High Negative), (2) those above the mean on motor activity and positive affect (High Positive), and (3) those below the mean on motor activity, positive, and negative affect (Low Reactive). Of the 208 infants screened in the first cohort, 29 were identified as High Negative, 22 as High Positive, and 30 as Low Reactive. Consistent with the selection criteria, a MANOVA comparing the three temperament groups on the three reactivity dimensions was significant, $p < .001$. Specifically, the High Negative group had significantly higher negative affect scores than both the High Positive and Low Reactive groups, $F(2, 78) = 19.24$, $p < .001$; Tukey's HSD, both *p*s $< .001$. The High Positive group had significantly higher positive affect scores compared to both the High Negative and the Low Reactive groups, $F(2, 78) = 37.40$, $p < .001$; Tukey's HSD, both *p*s $< .001$. The Low Reactive group had significantly lower motor activity scores than both the High Negative and the High Positive groups, $F(2, 78) = 11.38$, $p < .001$; Tukey's HSD, $p < .001$ and $p < .01$, respectively.

In the second cohort, coders used 7-point Likert-type scales to rate the infant's motor, positive, and negative reactions to each of the visual and auditory presentations. Thus, each infant had a total of three ratings on each session (visual 1, auditory 1, visual 2, auditory 2) for a total of 12 ratings. On the Motor Scale, a score of 7 indicated intense gross motor activity including back arching, body twisting, and hyperextensions of the arms and legs. A score of 1 indicated very little or no motor activity. A score of 7 on the Positive Affect Scale was used to describe infants who responded with many positive vocalizations, and many instances of gurgling, cooing, and smiling (at either the stimulus or the experimenter). Neutral vocalizations were also considered in scoring positive affect; however, neutral vocalizations on their own were not sufficient for a high score on the Positive Affect Scale. A score of 1 on the Positive Affect Scale was reserved for infants who did not smile at all or make more than two neutral or low-intensity positive vocalizations during the presentation. On the Negative Affect Scale, a score of 7 indicated a high degree of intense negative affect and described infants who cried or fussed continuously during the majority of the stimulus presentations. A 1 on the scale indicated an absence of negative affect across the different stimulus events. Three coders rated the tapes. Estimates of inter-rater reliability were computed for pairs of coders, based on 20% of the sample. Pearson correlations ranged from .62 to .95, with a mean correlation of .68 on the motor scale, .69 on the Positive Affect Scale, and .95 on the Negative Affect Scale.

Classifications into each of the three temperament groups (High Negative, High Positive, Low Reactive) were made based on the frequency of "high" scores across the four stimulus conditions. To be classified as High Negative, an infant had to receive a score of 4 or more on Motor Activity for both the visual and auditory presentations in either the first or second set of presentations. In addition, the infant had to have a score of 4 or more for Negative Affect during the same set of stimuli presentations. To be classified as High Positive, an infant had to have a score of 4 or more on Motor Activity for both the visual and auditory presentations in either the first or second set, as well as a score of 4 or more on Positive Affect during the same presentations. The Low Reactive group was comprised of infants who had scores of 3 or less on Motor Reactivity, Positive Affect, and Negative Affect during both the first and second sets of presentations. Also, an infant had to have seven scores (out of a possible 12) of 1 to be identified as low reactive.

Of the 225 infants screened in the second cohort, 27 were classified as High Negative, 23 as High Positive, and 22 as Low Reactive. Consistent with the selection criteria, these three groups differed significantly on each of the three reactivity dimensions. Specifically, the High Negative group was rated as significantly higher in negative affect compared to the other two groups, $F(2, 67) = 63.29$, $p < .001$; Tukey's HSD, both *p*s $< .001$. The High Positive group was scored as having significantly more positive affect than the other two groups, $F(2, 68) = 23.83$, $p < .001$; Tukey's HSD, both *p*s $< .001$. The Low Reactive group was rated as displaying significantly less motor activity than the other two groups, $F(2, 69) = 23.83$, $p < .001$; Tukey's HSD, both *p*s $< .001$.

To examine the comparability of the two selection systems, we double coded the cohort originally selected using the 7-point scale system utilized by Calkins et al. (1996) and Kagan and Snidman (1991). We then utilized the selection criteria outlined above (using the 7-point scales) to place infants from the initial cohort into each of the three temperament groups. We computed observed percent agreement and Cohen's κ between the two selection/classification outcomes. Observed percent agreement was 80.3% whereas Cohen's κ was .66. This suggests that there was good agreement between the two classification systems (Fleiss, 1981).

As a further check, we examined whether the temperament groups within the two cohorts differed on any of the major outcome measures (behavioral inhibition, social reticence, EEG asymmetry). They did not.

Procedure

Following the initial selection, families were invited to the laboratory when their infants were 9, 14, 24, and 48 months of age. When the infants were 9 months of age, brain electrical activity (EEG) was recorded and mothers completed a temperament survey. At each of the subsequent ages, EEG was recorded, mothers completed age-appropriate temperament surveys, and children's reactions to unfamiliar stimuli were observed in the laboratory.

Measures

EEG data collection. Several procedures were used during EEG data collection to help maximize the chances that the infants would sit quietly and maintain a steady, attentive state. At 9, 14, and 24 months, infants were seated in front of a table. At 9 months, infants sat on their mothers' laps to help minimize fussing and movement, and at 14 and 24 months infants sat alone in an infant seat with their mothers just off to one side. At each of these ages, a metal bingo wheel was placed on the table directly in front of the infant. An experimenter placed different numbers of brightly colored balls (1, 3, or 7) in the wheel and spun the wheel for a series of six trials each lasting 20 s. These trials were separated by 10-s intervals in which the experimenter tapped the balls on the outside of the bingo wheel to keep the infant's attention between trials. EEG was recorded for the entire 3-min period.

When the children were 4 years of age, the EEG collection room was decorated to resemble a space shuttle (see Fox et al., 1996, for a complete description of the testing room). The child sat in the space chair (a chair covered in silver fabric) and the mother sat on a sofa across the room. EEG was collected as the child watched a computer-generated video. In addition, the child was asked to sit quietly and (1) look at a toy spaceship that was placed approximately 18 inches from his/her face and then (2) sit with his/her eyes closed. The eyes-opened and eyes-closed segments each lasted for one minute. The eyes-open/eyes-closed conditions are similar to those used to collect baseline measures of EEG from adult subjects (Davidson, 1988).

Prior to the recording of EEG from each subject, a 50 μV 10 Hz signal was input into each of the channels and this amplified signal was recorded. This signal of known frequency and amplitude was later used for calibration purposes. At each age, the experimenter began preparing for EEG collection by measuring the circumference of the child's head in order to select a Lycra stretch cap of appropriate size. The stretch caps have electrodes for EEG recording sewn into the fabric according to the 10–20 system of electrode placement (Jasper, 1958). Thus, the electrode cap allows for a noninvasive, efficient, yet accurate, method of electrode placement. In order to ensure that the cap stayed in place during the recording, elastic straps on each side of the cap were snapped onto a cotton vest worn by the infant. At 9, 14, and 24 months, the cap was further secured with an elastic headband.

A small amount of abrasive gel (Omni-prep) was inserted into each of the six active sites on the cap (F3, F4, P3, P4, O1, and O2) as well as the reference site at the vertex (CZ). Using the blunt end of a Q-tip, each site was gently abraded. Following abrasion, a small amount of electrolyte gel was inserted in each site. The blunt end of a Q-tip was again used to ensure that the gel was making contact with the scalp in the area below each electrode site. Impedances were measured at each site and were considered acceptable if they were at or below 5 K ohms.

One channel of EOG was recorded from the right eye using two Beckman mini-electrodes, one placed at the outer canthus and the second placed at the supra orbit position. The EEG and EOG were amplified by separate Grass AC bio-amplifiers (7p511) with the high pass setting at 1 Hz and the low pass at 100 Hz. The data were digitized online using a HEM A/D board and acquisition software. The digitized data were stored for later analyses.

During EEG recording, a second experimenter pressed a button switch at the onset and offset of each stimulus condition. The output of the button switch went to one A/D channel, and was used to synchronize the stimulus times with the EEG.

EEG data reduction. The EEG data were digitized at a rate of 512 Hz. The EEG data were then re-referenced via software so that the data could be analyzed with an average reference configuration. The digitized EEG data were then displayed graphically for artifact scoring. Portions of the EEG record marked by eye movement or motor movement artifact were removed from all channels of the EEG record prior to subsequent analysis.

The re-referenced, artifact-scored EEG data were submitted to a discrete Fourier transform analysis that utilized a Hanning window with 50% overlap. The result of this analysis was to produce power in picowatt ohms (or microvolts squared) for each channel, for each of the stimulus conditions. Spectral power data in single Hz frequency bins from 1 to 12 Hz were computed for each of the stimulus conditions at each of the collection sites. At 9 months of age, power in the 4–6 Hz frequency band was computed for each site by summing the single hertz bins in these three frequencies for each of the stimulus conditions (1, 3, and 7 balls). At 14 and 24 months of age, power was computed in the 6–8 Hz band for each site by summing the single hertz bins in these three frequencies for each of the stimulus conditions (1, 3, and 7 balls). At 4 years of age, power in the 6–8 Hz band was computed separately for the eyes-closed and eyes-opened conditions. Again, power in the 6–8 Hz band was computed by summing the single hertz bins in the three frequencies. The use of different frequency bands at the different ages reflects observed developmental changes in the EEG. Specifically, at 9 months of age the majority of power was localized to the 4–6 Hz frequency range, while at older ages there was a clear shift in the locus of power to 6–8 Hz. Previous research with human infants has documented this shift in spectral power across the first years of life (Fox & Bell, 1990; Schmidt & Fox, 1998; Stroganova, Orekhova, & Posikera, 1999). The data used in analyses were the log power data from both the frontal and parietal regions, as well as laterality scores that were computed for each region at each age. Power and activation are thought to be reciprocally related (Davidson, 1988; Lindsley & Wicke, 1974). High power reflects low activation at a particular electrode site while low power reflects high activation. Laterality scores (ln right−ln left) are used to reflect the relative power in the right and left hemispheres. A positive score reflects greater R-power (or increased L-activation), whereas a negative score reflects greater L-power (or increased R-activation).

Observed behavioral inhibition. At 14 and 24 months, the infant's reactions to unfamiliar stimuli in the laboratory were coded to provide an index of behavioral inhibition (see Calkins et al., 1996; Kagan et al., 1987; Reznick, Gibbons, Johnson, & McDonough, 1989). At 14 months, the unfamiliar stimuli consisted of (1) an unfamiliar room/environment, (2) an adult stranger, and (3) a novel toy/object. At 24 months, the infant was presented with identical stimuli, and in addition, the infant's reactions to an adult stranger dressed in a clown costume were recorded, as well as his/her willingness to crawl through an inflatable tunnel when encouraged to do so by the experimenter.

At the beginning of the visit, the infant and mother entered an unfamiliar playroom with some toys on the floor. Mothers were instructed to work on questionnaires and to let infants play on their own. They were told to respond as they normally would if the infants attempted to get their attention. The free-play period lasted 5 min. Following the free-play session, the toys were removed from the room and an unfamiliar female research assistant entered the room with a toy dump truck and some blocks. The stranger sat quietly for 1 min, played with the truck for 1 min, and then (if the child had not yet approached) invited the child to join her in play for 1 min. After the third minute, the stranger took the truck out of the room and returned with an electronic robot. The battery-operated robot was approximately 18 inches in height, had flashing lights, made loud noises, emitted smoke, and moved around the room. The research assistant left the robot running in the room for 2 min. At 24 months, the observations continued when the experimenter returned to the room with an inflatable tunnel that she encouraged the child to crawl through. After she left, another female experimenter entered the room dressed as a clown. The clown was silent for 30 s, invited the child to approach for 1 min, and then removed enough of her costume for the child to realize that she was another experimenter whom he or she had met before.

At 14 months, an index of inhibition was computed based on the infant's reactions to these unfamiliar stimuli. Standardized scores of the following measures were summed to create a single summary index of inhibition: (1) latency to first touch a toy during free-play, (2) latency to vocalize during free-play, (3) time spent in proximity (within arms length) to mother during free-play, (4) latency to vocalize to the stranger, (5) latency to approach the stranger, (6) time spent in proximity to mother while the stranger presented the truck, (7) latency to vocalize to the robot, (8) latency to approach the robot, (9) time spent in proximity to mother during the robot episode. The summed index was standardized and scores on the index of inhibition ranged from −1.85 to 3.00. Intercoder reliability was computed for 15% of the sample using percent agreement given that all measures were based on recordings of time. Pearson correlations between pairs of coders on the individual measures ranged from .85 to 1.00.

At 24 months, a single composite measure of inhibition was computed by summing standardized scores on (1) time spent in proximity (within arms length) to mother during free-play, (2) time spent in proximity to mother during the truck episode, (3) time spent in proximity to mother during the robot episode, (4) time spent in proximity to mother during the tunnel episode, (5) latency to approach the stranger and/or touch the truck, (6) latency to approach and/or touch the robot, and (7) latency to pass through the tunnel. Intercoder reliability was computed for 24% of the sample using percent agreement given that all measures were based on recording of time. Pearson correlations between pairs of coders on the individual measures ranged from .77 to .97. The summed index of inhibition was standardized and scores on the index of inhibition ranged from −2.30 to 2.56.

Play with unfamiliar peers at 4 years. Behavioral inhibition was assessed at 4 years of age based on children's reactions to, and interactions with, unfamiliar peers. Four children and their mothers were scheduled to arrive at the laboratory at the same time. The four children were selected so that they were of the same age and sex. The children were also selected based on their observed behavioral inhibition at 24 months of age, such that each group consisted of one previously inhibited (half a standard deviation or more above the mean), one previously noninhibited (half a standard deviation or more below the mean), and two average children (within one standard deviation around the mean). The children in each quartet had never met each other outside the laboratory.

Upon arriving at the laboratory, the children and mothers waited in a common area of the lab until all four children had arrived and all parents had been briefed and informed consent was obtained. The four children were then led into a playroom with several age-appropriate toys spread around the room. While the children were in the playroom, parents were in a waiting area where they were asked to complete a series of questionnaires. Parents were able to observe the entire visit on a television monitor in the waiting area.

The visit was split into several episodes. A complete description of the visit may be found in Fox et al. (1995). For purposes of this study, data from the two free-play sessions were used. In the first and second free-play sessions the children were left alone in the playroom for 15 min. The entire play session was videotaped for later observational coding.

Behavioral coding of play with unfamiliar peers. Behaviors in the first and second play sessions were coded with Rubin's (1989) Play Observation Scale (POS). Ten-second intervals were coded for social participation (unoccupied, on-looking, solitary play, parallel play, peer conversation, and group play) and the cognitive quality of play (functional, dramatic, and constructive play; exploration; games with rules). This resulted in approximately 90 coding intervals per child in each of the two free-play sessions. For both cohorts, three independent observers coded the POS. Intercoder reliability on a randomly selected group of children totaling 30% of the two samples was calculated between pairs of observers using Cohen's kappa. For the full variable matrix, including social and cognitive play categories, kappas ranged from .81 to .94 for the first cohort, and .87 to .94 for the second cohort.

An index of social reticence was created by standardizing the mean proportion of time spent engaged in unoccupied and onlooker behaviors across both play sessions (see also Coplan et al., 1994). The standardized score of social reticence was used as the index of inhibition at 4 years. Scores on this index ranged from −1.19 to 4.55.

Maternal questionnaire data. At each assessment point, mothers were asked to complete a variety of questionnaires including temperament reports and demographic information. At 9 months of age, maternal reports of temperament were gathered using the Infant Behavior Questionnaire (IBQ; Rothbart, 1981). The IBQ is an 87-item parent rating form in which parents are asked to rate the frequency of specific infant behaviors as they occurred in the previous week. Parents rate the frequency of behaviors using a 7-point scale with an eighth option for "Does not apply." Scaled scores are derived from the measure by taking the mean ratings on all items in the particular scale, omitting the items marked as "Does not apply." Of particular interest in this study were the scales "Fear" (distress and extended latency to approach intense or novel stimuli), and "Smiling and Laughing." The Fear scale has 16 items with an internal consistency alpha of .84. The Smiling and Laughing scale has 15 items with an internal consistency alpha of .73 (Rothbart, 1981).

At 14 and 24 months, maternal reports of temperament were gathered using the Toddler Behavior Assessment Questionnaire (TBAQ; Goldsmith, 1987, 1996). The TBAQ is a 111-item parent rating form in which parents are asked to rate the frequency of specific behaviors as they occurred in the past month. The TBAQ is modeled after the IBQ and uses a similar response format in which parents rate the frequency of specific behaviors using a 7-point Likert-type scale. As on the IBQ, there is an eighth option for "Does not apply." Six scale scores are created from the measure by taking the mean of items for a particular scale, omitting all items answered with "Does not apply." Of particular interest in this study were the scales Social Fearfulness (inhibition, distress, withdrawal, or signs of shyness in novel or uncertainty-provoking situations) and Pleasure (smiling, laughter, and other hedonically positive vocalizations or playful activity in a variety of nonthreatening or familiar situations) (Goldsmith, 1996). The Social Fearfulness scale consists of 19 items and has an internal consistency alpha of .87. The Pleasure scale consists of 19 items and has an internal consistency alpha of .86.

During the 24-month visit, mothers completed a nonparental care survey in which they were asked to report if the child was currently or had in the past been cared for on a regular basis by someone other than the child's mother or father. In addition to describing the type of care, mothers were asked to report how many children (both siblings and nonsiblings) were cared for in the same setting. Based on this survey, children were classified as having been in exclusive home care or in nonparental care with at least one nonsibling during the first 24 months of life.

During the 4-year visit, mothers completed the Colorado Child Temperament Inventory (CCTI; Buss & Plomin, 1984; Rowe & Plomin, 1977). The CCTI is a 30-item parental report that assesses six temperament dimensions. The dimensions of interest were Shyness and Sociability. As a measure of adjustment/maladjustment, mothers completed the Child Behavior Checklist (CBCL; Achenbach & Edelbrock, 1983). The CBCL is a 113-item checklist in which parents use a 3-point scale to rate how descriptive of their own child a series of behavior problems are. The CBCL yields eight narrow-band factors that are further reduced to two broadband factors, Internalizing and Externalizing behavior problems. The prevalence of Internalizing and Externalizing behavior problems were of particular interest in this study.

Attrition by temperament group. Of the 153 infants selected (Low Reactive, $n = 52$; High Negative, $n = 56$; High Positive, $n = 45$), 122 participated at 9 months of age (Low Reactive, $n = 47$; High Negative, $n = 43$; High Positive, $n = 33$); 123 at 14 months of age (Low Reactive, $n = 43$; High Negative, $n = 44$; High Positive, $n = 36$), 125 at 24 months of age (Low Reactive, $n = 44$; High Negative, $n = 44$; High Positive, $n = 37$), and 118 at 48 months of age (Low Reactive, $n = 39$; High Negative, $n = 44$; High Positive, $n = 35$). A series of chi-square analyses were computed to determine whether participation across time was differentially related to the 4-month temperament groups. The only significant chi-square revealed that families with infants classified as Low Reactive at 4 months were more likely than families with infants classified as either High Negative or High Positive to participate in the laboratory visit at 9 months of age, $\chi^2(2) = 6.02$, $p = .05$. Beyond the 9-month visit, however, participation was not differentially related to temperament group, (all χ^2 *ns*).

Similarly, analyses were conducted to examine whether refusal or extreme fussiness during EEG collection, which prevents the collection of usable EEG data, was differentially related to temperament group. Non-significant chi-square analyses at each age confirmed that compliance during EEG collection was not differentially related to the original 4-month temperament classifications. In sum, despite varying numbers of participants across age and across portions of data collection, variable participation and compliance were not directly related to the temperament classifications.

RESULTS

Four-Month Temperament Group Differences across Age

The first question addressed was how children in the 4-month temperament groups differed in their reactions to novel situations and people as observed in the laboratory at 14, 24, and 48 months of age. One-way ANOVAs were computed at each age with 4-month temperament group as the between subjects factor and observed inhibition as the dependent variable. The inhibition measures used were the composite measures of observed inhibition in the laboratory at 14 and 24 months of age, and the social reticence composite from the quartet play session during the 48-month visit.

At 14 months of age, the 4-month temperament groups differed significantly on observed inhibition, $F(2, 120) = 9.40$, $p < .001$. Specifically, infants in the High Negative group displayed significantly more inhibition in the laboratory, $M = .50$, $SD = 1.23$, $n = 44$, compared to infants in both the Low Reactive, $M = -.12$, $SD = .67$, $n = 43$, and High Positive, $M = -.39$, $SD = .82$, $n = 36$, temperament groups (Tukey's HSD, $p < .01$ and $p < .001$, respectively). The 4-month temperament groups also differed significantly on observed inhibition at 24 months of age, $F(2, 122) = 5.56$, $p < .01$. Specifically, infants in the High Positive group displayed significantly less inhibition in the laboratory, $M = -.51$, $SD = .85$, $n = 37$, compared to infants in both the Low Reactive, $M = .08$, $SD = .93$, $n = 44$, and High Negative, $M = .13$, $SD = 1.01$, $n = 44$, groups (Tukey's HSD, $p < .05$ and $p < .01$, respectively). At 48 months of age, there was a nonsignificant effect of 4-month temperament group on ob-

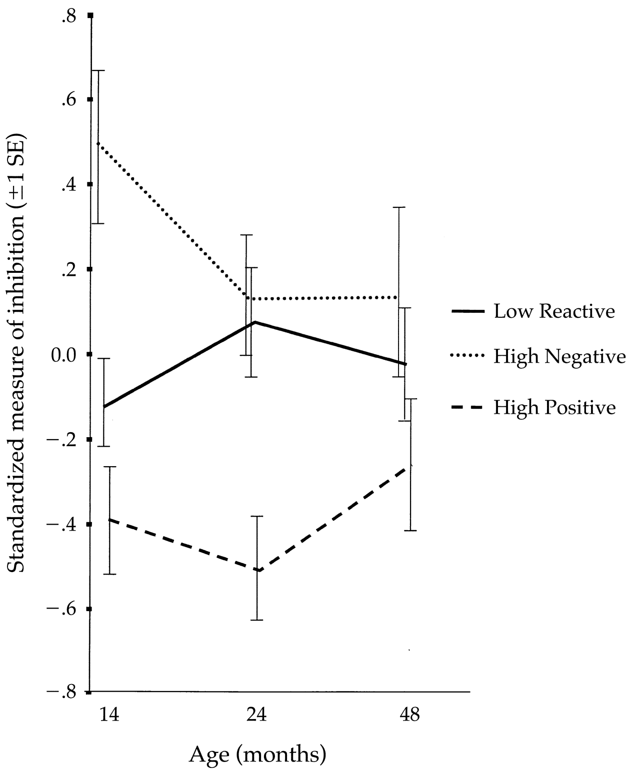

Figure 1 Mean scores on standardized measures of inhibition at 14, 24, and 48 months as a function of 4-month temperament group. At 14 months, Low Reactive, $n = 43$; High Negative, $n = 44$; High Positive, $n = 36$. At 24 months, Low Reactive, $n = 44$; High Negative, $n = 44$; High Positive, $n = 37$. At 48 months, Low Reactive, $n = 39$; High Negative, $n = 44$; High Positive, $n = 35$.

served reticence during interactions with unfamiliar peers (High Negative: $M = .13$, $SD = 1.30$, $n = 44$; Low Reactive: $M = -.03$, $SD = .83$, $n = 39$; and High Positive: $M = -.26$, $SD = .88$, $n = 35$; see Figure 1).

As can be seen in Figure 1, there is a changing pattern of relations among the 4-month temperament groups across age. At 14 months, infants from the High Negative group stand out as particularly inhibited, but by 24 months they are, as a group, no longer different in behavioral inhibition from Low Reactive infants. Infants from the High Positive group, on the other hand, stand out as particularly uninhibited across the assessment age points. This pattern of data suggests a good deal of discontinuity among the infants classified as High Negative at 4 months of age and greater continuity of response among the infants classified as High Positive. An examination of individual profiles within the High Motor/High Negative group suggests that while some of the infants demonstrated a clear pattern of decreasing inhibition over time, a distinct subgroup of infants maintained a high level of inhibition through to the 48-month assessment. Thus, the next series of analyses were conducted to isolate discrete profiles within the original 4-month temperament groups that would isolate infants demonstrating continuous and discontinuous patterns of inhibition over time.

Identification of Groups Based on Patterns of Continuity and Change over Time

Within each of the 4-month temperament groups it appeared as though distinct groups of children could be identified who displayed consistently high or low levels of inhibition over time. Given the variable number of participants across time, children were considered eligible for classification into behavior profile groups as long as they had behavioral data from the 48-month visit, and either the 14- or 24-month visits. The first group of children we identified were those who were consistently inhibited over time. A group of Continuously Inhibited children comprised those who were highly reticent during play with unfamiliar peers at 4 years of age (standardized score on reticence variable $> .50$), and also above the mean during at least one of the earlier assessments of behavioral inhibition (standardized score on behavioral inhibition aggregate at 14 or 24 months $> .00$). A group of Continuously Uninhibited children comprised those who were extremely low in social reticence at 4 years of age (standardized score on reticence variable $< -.50$), and also extremely low during at least one of the earlier assessments of behavioral inhibition (standardized inhibition score at either 14 or 24 months $< -.50$). A third group of children was identified who showed a distinct pattern of decreasing inhibition over time. Specifically, the Change group consisted of children who were highly inhibited during the 14-month or 24-month assessments (standardized inhibition score at 14 or 24 months $> .50$) but were below the mean in observed reticence during the 4-year assessment. It is interesting to note that the number of children who followed a pattern of change from highly uninhibited at 14 or 24 months of age to inhibited at 4 years of age was insufficient for statistical analysis.

Of the 153 selected infants, 115 children had sufficient data to allow classification. That is, these 115 children had complete behavioral data at 14 or 24 months and at 4 years of age. Consistent with the attrition analyses, the 38 children (153−115) with incomplete data were evenly distributed among the three 4-month temperament groups. Of the 115 children, more than half ($n = 64$) met the criteria for one of three behavioral profile groups. Specifically, 17 children were classified as Continuously Inhibited, 23 as Continuously Uninhibited, and 24 as Change, while 51 children were unclassifiable. A significant chi-square test revealed that the proportion of children in the behavioral profile groups, as well as those who were unclassifiable, was related to 4-month temperament, $\chi^2(6) = 30.79$, $p < .001$ (see Table 1). Specifically, 66% ($n = 29$) of the children in the High Negative temperament group met the criteria for one of the three behavior profile groups. Approximately equal proportions of the High Negative children were classified as Continuously Inhibited ($n = 12$) and Change ($n = 13$), whereas only four children from the High Negative temperament group displayed continuously uninhibited behavior over time. Fifteen of the High Negative children were unclassifiable (i.e., there was no clear pattern to their behavioral data over time). Therefore, of all children in the High Negative temperament group with sufficient data for classification, including those who could not be assigned to one of the three behavior profile groups, 27% (12 of 44) were classified as Continuously Inhibited, 29% (13 of 44) were classified as changing from Inhibited to Not Inhibited, 9% (4 of 44) were classified as Continuously Uninhibited, and 34% (15 of 44) could not be assigned into any of the three categories.

Fifty-nine percent ($n = 19$) of children in the High Positive group with sufficient data for classification met the criteria for one of the three behavior profile groups. Almost all of these children were classified as Continuously Uninhibited ($n = 15$). One child was classified as Continuously Inhibited and three were classified as changing from Inhibited to Not Inhibited. Thirteen children from the High Positive group did not show a consistent pattern of behavior over time and were assigned to the Not Classified category. Of all children in the High Positive temperament group with sufficient data for classification, 47% (15 of 32) were classified as Continuously Uninhibited, 3% (1 of 32) were classified as Continuously Inhibited, 9% (3 of 32) were classified as changing from Inhibited to Not Inhibited, and 41% (13 of 32) could not be classified into any of the three categories.

In contrast to these clear associations between the High Negative and High Positive 4-month temperament groups and profiles of behavioral inhibition, only 41% ($n = 16$) of children in the Low Reactive group with sufficient behavioral data met the criteria for classification into one of the three behavior profile groups. Four were classified as Continuously Inhibited, four as Continuously Uninhibited and eight as changing from Inhibited to Not Inhibited. The remaining 23 did not show a consistent pattern of behavior across age and were assigned to the Not Classified group. Of the 39 children in the Low Reactive temperament group, 10% (4 of 39) were classified as Continuously Inhibited, 10% (4 of 39) were classified as Continuously Uninhibited, 20% (8 of 39) were classified as changing from Inhibited to Not Inhibited, and 59% (23 of 39) could not be classified into any of the three behavioral profile groups.

Comparisons between Children Who Were Continuously Inhibited and Those Who Changed from within the High Negative Group

A series of analyses was conducted to examine whether it was possible to identify retrospectively factors that might account for the divergent pathways followed by children who had been classified as High Negative at 4 months of age (i.e., Continuously Inhibited versus Change). Specifically, children who were High Negative and in the Continuously Inhibited group were compared to children who were High Negative and in the Change group on maternal reports of temperament and measures of brain electrical activity (frontal power and asymmetry). In addition, the groups were compared in terms of their gender and experiences in nonparental care.

Observed Inhibition and Maternal Report of Temperament

Preliminary comparisons were conducted in order to ensure that the Continuously Inhibited group was

Table 1 Behavior Profile Classification by 4-Month Temperament Group

	Behavior Profile Classification			
4-Month Temperament Group	Continuously Inhibited	Continuously Uninhibited	Change	Not Classified
High Negative	12	4	13	15
High Positive	1	15	3	13
Low Reactive	4	4	8	23

Note: $\chi^2(6) = 30.79$, $p < .001$.

not simply more reactive to novelty to begin with relative to the Change group. In order to do so, the two groups were compared on original ratings of reactivity as assessed at 4 months of age. The two groups did not differ significantly on ratings of motor, positive, or negative reactivity at 4 months of age (all *p*s > 10). Similarly, the Continuously Inhibited and Change groups did not differ on maternal reports on the IBQ Distress to Novelty scale at 9 months of age, $t(18) = .75$, *ns*. Therefore, based on both behavioral observations and maternal reports, the Continuously Inhibited and Change groups of infants appeared to be equally distressed by novelty during the first year of life.

Although the two groups did not differ significantly on observed behavioral inhibition during the 14- or 24-month visits to the laboratory, $t(21) = -1.21$, *ns*; $t(21) = -1.05$, *ns*, respectively, children in the Continuously Inhibited group were rated as more Socially Fearful on the TBAQ at both ages compared to children in the Change group, $t(21) = 4.07$, $p = .001$ at 14 months and $t(20) = 2.56$, $p < .05$ at 24 months. Similarly, at 4 years of age more children in the Continuously Inhibited group were rated as Shy, $t(23) = 3.11$, $p < .01$, and less Sociable, $t(23) = -2.32$, $p < .05$, by their mothers on the CCTI compared to children in the Change group. In addition, children in the Continuously Inhibited group were rated by their mothers as having more behavior problems of an Internalizing nature than were children in the Change group, $t(19) = 2.71$, $p < .05$. Table 2 presents the means and standard deviations for the variables for each of the two groups of children.

Together these results suggest that children in these two groups began as equally reactive to novel events and stimuli in the first year of life. Although there were no differences in observed inhibition during either the 14- or 24-month assessments, maternal reports of temperament suggest that by 14 months of age these children were beginning to follow different developmental pathways.

Table 2 Mean Measures of Observed Inhibition and Maternal Reports of Temperament and Behavior Problems for the Continuously Inhibited and Change Groups

Measure	Continuously Inhibited	Change
9 months		
Distress to Novelty (IBQ)[a]	3.76 (.94)	3.39 (1.26)
14 months		
Observed Inhibition[b]	.96 (1.23)	1.53 (1.01)
Social Fear (TBAQ)[c]	4.89 (.77)	3.77 (.50)
24 months		
Observed Inhibition[d]	.28 (.75)	.69 (1.07)
Social Fear (TBAQ)[e]	5.07 (.89)	4.17 (.77)
48 months		
Observed Reticence[f]	.44 (.22)	.07 (.05)
Shyness (CCTI)[g]	3.32 (.80)	2.46 (.56)
Sociability (CCTI)[g]	3.15 (.54)	3.63 (.51)
Internalizing (CBCL)[h]	7.09 (4.39)	3.00 (1.94)

Note: Standard deviations are given in parentheses.
[a] $n = 10$ for Continuously Inhibited (CI), $n = 10$ for Change (Ch).
[b] $n = 10$ for CI, $n = 13$ for Ch.
[c] $n = 12$ for CI, $n = 11$ for Ch.
[d] $n = 11$ for CI, $n = 12$ for Ch.
[e] $n = 10$ for CI, $n = 12$ for Ch.
[f] $n = 12$ for CI, $n = 13$ for Ch.
[g] $n = 12$ for CI, $n = 13$ for Ch.
[h] $n = 11$ for CI, $n = 10$ for Ch.

EEG Asymmetry and Power

In the next series of analyses, we wished to examine whether the Continuously Inhibited and Change groups differed in patterns of brain electrical activity beginning from 9 months of age. At each age (9, 14, 24, and 48 months), an index of frontal asymmetry was computed by subtracting the natural log of F3 power from the natural log of F4 power. As such, positive values on this metric reflect greater left frontal activation, while negative values reflect greater right frontal activation. Figure 2 graphically depicts the mean asymmetry scores at 9, 14, 24, and 48 months for the two groups of children. The first two columns of Table 3 present the means, standard deviations, and *n*s for the Continuously Inhibited and the Change groups at each age.

Nine months. At 9 months of age, children in the Continuously Inhibited group displayed a greater degree of right frontal asymmetry, $M = -.25$, $SD = .21$, $n = 9$, compared to children in the Change group, $M = -.06$, $SD = .11$, $n = 8$, $t(15) = -2.81$, $p < .05$. To examine the hemispheric source of this difference in frontal power, a repeated measures ANOVA was computed with hemisphere as the within-subject factor (left/right) and behavior profile group as the between subjects factor (Continuously Inhibited/Change). There was a main effect of hemisphere, $F(1, 15) = 14.51$, $p < .01$; however, this was qualified by a significant interaction between hemisphere and behavior profile group, $F(1, 15) = 5.20$, $p < .05$. To interpret the significant interaction term, within group differences in hemispheric power were examined as well as between group differences in power within each hemisphere. Infants in the Continuously Inhibited group had significantly more power (or less activation) in F3 (left) than they did in F4 (right), paired-$t(8) = 3.61$, $p < .01$, whereas F3 and F4 power did not differ for infants in

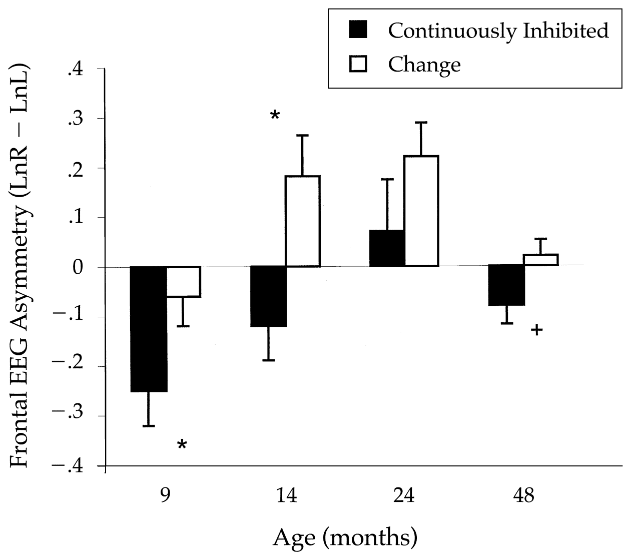

Figure 2 Frontal EEG asymmetry scores (LnR − LnL) for Continuously Inhibited and Change groups. At 9 months power was recorded in the 4–6 Hz frequency band. At 14, 24, and 48 months power was recorded in the 6–8 Hz frequency band. $^{*}p < .05$; $^{+}p < .10$.

the Change group, paired-$t(7) = 1.64$, *ns*. The Continuously Inhibited and Change groups did not differ in absolute power recorded from F3 or F4, $t(15) = .897$, *ns*, and $t(15) = -.09$, *ns*, respectively. A similar analysis using log power data from the parietal region revealed no asymmetry differences between the Continuously Inhibited and Change groups, $t(15) = .15$, *ns*.

Fourteen months. Similarly, the Continuously Inhibited and Change groups differed significantly in frontal asymmetry scores at 14 months of age, $t(16) = -2.31$, $p < .05$. Specifically, the Continuously Inhibited group exhibited right frontal asymmetry, $M = -.12$, $SD = .17$, $n = 6$, whereas the Change group showed left frontal asymmetry, $M = .18$, $SD = .29$, $n = 12$. To examine the hemispheric source of the difference in asymmetry scores, a repeated measures ANOVA was computed with hemisphere as the repeated factor (left/right) and behavior profile group as the between subjects factor (Stable Inhibited/Change). There was a significant interaction between hemisphere and behavior profile group, $F(1, 16) = 5.35$, $p < .05$. Follow-up comparisons revealed that the Change group had significantly more power (or less activation) in F4 compared to F3. There was not a significant difference in absolute power between F3 and F4 in the Continuously Inhibited group. The Continuously Inhibited and Change groups did not differ in absolute power recorded from F3 or F4, $t(16) = .18$,

Table 3 Means, Standard Deviations, and *n*s for Asymmetry Scores for Children in the Continuously Inhibited, Change, Comparison, and Continuously Uninhibited Groups

Age (months)	Continuously Inhibited	Change	Comparison	Continuously Uninhibited
9	−.25 (.21)	−.06 (.11)	.00 (.36)	.07 (.24)
	$n = 9$	$n = 8$	$n = 21$	$n = 13$
14	−.12 (.17)	.18 (.29)	.13 (.28)	−.01 (.28)
	$n = 6$	$n = 12$	$n = 19$	$n = 14$
24	.07 (.33)	.22 (.23)	.00 (.27)	.14 (.39)
	$n = 10$	$n = 11$	$n = 18$	$n = 14$
48	−.08 (.12)	.02 (.11)	−.05 (.12)	.07 (.19)
	$n = 10$	$n = 12$	$n = 21$	$n = 14$

ns, and $t(16) = -.85$, *ns*, respectively. The groups did not differ in asymmetry scores based on log power data from the parietal region, $t(16) = -.82$, *ns*.

Twenty-four months. At 24 months of age, the Continuously Inhibited group had a mean asymmetry score of .07, $SD = .33$, $n = 10$, and the Change group had a mean asymmetry score of .22, $SD = .23$, $n = 11$. These means did not differ significantly, $t(19) = -1.21$, *ns*. There were also no mean differences in parietal asymmetry.

Four years. At 4 years of age, during the eyes closed baseline condition, children in the Continuously Inhibited group displayed right frontal asymmetry, $M = -.08$, $SD = .12$, $n = 10$, compared to children in the Change group, who displayed greater left frontal asymmetry, $M = .02$, $SD = .11$, $n = 12$. The difference in asymmetry scores approached significance, $t(20) = -1.96$, $p = .06$. A repeated measures ANOVA was computed with hemisphere as the repeated factor (left/right) and behavior profile group as the between subject factor (Continuously Inhibited/Change). The interaction effect approached significance, $F(1, 20) = 3.85$, $p = .06$. Follow-up comparisons revealed that the Continuously Inhibited group tended to have less power in F4 than they did in F3. The Change group did not differ in absolute power between F3 and F4, and the Continuously Inhibited and Change groups did not differ from each other in terms of power in either F3 or F4. There were no significant differences between the groups when they were compared on an index of asymmetry computed using log power data from the parietal region, $t(20) = -.68$, *ns*.

Relations with Gender and Daycare Experience

To examine whether environmental variables such as gender and nonparental care experiences were related to the Continuously Inhibited versus Change

Table 4 Numbers of Children in Nonparental Care during the First 24 Months of Life for Continuously Inhibited and Change Groups

	Continuously Inhibited	Change
Exclusive parental care	9	4
Nonparental care	3	9

Note: Fisher Exact Test, $p < .05$.

classifications, a series of chi-square analyses were conducted. Although it appeared that gender of the child was related to change in inhibition status, the Fisher Exact Test was nonsignificant ($p < .11$). Eight of the 12 children in the Continuously Inhibited group were boys while nine of the 13 children in the Change group were girls.

Continuity and discontinuity of inhibition was significantly related to the child's experiences in nonparental care (i.e., nonparental care with at least one nonsibling in the group) during the first two years of life (Fisher Exact Test, $p < .05$; see Table 4). Of the 12 children in the Continuously Inhibited group, nine were exclusively cared for by a parent in the home during the first 24 months of life. In contrast, of the 13 children in the Change group nine were in nonparental care situations with at least one other child (nonsibling) during the first 24 months of life.

Comparisons between Children Classified as Continuously Inhibited and Continuously Uninhibited

To compare the temperamental and physiological profiles of Continuously Inhibited and Continuously Uninhibited children over time, a third group was included as a comparison group. Children selected as a comparison group were those from the 4-month Low Reactive group who did not meet the selection criteria for any of the three behavior profile groups. We selected this group because we believe they presented no clear temperamental bias (they were neither High Negative nor High Positive) and, in addition, displayed no clear behavior pattern over age. They were our "most average" children. A total of 23 children comprised this comparison group. Children from these three groups (Continuously Inhibited, Continuously Uninhibited, and Comparison) were compared on maternal report of temperament and behavior problems, and on indices of frontal EEG across all ages (see Table 5 and Figure 3).

Observed inhibition and maternal reports of temperament. At 9 months of age, the three groups differed on maternal reports (IBQ) of Smiling/Laughing and Distress to Novelty, $F(2, 42) = 5.63$, $p < .01$, and $F(2, 42) = 9.08$, $p < .01$, respectively. Post hoc comparisons revealed that children in the Continuously Inhibited group were rated as less positive in affect compared to children in both the Continuously Uninhibited and Comparison groups, Tukey's HSD, both ps $< .01$, and more distressed to novelty compared to children in both the Continuously Uninhibited group and Comparison groups, Tukey's HSD, both ps $< .001$.

Similarly, at both 14 and 24 months of age, the groups differed on maternal reports of positive affect (TBAQ Pleasure), $F(2, 44) = 4.64$, $p < .05$ and $F(2, 43) = 4.73$, $p < .05$, respectively. Specifically, children in the Continuously Uninhibited group were rated as higher in Pleasure than were children in the Continuously Inhibited group at both ages, Tukey's HSD, $p < .05$ and $p < .01$, respectively. The groups also differed on maternal reports of Social Fear at both 14 and 24 months of age, $F(2, 44) = 13.75$, $p < .001$ and $F(2, 43) = 9.60$, $p < .001$, respectively. At both ages, children in the Continuously Inhibited group were rated as more socially fearful than children in both the Comparison and Continuously Uninhibited groups, all Tukey's HSD, $p < .001$.

At 48 months of age children in the three groups were rated differently by their mothers on the CCTI dimensions of Shyness, $F(2, 46) = 12.82$, $p < .001$, and Sociability, $F(2, 46) = 4.88$, $p = .01$. Specifically, children in the Continuously Inhibited group were rated as more shy than children in the Comparison group, who in turn were rated as more shy than children in the Continuously Uninhibited group, all Tukey's HSD, $p < .05$. Similarly, children in the Continuously Uninhibited group were rated as more Sociable than were children in the Continuously Inhibited group, Tukey's HSD, $p < .01$.

The groups also differed on maternal reports of Internalizing behavior problems, $F(2, 43) = 4.77$, $p < .05$, such that children in the Continuously Inhibited group were rated as having more Internalizing problems compared to children in the Continuously Uninhibited and Comparison groups, both Tukey's HSD, $p < .05$. However, the groups did not differ on maternal reports of Externalizing problems, $F(2, 43) = 1.49$, *ns*.

EEG asymmetry and power. Figure 3 presents the mean frontal asymmetry scores for the three groups of children at each age. The first, third, and fourth columns of Table 3 present the means, standard deviations, and *n*s for the Continuously Inhibited, Comparison, and Continuously Uninhibited groups at each age.

At 9 months of age, an ANOVA revealed a main effect of group on the index of frontal asymmetry, $F(2, 40) = 3.37$, $p < .05$. Specifically, children in the

Table 5 Means and Standard Deviations on Measures of Observed Inhibition and Maternal Reports of Behavior Problems for the Continuously Inhibited, Comparison, and Continuously Uninhibited Groups

Measures	Continuously Inhibited	Comparison	Continuously Uninhibited
9 months			
Smiling (IBQ)[a]	4.55 (.58)	5.39 (.84)	5.50 (.64)
Distress to Novelty (IBQ)[a]	3.76 (.94)	2.49 (.76)	2.54 (.83)
14 months			
Observed Inhibition[b]	.96 (1.23)	−.26 (.64)	−.80 (.58)
Pleasure (TBAQ)[c]	4.47 (.48)	4.79 (.68)	5.13 (.45)
Social Fear (TBAQ)[c]	4.89 (.77)	3.76 (.63)	3.48 (.81)
24 months			
Observed Inhibition[d]	.28 (.75)	−.15 (.97)	−.73 (.65)
Pleasure (TBAQ)[e]	4.71 (.44)	5.26 (.58)	5.45 (.69)
Social Fear (TBAQ)[e]	5.07 (.89)	3.77 (.68)	3.57 (1.14)
48 months			
Observed Reticence[f]	1.70 (1.49)	.00 (.60)	−.76 (.17)
Sociability (CCTI)[g]	3.15 (.54)	3.49 (.42)	3.71 (.45)
Shyness (CCTI)[g]	3.32 (.80)	2.57 (.79)	1.87 (.60)
Internalizing (CBCL)[h]	7.09 (4.39)	3.50 (2.87)	3.93 (2.60)
Externalizing (CBCL)[h]	11.00 (5.67)	7.85 (6.91)	11.20 (6.01)

[a] $n = 10$ for Continuously Inhibited (CI), $n = 22$ for Comparison (C), $n = 13$ for Continuously Uninhibited (CU).
[b] $n = 10$ for CI, $n = 19$ for C, $n = 15$ for CU.
[c] $n = 12$ for CI, $n = 20$ for C, $n = 15$ for CU.
[d] $n = 11$ for CI, $n = 22$ for C, $n = 15$ for CU.
[e] $n = 10$ for CI, $n = 21$ for C, $n = 15$ for CU.
[f] $n = 12$ for CI, $n = 23$ for C, $n = 15$ for CU.
[g] $n = 12$ for CI, $n = 22$ for C, $n = 15$ for CU.
[h] $n = 11$ for CI, $n = 20$ for C, $n = 15$ for CU.

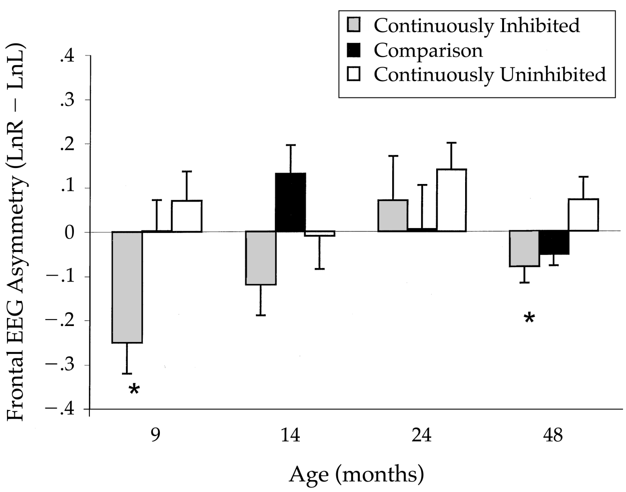

Figure 3 Frontal EEG asymmetry scores (LnR − LnL) for Continuously Inhibited, Comparison, and Continuously Uninhibited groups. At 9 months power was recorded in the 4–6 Hz frequency band. At 14, 24, and 48 months power was recorded in the 6–8 Hz frequency band.

Continuously Uninhibited group displayed a pattern of left frontal asymmetry, $M = .07$, $SD = .24$, $n = 13$, whereas children in the Continuously Inhibited group displayed a pattern of right frontal asymmetry, $M = -.25$, $SD = .21$, $n = 9$, Tukey's HSD, $p < .05$. The mean asymmetry pattern for children in the Comparison group was close to zero or symmetry, $M = .00$, $SD = .36$, $n = 21$, and did not differ significantly from either of the other groups. To examine the hemispheric source of the difference in asymmetry scores between the Continuously Inhibited and Continuously Uninhibited groups, a repeated measures ANOVA was computed with hemisphere as the repeated factor (left/right) and behavior profile group as the between subject factor (Continuously Inhibited, Continuously Uninhibited). There was neither a main effect of hemisphere nor a main effect of behavior profile group. There was, however, a significant behavior profile group × hemisphere interaction, $F(1, 20) = 10.92$, $p < .01$. To interpret the significant interaction term, within group differences in hemispheric power were examined as well as between group differences in power within each hemisphere. The infants in the Continuously Inhibited group had significantly more power (or less activation) in F3 (left) than they did in F4 (right), paired-$t(8) = 3.61$, $p < .01$, whereas F3 and F4 power did not differ significantly for infants in the Continuously Uninhibited group, paired-$t(12) = -1.12$, *ns*. The Continuously Inhibited and Continuously Uninhibited groups did not differ in power recorded from F3 or F4, $F(1, 20) = .55$, *ns* and $F(1, 20) = .43$, *ns*, respectively. There were no significant group differences in asymmetry scores using the log power data from the parietal region.

The three groups did not differ on indices of frontal asymmetry at 14 or 24 months of age. At 48 months of age, however, an ANOVA revealed a main effect of group, $F(2, 42) = 3.91$, $p < .05$, for frontal asymmetry during the eyes closed condition. Specifically, the Continuously Uninhibited group displayed greater left frontal asymmetry, $M = .07$, $SD = .19$, $n = 14$, compared to both the Continuously Inhibited, $M = -.08$, $SD = .12$, $n = 10$, and Comparison groups, $M = -.05$, $SD = .12$, $n = 21$, both Tukey's HSD, $p < .05$. To examine the hemispheric source of the difference in asymmetry scores, a repeated measures ANOVA was computed with hemisphere as the repeated factor (left/right) and behavior profile group as the between subjects factor (Continuously Inhibited, Comparison, and Continuously Uninhibited). There was neither a main effect of hemisphere nor a main effect of behavior profile group. There was, however, a significant behavior profile group $\times$ hemisphere interaction, $F(2, 42) = 3.96$, $p < .05$. To interpret the significant interaction term, within group differences in hemispheric power were examined as well as between group differences in power within each hemisphere. The children in the Continuously Inhibited and Comparison groups both showed a trend toward having more power (or less activation) in F3 (left) than they did in F4 (right), paired-$t(9) = 2.01$, $p = .08$ and paired-$t(20) = 1.96$, $p = .06$, respectively. F3 and F4 power did not differ for children in the Continuously Uninhibited group, paired-$t(13) = -1.40$, *ns*. The three groups did not differ in absolute power recorded from F3, $F(2, 42) = 1.18$, *ns*, or F4, $F(2, 42) = .37$, *ns*, respectively. There were no significant group differences in asymmetry scores using the log power data from the parietal region.

DISCUSSION

One of the main goals of this study was to examine the continuity of behavior over time in children selected during the first year of life for certain temperamental styles. Previous data and theory had suggested that young infants who express a high degree of motor reactivity and negative affect may be more likely, compared to less reactive infants, to exhibit behavioral inhibition as toddlers. In the present study, a large group of 4-month-old infants was screened for motor reactivity and affect expression patterns. Approximately 10% of these infants were identified as displaying high motor reactivity and high negative affect in response to novelty. When this select group of infants was followed over the course of 4 years, slightly more than one quarter of them displayed a pattern of continuously inhibited behavior. A similar number of infants in this group initially presented with behavioral inhibition but, over time, changed so that by 4 years of age they were no longer inhibited. The remaining children showed no discernable pattern over time.

This pattern of continuity and discontinuity in temperament was significantly different from that found in a group of infants selected at 4 months of age for low reactivity. Within that group, approximately 60% of the children did not show any identifiable pattern of continuity of inhibition (or lack of inhibition) over time. Few were inhibited or reticent at 4 years of age and fewer still were highly uninhibited at any assessment point across the 4-year period of the study. Thus, there appears to be a strong temperamental bias among high reactive, negative infants towards the expression of behavioral inhibition in the toddler years. The data from our study illustrate the notion of heterotypic continuity and coherence as described by Caspi (1998). Our hypothesis was that negative reactivity to novelty in infancy would be associated with behavioral inhibition in the toddler years and reticence in preschool children. This applied to only a subgroup of the high negative children, however.

It is important to note that our ability to identify continuity in inhibition over age is compromised by the unreliability of measurement at each point of our study. The wide range of intercoder reliability for the selection systems at 4 months of age as well as for the coding of behavioral inhibition at both 14 and 24 months of age may each have contributed to the apparent variability in outcome among our temperament groups.

To examine in greater detail the pattern of continuity and discontinuity among the High Negative group, we created two subcategories based on their behavior over time. One group of children remained inhibited over the first 2 years of life and was highly reticent at 4 years of age. A second group was inhibited during the first 2 years of life but by 4 years of age did not evidence behaviors reflecting social reticence. Comparison of these two groups revealed a number of important factors with respect to parent perceptions of the child as well as to the underlying physiology differentiating these two developmental patterns. During the first year of life, parents of High Negative infants viewed their infants as highly reactive to novelty and highly irritable. By the time infants were 14 months of age, however, parents of infants who eventually changed from inhibited to noninhibited rated their children as less socially fearful. Subsequently, at 24 and 48 months, parents continued to rate the children who changed as less fearful, less shy, and more sociable compared to those children who remained inhibited. Of interest is the fact that at 14 months of age (the first time parent ratings in these two subgroups differed) the two subgroups of High Negative infants were not different in their inhibition scores as derived from a laboratory assessment. Parent report, however, did differentiate the two groups. Parents observe their children across multiple contexts and thus may have noted important differences in their toddlers' fearful or inhibited behavior that were not identified in the lab setting. In addition, these perceptions may have contributed to the direction of change in the children's behavior over time.

Although our behavioral observations of the infants at 4 or 14 months of age did not discriminate between those High Negative infants who changed from inhibited to noninhibited compared to those who remained inhibited, there were significant differences in the pattern of brain electrical activity recorded at both 9 and 14 months of age. Specifically, infants who were to remain inhibited over the 4-year period of the study exhibited right frontal EEG asymmetry while infants who were to change exhibited less right frontal EEG asymmetry at nine months of age and left frontal EEG asymmetry at 14 months of age.

A similar difference in 9-month frontal EEG asymmetry between inhibited and noninhibited infants had previously been reported in the literature (Calkins et al., 1996). That study compared the High Negative and High Positive infants selected at 4 months of age who were in one of the two cohorts reported in the present report. Data in that paper compared these two groups on measures of EEG at 9 months of age and measures of behavioral inhibition at 14 months of age. The current findings are based on the pattern of children's behavior over a 4-year period and with twice the number of selected children. These findings compare two groups of High Negative infants who differ in their pattern of inhibition outcome over the 4-year study period (Continuously Inhibited versus Change). The group that remained stable and inhibited exhibited right frontal asymmetry. The group that changed exhibited left frontal asymmetry by 14 months of age. This asymmetry pattern was evident at nine and 14 months of age. Although there were no differences in frontal asymmetry at 24 months, there was a trend toward a similar difference in frontal asymmetry between groups when children were 4 years of age.

The right frontal EEG pattern observed in the continuously inhibited group is similar to previous findings with infants (Davidson & Fox, 1989; Fox, Bell, & Jones, 1992), children (Fox et al., 1996), and adults (Davidson, 1992; Schmidt & Fox, 1994). Prior studies with infants suggested that those infants exhibiting right frontal EEG asymmetry may be predisposed to express negative affect when confronted with a novel, mildly stressful situation.

The EEG measures brain electrical activity recorded from different scalp locations. The precise source generators of the EEG are not certain. Thus, claims regarding relations between differences among individuals in regional brain electrical activity must be conservative with regard to actual differences in neural location and activity. Nonetheless, recent research from Davidson's laboratory would seem to support the adequacy of the EEG in reflecting neural activity and the role of prefrontal cortex in emotion. In a recent paper, Davidson and coworkers (Larson et al., 1998) report a significant correlation between glucose metabolism and EEG activity suggesting that differences in EEG power may indeed reflect regional patterns of neural activation.

Of interest are recent studies (Davidson & Irwin, 1999) utilizing functional MRI neuroimaging technology that have found a reciprocal relation between amygdala activity and prefrontal activation. These studies suggest that prefrontal activation inhibits the amygdala in response to stimuli designed to elicit negative affect. The amygdala is a structure in the limbic system implicated in conditioned fear responses (Davis, 1992). Greater amygdala activation has been associated with the potentiation of conditioned fear (Davis, Hitchcock, & Rosen, 1987). Thus, individual variation in the degree to which prefrontal activity inhibits amygdala may be critical for the inhibition or lack of inhibition of fear behaviors. Kagan and his colleagues have suggested that the temperamental origins of behavioral inhibition may be related to the excitability of certain areas of the amygdala, specifically the central nucleus (Kagan & Snidman, 1991). This hypothesis is based in part on those animal studies in which this area has been identified as part of the "fear circuit" (LeDoux, 1987). Specifically, animals that were conditioned with a light and electric shock displayed heightened activation in these limbic areas and the fear responses could be dampened with ablation of selected brain regions within this circuit (Davis, 1992; Davis, Hitchcock, & Rosen, 1987). Based on these findings, Kagan argued that infants' motor and affective reactions to novelty might reflect activity in this fear circuit. Specifically, infants exhibiting high degrees of motor arousal and negative affect in response to novelty may do so because of an over-activated fear circuit. This over-activation would later be expressed in the form of behavioral inhibition to the unfamiliar during the toddler and preschool years. More recent work of Davis and colleagues (Davis, 1998; Davis & Lee, 1998) has suggested, however, that areas immediately outside the amygdala (specifically the bed nucleus) may be associated with nonconditioned fear and perhaps this neural center may have an important role in anxiety rather than fear. Irrespective of whether the neural circuits underlying inhibition are through the amygdala or bed nucleus, it is interesting to note that outputs from either lead to changes in autonomic, neurendocrine, and behavioral/motor responses which have a parallel to the findings in behavioral inhibition work with human infants and children.

Of significance to this study was the finding that frontal EEG asymmetry differentiated those High Negative infants who would remain inhibited and reticent over the 4-year period from those who would change in behavior. The High Negative infants who were stable in their inhibition displayed right frontal EEG asymmetry while the High Negative infants who changed displayed, as a group, left frontal EEG asymmetry. This psychophysiological measure may reflect an important marker for reticent behavior in young children suggesting that only a subgroup of the High Negative infants have a disposition toward reticence. Patterns of frontal EEG asymmetry at 9 months of age may reflect the temperamental disposition to regulate negative affect among these infants. Infants exhibiting left prefrontal EEG asymmetry may be predisposed to modulate negative affect by utilizing approach behaviors whereas infants exhibiting right prefrontal EEG asymmetry may be less likely to modulate negative responses.

Examination of differences in frontal power between groups might have assisted in the interpretation of the different patterns of EEG asymmetry. Activation measured from scalp leads over left prefrontal cortex has been associated with the expression of positive affect and approach behaviors whereas activation of right prefrontal cortex has been associated with the expression of negative affect and withdrawal behaviors. Both Davidson (Henriques & Davidson, 1991) and Fox (Fox et al., 1995) have reported that differences in frontal power are associated with these behavioral or motivational responses. Despite significant group differences in frontal EEG asymmetry, we could find no consistent pattern of difference between groups in either left or right frontal EEG power/activation.

Examination of factors associated with change in inhibition over time indicated that early childcare environments might be important in understanding the patterns of continuity and change in the expression of behavioral inhibition. Infants originally selected as High Negative at 4 months of age but who were placed in nonparental care situations during the first 2 years of life were more likely to change their behavior than were similarly reactive infants who remained in the exclusive care of their parents. There are a number of possible explanations for this relation. First, it may be that High Negative infants who were placed in nonparental care were temperamentally different (i.e., less reactive) compared to those who stayed at home. However, inspection of group means on 4-month scores for motor reactivity as well as positive and negative affect did not reveal any differences. Nor were there differences in maternal reports of negative reactivity when the infants were 9 months of age. Second, early infant temperament may influence a parent's decision to place a child in nonparental care. It is interesting to note that High Negative infants, as a group, were less likely to be placed in nonparental care compared to infants from the two other 4-month temperament groups, $\chi^2(2) = 7.24$, $p < .05$. Third, the experience of nonparental care, and/or the family environments experienced by children in nonparental care, may contribute to change in the phenotypic expression of the temperament. Because detailed descriptions of the home and nonparental care environments were not available, it is not possible to isolate the precise characteristics of these environments that contributed to patterns of continuity or change in inhibition. It could be that children in nonparental care situations had more experience interacting with people outside the immediate family unit, not only while in nonparental care but in the home as well. Or the relation might be due more directly to the experiences children have while in nonparental care. For example, it is possible that infants in nonparental care are more likely to interact with other infants and children and are less likely to have their immediate needs met in the same manner as are infants who stay at home. Increased exposure to different children and less immediate attention to individual reactions may have led to an increase in independence and decrease in fearfulness in the High Negative infants. Alternatively, personality characteristics of parents who choose to keep their children in their exclusive care, as expressed through parenting behaviors, may contribute to the continuity of inhibition. For example, previous reports by Arcus, Gardner, and Anderson

(1992) and Park, Belsky, Putnam, and Crnic (1997) indicated that inhibited infants who experienced less solicitous caregiving were more likely to exhibit decreased inhibition over time.

The data from this study suggest, as well, that there may be a second important temperamental subgroup of children who can be identified by their behavioral and psychophysiological patterning during the first year of life. At 4 months of age, we recruited infants who exhibited high motor reactivity and high positive affect. This group is different from the group selected by Kagan and Snidman (1991) as a comparison for the High Negative infants at 4 months of age. Whereas Kagan and Snidman recruited a sample of Low Reactive infants as a comparison group, the current study included both a Low Reactive and a High Positive group of infants. Follow-up of these latter infants revealed that close to one half maintained a profile of exuberance across the 4-year period of the study. These children displayed high sociability, lack of fear, and high approach relative to the continuously inhibited children. From the youngest age, these infants appeared to exhibit exuberance for novelty and social interaction that was unique and different from their inhibited counterparts. Parental report of infant temperament confirmed these observations. At 9,14, and 24 months of age the exuberant infants were more sociable and less distressed compared to the continuously inhibited infants. At age 4, parents rated these preschoolers as highly sociable and not shy or fearful. Although exuberant, these children did not appear to be hard to manage, nor did they exhibit maladaptive behaviors. They were not rated as higher in behavior problems of either an internalizing or an externalizing nature compared to the other children. Thus, while positive and social in their behavior, they were not dysregulated in their behavioral patterns.

This group of exuberant children displayed their own unique pattern of brain electrical activity. At 9 months of age they exhibited left frontal asymmetry. This same pattern was again evident at 4 years of age. Left frontal EEG has been previously associated with the tendency to express positive affect or emotions associated with approach tendencies and has been thought to underlie successful modulation of positive affect (Fox, 1994). Thus, the evidence suggests that as early as 9 months of age there is a physiological pattern reflecting the disposition toward sociability and approach among this subgroup of infants. The high degree of continuity found within the High Positive group may be a result of the degree to which parents in our sample value expressions of positive affect, sociability, and exuberance in their children. Certainly, these are traits that in Western culture are valued in young children. Infants with a disposition to express positive affect might be reinforced for this temperamental style and encouraged in their sociability. The high degree of continuity and little change over time would seem to indicate that these behaviors are rewarded. The relative consistency of behavior within this group compared to the other 4-month temperament groups suggests that early positive reactivity should be studied on its own as an important early infant disposition.

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ADDRESSES AND AFFILIATIONS

Corresponding author: Nathan A. Fox, Department of Human Development, 3304 Benjamin Building, University of Maryland, College Park, MD 20742; e-mail: nf4@umail.umd.edu. Heather A. Henderson and Kenneth H. Rubin are also at the University of Maryland; Susan D. Calkins is at the University of North Carolina at Greensboro; and Louis A. Schmidt is at McMaster University, Hamilton, Ontario, Canada.

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