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Longitudinal Stability of Temperamental Exuberance and Social–Emotional Outcomes in Early Childhood

Kathryn A. Degnan
University of Maryland

Amie Ashley Hane
Williams College

Heather A. Henderson and Olga Lydia Moas
University of Miami

Bethany C. Reeb-Sutherland and Nathan A. Fox
University of Maryland

The goals of the current study were to investigate the stability of temperamental exuberance across infancy and toddlerhood and to examine the associations between exuberance and social–emotional outcomes in early childhood. The sample consisted of 291 4-month-olds followed at 9, 24, and 36 months and again at 5 years of age. Behavioral measures of exuberance were collected at 9, 24, and 36 months. At 36 months, frontal electroencephalogram (EEG) asymmetry was assessed. At 5 years, maternal reports of temperament and behavior problems were collected, as were observational measures of social behavior during an interaction with an unfamiliar peer in the laboratory. Latent profile analysis revealed a high, stable exuberance profile that was associated with greater ratings of 5-year externalizing behavior and surgency, as well as observed disruptive behavior and social competence with unfamiliar peers. These associations were particularly true for children who displayed left frontal EEG asymmetry. Multiple factors supported an approach bias for exuberant temperament but did not differentiate between adaptive and maladaptive social–emotional outcomes at 5 years of age.

Keywords: temperament, longitudinal, EEG asymmetry, behavior problems, social-emotional outcomes

Positive reactivity to novelty is a temperamental construct associated with approach behavior and related to child social–emotional outcomes. Infants who display positive affect and motor reactivity to novel stimuli are more likely to show uninhibited, exuberant, and sociable behavior in infancy (Hane, Fox, Henderson, & Marshall, 2008; Putnam & Stifter, 2002) and toddlerhood (Calkins, Fox, & Marshall, 1996; Fox, Henderson, Rubin, Calkins, & Schmidt, 2001; Park, Belsky, Putnam, & Crnic, 1997; Putnam & Stifter, 2005). In addition, a combination of high positive affect and approach behavior is associated with impulsivity, positivity, and sociability in childhood (Fox et al., 2001; Pfeifer, Goldsmith, Davidson, & Rickman, 2002; Stifter, Putnam, & Jahromi, 2008). Together, positive reactivity, approach, and sociability define the broad construct of temperamental exuberance (Pfeifer et al., 2002; Putnam & Stifter, 2005; Rothbart, Ahadi, Hershey, & Fisher, 2001).

From a motivational systems perspective, exuberance is likely supported by an underlying motivation to approach, which guides individual levels of positive reactivity (Fox, 1991; Gray, 1982). This motivational tendency may be represented by distinct neural profiles, indices of which can be found in patterns of left frontal electroencephalogram (EEG) asymmetry (Fox, 1994). This continuation in positive approach across both behavioral and biological levels may be associated with adaptive, sociable behavior. However, if children do not develop methods of regulating their approach, they may display more oppositional or externalizing behavior problems (Polak-Toste & Gunnar, 2006; Stifter et al., 2008).

Historically, the field of child temperament has focused on children's problematic behaviors, linked with negative reactivity to frustration- or fear-eliciting events and stimuli (Rothbart & Bates, 2006). However, there has been a recent interest in the development of positive affect and temperamental exuberance (Dennis, 2006; Rydell, Thorell, & Bohlin, 2007; Stifter et al., 2008). Though exuberance is associated with low levels of both behavioral inhibition and social wariness (i.e., uninhibited behavior; Fox et al., 2001), there is evidence to suggest that these approach biases represent an orthogonal, independent temperamental construct (Dennis, 2006; Laptook et al., 2008; Pfeifer et al., 2002) associated with distinct outcomes. Therefore, the current study examines patterns of exuberance across early childhood, as well as the role of frontal EEG asymmetry in differentiating adaptive and mal-

Kathryn A. Degnan, Bethany C. Reeb-Sutherland, and Nathan A. Fox, Department of Human Development, University of Maryland; Amie Ashley Hane, Department of Psychology, Williams College; Heather A. Henderson and Olga Lydia Moas, Department of Psychology, University of Miami.

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Correspondence concerning this article should be addressed to Kathryn A. Degnan, Department of Human Development, 3304 Benjamin Building, University of Maryland, College Park, MD 20742. E-mail: kdegnan@umd.edu

adaptive social–emotional outcomes for highly exuberant children.

Definition of the Construct

Recently, exuberance has been put forth as a temperamental construct worthy of empirical investigation. It has been operationalized in multiple ways but is thought to be supported by an overall motivational state linked to reward sensitivity and expectancies (Polak-Toste & Gunnar, 2006). Although there is some debate as to which neural systems are implicated, positive reactivity and approach tendencies likely stem from heightened activation of the behavioral activation system (BAS), lower activation of the behavioral inhibition system (BIS), or systems that support the anticipation and saliency of rewarding stimuli (Depue & Collins, 1999; Gray & McNaughton, 2000; Panksepp, 1998; Zuckerman, 1991). Specifically, Gray's (1982) motivational view of temperament suggests that heightened BAS activity leads to greater conditioned approach and impulsivity. In addition, Depue and Collins' (1999) behavioral facilitation system (BFS) model suggests that dopaminergic projections to neural sites involved in encoding the salience of reward stimuli are implicated in individual differences in approach behavior. Therefore, individuals with heightened reactivity of the BAS and/or BFS may be quick to approach and experience greater positive affect in response to reward (Depue & Collins, 1999; Polak-Toste & Gunnar, 2006). It is these tendencies that are believed to support an exuberant style of temperament.

In the developmental literature, terms such as positive affectivity, surgency, extraversion, approach reactivity, impulsivity, and sensitivity to reward are often used to describe exuberant temperament (Polak-Toste & Gunnar, 2006; Rothbart & Bates, 2006). One research team has observed a subset of their infant sample as approaching novelty and enjoying social interaction, and suggested links to fearlessness, risk-taking, and social competence (Fox et al., 2001; Hane et al., 2008). Another research team described their childhood sample in terms of increased positive affect and a heightened, fearless approach to novel stimuli (Pfeifer et al., 2002). In general, positive affect and approach behavior together have been posited as the core, distinguishing factors involved in exuberance, surgency, or extraversion (Putnam & Stifter, 2005; Rothbart et al., 2001; Watson & Clark, 1997).

There are clear distinctions between the temperaments of behavioral inhibition and exuberance. For instance, one study examining measures of both behavioral inhibition and exuberance across childhood showed nonlinear relations between them, in which high exuberance was predicted by average levels, as opposed to low levels, of behavioral inhibition (Pfeifer et al., 2002). In addition, Putnam and Stifter (2005) described multiple types of behavior on the basis of levels of approach and positive or negative affect, where low approach combined with negative affect reflected behavioral inhibition and high approach combined with positive affect reflected exuberance. These profiles were also distinguished by latency to touch novel toys throughout infancy and concurrent behavior problems (Putnam & Stifter, 2005). Furthermore, work has shown that behavioral inhibition or low approach behavior is present when negative affect is high but little positive affect is present (Laptook et al., 2008; Park et al., 1997). Thus, the combination of positive affect and approach seems to define exuberant behavior. In addition, whereas positive affect emerges early and has been observed to display stability across infancy, increased wariness or low approach to novelty may not emerge until 8 months of age (Putnam & Stifter, 2002) and is observed to display both stability and instability across toddlerhood and childhood (Degnan & Fox, 2007), suggesting separate developmental patterns for behavioral inhibition and exuberance.

Developmental studies suggest high continuity of exuberance within measurement type, as well as moderate continuity between measurement types, across infancy and across childhood (Majdandžić & van den Boom, 2007; Stifter et al., 2008). Specifically, high levels of continuity have been reported for observed exuberance or uninhibited behavior (Fox et al., 2001; Putnam & Stifter, 2002). There also is support for moderate stability in parent report of positive affect across infancy and toddlerhood (Rothbart, 1986) and approach/sociability between infancy and middle childhood (Pedlow, Sanson, Prior, & Oberklaid, 1993). Furthermore, Rothbart and colleagues (2001) found strong associations between parent-reported positive affect in infancy and approach motivation in middle childhood. This work suggests that the behaviors that underlie exuberance represent a rather stable temperament construct. However, few studies have specifically examined the longitudinal continuity of exuberance, using behavioral measures, across both infancy and toddlerhood.

Outcomes of Exuberance

Overall, exuberance reflects a strong motivation to approach, especially in the presence of novelty, combined with a tendency for heightened positive affect. These positive approach tendencies are thought to be supported by biological systems linked to both an underlying motivational bias to approach (Gray, 1982) and a reactive reward-approach system (Depue & Collins, 1999). However, in relation to outcomes, there are multiple ways that approach behavior might be manifest. Consistent with the motivational framework, individuals with a heightened approach system would display greater positive affect and approach toward novel social stimuli in the form of positive sociability. In essence, they would revel in these social situations (Fox et al., 2001). Another viewpoint, supported by Depue & Collins' (1999) reactive BFS model, suggests that positive approach would occur only when one's goals are not being blocked. In turn, when these individuals' goals are blocked, they would respond with greater frustration and potentially aggressive behavior toward the source of the blockage. Thus, high levels of approach and positive reactivity to reward or novelty (i.e., exuberance) may lead to both socially adaptive and maladaptive outcomes.

Indeed, across empirical studies, exuberance and its associated factors of positivity and approach are related to both adaptive and maladaptive social–emotional outcomes. For example, two separate research programs have reported that parent-rated positive affect in elementary school children was related to greater externalizing behavior problems (Eisenberg et al., 1996; Rothbart, Ahadi, & Hershey, 1994). Observed exuberance, or positive reactivity to novelty, in infancy or toddlerhood has been related to greater mother-reported anger (Calkins et al., 1996), observed anger during an arm-restraint task (He et al., 2009), observed frustration during two emotionally challenging tasks (Dennis, 2006), and parent report of externalizing problems (Putnam & Stifter, 2005; Stifter et al., 2008) in toddlerhood and preschool.

Similarly, teacher ratings of surgency have been associated with greater peer ratings of girls' wild behavior in kindergarten (Berdan, Keane, & Calkins, 2008). Furthermore, studies of disinhibition (i.e., novelty seeking and impulsivity) have found associations with externalizing/antisocial diagnoses (Hirshfeld-Becker et al., 2002; Hirshfeld-Becker et al., 2006; Hirshfeld-Becker et al., 2007).

However, there is also evidence that exuberance, or positive reactivity, is associated with adaptive outcomes. Caspi and Silva (1995) reported that an outgoing, confident group of preschool children displayed less behavioral control but greater social potency at 18 years of age and again in adulthood (Caspi et al., 2003). An important factor for this confident group, as opposed to a similar undercontrolled group that showed more maladaptive outcomes, was the expression of high levels of positive affect during the preschool assessment (Caspi et al., 2003; Caspi & Silva, 1995). Indeed, positive reactive infants have shown greater joy and sociability in infancy and childhood (Fox et al., 2001; Hane et al., 2008), and exuberant children have shown greater organized (i.e., appropriate and productive) emotion-regulation behaviors (Dennis, Hong, & Solomon, 2010; Rydell et al., 2007). In addition, studies with adolescents have shown extraversion to be positively associated with greater self-esteem and teacher-reported social competence (Davey, Eaker, & Walters, 2003; Grazlano & Ward, 1992).

Somewhat limited in this literature is an examination of both externalizing and internalizing types of behaviors. In addition, most behavioral outcomes in these studies have been reported by adults or peers in the classroom. A more thorough investigation of observed social behavior with peers during structured interactions is needed in order to decipher the specific outcomes for children with an exuberant temperament. For example, social competence can be measured in multiple ways. In childhood, behaviors such as displaying positive affect, being socially engaged with peers, and attempting social problem solving would fall under this rubric. However, behaviors such as displaying negative affect, being uninvolved or unoccupied during structured peer activities, and acting aggressively toward others would be considered socially incompetent. Moreover, a multi-informant, multi-measure approach would help distinguish between perceived behavior and observed social behavior in adults.

Frontal EEG Asymmetry

One factor that may influence continuity in exuberance over time is frontal EEG asymmetry. Stemming from Gray's (1982) motivational systems theory, Davidson (1994a) suggested that the pattern of frontal EEG asymmetry might reflect an underlying motivational bias to respond to the environment in a particular manner. In general, motivation to withdrawal has been associated with resting right frontal asymmetry, whereas resting left frontal asymmetry has been associated with approach-related behavior (Davidson, 1994b). Therefore, if left asymmetry is a biomarker of approach, then children who show coherence between their electrophysiological profile of left frontal asymmetry and an early behavioral profile of approach and positivity may display a persistent pattern of temperamental exuberance across early childhood, including sustained positive affect in response to novelty and high sociability in peer interactions.

Davidson and Fox (1989) examined whether differences in EEG asymmetry are markers for individual differences in emotionality in infancy and argued that infants who show a characteristic left-sided frontal EEG asymmetry may be more likely to display positive affect. Although much of this work has focused on differences among behaviorally inhibited children, infants who are positively reactive to novelty have been shown to exhibit greater relative left frontal activation (Calkins et al., 1996; Fox et al., 2001; Hane et al., 2008).

Because greater left frontal EEG asymmetry has been linked to higher levels of positive reactivity, it should be implicated in temperamental exuberance. However, asymmetry may also be one mechanism influencing the continuity of temperamental exuberance over time (Coan & Allen, 2003). This idea is supported by evidence for the indirect effects of left frontal EEG asymmetry on the discontinuity in behavioral inhibition (Degnan & Fox, 2007). A study examining the relations between negative reactivity at 9 months of age and social wariness at 4 years of age found that frontal asymmetry moderated the relation between infant temperament and later social behavior. Specifically, negative reactivity predicted later wariness but only when children displayed right frontal EEG asymmetry at 9 months of age (Henderson, Fox, & Rubin, 2001). When children showed left frontal EEG asymmetry as infants, their negative reactivity in infancy did not correlate with their level of social wariness in preschool. Given that left frontal EEG asymmetry has been linked to approach, positive affect, and sociability (Fox, 1991), this characteristic may influence the development of stable approach tendencies (i.e., exuberance). Therefore, the current study examined left frontal EEG asymmetry in toddlerhood as a biomarker for approach motivation. Specifically, this measure of asymmetry was examined in order to explore whether a proximal approach-related neural profile was associated with a pattern of exuberance over time and whether it supported a particular pattern of social behavior later in early childhood.

Current Study

The first goal of the current study was to explore the longitudinal stability of exuberance—including positive affect, approach behavior, and sociability—across infancy and toddlerhood. Supported by the motivation systems perspective of temperament (Gray, 1982), positive affect and approach behavior, especially toward novel or social stimuli, have been associated with a general motivational bias to approach. In addition, previous work has suggested that these factors are interrelated and subsumed under the rubric of temperamental exuberance (Polak-Toste & Gunnar, 2006; Putnam & Stifter, 2005), although only a limited number of studies have used detailed examinations of all of these behaviors. Furthermore, previous work has found a high level of stability in exuberant reactions over childhood (Fox et al., 2001; Majdandić & van den Boom, 2007). Therefore, it was expected that a subset of children would display a high, stable exuberance profile.

The second goal of the study was to examine the relations between high, stable exuberance and social–emotional outcomes at 5 years of age. Throughout the literature, there are multiple ways positive approach behavior might be displayed. Consistent with the motivational framework, individuals with a heightened approach system would display greater positive affect and approach toward novel social stimuli (Fox et al., 2001). However, another viewpoint suggests that positive approach would occur only when one's goals are not being blocked. Hence, when goals are blocked, individuals would display frustration and aggressive behavior (Depue & Collins, 1999). In addition, empirical studies have found that infants who display positive affect and an approach-driven motivational bias show high levels of positive affect and sociability (Hane et al., 2008) but are also rated higher on caregiver reports of externalizing problems (see e.g., Stifter et al., 2008). Thus, it was expected that the high, stable exuberance profile would relate to both adaptive (e.g., social engagement and competence) and maladaptive (e.g., externalizing behavior problems) functioning at later ages.

Furthermore, resting frontal EEG asymmetry at 36 months was examined as a potential moderator of the associations between exuberance and behavioral outcomes. The motivation-direction hypothesis suggests that motivation to withdrawal or approach is associated with differences of asymmetries in resting frontal EEG activity (Davidson, 1994b). Specifically, the continuation of positive approach tendencies is thought to be supported by the neural mechanisms underlying left frontal EEG asymmetry. Therefore, the combination of an exuberant temperament and an underlying motivational bias for approach would be associated with greater sociability. However, this combination of temperament and neural bias may also predict externalizing behavior problems if methods of regulating this approach behavior fail. Furthermore, EEG asymmetry at 36 months was utilized in order to examine the level of motivational bias coexistent or proximal to the enduring patterns of temperamental exuberance in late toddlerhood, because these neural profiles could potentially change with development.

Method

Participants

As part of a longitudinal study conducted in a large metropolitan area of the Mid-Atlantic region of the United States, families were contacted by mail and screened by phone to ensure that infants were born full-term, had not experienced any serious illnesses or problems in development thus far, and were not on any long-term medication. As a result, 779 infants who met these criteria were brought into the laboratory at 4 months of age for an additional temperament screening, during which affect (positive and negative) and motor reactivity during the presentation of novel visual and auditory stimuli were observed (for more details, see Hane et al., 2008). Of these infants, 291 (135 male, 156 female) were selected on the basis of their classification into one of three different temperament groups: high negative/high motor reactive (n = 105); high positive/high motor reactive (n = 103); and control (n = 83), whose members were below the cutoffs on negative/positive/motor reactivity. Of these, 187 (64.3%) were Caucasian, 41(14.1%) were African American, and 63 (21.6%) were of other ethnicity. At the outset of the study, the majority of families spoke English at home, although approximately 2% spoke at least one additional language in the home (i.e., Spanish, Indian, Russian, or Chinese). Information regarding family income was not collected; however, most mothers were at least college-educated (84.4%), and the others (15.6%) had at least a high school education.

Procedures

Following the temperament screening at 4 months of age, infants were assessed at 9, 24, and 36 months, as well as 5 years of age. When the infants were 9 months, their behavioral and affective reactivity were assessed during a number of emotion-eliciting paradigms adapted from the Laboratory Temperament Assessment Battery (Lab-TAB; Goldsmith & Rothbart, 1999). At 24 and 36 months, behavior and affect were observed during behavioral inhibition (Fox et al., 2001) and risk-taking (Kochanska, 1995; Pfeifer et al., 2002; Putnam & Stifter, 2005) paradigms. In addition, resting EEG asymmetry was assessed at 36 months. At 5 years, children were brought to the laboratory for a peer dyad assessment that included free-play (FP), cleanup (CL), and social problem solving (ST) tasks, and mothers completed a series of questionnaires about their child's behavior and temperament.

Measures

Positive approach. At 9 months of age, infants completed a number of tasks from the Lab-TAB assessment (Prelocomotor Version 3.1; Goldsmith & Rothbart, 1999), including masks, unpredictable toys, puppets, and peek-a-boo. All were carried out in accordance with Lab-TAB guidelines (for more details, see Hane, Fox, Polak-Toste, Ghera, & Guner, 2006). Video recordings of the assessment were coded in epochs for aspects of positive affect and approach behavior. Specifically, intensity of smiling (0–2), intensity of positive motor behavior (0–2), and latency to display joy (reverse-scored; in seconds) were recorded during the puppet and peek-a-boo episodes, in addition to the intensity of approach behavior (0–3) and duration of attention toward the puppets (in seconds). For the toy and mask episodes, intensity of positive affect (0–3), intensity of positive motor behavior (0–2), and presence of approach toward the stimuli (0, 1) were recorded. Interrater reliability was achieved by two independent observers who were blind to all other data in the study. Reliabilities across 20% of the cases were achieved separately for each of the scales during each episode. Kappas ranged from .75 to .92 (M = .85) for the puppet codes, .81 to .84 (M = .83) for the peek-a-boo codes, .59 to .98 (M = .78) for the unpredictable toy codes, and .76 to .97 (M = .85) for the mask codes. Intraclass correlations (ICCs) computed for latency to joy during puppets (r = .93) and peek-a-boo (r = .84), as well as duration of attention to the puppets (r = .97), showed good interrater reliability.

All codes were standardized and averaged across epochs and within task and were subsequently averaged across tasks to create a Positive Approach measure (M = –0.03, SD = 0.49; α = .64). Although the puppet and peek-a-boo episodes were designed to elicit joy and approach and the toy and mask episodes were designed to elicit fear and withdrawal, some infants displayed positive affect and approach behavior during the toy and mask episodes. Therefore, behavior and affect across all four tasks were included so that higher scores on the composite score reflected a more extreme level of positive approach during both positive and negative emotion-eliciting stimuli.

Exuberance. At 24 and 36 months of age, children were assessed for exuberant affect and behavior during the standard behavioral inhibition paradigm (Fox et al., 2001; Kagan, Reznick, & Snidman, 1987), as well as an exuberance/risk-taking paradigm

(Kochanska, 1995; Pfeifer et al., 2002; Putnam & Stifter, 2005). The behavioral inhibition paradigm tasks were presented separately in a specified order, whereas the exuberance/risk-taking task stimuli were spread out across the playroom floor. At both time points, the behavioral inhibition paradigm included an FP task, a stranger approach task, a robot task, and a tunnel task (for more details, see Fox et al., 2001). At 24 months, the exuberance/risk-taking tasks included asking children to stick their hands into a black box, climb up steps to jump onto a mattress, watch a confetti popper, and approach a vacuum cleaner. At 36 months, the exuberance/risk-taking tasks included asking them to put on a blood pressure cuff, jump on a trampoline, touch a gorilla mask, climb up steps toward the wall, touch a realistic-looking snake, touch an unpredictable mechanical dragon toy, and sit close to the experimenter to read a book.

At each age, the children were asked by the experimenter to approach or perform each task in the order listed in the previous paragraph. If they did not approach, the experimenter was permitted to prompt them. Once they approached/performed the task, or it was clear that they were refusing to participate, the experimenter requested that they go on to the next set of stimuli. Throughout the risk-taking episodes, the experimenter maintained a neutral tone, except while reading the book to the children at 36 months, when the experimenter was permitted to try to engage them as much as possible. Each task was coded (in seconds) for latencies to touch/approach the stimuli, latency to vocalize, proportion of time spent in proximity to the mother, proportion of time spent in proximity to the experimenter, number of experimenter prompts, activity level (range: 0–3), and degree of approach toward stimuli (range: 0–3). Interrater reliability (ICCs across 20% of the cases) for these continuous measures ranged from .78 to .98 (M = .87). Each task was also coded in 30-s epochs for the presence of smiling, positive vocalizations, talking to the experimenter, smiling at the experimenter, gesturing to the experimenter, verbal initiations to the experimenter, and willingness to perform each task. Interrater reliability (kappas) for these measures ranged from .60 to .82 (M = .70).

All scores were standardized and averaged across task. Average scores that were highly skewed were dichotomized as 0 (*not present*) and 1 (*present*). Average codes were then combined into three subscales at each age: Positivity, Approach, and Sociability. Positivity and Approach subscales were designed on the basis of the work by Stifter and colleagues (e.g., Putnam & Stifter, 2005), and the Sociability subscale was added as a unique part of the current study. The Positivity subscale included smiling and positive vocalizations (24-month α = .74; 36-month α = .81). The Approach subscale included latencies to touch/approach the stimuli (reverse-scored), proximity to the mother (reverse-scored), latency to vocalize (reverse-scored), activity level, number of prompts (reverse-scored), degree of approach, and willingness to perform each task (24-month α = .63; 36-month α = .83). The Sociability subscale included all of the codes with reference to the experimenter, specifically: proximity, talking, smiling, gesturing, and verbal initiations (24-month α = .79; 36-month α = .86). Finally, an overall Exuberance subscale was computed at each age as the average of the Positivity, Approach, and Sociability subscales (24-month: M = 0.10, SD = 0.30, α = .79, intercorrelations: .44 to .66; 36-month: M = 0.10, SD = 0.29, α = .71, intercorrelations: .24 to .57).

EEG asymmetry. At 36 months of age, frontal EEG asymmetry was assessed during a baseline task for a total of 2 min. During the collection of EEG, children were asked to sit quietly and were read a book by the experimenter. While the child was quietly attending to the book, EEG was collected during four 30-s epochs—two epochs while the room was illuminated and two epochs while the room was darkened. In addition, glow-in-the-dark stars were pasted on the wall facing the child to distract them from the darkness of the room. Epochs alternated between light and dark conditions.

Prior to EEG collection, the toddler was fitted with a Lycra stretch cap (Electro-Cap International, Eaton, OH) containing electrodes according to the 10–20 system of electrode placement. EEG was recorded from 14 scalp sites (F3, F4, F7, F8, Fz, C3, C4, P3, P4, Pz, O1, O2, T7, and T8) and two mastoid sites (A1 and A2). An anterior midline site (Afz) served as the ground electrode, and the EEG was collected in reference to the vertex (Cz). The scalp underlying each electrode site was gently abraded, and electrolytic gel was inserted into the space between the scalp and the electrode. Impedances were considered acceptable if they were at or below 10 kΩ. The EEG data were digitized at a rate of 512 Hz using a 12-bit A/D converter ($\pm$2.5-V input range) and Snap-Master acquisition software (HEM Data Corporation, Southfield, MI). The EEG signal was amplified by a factor of 5,000 using custom bioelectric amplifiers (SA Instrumentation, San Diego, CA). The high-pass and low-pass filter settings were 0.1 Hz and 100 Hz, respectively. A 50-μV 10-Hz signal was recorded from each channel and used for calibration purposes. All further processing was carried out using the EEG Analysis System from James Long Company (Caroga Lake, NY).

EEG channels were re-referenced to an average-mastoids reference. Electrooculogram (EOG) was recorded from the left eye using two Beckman mini-electrodes. Data were displayed graphically for artifact scoring, and portions of the EEG that exceeded 225 μV were excluded from analysis. A significant number of infants with otherwise usable EEG data had poor-quality or no EOG signal. For those infants with good EOG data, EOG–EEG propagation factors were computed and found to be of small magnitude, indicating that the eye blinks had a limited effect on the EEG signal, including the frontal leads. Therefore, EOG data were not used in further analysis or processing.

EEG was analyzed with discrete Fourier transform (DFT) analysis using a 1-s Hanning window with 50% overlap. The power in picowatt ohms (or microvolts squared) was computed for each site. Spectral power data in single-hertz frequency bins from 1 to 30 Hz were computed for each of the epochs at each electrode site. Power in the 6–9 Hz alpha-range band was calculated for each site by summing the power in the single-hertz bands of these four frequencies across trials. The power data in the 6–9 Hz band was then log-transformed at frontal and parietal regions (F3 and F4, P3 and P4), and the asymmetry score was computed as power in the right hemisphere minus power in the left hemisphere (M = .01, SD = .19). Infants who had insufficient EEG data (less than 30 s of artifact-free data) or had asymmetry scores that were outside of a $\pm$1.00 range were excluded as outliers (n = 4). This final asymmetry score was normally distributed (M = .02, SD = .13). Because power is reciprocally related to activation, positive scores reflected left asymmetry, and negative scores reflected right asymmetry.

Five-year outcomes: Maternal report.

Child Behavior Checklist (CBCL 1.5-5; Achenbach & Rescorla, 2000). The CBCL was used to assess child behavior problems at 5 years of age. Mothers used a 3-point scale ranging from 0 (*never*) to 2 (*often*) to rate how often their children displayed a series of behavior problems. The CBCL is reduced to two broadband factors: Externalizing (i.e., physically attacks people) and Internalizing (i.e., unhappy, sad, or depressed). These scores have shown internal consistency and moderate stability across a 12-month period of time (for details, see Achenbach & Rescorla, 2000). As Achenbach and Rescorla (2000) have suggested for developmental research, the raw scores were used in the present study. Externalizing scores ranged from 0 to 30 ($M = 8.89$, $SD = 6.60$). Internalizing scores ranged from 0 to 20 ($M = 6.24$, $SD = 4.90$).

Child Behavior Questionnaire (CBQ; Rothbart et al., 2001). The CBQ was used as a measure of child temperament at 5 years of age. Mothers responded to whether 195 items were true about their child on a scale ranging from 1 (*extremely untrue*) to 7 (*extremely true*). These items then formed several dimensions that could be reduced to three broad factors (Rothbart et al., 1994): Surgency, Negative Affect, and Effortful Control. Surgency ($M = 4.58$, $SD = 0.63$) includes the dimensions of activity level, high-intensity pleasure, impulsivity, and shyness (reverse-scored). Negative Affect ($M = 3.89$, $SD = 0.70$) includes the dimensions of anger, discomfort, fear, sadness, and soothability (reverse-scored). Effortful Control ($M = 5.31$, $SD = 0.55$) includes the dimensions of attention focusing, inhibitory control, low-intensity pleasure, and perceptual sensitivity.

Colorado Child Temperament Inventory (CCTI; Rowe & Plomin, 1977). The CCTI was used as a measure of child temperament at 5 years of age. Mothers responded to whether 30 items described their child on a scale ranging from 1 (*unlike child*) to 5 (*like child*), which formed six subscales (Buss & Plomin, 1984). All subscales—including Emotionality ($M = 2.59$, $SD = 0.75$), Activity Level ($M = 3.93$, $SD = 0.65$), Attention ($M = 3.44$, $SD = 0.65$), Soothability ($M = 3.40$, $SD = 0.61$), Shyness ($M = 2.24$, $SD = 0.81$), and Sociability ($M = 3.78$, $SD = 0.61$)—were included in the present analysis. In addition, the Emotionality score was subtracted from the Soothability score to form the composite measure Emotion Regulation ($M = 0.82$, $SD = 1.15$).

Maternal-report composites. Subscales of temperament from the CBQ and CCTI were standardized and aggregated to form broad measures of Surgency, Negative Reactivity, and Regulation at 5 years of age. Specifically, CBQ Surgency, CCTI Activity Level, CCTI Shyness (reversed-scored), and CCTI Sociability scores were averaged to form the overall 5-year Surgency composite ($M = 0.01$, $SD = 0.76$; $\alpha = .77$; intercorrelations: .24 to .69). CBQ Negative Affect and CCTI Emotion Regulation (reverse-scored) scores were averaged to form the overall 5-year Negative Reactivity composite ($M = 0.01$, $SD = 0.91$; $\alpha = .78$), $r(222) = .64$. CBQ Effortful Control and CCTI Attention scores were averaged to form the overall 5-year Regulation composite ($M = 0.00$, $SD = 0.84$; $\alpha = .60$), $r(226) = .43$. Internalizing and Externalizing scores from the CBCL were left as separate indices of behavior problems at 5 years.

Five-year outcomes: Peer dyad. Children interacted with an unfamiliar peer in the laboratory during FP, CL, and ST episodes at 5 years of age. Children were introduced in the hallway and then led into the playroom to begin the assessment. The interactions were videotaped through a one-way mirror for later behavioral coding and analysis. A team of coders was assigned to each episode, and interrater reliability was achieved on at least 20% of each type of interaction prior to coding the remainder of the sample.

FP episode. For this task, a broad range of age-appropriate toys were scattered across the floor, and children were allowed to play for 10 min. Behavior was rated in 2-min epochs for wariness, unfocused/unoccupied behavior, aggression, social interest, activity level, negative affect, and positive affect. Ratings ranged from 1 (*none observed in epoch*) to 7 (*observed throughout epoch*). Interrater reliability (ICCs) ranged from .73 to .94 ($M = .82$). Each code was averaged across epochs.

CL episode. For this task, children were given 5 min to clean up the toys used in the FP episode. Coders assessed the duration of time (in seconds) spent cleaning up the toys, refusing to clean up the toys, and uninvolved in cleaning up the toys. Interrater reliability (ICCs) ranged from .90 to .97 ($M = .93$). For the current analyses, the proportion of time unoccupied ($M = .09$, $SD = .09$) was created by dividing the amount of time (in seconds) uninvolved (not cleaning or refusing) by the total time given to clean up the toys.

ST episode. For this task, children were asked to share a Leapster portable learning system (LeapFrog), which they could use to independently play an educational phonics game. The children were allowed to play with the toy for a total of 5 min. Social initiations were coded on the basis of schemes used by Rubin and Krasnor (1983) and Stewart and Rubin (1995).

An attempt to get the toy was coded when children were not in possession of the toy and initiated an interaction in order to gain control and/or make it clear to the peer that they wanted a turn. Attempts to get the toy were then classified by the goal of the initiation: stop action (explicit attempt to stop peer from using the toy), agonistic (aggression directed at the peer), or object acquisition (socially assertive but competent initiations). Each attempt was further classified by the type of strategy used to achieve the goal: passive (e.g., pointing or hovering), active (e.g., touching, hitting, or taking), or verbal (e.g., asking or telling). Agreement between coders (ICCs) on identifying attempts to get the toy was .91. ICCs for ST goals were .67 for stop action, .62 for agonistic, and .91 for object acquisition. ICCs for ST strategies were .77 for passive, .86 for active, and .93 for verbal strategies. Proportions of each goal and strategy classification were calculated by dividing the frequencies of each code by the total number of attempts to get the toy. Proportions of interest were object-acquisition goals ($M = .67$, $SD = .43$) and passive ($M = .07$, $SD = .18$), active ($M = .32$, $SD = .34$), and verbal ($M = .36$, $SD = .35$) strategies.

Social dyad composites. Measures from the FP, CL, and ST episodes were standardized and averaged to represent Social Reticence, Disruptive Behavior, and Social Competence at 5 years of age. All three composites were formed on a theoretical basis and confirmed by factor analysis. Specifically, Social Reticence was formed on the basis of work by Rubin and colleagues (see e.g., Fox et al., 2001) and consisted of FP Wariness, FP Unfocused/Unoccupied, CL Proportion of Time Unoccupied, and ST Passive

Strategies ($M = -0.03$, $SD = 0.62$; eigenvalue = 1.58, average loading = .62). Overall, the definitions of these scores were consistent with the construct of social reticence examined extensively by Rubin and colleagues (Rubin, Coplan, Fox, & Calkins, 1995), whereby children remain vigilant to the peer but do not interact, remaining in an unoccupied, onlooking state. Disruptive Behavior was formed on the basis of existing literature on behavior that would be considered disruptive and problematic in early childhood (see e.g., Campbell, 2006; Kopp, 1989) and consisted of the average of FP Negative Affect, FP Aggression, ST Active Strategies, and ST Verbal Strategies—reverse-scored ($M = 0.01$, $SD = 0.61$; eigenvalue = 1.29, average loading = .52). Social Competence was formed to reflect positive sociable behavior that supported the goal of the individual tasks and consisted of the average of FP Social Interest, FP Positive Affect, FP Activity Level, ST Positive Affect, and ST Proportion of Object-Acquisition Goals ($M = 0.00$, $SD = 0.62$; eigenvalue = 1.81, average loading = .52).

Summary of measures. In the present study, measures of temperamental exuberance included positive temperamental reactivity group membership at 4 months; Positive Approach at 9 months; and Positivity, Approach, Sociability, and overall Exuberance at 24 and 36 months of age. Social–emotional outcome measures at 5 years included maternal report composites of Internalizing, Externalizing, Surgency, Negative Reactivity, and Regulation, as well as observed behavior composites of Social Reticence, Disruptive Behavior, and Social Competence. Table 1 gives a detailed breakdown of the measures included in each of these composites. Of the possible 291 participants recruited at 4 months, 212 (73%) had complete data at 9 months, 224 (77%) had complete data at 24 months, and 218 (75%) had complete data at 36 months. Reasons for missing data included technical difficulties with the video collection, difficulty scheduling laboratory visits at these ages, family relocating, and permanent attrition ($n = 13$). Families missing data at 9, 24, and/or 36 months were not significantly different from the overall sample by 4-month temperament group, $\chi^2(2, N = 291) = 2.44$, $p = .30$; gender, $\chi^2(1, N = 291) = .73$, $p = .39$; or any of the 5-year outcome measures (all ps $> .30$). Additional data was lost for the 36-month frontal EEG asymmetry acquisition due to technical difficulties or child refusal. Participants missing EEG data were not significantly different from those with complete data by gender, $\chi^2(1, N = 291) = .06$, $p = .81$, but there was a significant difference by 4-month temperament group, $\chi^2(1, N = 291) = 6.05$, $p = .05$. Further investigation revealed that there were significantly more control participants missing EEG data at 36 months than participants selected for positive or negative reactivity ($p < .05$).

Of the originally selected 291 participants, 226 had complete maternal report data and 206 had complete peer dyad data at 5 years. Reasons for missing data included technical difficulties with the video collection, difficulty scheduling a laboratory visit, family relocating, and permanent attrition since infancy ($n = 13$). Participants with missing 5-year maternal report data were not significantly different from those with complete data by gender, $\chi^2(1, N = 291) = .57$, $p = .45$, or 4-month temperament group, $\chi^2(1, N = 291) = 3.46$, $p = .18$. Participants with missing 5-year peer dyad data were not significantly different from those with complete data by gender, $\chi^2(1, N = 291) = 1.62$, $p = .20$, but there was a significant difference by 4-month temperament group, $\chi^2(1, N = 291) = 6.72$, $p = .04$. Further investigation revealed that there were significantly more control participants missing peer dyad data at 5 years than participants selected for positive or negative reactivity ($p < .05$).

As described in the next section, the longitudinal analysis of the exuberance measures used maximum likelihood estimation, which allows for missing data longitudinally and assumes the missing

Table 1
Study Measures by Age, Construct, and Subscale

Construct, age, and measure	Behavior/subscale
Exuberance profile	
4-mo. Positive Reactivity	Positive affect and motor reactivity
9-mo. Positive Approach	Intensity of smiling, positive motor behavior, peak to joy, attention toward puppets, and approach toward stimuli
24- and 36-mo. Positivity	Smiling and positive vocalizations
24- and 36-mo. Approach	Speed to touch/approach the stimuli, distance from mother, speed to vocalize, activity level, number of prompts (reverse-scored), degree of approach, and willingness to perform each task
24- and 36-mo. Sociability	Proximity, talking, smiling, gesturing, and verbal initiations (all toward experimenter)
Frontal EEG asymmetry	
36-mo. Baseline EEG	Power in right hemisphere minus power in the left hemisphere
Behavior problems	
5-yr. Internalizing	CBCL Emotionally Reactive, Anxious/Depressed, Somatic Complaints, and Withdrawn subscales
5-yr. Externalizing	CBCL Attention Problem and Aggressive Behavior subscales
Temperament	
5-yr. Surgency	CBQ Surgency, CCTI Activity Level, CCTI Shyness (reverse-scored), and CCTI Sociability
5-yr. Reactivity	CBQ Negative Affect and CCTI Emotional Regulation (reverse-scored)
5-yr. Regulation	CBQ Effortful Control and CCTI Attention
Social behavior	
5-yr. Social Reticence	FP Wariness, FP Unfocused, CL Proportion of Time Unoccupied, and ST Passive Strategies
5-yr. Disruptive Behavior	FP Negative Affect, FP Aggression, ST Active Strategies, and ST Verbal Strategies (reverse-scored)
5-yr. Social Competence	FP Social Interest, FP Positive Affect, FP Activity Level, ST Positive Affect, and ST Proportion of Object-Acquisition Goals

Note. EEG = electroencephalogram; CBCL = Child Behavior Checklist; CBQ = Child Behavior Questionnaire; CCTI = Colorado Child Temperament Inventory; FP = free play; CL = cleanup; ST = social problem solving.

data across repeated measures are missing at random (Little & Rubin, 1987; Muthén & Muthén, 2007). An analysis of the exuberance data across infancy and childhood suggests that patterns of missing data did not violate the assumption that it was missing completely at random (MCAR), Little's MCAR $\chi^2(9) = 4.91$, $p = .84$. In addition, analyses of the data included in each of the regression analyses discussed in the next section (Exuberance profiles, EEG asymmetry, and 5-year data) suggest that patterns of missing data per analysis do not violate the assumptions of missing data, $\chi^2(7) = 5.67$, $p = .58$, and $\chi^2(7) = 12.63$, $p = .08$, for 5-year maternal report outcomes and peer dyad outcomes, respectively. Therefore, all available data are used throughout each analysis.

Results

Preliminary Analyses

All measures were examined for assumptions of normality (descriptive statistics are reported throughout the Method section). A series of *t* tests were used to examine gender effects on all measures. Gender was not associated with any of the measures of positive reactivity, approach, exuberance, or asymmetry across infancy and toddlerhood (all *p*s $> .05$). However, gender was associated with a number of 5-year outcome measures. Specifically, boys were rated as higher on Externalizing problems, $t(223) = 2.67$, $p = .01$, $d = 0.35$, and Surgency, $t(227) = 3.18$, $p = .00$, $d = 0.42$, and lower on Regulation, $t(227) = -2.85$, $p = .01$, $d = 0.38$, than were girls. In addition, boys displayed greater Social Competence, $t(204) = 2.03$, $p = .04$, $d = 0.29$, and Disruptive Behavior, $t(204) = 2.40$, $p = .02$, $d = 0.33$, than did girls during the peer dyad assessment. Given these effects, gender was entered as a control variable in all predictive analyses that included 5-year externalizing behavior, surgency, regulation, social competence, and disruptive behavior as dependent variables.

Analysis of variance was used to examine 4-month temperament group differences on all independent and dependent measures at 9 months, 24 months, 36 months, and 5 years of age. Temperament group at 4 months was significantly related to 9-month Positive Approach, $F(2, 211) = 3.20$, $p = .04$, $\eta_p^2 = .03$, with the 4-month positive reactivity ($M = 0.02$, $SD = 0.45$) and the control groups ($M = 0.04$, $SD = 0.53$) displaying significantly greater 9-month positive approach than did the negative reactivity group ($M = -0.14$, $SD = 0.46$). Temperament group was not significantly associated with any of the 24-month and 36-month exuberance or the 5-year outcome measures (all *p*s $> .05$).

Pearson correlations were used to examine relations between all continuous independent and dependent measures at 9, 24, and 36 months and 5 years of age. In addition, all correlations were confirmed via visual inspection of scatter plots. Positive Approach at 9 months was significantly related to 24-month Exuberance, $r(166) = .22$, $p = .01$, $d = 0.45$. In addition, Exuberance at 24 months was significantly related to 36-month Exuberance, $r(193) = .31$, $p < .001$, $d = 0.65$, and 5-year Social Reticence, $r(180) = -.24$, $p = .001$, $d = 0.49$. Finally, Exuberance at 36 months was significantly related to 5-year Surgency, $r(195) = .29$, $p < .001$, $d = 0.60$, and 5-year Social Reticence, $r(183) = -.16$, $p = .03$, $d = 0.32$.

Longitudinal Profiles of Exuberance

In order to examine associations between longitudinal patterns of exuberance and outcomes at 5 years, latent longitudinal profiles of exuberance were estimated. To generate these profiles, latent class analysis (LCA), a subtype of structural equation mixture modeling (SEMM), was performed using Mplus 5.21 (Muthén & Muthén, 2007). This type of analysis seeks to identify unmeasured (i.e., latent) class membership among participants using categorical and/or continuous observed indicator variables, as in structural equation modeling. Although similar to cluster analysis, LCA offers many advantages over traditional cluster techniques. First, use of SEMM's maximum likelihood method assumes the data are MCAR, which allows the model parameters to be informed by all cases that contribute a portion of the data and is recommended as an appropriate way to accommodate missing data (Little & Rubin, 1987; Schafer & Graham, 2002). An analysis of the exuberance data across infancy and childhood suggests that patterns of missing data did not violate the assumption that data were MCAR, Little's MCAR $\chi^2(9) = 4.91$, $p = .84$, $\varphi = .13$. Second, unlike traditional cluster analysis algorithms, which group cases near each other by some definition of distance (e.g., Euclidean distance for k-means cluster analysis), the LCA approach relies on a formal statistical model based on probabilities to classify cases. The maximum likelihood method estimation iteratively calculates model parameters to be those that are most likely to account for the observed data. Then classification is based on Bayes' theorem, which computes a posterior probability (on the basis of a function of the model's parameters) of membership for each latent class. Individuals can then be assigned a latent class for which their posterior probability is highest (Dayton, 1998; McCutcheon, 1987; Muthén, 2004).

In the present study, longitudinal latent classes were estimated using the observed measures of exuberance at 4, 9, 24, and 36 months of age. Specifically, a categorical indicator of positive reactivity group membership at 4 months (0 = *not in positive group*, 1 = *in positive group*), the Positive Approach composite at 9 months, and the Exuberance score composites at 24 and 36 months were used to define the longitudinal profiles of exuberance in the current sample. A model using the individual scores of Positive Affect, Approach, and Sociability at 24 and 36 months resulted in the same profiles, and therefore the more simplified version (i.e., using composites of exuberance) is presented here. Because different measures were used across time, the average proportion of 4-month positive group membership, as well as the average level of 9-month Positive Approach and 24- and 36-month Exuberance, were estimated independently within each class (i.e., latent profile analysis [LPA]; Gibson, 1959), as opposed to estimating latent growth parameters (i.e., intercept and slope). Models with one–four profiles were tested. Best model fit was assessed using Bayesian information criteria (BIC), according to which the lowest number indicates best fit. This index has been shown to identify the appropriate number of groups in finite mixture models and penalizes the model for the number of parameters, thus guarding against models overfitting the data. In addition, the Lo–Mendell–Rubin likelihood (LMRL) ratio test (Lo, Mendell, & Rubin, 2001), which tests the significance of the –2 log-likelihood difference between models with k and k – 1 profiles, was also used.

The LPA was computed using all 291 participants who had data for at least one time point (i.e., 4 months of age). Model fit (BIC) for the current sample was 889.05 for one profile, 884.21 for two profiles, 906.17 for three profiles, and 928.52 for four profiles. The LMRL showed that the two-profile model was significantly better than the one-profile model ($p < .01$); however, the three-profile model was not significantly better than the two-profile model ($p = .40$), and the four-profile model was not significantly better than the three-profile model ($p = .30$). In addition, the four-profile model produced reliability problems with the estimates. Given that the lowest BIC value was combined with a significant LMRL for the two-class model, this model was chosen as the best fitting model. The posterior probabilities of membership were high ($M = .83$), reflecting adequate confidence in profile assignment. The high Exuberance profile ($n = 83$, or 28%; 50 female) displayed a higher percentage of membership in the 4-month positive group (46%) and higher levels of 9-month Positive Approach, 24-month Exuberance, and 36-month Exuberance. The low Exuberance profile ($n = 208$, or 72%; 105 female) displayed a lower percentage of membership in the 4-month positive group (31%), and lower levels of 9-month Positive Approach, 24-month Exuberance, and 36-month Exuberance. Means of each standardized Exuberance measure from 9 to 36 months are presented in Figure 1 for each latent class. This figure shows that the two classes were indeed distinct and their distribution of scores was nonoverlapping at each measurement point. However, for the remaining analyses, the continuous probability score of membership in the high Exuberance profile was used as the measure of Exuberance profile in order to preserve the level of individual variability.

Profiles of Exuberance and 5-Year Outcomes

A series of hierarchical linear regressions were computed to test the associations of the longitudinal profiles of exuberance, EEG asymmetry, and their interaction with measures of behavior and temperament outcomes at 5 years of age. When appropriate, gender was controlled for in the first step and the interactions were entered in the second step of each regression analysis. Both the high-exuberance probability score and the frontal EEG asymmetry score were mean-centered and multiplied together to compute the interaction term. These mean-centered scores and interaction terms were used in the regression analyses (see Tables 2 and 3). Interactions were then probed and plotted according to standards outlined by Aiken and West (1991). High (left) and low (right) values of the moderator (frontal EEG asymmetry) were computed as ±1 *SD* (0.13) when investigating any significant interactions. Follow-up statistical tests from these probes are noted in the next sections.

Predicting 5-year maternal report measures. Individual regressions were computed for the maternal report measures of Internalizing, Externalizing, Surgency, Negative Reactivity, and Regulation composites from the 5-year assessment (see Table 2). There were no main or interaction effects of Exuberance profile or asymmetry on 5-year Internalizing, Negative Reactivity, or Regulation. However, Exuberance profile and asymmetry did significantly interact to predict ratings of 5-year Surgency. In addition, their interaction was associated with ratings of 5-year Externalizing at a trend level.

Follow-up regressions revealed that Surgency maternal ratings at 5 years were associated with being in the high Exuberance

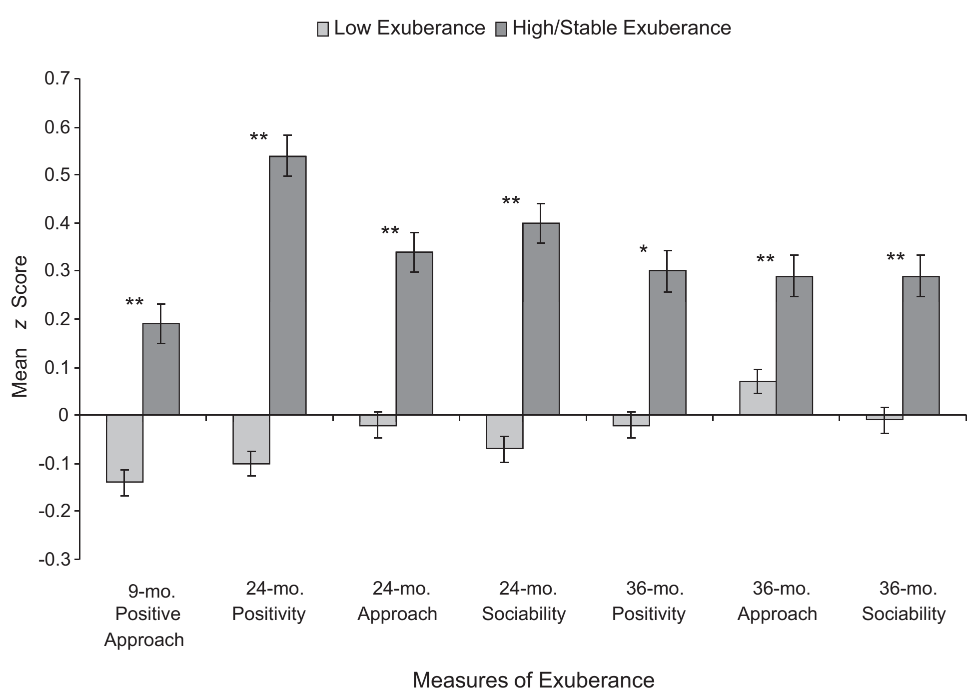

Figure 1. Latent profiles mean differences on measures of exuberance across infancy and toddlerhood. Error bars represent standard errors. * $p < .05$. ** $p < .01$.

Table 2
Hierarchical Linear Regression Analyses Predicting 5-Year Maternal Report Outcomes

Step and variable	Internalizing		Externalizing		Surgency		Reactivity		Regulation	
	R^2	β	R^2	β	R^2	β	R^2	β	R^2	β
Step 1 (*df*s = 3, 129)	.02		.02		.06[†]		.01		.09[*]	
Gender[a]				−.12		−.19[*]				.29[*]
Probability of high exuberance		−.15		.09		.11		−.07		−.06
Frontal EEG asymmetry		−.00		.03		.12		−.01		−.05
Step 2 (*df*s = 4, 129)	.03		.05[†]		.09[*]		.02		.10	
Gender[a]				−.11		−.18[*]				.28[*]
Probability of high exuberance		−.15		.08		.11		−.07		−.06
Frontal EEG asymmetry		−.01		−.01		.07		−.05		−.02
Probability of High Exuberance × Frontal EEG Asymmetry		.05		.17		.18[*]		.14		−.12

Note. EEG = electroencephalogram.
[a] Entered into model only when significantly related to outcome measure in preliminary analysis.
[†] $p = .06$. [*] $p < .05$.

profile, but only when children exhibited left frontal EEG asymmetry (see Figure 2). Specifically, when children exhibited left frontal EEG asymmetry, the probability of being in the high Exuberance profile was positively related to higher ratings of Surgency at 5 years (*B* = 0.61, *SE* = 0.26, 95% CI [0.09, – 1.13], β = .28), *t*(129) = 2.32, *p* = .02. However, when children exhibited right frontal EEG asymmetry, the probability of being in the high Exuberance profile was not significantly related to Surgency (*B* = –0.15, *SE* = 0.27, 95% CI [–0.68, –0.39], β = –.07), *t*(129) = –0.56, *p* = .58.

Follow-up regressions revealed that Externalizing problems at 5 years were associated with being in the high Exuberance profile, but only when children exhibited left frontal EEG asymmetry (see Figure 3). Although this was only a trend-level interaction effect, the simple slopes analyses showed that there was indeed a close to significant effect for the probability of being in a high Exuberance profile on Externalizing problems when children exhibited left frontal EEG asymmetry (*B* = 4.61, *SE* = 2.29, 95% CI [0.08, – 9.14], β = .25), *t*(128) = 2.01, *p* = .05. However, when children exhibited right frontal EEG asymmetry, the probability of being in a high Exuberance profile was not significantly related to Externalizing problems (*B* = –1.66, *SE* = 2.37, 95% CI [–6.36, – 3.03], β = –.09), *t*(129) = –0.70, *p* = .49.

Predicting 5-year peer dyad behavior measures. Individual regressions were computed for the observed measures of Social Reticence, Disruptive Behavior, and Social Competence from the 5-year peer dyad assessment (see Table 3). There was a main effect of Exuberance profile on 5-year Social Reticence, such that the greater the probability of having a high Exuberance profile, the lower the frequency of Social Reticence behavior during the 5-year peer dyad assessment. There was also a main effect of 36-month frontal EEG asymmetry on 5-year Disruptive Behavior, such that children with greater left frontal asymmetry scores at 36 months displayed greater Disruptive Behavior during the 5-year peer dyad assessment. There was also a significant interaction of Exuberance profile and asymmetry on 5-year Social Competence.

Follow-up regressions revealed that Social Competence at 5 years was associated with being in the high Exuberance profile, but only when children exhibited left frontal EEG asymmetry (see Figure 4). Specifically, when children exhibited left frontal EEG asymmetry, the probability of being in a high Exuberance profile

Table 3
Hierarchical Linear Regression Analyses Predicting 5-Year Peer Dyad Outcomes

Step and variable	Social Reticence		Disruptive Behavior		Social Competence	
	R^2	β	R^2	β	R^2	β
Step 1 (*df*s = 3, 129)	.05[*]		.07[*]		.06[†]	
Gender[a]				−.13		−.23[*]
Probability of high exuberance		−.21[*]		−.08		.11
Frontal EEG asymmetry		.04		.18[*]		.03
Step 2 (*df*s = 4, 129)	.05		.07		.09[*]	
Gender[a]				−.13		−.22[*]
Probability of high exuberance		−.21[*]		−.08		.10
Frontal EEG asymmetry		.04		.15		−.03
Probability of High Exuberance × Frontal EEG Asymmetry		.02		.09		.19[*]

Note. EEG = electroencephalogram.
[a] Entered into model only when significantly related to outcome measure in preliminary analysis.
[†] $p = .06$. [*] $p < .05$.

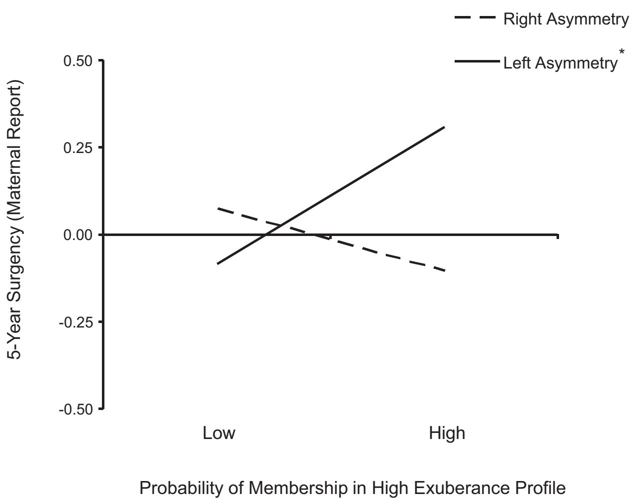

Figure 2. Probability of High Exuberance Profile × 36-Month Frontal EEG Asymmetry interaction predicting ratings of 5-year surgency. * $p < .05$.

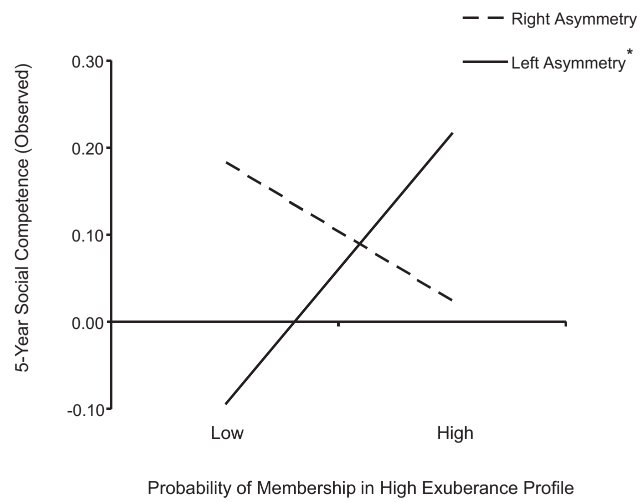

Figure 4. Probability of High Exuberance Profile × 36-Month Frontal EEG Asymmetry interaction predicting 5-year social competence during a peer dyad. * $p < .05$.

was positively related to greater Social Competence behaviors at 5 years ($B = 0.49$, $SE = 0.22$, 95% CI [0.06, 0.92], $\beta = .29$), $t(122) = 2.26$, $p = .03$. However, when children exhibited right frontal EEG asymmetry, the probability of being in a high Exuberance profile was not significantly related to Social Competence ($B = -0.15$, $SE = 0.22$, 95% CI [−0.59, 0.29], $\beta = -.09$), $t(122) = -0.68$, $p = .50$.

Discussion

The current study examined multiple indicators of exuberance across infancy and toddlerhood to investigate their longitudinal stability, as well as the adaptive and maladaptive outcomes of this temperamental profile at 5 years of age. From a motivational systems perspective, exuberance is likely supported by an underlying motivation to approach (Fox, 1991; Gray, 1982). Continuity in these approach biases has been suggested to result in multifinality, whereby different outcomes may result due to additional intervening factors (Polak-Toste & Gunnar, 2006). Furthermore, previous literature has found exuberance to be associated with both externalizing behavior problems and prosocial behavior (Rydell et al., 2007; Stifter et al., 2008). However, few developmental studies have examined exuberance over time or mitigating factors in its relation to social–emotional outcomes.

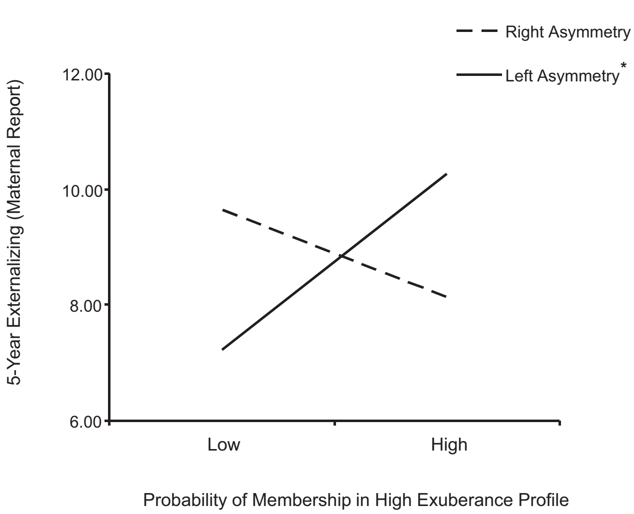

Figure 3. Probability of High Exuberance Profile × 36-Month Frontal EEG Asymmetry interaction predicting ratings of 5-year externalizing problem behavior. * $p < .05$.

Overall, the current results suggest moderate levels of stability and continuity in exuberance across infancy and toddlerhood. Results revealed that infants selected at 4 months for high levels of positive reactivity to novelty showed greater positive approach to both joy- and fear-eliciting stimuli at 9 months of age. In addition, levels of infant positive approach at 9 months were associated with greater overall exuberance at 24 months, which included positivity, approach behavior, and sociability with an experimenter. Finally, levels of overall exuberance at 24 and 36 months of age were found to be relatively stable across toddlerhood. Within the developmental literature, positive reactivity, approach behavior, and sociability have all been associated with the construct of exuberance (Pfeifer et al., 2002; Putnam & Stifter, 2005; Rothbart et al., 2001) and are believed to be supported by similar neural systems linked to the behavioral activation and facilitation systems (Depue & Collins, 1999; Gray & McNaughton, 2000).

When examining a latent profile analysis of each of these indices of exuberance, measured across infancy and toddlerhood, two longitudinal patterns of exuberance were found: a stable high pattern and a low pattern. In addition, as expected, every one of the exuberance factors examined (i.e., positivity, approach, and sociability) differentiated these longitudinal patterns, suggesting that at high levels, all are indicators of exuberance (see Figure 1). Although few studies have examined the longitudinal stability and continuity of multiple exuberance factors, these results confirm the high level of stability suggested by previous studies (Fox et al., 2001; Putnam & Stifter, 2005). In addition, these profiles support the idea that low exuberance may not equate to extremely inhibited tendencies. Whereas the low Exuberance profile was statistically lower on all measures of exuberance, the low profile's means were quite similar to the overall sample means. On the other end of the continuum, high exuberance is not necessarily just low behavioral inhibition. Although far from conclusive, these findings support the notion that exuberance and behavioral inhibition are related, but separable, dimensions of temperament. The current findings suggest that a subset of children exhibit consistently high levels of exuberant behavior and affect—which includes positivity, approach behavior, and sociability—throughout infancy and toddlerhood. Future work should examine the exact interplay between these longitudinal patterns of exuberance and longitudinal patterns of behavioral inhibition. Also, it is important to note that additional longitudinal patterns may exist in an unselected community sample or within a particular assessment point. Further research should replicate and confirm these patterns in different samples before they are considered representative of the population (Bauer & Curran, 2004).

The present study, in addition to investigating the stability and continuity of exuberance over time, examined whether these longitudinal patterns were related to social–emotional outcomes at 5 years of age. Furthermore, patterns of resting frontal EEG asymmetry were thought to moderate these longitudinal associations. Given that exuberance is suggested to reflect a strong motivation to approach, supported by biological approach- and reward-related systems, there are multiple behavioral profiles that might result from this style of temperament (Polak-Toste & Gunnar, 2006; Stifter et al., 2008). Although the heightened positive affect and approach of social novelty would likely lead to greater sociability, links with greater reward expectancies might result in frustration and aggression when these rewards or goals are blocked (Depue & Collins, 1999). Patterns of left frontal EEG asymmetry are thought to indicate a general motivation to approach and have been associated with positive affect, whereas patterns of right frontal EEG asymmetry are thought to indicate a motivation to withdraw and have been associated with negative affect (Davidson, 1994b; Davidson & Fox, 1989). Therefore, children who display a heightened, stable level of exuberance and left frontal EEG asymmetry would be considered to have consistent positive approach tendencies, whereby they would be more likely to evidence even greater approach behaviors in early childhood, as compared with those with just heightened exuberance or just left frontal EEG asymmetry. However, the literature is not clear as to whether left frontal EEG asymmetry would enhance relations toward adaptive sociable behavior or maladaptive disruptive behavior. Given the associations between left frontal asymmetry and positive affect, it is possible that the combination of exuberance and this electrophysiological profile would lead to greater social competence and sociability. However, because anger and aggression have also been linked to approach behaviors and physiological approach motivation (Harmon-Jones & Allen, 1998; He et al., 2010), it is possible that a pattern of left EEG asymmetry would also enhance disruptive behavior problems. In the current study, frontal EEG asymmetry was examined in toddlerhood as a proximal indicator of the motivational tendency to approach or withdraw. Overall, the current study explored whether exuberance related to both adaptive (i.e., social competence) and maladaptive (i.e., disruptive behavior) outcomes. In addition, frontal EEG asymmetry was examined as a potential moderator of these associations.

In terms of social behavior at 5 years of age, children with a greater likelihood of following a high, stable Exuberance profile were found to display less social reticence with an unfamiliar peer 2 years later. Frontal EEG asymmetry did not moderate this association. This result supports previous work connecting exuberance with low levels of shyness (Fox et al., 2001; Rothbart et al., 1994). However, the current results also extend this literature by demonstrating an association between high, stable patterns of exuberance across early childhood and observed social withdrawal behavior. Given that exuberant, approach-driven children would likely have low levels of behavioral inhibition, this result is somewhat expected. Previous research has suggested that early behavioral inhibition transitions into social reticence as development progresses (Rubin, Coplan, & Bowker, 2009); thus, the current measure of social reticence is thought to reflect behaviorally inhibited behavior at 5 years of age. Although the current association may call into question the independence of temperamental inhibition and exuberance, it is important to note that a post hoc analysis of the Social Reticence means by Exuberance profile revealed that the average Social Reticence score for the low Exuberance profile was almost identical to the average Social Reticence score for the entire sample. So, although high-exuberance children would be expected to display little social wariness with an unfamiliar peer, low-exuberance children are not necessarily more likely to display greater social wariness. These mean differences support the idea that temperamental inhibition and exuberance are related but separable constructs. Similar findings were reported by Pfeifer and colleagues (2002), who found high exuberance was predicted by average levels, as compared with low levels, of behavioral inhibition.

Social competence was also associated with early exuberance; however, this association was moderated by frontal EEG asymmetry. Specifically, children who were more likely to display high, stable exuberance across infancy and toddlerhood and exhibited left, but not right, frontal EEG asymmetry were reported as having greater social competence with an unfamiliar peer 2 years later (see Figure 4). Therefore, children who exhibited an approach-driven temperamental style that was supported by a physiological motivation to approach displayed greater social competence. For the current study, socially competent behavior included positive, sociable behavior that supported the goal of the individual tasks, such as social interest during FP or positive affect during FP and ST. Given the theoretical link between exuberance and approach behavior (Polak-Toste & Gunnar, 2006; Putnam & Stifter, 2005), it was expected that children with both heightened behavioral exuberance and left frontal asymmetry would display increased social interest and positive affect while interacting with an unfamiliar peer. In addition, previous work has suggested that exuberant temperament is linked to later sociability, positive affect, and social competence (Davey et al., 2003; Fox et al., 2001; Hane et al., 2008; Rydell et al., 2007). For exuberant children, social interaction is likely to be a great reward mechanism, especially in novel situations or contexts. Therefore, it follows that heightened levels of exuberance combined with a physiological motivation to approach would lead to greater positive, sociable behavior.

The current study also found that greater exuberance in toddlerhood was associated with mother-reported surgency and externalizing behavior problems at 5 years of age, but only when children displayed a pattern of left frontal EEG asymmetry. Specifically, children who were more likely to display high, stable exuberance across infancy and toddlerhood and exhibited left, but not right, frontal EEG asymmetry were reported as having greater surgency and greater externalizing behavior problems 2 years later (see Figures 2 and 3). Therefore, children who exhibited an approach-driven temperamental style, supported by a physiological motivation to approach, were at greater risk for disruptive behavior. Indeed, although surgency is not consistently considered disruptive, the current measure does include an impulsivity subscale (Rothbart et al., 2001), which links it conceptually to externalizing types of behavior. In addition, these results support Depue and Collins' (1999) idea that children with a heightened motivation to approach reward would also display greater frustration or anger when their goals were blocked. Additionally, research has shown anger to be associated with approach behavior, but only when supported by left frontal EEG asymmetry (He et al., 2010). Overall, heightened exuberance in early childhood combined with a physiological profile consistent with an approach motivational style seems to also result in greater disruptive types of behavior and personality.

In sum, EEG asymmetry at 36 months influenced the relations between a high, stable Exuberance profile into late toddlerhood and 5-year social–emotional outcomes. In general, these results support the motivation-direction perspective for frontal EEG asymmetry, whereby left asymmetry is associated with approach motivation and right asymmetry is associated with withdrawal motivation (Carver & Harmon-Jones, 2009; Davidson, 1994b; van Honk & Schutter, 2006). An inherent part of this hypothesis is that activation of the approach system supports movement toward desired outcomes or goals. However, it is remarkable that these Exuberance × Asymmetry effects were found in relation to adaptive (i.e., social competence), as well as maladaptive (i.e., externalizing problems), outcomes. Indeed, studies have shown that left frontal EEG asymmetry is associated with positive affect and behavioral approach toward enticing stimuli (Hane et al., 2008; Harmon-Jones, 2004). In addition, however, others have suggested that anger, although a negative emotion, is related to the approach system in terms of goal persistence and left resting frontal EEG asymmetry (Harmon-Jones & Allen, 1998; He et al., 2010). In fact, a recent study found that observed infant anger was associated with early approach behavior to novel stimuli, but only when infants had left resting frontal EEG asymmetry (He et al., 2010). The current results extend this literature by revealing that, similar to inhibited profiles (Fox et al., 2001), continuity in approach-related tendencies is influenced by resting frontal EEG asymmetry, with a persisting approach-driven style evident for only those children who show a corresponding profile of high exuberance and left frontal EEG asymmetry. However, unlike profiles of inhibition over time, in which right frontal asymmetry mitigates paths to various forms of social withdrawal and anxiety, (see e.g., Fox et al., 2001), left frontal asymmetry seems to enhance relations to both adaptive and maladaptive outcomes for children with an exuberant temperament. Indeed, this same type of effect was found in a study examining children of mothers with depression, where left frontal asymmetry was associated with both anxious and aggressive behavior problems (Forbes et al., 2006).

Although this lack of differentiated effects may be somewhat supported by approach-driven motivational systems, additional factors might account for both the associations with adaptive and maladaptive outcomes and the somewhat weak effect sizes found for the Exuberance × Asymmetry interactions in the current analysis. Given that, from a motivational framework (Gray, 1982), exuberance is linked closely to approach behavior, outcomes of this temperamental style would be expected to relate to movement toward desired outcomes or goals, such as social interaction with others. However, following Depue and Collins' (1999) framework of the behavioral facilitation system, this strong motivation to approach reward-based stimuli would result in heightened frustration or anger when one's path to these goals was blocked. Therefore, given the context, exuberant children with left frontal EEG asymmetry would be expected to display either positive sociability or disruptive behavior problems. It is important to note that the current results revealed that these children were observed displaying greater social competence, but mothers reported them as greater in externalizing problems. It is conceivable that parents would be in a position to observe many more frustrating situations for an exuberant child, such as asking them to stop playing, wait for dessert, or take turns on the playground. Therefore, although exuberant children in the current study were not observed to display greater disruptive behavior, they might be more prone to that type of behavior in other contexts (i.e., at home or school). Furthermore, additional factors, such as the development of inhibitory control and other regulatory mechanisms, would influence levels of both social competence and disruptive behavior, in opposite ways. Perhaps children from this sample have individually varying levels of regulation. If exuberant children developed a greater capacity to regulate their approach tendencies and frustration to goal blockage, they would display less disruptive behavior and greater social competence. In turn, children who did not develop these regulatory skills would display greater disruptive behavior and less socially competent behavior. It is possible that both types of children can be found in the current sample, which would account for the associations with adaptive and maladaptive outcomes, as well as the somewhat modest effects found for the Exuberance × Asymmetry interactions. Further research is needed to clarify the roles of context and regulation in these differential profiles for exuberant children.

Also of note is the small number of gender effects found. Male children were reported to have greater surgency and less regulation but also were observed to display greater social competence with a peer. However, there were no gender effects on the temperament or EEG asymmetry outcome associations. The role of gender and gender socialization may have a particular impact on the development of exuberance over time. Future research should explore how gender influences the development of children's positive affect, approach behavior, and sociability, which were included under the rubric of exuberance in the current study, as well as how the child's gender influences the perception of these characteristics by others (e.g., parents and teachers).

Implications and Limitations

A limitation of the current study is that the amount of missing data may have biased the current results by limiting generalizability. Missing data analyses revealed that data was lost primarily from the 4-month control group, which would presumably have less of an impact on the results than would loss from either of the extreme temperament groups. In addition, only a small number of participants were lost due to permanent attrition. However, any attrition or missing data can decrease the generalizability of results from the current study to nonselected or more complete samples. In addition, the current level of attrition, combined with the potentially lower power to detect interaction effects (see McClelland & Judd, 1993), may have limited the power to detect more significant effects of exuberance and EEG asymmetry on 5-year outcomes.

A strength of the current study is the longitudinal LPA approach used to form the profiles of exuberance. These profiles were formed on the basis of probabilities, which allows for the possibility that there is uncertainty concerning which profiles people belong to and allows one to predict outcomes using the probability of membership in a group. LPA also offers the flexibility to describe behavior over time when the measurement of behavior changes, which is against the assumption of most variable-based or growth modeling approaches. Overall, the current approach is a useful tool for describing individual differences; however, it is important not to reify the latent profiles, because they do not necessarily represent qualitatively distinct groups in the population and may not be generalized to other samples. In particular, the structure and number of Exuberance profiles over time may be different in the overall population. Thus, the current analysis should be replicated in other samples in order to validate both the formation of the latent profiles and the associations with later outcomes over time.

The current results suggest that positive affect, approach behavior, and sociability all contribute to one's level of temperamental exuberance. In addition, the existence of a stable, high Exuberance profile across infancy and toddlerhood was supported. Finally, exuberance was shown to exhibit multifinality and converged on a combination of adaptive (i.e., social competence) and maladaptive (i.e., externalizing problems) behaviors. However, many of these results were found only when children's electrophysiology also supported a motivation to approach. In addition, these effects were somewhat modest, as the range of scores in Figures 1–3 suggest. Therefore, additional factors must be implicated in distinguishing these outcomes further, whereas EEG asymmetry is likely supportive of an already heightened level of approach but does not seem to guide whether children display adaptive or maladaptive behaviors in early childhood. Additional work should examine multiple subtypes of exuberant and socially withdrawn temperamental styles (e.g., surgent, sociable, reticent, disinterested) to determine the precise relations between social behavior, approach–withdrawal motivation, and frontal EEG asymmetry. In addition, information from multiple contexts (e.g., home, lab, school) about child behavior would assist in the formation of these distinct subgroups.

Overall, affective, behavioral, and physiological factors were found to support a general approach bias for exuberant temperament but did not differentiate the types of social–emotional outcomes that develop by 5 years of age. Future research that examines additional factors (e.g., context or regulatory processes) that might mitigate trajectories of exuberance across time should prove most informative, because the findings reported here mainly confirm the stability of an exuberant temperament that is grounded in approach and reward motivation. In addition, the specific constructs of exuberance should be explored to determine whether particular aspects of this temperamental style predispose children to display social competence or disruptive behavior. These lines of research have important implications for children's social–emotional development across a pivotal time in early childhood, as they begin to enter formal schooling (i.e., kindergarten) and engage in peer interactions on a regular basis.

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