

## Review Article

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# Child Temperament: An Integrative Review of Concepts, Research Programs, and Measures

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This article provides a review and synthesis of concepts, research programs, and measures in the infant and child temperament area. First, the authors present an overview of five classical approaches to the study of child temperament that continue to stimulate research today. Subsequently, the authors carve out key definitional criteria for temperament (i.e., inclusion criteria) and the traits that qualify as temperamental according to the overview and defined criteria. The article then reviews leading programs of research that are concerned with the ways in which early childhood temperament affects psychosocial development, both normal and abnormal. After touching on measurement issues and tools, the authors conclude with an outlook on child temperament research.

*Keywords:* infant and child temperament, emotionality, personality, development, childhood

Although modern research on infant and child temperament has its origins in the 1950s, it was not until the 1980s that it became one of the central themes of today's developmental psychology and child psychiatry. In a landmark roundtable article (Goldsmith et al., 1987), the participants displayed considerable disagreement about what temperament is. It was obvious that, within the young temperament field, various schools of research were about to emerge. Twenty years later, the most important division in the field of child temperament is between an inductive approach to temperament, which favors the gathering of facts over broad concepts (Kagan & Fox, 2006) and a deductive one, which is more theory driven (Rothbart & Bates, 2006). The current review first describes and then integrates threads from several approaches to child temperament. We seek to identify common ground for definitional and substantive issues in the child temperament area. We also comment on measurement issues and conclude with some future directions. Because brevity of exposition was an important aim, the current review presents essentials rather than extensive treatments of concepts and findings.

## Approaches to Child Temperament

### *The Child Psychiatric Approach of Alexander Thomas and Stella Chess*

Thomas and Chess's contribution to research on child temperament is best introduced by looking at reasons that motivated the illustrious couple to devote their professional lives to the study of child temperament:

While recognizing the vital contribution that the child's environment ... made to the course of psychological development, we could not find in our clinical cases or the research literature the direct correlations between such environmental factors and individual differences in patterns of development that ... environmentalist views demanded. This dissatisfaction with the prevalent theories of the time was a major reason in our decision to investigate the active role played by the child's own characteristics, and specifically his temperament, through the initiation of the NYLS (Chess & Thomas, 1984, pp. 14-15).

The New York Longitudinal Study (NYLS) began in 1956 and followed 133 individuals from 84 families, predominantly educated New York families, from 3 months of age to adulthood. The NYLS approach to identifying the basic temperament dimensions is crucial to an understanding of Thomas and Chess's empirical approach. As described by Thomas, Chess, Birch, Hertzog, and Korn (1963),

A content analysis was ... performed on the interview protocols of the first twenty-two children studied. In the course of this analysis the protocol data were distributed against a wide variety of formal behavioral attributes. It was found that nine categories of functioning could be scored continuously throughout the protocols. Further, the distributions of scores in each of these categories were sufficiently wide to permit differentiation among individuals within each category. Although various amounts of data were available for additional categories of functioning, their distribution failed to satisfy either the requirement of ubiquitousness (being scorable and present in all protocols), or of sufficient variability to permit interindividual comparison (p. 40).

The nine resulting temperamental dimensions were (a) activity level, (b) rhythmicity (regularity), (c) approach/withdrawal, (d) adaptability, (e) sensory threshold, (f) intensity of reaction, (g) quality of mood, (h) distractibility, and (i) attention span/persistence. According to Thomas and Chess (1977), what most clearly distinguishes these dimensions from personality traits is their formal or stylistic nature: "Temperament can be equated with the term behavioral style. Each refers to the how rather than the what (abilities or content) or the why (motivation) of behavior" (p. 9). Although the NYLS list of dimensions has been seminal, factor analytic work by various research teams (e.g., Martin, Wiesenbaker, & Huttunen, 1994) has shown a certain redundancy between the dimensions. Thus, few psychologists use the full list anymore.

In addition to the nine dimensions, Thomas and Chess also introduced a typology of child temperaments—the “difficult,” the “slow-to-warm,” and the “easy”—that resulted from a combination of factorial analyses and the intent to identify the clinically most significant configurations of temperament traits. However, Thomas and Chess recognized that behaviors that lead to a child being classified as “easy” or “difficult” can vary based on parental and cultural values, attitudes and practices (see p. 24). Hence, they emphasized interactionism in terms of *goodness-of-fit*. Psychological development is not only influenced by the child’s temperament, but, to an equally important extent, also by the adequacy (i.e. fit) of parental responses to this temperament. Finally, Thomas and Chess’s emphasis on applications of temperament concepts in prevention and intervention proved particularly influential (e.g., Carey & McDevitt, 1994; McClowry et al., 2008).

#### *Buss and Plomin’s Criterial Approach to Temperament*

Buss and Plomin (1975, 1984) defined traits as temperament if they fulfilled certain criteria—thus the designation of their approach as “criterial.” They chose criteria on the basis of comparative psychology, in particular the work of S. Diamond (1957). Diamond thought that observations of adult human behavior, “no matter how sophisticated in either a statistical or a clinical sense, have the common failing that they are unable to distinguish between the essential foundations of individuality and its cultural elaboration” (pp. 3-4). To identify these essential foundations of individuality, Diamond argued, one had to look at the animal world. He concluded that four temperamental traits are shared by primates: fearfulness, aggressiveness, affiliativeness, and impulsiveness. In Diamond’s view, only those dimensions that are useful to describe behavioral differences in primates should be relevant for the study of human temperaments.

Buss and Plomin (1975) both endorsed and expanded Diamond’s “phylogenetic” approach to defining temperament. They required that temperament traits show early appearance in ontogenesis, “preferably infancy (the first two years of life)” (Buss & Plomin, 1984, p.84). Thinking of temperament as the constitutional part of personality, they also proposed a third criterion, heritability. The more heritable a given trait, the more likely it is to be a temperament. This view implied that temperament traits are those presenting particularly strong links to physiological and biological processes. Their final criterion was continuity. More specifically, Buss and Plomin (1984) said, “[W]e are more interested in traits that are predictive of later development, that is, traits that show some continuity or at least have *residuals* for later personality” (p. 85).

Originally, the authors thought that four traits fulfilled these criteria, namely, emotionality, activity, sociability, and impulsivity. Emotionality is a predisposition to get easily distressed and upset. The “total activity level refers to the total energy output” (Buss & Plomin, 1975, p. 32-33). Sociability “is the tendency to prefer the presence of others to being alone” (Buss & Plomin, 1984, p. 63). Sociability is not the same as shyness, because shy people may desire the presence of others, but they avoid it because they tend to be tense and anxious when surrounded by other people, especially unfamiliar people. Im-

pulsivity was originally included (Buss & Plomin, 1975) but later dropped because factor analyses had shown that the trait seems to be composed of various subcomponents, only some of which replicated. More important, Buss and Plomin (1984) concluded that impulsivity does not emerge until school age, a view that contradicted their criterion of a very early appearance in development. The authors developed two questionnaire measures, The Colorado Child Temperament Inventory (Rowe & Plomin, 1977)—an amalgamation of the Thomas-Chess dimensions and their early Emotionality Activity, Sociability, and Impulsivity (EASI) inventory; and the EAS Survey for Children (Buss & Plomin, 1984), tapping Emotionality, Activity, and Sociability.

*Temperament as Variability in Developing Emotion Systems:  
The Approach of Goldsmith and Campos*

Goldsmith and Campos (1982; see also Goldsmith 1993) refer to temperament primarily as individual differences in the emotional domain: “We simply define temperament as early developing in tendencies to experience and express emotions, including their regulatory aspects” (Goldsmith, Lemery, Aksan, & Buss, 2000, p. 2). Whereas the term *emotionality* in the temperament area often refers to individual differences in negative emotions, Goldsmith and Campos look at temperament as individual differences in the primary emotions, including positive emotions (i.e., joy, interest, sadness, anger, fear). Individual differences in these emotional predispositions are expressed in intensive and temporal aspects of behavior, including vocal, facial, and motor expressions. Together with Rothbart, Goldsmith developed an extensive laboratory assessment battery, the Lab-TAB (Goldsmith & Rothbart, 1996), and a multidimensional inventory to gather caretaker ratings of infant and child temperament, the TBAQ (Goldsmith, 1996). These instruments were originally devised to measure five emotional temperamental components (motor activity, anger, fearfulness, pleasure/joy, interest/persistence), but newer versions of these tools can be used to assess a larger number of temperament dimensions (TBAQ-R, Goldsmith, 2000). Although the seminal article by Goldsmith and Campos did not emphasize heritability in defining temperament, Goldsmith and his colleagues have extensively studied heritability of temperament (Goldsmith, Reilly, Lemery, Longley, & Prescott, 1999; Ruf et al., 2008).

As implied by the preceding definition, the current approach views not only emotion, but also emotion regulation as a component of temperament. The concept of emotion regulation, which is similar to effortful control (see p. 11), is one of the most complex temperamental constructs. It has been defined as consisting of “the extrinsic and intrinsic processes responsible for monitoring, evaluating, and modifying emotional reactions, especially their intensive and temporal features to accomplish one’s goals” (Thompson, 1994, pp. 27-28). An important discussion of the emotion regulation concept in general, and of the distinctions between the concepts of emotion and emotion regulation, can be found in a special issue on emotion regulation that appeared in *Child Development* (2004, Vol. 72, Issue 2). Emotion regulation

is commonly spoken of as a distinct event or process that occurs after an emotion event, such as when a child is blocked in pursuit of a goal, feels angry, but then avoids expressing anger. However, Campos, Frankel, and Camras (2004) argued that emotion and emotion regulation may be inseparable. Emotions and emotion regulation happen at the same time, and emotional responses depend on preexisting regulatory processes, such as cortical inhibition or one's interpretations of an event. Cole et al. (2004) in contrast, were more convinced that there could be an empirical distinction between the two concepts, as can be found, for example, in measures of the dynamic time course of emotions. Nevertheless, they also agreed with Campos et al. that "emotions are inherently regulatory" (p. 319). If stretched in time, the relationship between emotion and emotion regulation becomes a question about how regulatory processes affect the expression of emotionality over longer periods of time. Longitudinal work by Eisenberg and coworkers (Eisenberg, Fabes, Guthrie, & Reiser, 2000) has provided important insights into this question.

#### *The Neurobiological Developmental Approach of Rothbart*

The relationships between emotion and emotion regulation are also central to the approach of Rothbart, though with a stronger emphasis on attentional and neurobiological mechanisms. Specifically, Rothbart defines temperament as constitutional differences in reactivity and self-regulation. The concept of reactivity refers to biological arousability, which includes arousal in neuroendocrine, autonomic, and affective systems. Individual differences in reactivity may be measured by threshold of reactivity, latency of responding, intensity of a given reaction, and rise and recovery time. Self-regulation, in contrast, refers to processes that "increase, decrease, maintain, and restructure the patterning of reactivity in either an anticipating or correctional manner" (Rothbart & Derryberry, 1981, pp. 51-52). Behavioral processes related to self-regulation include approach, avoidance, inhibition, and attentional self-regulation.

Rothbart and colleagues have identified three broad dimensions of temperament, each of which includes a series of narrower dimensions: (a) *surgency-extraversion*, composed of scales such as positive anticipation, activity level, and sensation seeking; (b) *negative affectivity*, including fear, anger-frustration, and social discomfort; and (c) *effortful control*, which includes facets such as inhibitory control, attentional focusing, and perceptual sensitivity (Posner & Rothbart, 2007; Rothbart & Bates, 2006). An important assumption in this model is that both reactive and self-regulatory behaviors are intimately linked to neurobiological processes. A case in point is effortful control, defined as the capacity to inhibit a dominant response in favor of a subdominant one (Rothbart & Bates, 2006). This capacity, which is related to persistence, emerges around the first birthday and strongly improves between the second and the third birthday. Individual differences in effortful control result from the efficiency of networks controlling attention, in particular those relating to executive control of attention. As we shall see in more detail later (pp. 20-21), these networks

are linked to specific neurotransmitters and anatomical brain areas. For example, the executive (or anterior) attention network is related to the anterior cingulate cortex, the basal ganglia, and the lateral prefrontal cortex. Preliminary evidence suggests that neuromodulation of this system may involve dopamine.

Laboratory measures of temperament include a series of structured tasks—best exemplified by Goldsmith’s Lab-TAB—and more recently, computer-based tests for the assessment of individual differences in attentional processes, such as the spatial conflict task and the Child Attention Network Test (Posner & Rothbart, 2007). Questionnaire measures of temperament have been developed for each age period from infancy to adulthood.

#### *Kagan’s Biotypological Approach to Temperament*

Unlike Rothbart’s theory-driven approach, Kagan’s approach to the study of child temperament is more inductive. In contrast to scientists who “begin with a theoretical view of the human temperaments and devise measures of them,” he aligns himself with a smaller group that “allows the data to guide the invention of temperamental categories” (Kagan & Fox, 2006, p. 183). Despite this preference for induction over deduction, his work is not merely a compilation of tiny facts. Rather, addressing manifold issues in the study of temperament (Kagan, 1994; Kagan & Snidman, 2004), his work occupies a central place among current approaches to temperament.

Kagan and colleagues studied behavioral inhibition to unfamiliarity and its counterpart, an uninhibited style, with an emphasis on the longitudinal study of behavioral and physiological manifestations from early infancy onward. A first longitudinal study revealed that 2-year-olds who show consistent avoidance or distress to unfamiliar people, procedures, and situations preserved some of these tendencies until 7 years of age, along with greater sympathetic tone in the cardiovascular system. Two-year-olds showing minimal avoidance or distress in the same situations also tended to preserve these behavioral dispositions, along with greater parasympathetic tone (Kagan, Reznik, & Snidman, 1988).

This work was followed by a new large-scale longitudinal study in which infants were examined in the laboratory from 4 months of age, and the spectrum of physiological measures was considerably extended. On the assumption that early forms of behavioral reactivity to unfamiliarity would be linked to a differential threshold of excitability in the amygdala, Kagan focused on motor unrest and crying as potential markers of amygdalar hyperreactivity. In the new study, about 20% of healthy Caucasian 4-month-old infants showed frequent motor activity and crying at the unexpected appearance of unfamiliar visual, auditory, or olfactory stimuli. These infants were called *high-reactive*. About 40% of the infants reacted with minimum motor activity and minimal crying to the same events and were called *low-reactive* (Kagan & Snidman, 2004). Compared with low-reactive infants, high-reactive infants were 3 times more likely to have developed anxiety symptoms by the age of 7 years (Kagan, Snid-

man, Zentner, & Peterson, 1999). High-reactive infants in adolescence reported, in an interview, more frequent bouts of sadness, and showed frequent heart rate changes, sweating of palms, muscle tension, facial flushing, and breathing difficulty, with high systolic blood pressure as well as distinct EEG and ERP waveforms at 11 and 15 years of age (Kagan & Snidman, 2004; Kagan, Snidman, Kahn, & Towsley, 2007).

Kagan refers to high- and low-reactive infants as distinctive categories produced by different biological factors rather than as children who fall on a continuum of reactivity. In his view, emergent phenomena cannot often be accounted for by adding quantities. Furthermore, he interprets the biological literature as implying that distinctly different phenotypes often originate in distinct genomes (Kagan, 2008). Finally, Kagan acknowledges that a great variety of different personalities may emerge from a high-reactive temperament, depending on encountered environments, such as social class, culture, family, and historical era. Even so, Kagan regards temperament as imposing a certain restraint on possible outcomes: "A low-reactive infant might become a trial lawyer, investment banker, navy pilot, or criminal, but it is unlikely that he will become a frightened recluse" (Kagan & Snidman, 2004, p. 3).

#### *Adaptations of Adult Temperament Theories to Childhood: Gray, Cloninger, and Strelau*

The approaches just described are all developmental, based on extensive studies of infants and children. There are also well-known theories focusing on adult temperament, whose possible connections to child temperament are being explored. For example, Gray's (1991) well-known neural theory of the Behavioral Inhibition System (BIS) and Behavioral Approach System (BAS) has exerted considerable influence over theory building in the child temperament area. It has been adapted, for example, by Martin (1999) in the revised Temperament Assessment Battery for Children (TABCR), which measures negative emotionality, activity, and persistence (based on NYLS concepts), as well as inhibition and impulsivity, which derive from the BIS and BAS.

Cloninger (1987) is best known for his bold vision of an intimate connection between temperamental characteristics and neurotransmitter systems. Specifically, he sees novelty seeking, the tendency to seek out novel stimulation, as influenced by the dopaminergic system; harm avoidance, the tendency to avoid aversive stimulation and show behavioral inhibition, as influenced by the serotonergic system; and reward dependence, the tendency to seek out and strongly respond to social rewards, as an expression of the neuroadrenergic system. Persistence, the tendency to be persevering and industrious, has not (yet) been attributed to a specific neurotransmitter system. Recent studies suggest that the four temperament components can be assessed as early as preschool age (Constantino, Cloninger, Clarke et al., 2002; Goth, 2008). Integrating temperament concepts from work in the Soviet temperament tradition and that in Western research, Strelau's (1989) Regulative Theory of Temperament emphasizes how individuals differ in reactivity or arousability and how their characteristic patterns of activity serve to maintain their preferred levels of arousal. Although researchers in the Pavlovian tradition derived their

theories from work on adults, they were among the first to apply temperament concepts to developmental and educational contexts (Merlin, 1955; see Strelau 1983).

## The Nature of Infant and Child Temperament: An Integrative Perspective

### *Definitions*

Against the background of the preceding overview of child temperament concepts, we would like to propose an integrative perspective. As will be shown, integration is possible within the boundaries of definitional criteria and fundamental temperament components emerging in childhood.

Most current temperament researchers would agree with Buss and Plomin's (1984) notion that early ontogenetic appearance, moderate stability, and distinctive biological manifestations are key ingredients of a definition of temperament. As we shall see in the next section, there is now evidence that a select number of traits fulfill these criteria; that is, relatively enduring emotional-behavioral traits that appear in infancy or toddlerhood along with a distinct biological profile. The idea of temperament is further supported by animal research showing that some of the most basic human behavioral traits (activity, timidity, emotionality) can also be observed in primates and certain social mammals such as in dogs (Jonas & Gosling, 2005).

In contrast to the aforementioned criteria of early appearance, animal counterparts, proximity to biological mechanisms, and stability or "predictiveness," heritability has not been established as a useful inclusion criterion for temperament over the last two decades. This failure is not because temperament traits are not heritable—they are. However, heritability is not a distinctive feature, because almost any psychological characteristic is partly heritable and many characteristics are equally or more heritable than temperamental characteristics. Thus, a perhaps more interesting question that behavior genetics research can answer is what phenotypes are more or less susceptible to environmental influence. For example, in a number of studies, positive emotionality traits were found to have a bigger shared environment component than were other temperament dimensions (e.g., Goldsmith, Lemery, Buss, & Campos, 1999; Rothbart & Bates, 2006).

Even though heritability may not currently be a useful defining feature of a temperament, molecular genetics and more sophisticated behavior genetic research might alter this picture. Temperament variables as typically defined, whether by behavior in standardized situations or by caregiver or teacher ratings, are broad phenotypes. Research, however, might identify phenotypes closer to the "basic" processes, closer to the direct products of genetic variations. In other words, research might find that endophenotypes (Gottesman & Gould, 2003), such as attentional responses to novelty, relate to specific genes, such as those that influence availability of the neurotransmitter dopamine. The specific aspect of the response may be just one compo-

ment of the naturalistic behavior pattern that would define a temperament trait, such as impulsivity. Based on current trends, knowledge about temperament substrates in neuroanatomical, neurochemical, and psychophysiological mechanisms may be possible, along with their associations with specific genes, such as the association of impulsivity with the dopaminergic and other genes (Dick, 2007).

Table 1. Inclusion Criteria for Child Temperament.

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1. Individual differences in normal behaviors pertaining to the domains of affect, activity, attention, and sensory sensitivity
  2. Typically expressed in formal characteristics such response intensities, latencies, durations, thresholds, and recovery times
  3. Appearance in the first few years of life (partial appearance in infancy, full expression by preschool age)
  4. Counterpart exists in primates as well certain social mammals (e.g., *Canis familiaris*)
  5. Closely, if complexly linked to biological mechanisms (e.g., neurochemical, neuroanatomical, genetic)
  6. Relatively enduring and predictive of conceptually coherent outcomes (e.g., early inhibition predicting internalizing, early difficulty externalizing disorders)
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Having identified some key criteria for temperament (see Table 1 for a summary), we should touch on the meaning of temperament compared with personality. The literature is replete with different definitions of personality and temperament; thus psychology students (and not only students!) typically struggle with this distinction. This situation is aggravated by recent research that examines the Big Five dimensions in early childhood, concluding that the Big Five, or derivatives thereof, can be measured at preschool age. To make matters even more confusing, these purported rudimentary forms of the Big Five personality factors are similar to several temperament dimensions.

One reason for this confusion relates to personality being defined in two different ways. In one sense, personality refers to goals, coping styles, defensive styles, motives, self-views, life stories, and identities (McAdams & Pals, 2006). In another, very different, sense, authors use the term personality to refer to a handful of basic personality *traits*. Within the latter sense, one tradition of research proposes three big traits consisting of extraversion (surgency), neuroticism (negative affectivity), and constraint (Eysenck, 1992; Rothbart, Ahadi, & Evans, 2000; Tellegen, in press), whereas a second, lexical tradition of research advocates the existence of five major personality traits, the so-called Big Five (extraversion, neuroticism, agreeableness, openness, and conscientiousness). Although historically, the major aim of research on the basic personality traits was to identify the fundamental respects in which individuals differ from each other, more recently, the emphasis of this research is on identifying the biological, evolutionary, and ontogenetic foundations of the big personality dimensions.

Indeed, today's main foci of research on the fundamental personality traits read like the current inclusion criteria for temperament: biological, genetic foundations (e.g., Canli, 2006), presence in primates and social mammals (e.g., Jones & Gosling, 2005), temporal stability or predictiveness (e.g., Roberts, Kuncel, Shiner, Caspi, & Goldbert, 2007), and, of increasing interest, appearance in the earliest stages of life (e.g., Measelle, John, Ablow, Cowan, & Cowan, 2005). Thus, the recent study of fundamental personality traits is, de facto, a study of temperament (Zuckerman, 1991). Much confusion could be averted by calling the Big Three—and, to an extent, the Big Five personality factors (see Nettle, 2006)—*temperament*, while reserving the term *personality* to a much more comprehensive set of attributes characterizing the whole person (McAdams & Pals). Many would prefer to continue to use the word *personality* to describe Big Five-type traits. However, if this is done, it will be important to clarify whether the term is being used to describe the basic traits or the late-emerging, complex traits.

#### *Basic Temperament Traits*

In this section, we describe a number of temperament components that fulfill most of the preceding criteria, are seen as temperamental by most current temperament researchers, and have been studied relatively extensively (Caspi & Shiner, 2006; Rothbart & Bates, 2006). For each of the components, we provide a description of the characteristic, touch on biological mechanisms, discuss findings related to temporal stability and give examples for their measurement. Due to space limitations, we cannot dwell on animal counterparts to the human attributes. However, the temperament characteristics to be described next have been found and studied in animals, most particularly the first four (Gosling, 2001; Jones & Gosling, 2005).

As a caveat, it is important to keep in mind that the “temperament credentials” of the following attributes differ from case to case; they are relatively strong for behavioral inhibition, but more modest for sensory sensitivity. Furthermore, sometimes important differentiations occur within a given category. Thus, concepts such as positive emotionality or activity level are best seen as families of temperament characteristics rather than as highly specific dispositions, with some family members more closely related than others.

*Behavioral inhibition (fear).* Many lists of temperament traits include a general negative emotionality dimension. Such a dimension has support from both factor analytic studies of questionnaires and more basic research on neural systems. Nevertheless, there are likely to be important distinctions in sub-dimensions of negative emotionality (Rothbart & Bates, 2006). One subdimension is behavioral inhibition. Although behavioral inhibition is often mentioned in the same breath as shyness, it is a relatively broad construct encompassing (a) inhibition in front of unfamiliar same-age children, (b) inhibition in front of unfamiliar adults, (c) avoidance of physical risks, (d) inhibition in evaluative situations as when performing in front

of others, (e) inhibition in situations of separation, and (f) inhibition in unfamiliar situations and surroundings (Bishop, Spence, & McDonald, 2003). Furthermore, it is also important to distinguish behavioral inhibition from inhibitory control. The former is reactive and results from relatively automatic fear or distress responses in novel situations. The latter, in contrast, involves the regulatory use of executive attention (see below, section on attention/persistence) and expresses itself in behaviors such as resisting temptation or delaying gratification.

Although there is evidence for a close connection between behavioral inhibition and fear, Kagan sees the core feature of inhibition as an intolerance of uncertainty rather than a proneness to fear (Kagan & Snidman, 2004). This view is consistent with recent evidence suggesting that the amygdala may be more typically involved in the processing of novel, unfamiliar, or ambiguous stimuli than in the processing of fear signals as such. For example, Schwartz and colleagues (Schwartz, Wright, Shin, Kagan, & Rauch, 2003) found that adults who had been categorized as inhibited in the second year of life, compared with those previously categorized as uninhibited, had a greater response within the amygdala to novel versus familiar faces (see Henderson & Wachs, 2007, for a recent review of evidence for other biological correlates of inhibition such as frontal EEG asymmetry). In early infancy, individual differences in this trait tend to be expressed by the degree of tenseness, motor activity, and crying shown in response to the unexpected appearance of unfamiliar visual, auditory, or olfactory stimuli (Kagan & Snidman, 2004; Pulver, 1959), and these patterns of reactivity have been shown to be moderately stable between infancy and adolescence (Kagan et al., 2007; Meili & Meili-Dworetzki, 1972). These authors also introduced a vast array of laboratory, Q-sort and questionnaire measures to assess behavioral inhibition from infancy to adolescence.

*Irritability/frustration.* Broadly, irritability refers to some infants being more easily upset by minor discomforts than others. Individual differences in irritability may be related to differences in the neural circuits involved in responses to unconditioned punishers, e.g., Gray's (1991) fight-flight system. Panic and defensive aggression would be extreme examples of this system. One of the most frequently used measures of neonatal irritability is the Neonatal Brazelton Assessment Scale (NBAS; Brazelton & Nugent, 1995). Although not a test of temperament per se, clusters of items pertaining to subfacets of the NBAS (e.g., irritability, rapidity to build-up, and peak of excitement) are seen as temperamental in nature (Worobey, 1986). Individual differences in neonatal irritability have been found to relate to significant outcomes, such as later temperamental difficulty and social anxieties (e.g., Riese, 1987; Zentner, 2004).

Irritability is perhaps one of the key elements of the construct of difficult temperament measured by the Infant Characteristics Questionnaire (ICQ; Bates, Freeland, & Lounsbury, 1979), which was defined by a factor including frequent and intense negative affect and the degree of difficulty the infant presents caregivers. Part of what is experienced by caregivers as difficult may be, in addition to the infants' sensitivity to aversive stimuli, the "demanding" way in which this sensitivity is expressed.

Compared with temperamentally “easy” infants, temperamentally difficult infants showed higher levels of irritation and demandingness in cries recorded at a time when they were hungry, both as rated by unrelated mothers and as seen in objectively measured differences in sound spectrographs of their cries (Lounsbury & Bates, 1982). Difficultness exhibits relatively high levels of stability from early infancy onward (Lee & Bates, 1985; Lemery, Goldsmith, Klinnert, & Mrazek, 1999). In the Fullerton Longitudinal Study (Guerin, Gottfried, Oliver, & Thomas, 2003), difficult temperament in late infancy turned out to be a significant predictor of conceptually related temperament dimensions in adolescence, such as poor task orientation and high activity level (see also Caspi 2000; Chess & Thomas, 1984).

Another, qualitatively different kind of irritability is seen in individual differences in frustration. Frustration may be defined as negative affect in reaction to interruption of ongoing tasks or blocking of behaviors related to approach and goal attainment. Frustration can be assessed, for example, by infants’ responses to toys that are out of reach or behind a Plexiglas barrier (Rothbart, Derryberry, & Hershey, 2000). Differences in aggression and irritation in response to frustration become increasingly evident in the later months of the first year, as infants become more active in their explorations and more capable of expressing particular wishes. Individual differences on this subdimension may pertain in part to the same neural circuits involved in the response to unconditioned punishers (Panksepp, 1998). Infants’ level of frustration, as measured in the laboratory at 6.5 and 10 months of age, was found to predict parent-reported anger-frustration (but not fear) when the child was 7 years old (Rothbart Derryberry, & Hershey, 2000). However, differences on this subdimension also appear to involve the same dopaminergic circuits involved in Gray’s (1991) BAS. Indeed, infants with short latencies to reach for an object turned out to be not only higher in positive anticipation, but also in aggression and frustration at school age (Rothbart, Derryberry, & Hershey, 2000). One possible explanation is that, compared with low approach tendencies, high approach tendencies inevitably lead to a higher probability of encountering obstacles, thereby inducing anger and frustration (Posner & Rothbart, 2007). Bates et al. (1998) suggest that their dimension of “resistance to control,” which is a factor independent of difficult temperament, and which involves the toddler ignoring prohibitions and getting upset when blocked, also involves strong approach tendencies, along with low levels of effortful control.

*Positive emotionality.* One of the most important behavior systems involves the processing of information about potential rewards, such as food and the many other things we find interesting and useful for our survival. Individual differences in these systems are, in one way or another, linked to frequencies and intensity of positive emotions, such as interest, eagerness, and associated behaviors such as approach and investigation. The variations in positive emotionality are captured by subcomponents, such as positive anticipation, sensation or novelty seeking, smiling and laughter, and, possibly, activity level (see next section). The neurobiological underpinnings of these emotions and behaviors

are not fully understood, but evidence suggests that they are linked to a number of neural circuits, such as midbrain dopamine systems projecting from the substantia nigra and the ventral tegmental area, as well as systems controlling locomotion such as the nucleus accumbens (Posner & Rothbart, 2007; see also Gray, 1991; Panksepp, 1998). This appetitive positive affect system is sided by a consummatory positive affect system, which is implicated in processing sensory pleasure such as hedonic touch or taste and which involves the opiate and GABA system in the ventral striatum and orbital frontal cortex (Burgdorf & Panksepp, 2006). It seems likely that individual differences in positive emotionality traits are due to individual differences in these neural circuits. It is important to recognize that differences in positive emotionality are not simply the inverse of negative emotionality, but are to a substantial degree independent.

In infancy, individual differences in this trait are expressed, for instance, by the total amount of smiling, laughing, and (non-fussy) motor acts, such as clapping hands and reaching when in a playful situation, such as in response to a pop-up bunny (Kochanska, Coy, Tjebkes, & Husarek, 1998). Behaviors expressive of positive emotionality across early childhood are included in temperament scales such as “Smiling and Laughter,” “Positive Anticipation,” and “High-Intensity Pleasure” (Putnam, Garstein, & Rothbart, 2006; Rothbart, Chew, & Gartstein, 2001). Findings suggest that components of positive emotionality tend to be quite stable across the early childhood period, regardless of whether they are measured by laboratory observation (Putnam & Stifter, 2005; Rothbart, Derryberry, & Hershey, 2000) or via parental reports (Lemery et al., 1999; Putnam et al., 2006).

*Activity level.* Activity level is traditionally considered an important component of children’s temperament (e.g., Buss & Plomin, 1975; Fagot & Brian, 1994; Henderson & Wachs, 2007; Thomas & Chess, 1977). According to a classical definition, “level of activity refers to total energy output,” which is most clearly expressed in amount of movement (Buss & Plomin, 1984, pp. 31-32; see also Wachs, 1990). It is sometimes argued that activity level, rather than being a basic or independent dimension of temperament, may be a derivative of positive emotionality, especially when the latter is seen as an expression of a general behavioral facilitation or activation system (Rothbart & Bates, 2006). However, because briskness, tempo, and vigor of movement appear to be present in positive, as well as in negative and in neutral behavior, and neural circuits implicated in positive affect are separate from those regulating locomotion, it seems reasonable to look at both traits separately.

In their revised theory of temperament, Buss and Plomin provided a number of specific operationalizations. Thus, frequency of activity per time unit (rate) is indicated by walking speed, talking speed, and tendency to hurry. Duration is expressed in time spent in high-energy activities and in the continuation of energetic activity after most other children have stopped. Activity level could also be gauged from children’s reactions to “enforced idleness,” which cause much more restlessness in high-active than in low-active children (Buss & Plomin, 1984, p. 94).

Almost every questionnaire measure of infant and child temperament includes an activity level scale. Activity level can also be assessed through direct observations of a child's behavior (Eaton, Enns, & Presse, 1987) or by means of so-called actigraphs (or actometers). The latter, which can be worn on the ankle, wrist, or trunk, record the cumulative intensity and frequency of movement during specified time intervals (Saudino & Eaton, 1991; Wood, Saudino, Rogers, Asherson, & Kuntsi, 2007). Activity level is relatively stable between the toddler and school age periods, regardless of whether it is measured by actometers (Buss, Block, & Block, 1980) or by parent report (Guerin et al., 2003). However, likely due to changes between early and late infancy in the psychological significance of activity, other studies have provided ambiguous results (Lemery et al., 1999).

*Attention/persistence.* Attention span, as well as persistence, is viewed as a temperamental characteristic by most temperament researchers. Rothbart, in particular, has introduced an overarching construct, called effortful control, which is the "ability to inhibit a dominant response and/or activate a subdominant response, to plan, and to detect errors" (Rothbart & Bates, 2006, p. 129). This ability can be differentiated into two major sub-components: attentional control (the capacity to maintain attention on tasks as well as to shift attention when desired) and inhibitory control (the capacity to plan and to suppress inappropriate action). Infants and children differ greatly along these dimensions.

Recent neuroimaging data suggest that these differences are associated with three biologically based attentional networks, or systems: the "alerting attentional system," the "orienting attention system," and the "executive attention system" (Posner & Rothbart, 2007; Rothbart & Bates, 2006). Developmentally, the first attention system to appear is the alerting attention system, which is involved in achieving and maintaining a state of alertness. Evidence suggests that, anatomically, this system is supported by the locus coeruleus, the right frontal cortex, and the parietal cortex, with norepinephrine as the principal neuromodulator. The second system, the orienting system, is involved in the selection of information from sensory input. This system is associated with posterior brain areas, including the superior parietal lobe, the temporal parietal junction, and the frontal eye field area, and is believed to be primarily regulated by the neurotransmitter acetylcholine. Finally, the third network, called the executive network, is involved in maintaining continuity of behavior in accordance with goals in the presence of possible distractions. Starting to develop toward the end of the first year of life, the executive system allows executive, self-directed attentional focusing—effortful control (Rothbart & Bates, 2006). Anatomically, the executive network is related to the anterior cingulate cortex, the basal ganglia, and the lateral prefrontal cortex, with dopamine as its prime neuromodulator (Posner & Rothbart, 2007).

In early infancy, attention is typically expressed in orienting and fixation to novel visual stimuli. At this early age, attention tends to be more reactive than self-regulatory; that is, it primarily involves orienting to exogenous stimulation (Posner & Rothbart, 2007). However, some evidence suggests that ability to control distress via atten-

tion may be traced to early infancy (e.g., Harman, Rothbart, & Posner, 1997; Strauss & Rourke, 1978). Laucht, Becker, and Schmidt (2006) found that infants' attention problems at the age of 3 months were related to novelty seeking in adolescence. Kochanska, Murray, and Harlan (2000) found that focused attention at 9 months predicted effortful control during toddlerhood. Rothbart and coworkers have developed various questionnaire measures for assessing temperamental dispositions related to effortful control and its subcomponents (see Table 3). Kochanska et al. (2000) developed a battery of laboratory-based tasks to measure effortful control between 22 months and 5 years. Individual differences in effortful control proved moderately enduring across this time. Preschool delay of gratification, which is a phenomenon related to effortful control, has been shown to predict cognitive and self-regulatory competencies in adolescence (Shoda, Mischel, & Peake, 1990). Computerized tests based on reaction times, such as the Attention Network Test (ANT), are also being used to examine individual differences in the efficiency of the brain systems related to alerting, orienting, and executive attention. Child versions of this test have been successfully used with preschoolers (Rueda et al., 2004) and toddlers (Gerardi-Caulton, 2000).

*Sensory sensitivity.* Compared with the preceding characteristics, sensory sensitivity's status as a distinct temperament dimension is less established by research. However, we find this characteristic to be intriguing enough that we provisionally list it as a basic dimension. Sensory sensitivity includes two separate, though possibly related facets, namely a) sensitivity to aversive stimuli such as loud noises or scratchy clothes, which are captured in the sensory discomfort construct (Kochanska et al., 1998; Rothbart et al., 2001), and b) the ability to react to sensory stimuli of low stimulative value, captured by the notion of perceptual sensitivity (Goldsmith, 1996; Rothbart et al., 2001). Related constructs such as threshold (Martin et al., 1994), sensory defensiveness (Goldsmith, Van Hulle, Arneson, Schreiber, & Gernsbacher, 2006) or high sensitivity (Aron, 2002) probably represent mixtures of both aspects of sensitivity.

Infants and children vary greatly in their responses to sensory stimuli. Some notice even very subtle changes in sound or sight whereas others remain unaware of them. Some avoid certain kinds of sensory experience, whereas others are sensation seekers. Questionnaire measures of sensory sensitivity in infants and children have become increasingly sophisticated and well standardized, typically differentiating between visual, auditory, and tactile sensitivity (Goldsmith et al., 2006). Kochanska et al. (1998) devised an experimental procedure for assessing individual differences in this domain. The researchers found a wide range of individual differences in the reaction of 9-month-old infants to taste (lemon juice), loud noises (produced by a blender), or touch (gently spraying water over the infant's face). Different parameters of affect responses to such stimuli, such as latency to first expression, behavioral acts of approach or avoidance, and average and peak intensity of emotion expressed in multiple channels (vocal, facial, bodily) tended to form coherent clusters. Coherence in responses across modalities, though modest, was also observed (Kochanska et al., 1998). More

recent studies with older children provide further evidence that individual differences in sensory sensitivity may be meaningfully related across modalities. For example, Liem, Westerbeek, Wolterwink, Kok, and de Graaf (2004) provided evidence that children's sensitivity to sour taste is related to sensitivity for bright colors. Furthermore, an instrument specifically devised to measure sensory sensitivity in children, the Short Sensory Profile, has a coherent factor structure and high internal reliability (Dunn, 1999). Sensitivity has been found to be moderately stable in parental reports between the toddler and middle childhood periods (Guerin et al., 2003).

#### *Other Temperament Characteristics and Interrelationships Among Characteristics*

The primary goal of the previous section was to describe early-appearing families of characteristics that respond to criteria for temperament and that are widely acknowledged and studied as infant and child temperament traits. Table 2 provides a summary of these characteristics along with capsule definitions. Additional information about these components can be found elsewhere (for gender differences, see Else-Quest, et al., 2006; for their significance in school, see Keogh, 2003).

Some researchers will find our list overinclusive, given the current state of evidence, whereas others will find that additional temperament traits have not been sufficiently considered. It is clear that not all (candidate) temperament traits have been studied and measured equally well. Thus, it is possible that our list could change as research proceeds.

*Table 2.* Summary and Capsule Definitions of Basic Child Temperament Dimensions.

<b>Dimension</b>	<b>Capsule definitions</b>	<b>Related dimensions</b>
Behavioral inhibition /fear	Inhibition of behavior in response to novel unfamiliar people and situations	Harm avoidance, shyness
Irritability/frustration	Aggressive or irritated behavior in response to painful and/or frustrating input	Difficultness, distress to limitations, anger proneness
Positive emotionality	Propensity to experience positive emotions, typically those associated with approach behaviors (e.g., positive anticipation, investigation, eagerness)	Playfulness, novelty seeking*
Activity level	Frequency, speed and vigor of gross motor movement and locomotion; intolerance toward enforced idleness	Briskness, energy
Attention/persistence	Capacity for attentional focusing and control as basis for voluntary behavior including persistence	Effortful control, distractibility, novelty seeking*
Sensory sensitivity	Ability to react to sensory stimuli (e.g., visual, auditory or tactile) of low stimulative value; proneness to sensory discomfort	Threshold, sensory defensiveness

\* Rather than unitary dimensions, novelty seeking and impulsivity may be the result of a combination of high levels of positive emotionality not contained by adequate levels of attentional or inhibitory control (see p. 23).

*Dimensions.* We think that impulsivity, for example, might also qualify as a temperament characteristic. However, it is at present unclear whether impulsivity is anything more (or less) than the reverse of effortful control, including its subcomponents attention and persistence, perhaps along with a component of positive emotionality. Indeed, one way to look at impulsivity is as an accelerator (positive emotionality) that is not contained in an appropriate breaking system (behavioral inhibition or inhibitory control). From this perspective, impulsivity would be rather a type (below) or a result of a temperament X temperament interaction (see p. 25) than a unitary dimension. Furthermore, in the current review, we wanted to prioritize those temperamental characteristics that are at least partially expressed in the first months of life. Early infancy signs of impulsivity seem to be behaviors related to attention regulation deficits (e.g., Laucht et al., 2006)—behaviors that belong to components already listed. A similar argument could be made for sociability/affiliativeness. Although evidence suggests that there could be temperament underpinnings to individual differences in social bonding and cooperativeness (Rothbart & Bates, 2006), other findings indicate that these dispositions are later emerging qualities, possibly resulting from a combination of the dimensions described earlier (such as lack of anger; see Rothbart, et al., 2000). It should also be noted that, as inclusive as the preceding list may seem at first glance, a wealth of child characteristics would not meet the inclusion criteria for temperament (e.g., abilities, intelligence, psychopathology, interests; also personality traits such as sense of humor, charm, imaginativeness, honesty, manipulativeness).

Some authors have defined certain temperament dimensions as fundamental and others as derivative or subordinate. As will be remembered, Rothbart and colleagues see only three factors as truly fundamental and independent temperament dimensions. Even if there is evidence to support such a triadic structure of temperament (Rothbart & Bates, 2006), most evidence for a threefold basic structure of temperament rests on factor-analytic elaboration of verbal reports. Whether analyses of behavioral observations would lead to a similar model and whether the subcomponents of the phenotypic factors would relate in parallel ways to theoretically important biological substrates remains open at present.

*Types.* There is also a second, person-centered or typological approach to the organization of temperament dimensions. Types are categories of people who share a similar configuration of characteristics. Recall that Thomas and Chess's threefold temperament typology distinguished between difficult, slow-to-warm, and easy children. More recently, a related triadic scheme has identified under-controlled (similar to the difficult category), over-controlled (similar to slow to warm), and resilient children (similar to easy) (e.g., Asendorpf & van Aken, 1999; Caspi & Silva, 1995; Hart et al., 2005). Because the post Thomas and Chess studies were based on children of preschool or later ages, the status of the types as temperaments is not fully established. On the basis of these studies, the three types can be described with the following distinctive attributes.

*Undercontrolled child:* willful, restless, inattentive, impulsive

*Overcontrolled child:* shy, obedient, self-critical, liked by adults

*Resilient child:* self-confident, able to concentrate, self-reliant and open

### *Temperamental Diversity: Where From and What for?*

Increasing interest is being directed to the evolutionary processes that may account for the appearance of temperament traits across species and for individual differences in temperament (Nettle, 2006). According to one point of view, natural selection operates toward maximizing the “best stuff.” Thus, characteristics that are linked to reproductive fitness should cease to exist as an individual differences trait because no variability within the species would be tolerated by natural selection. This kind of natural selection is usually referred to as *directional selection* (Buss & Plomin, 1984). Sometimes, however, what the “best stuff” ultimately turns out to be depends on fluctuations in environmental context. More specifically, at any time and in any geographical location, an optimum value exists for a trait from a fitness perspective, but this value may vary rapidly by time and location. Species must preserve diversity to survive such fluctuations—a selection mechanism sometimes referred to as *fluctuating selection* (Nettle, 2006).

Temperamental diversity probably evolved as a result of fluctuating selection. Indeed, animal evidence suggests that both physical and behavioral traits tend to be associated with fitness costs as well as fitness benefits, depending on environmental circumstances. This “trade-off” account of diversity can also be applied to variation in temperament and personality. Apart from advantages and disadvantages associated with each of the Big Five factors in adults (Nettle, 2006), studies also show that the same child temperament characteristics tend to be associated with positive or negative outcomes depending on a temperament-culture match (e.g., Chen et al., 1998; Super et al., 2008). Associations between temperament and outcomes also depend on other aspects of the environment, as will be discussed at the end of the following section.

### Programs of Longitudinal Research on Temperament and Development

In this section, we review programs of longitudinal research that address the consequences of early childhood temperament. Though such a review could start at the prenatal stage, the present collection already features a separate review article about prenatal predictors of temperament (Huizink, 2008). Thus, here we look at ways in which early childhood temperament affects social development, both normal and abnormal. Because this effect can happen in many different ways, we organize the literature according to three broad developmental mechanisms: differential linkage, temperament by temperament moderation, and temperament by environment moderation.

#### *Differential Linkage*

As noted by Bates in his longitudinal research (1989) and generally supported in a number of other studies (reviewed in Rothbart & Bates, 2006), a particular pattern of conceptually homologous links occurs between key dimensions of temperament and

later dimensions of adjustment. The specific kinds of behavior problems in later childhood appear to embody the specific temperament characteristics of early childhood. The two major dimensions of maladjustment or psychopathology are externalizing problems, such as aggression and rule-breaking problems, and internalizing problems, such as anxiety and depression. These outcomes are predicted by temperament dimensions that are conceptual analogs of the later, adjustment dimensions. The differential linkage pattern shows, in general, that (a) temperamental tendencies to be unmanageable in the early years, which could have elements of either strong approach (positive emotionality) tendencies or weak effortful control, or both, tend to predict later externalizing problems more strongly than they predict internalizing problems; (b) temperamental fearfulness or inhibition tends to predict later internalizing problems more strongly than it predicts externalizing problems; and (c) temperamental negative emotionality or irritability tends to predict both internalizing and externalizing problems. The element of irritability or negative emotionality seems to provide an account of the commonly observed comorbidity of internalizing and externalizing problems (Keiley, Lofthouse, Bates, Dodge, & Pettit, 2003). The temperament-adjustment linkage pattern is found even when the adjustment and temperament concepts are assessed with "adjustment-like" items discarded from measures of temperament and vice versa (Lemery, Essex, & Smider, 2002). The pattern has been found in multiple longitudinal studies, including the Bloomington Longitudinal Study (Bates & Bayles, 1984), the Child Development Project (Keiley et al., 2003), the Dunedin study (Caspi, Henry, McGee, Moffitt, & Silva, 1995), and a number of others (reviewed in Rothbart & Bates, 2006).

#### *Temperament X Temperament Moderation*

Theoretically, the implications of a given temperament trait should depend, at least partly, on the other traits in an individual's temperament profile. Compared with the rich array of patterns that might be possible, there has been relatively little empirical exploration of how one temperament trait moderates the link between another temperament trait and psychosocial adjustment. The main exception is the finding that temperamental effortful control matters more in the development of well-regulated and prosocial behavior for children who are high in negative emotionality than it does for children who are low in negative emotionality. This effect has been demonstrated most extensively in longitudinal studies by Eisenberg and her colleagues (e.g., Eisenberg et al., 2000), but it has also been shown by several other research teams (Rothbart & Bates, 2006).

#### *Temperament X Environment Moderation*

Just as the implications of a temperament trait should depend on the context of other temperament traits, the implications of a temperament trait for adjustment should also depend on the environment within which the child is developing (Wachs, 2000). Thomas and Chess (1977) articulated this connection early in the temperament area

in their notion of goodness of fit. In contrast to the relatively sparse empirical instantiation of temperament X temperament moderation, in the past 10 years there has been a remarkable explosion of research showing temperament X environment moderation in children's psychosocial adjustment. This work has been reviewed in detail in Bates and Pettit (2007) and Rothbart and Bates (2006). In brief, the literature shows substantial patterns of findings involving at least three kinds of temperament dimension—negative emotionality/irritability, fearfulness/inhibition, and effortful control/manageability—and many different aspects of the environment, but especially variations in the qualities of parenting that a child experiences.

The longitudinal studies of Kochanska have helped lead this entire area of research on moderation effects. Kochanska's research exemplifies one major kind of finding in which a child's level of fearfulness becomes either a regulatory advantage or disadvantage, depending on the parenting context. Children who were high in fearfulness developed internalized self-controls best in the context of mothers who controlled the child in a gentle versus a harsh way, whereas children who were fearless developed best with mothers who were warm and fun (e.g., Kochanska, 1997, see also Kochanska, Aksan, & Joy, 2007).

Another kind of temperament X environment moderator effect is that children with an adverse temperament are less likely to develop adjustment problems if in an environment that appropriately challenges their temperamentally based tendencies. For example, Arcus (2001), working in the Kagan tradition, studied infants who were high in negative emotional responses and who were fundamentally likely to develop behavioral inhibition traits in toddlerhood. She found that such infants whose parents and siblings treated them in more challenging, rather than supportive, ways showed less behavioral inhibition. In a study that implies a similar mechanism, but with a different temperament trait and different adjustment dimension, Bates et al. (1998) found that children who were temperamentally resistant to control, or unmanageable, and therefore prone to develop later externalizing behavior problems, were less likely to develop such problems if their mothers were highly controlling in response to the minor misbehaviors common in early childhood.

Considerable work is being done in the temperament X environment area (see Goodnight et al., 2008). Belsky, Bakermans-Kranenburg, and van IJzendoorn (2007) have highlighted one pattern of findings in the literature often referred to in terms of "differential susceptibility to environmental influences." Initially, this concept was introduced to account for the observation that differences in the quality of the rearing environment have a major impact on only a minority of genetically or temperamentally "vulnerable" children. However, it now seems that this minority of children not only suffers disproportionately from adverse environments; it also benefits disproportionately from supporting rearing environments. Other patterns can be seen in the emerging literature, too, and it will be of great theoretical and practical interest to see the further development of this area.

## A Note on Measurement

Assessment of infant and child temperament is typically based on laboratory procedures or parental reports assessed via questionnaires. Table 3 provides an overview of frequently used child temperament questionnaires, listed by age group. Most of these questionnaires have been translated into multiple languages.

Table 3. Overview of Widely Used Questionnaire Measures of Temperament by Age and Conceptual Model.

Infancy 0-12 months	Conceptual Model*
EITQ: Early Infancy Temperament Questionnaire – 76 items (Medoff-Cooper, Carey, & McDevitt, 1993)	CP
RITQ: Revised Infant Temperament Questionnaire – 95 items (Carey & McDevitt, 1978)	CP
IBQ: Infant Behavior Questionnaire – 94 items (Rothbart, 1981)	ND
IBQ-R: Infant Behavior Questionnaire Revised – 184 items (Gartstein & Rothbart, 2003)	ND
ICQ: Infant Characteristics Questionnaire – 24 items (Bates, Freeland, & Lounsbury, 1979)	other
<b>Toddlerhood 13-36 months</b>	
ICQ: Infant Characteristics Questionnaire – 32 items (Bates, Freeland, & Lounsbury, 1979)	other
TTS: Toddler Temperament Scale – 97 items (Fullard, McDevitt, & Carey, 1984)	CP
CCTI: Colorado Childhood Temperament Inventory – 30 items (Rowe & Plomin, 1977)	CB
EAS: EAS Temperament Survey for Children – 20 items (Buss & Plomin, 1984)	CB
TBAQ: Toddler Behavior Assessment Questionnaire – 108 items (Goldsmith, 1996; 2000)	ES
ECBQ: Early Childhood Behavior Questionnaire – 267 items (Putnam, Gartstein, & Rothbart, 2006)	ND
<b>Preschool 3-7 years</b>	
BSQ: Behavioral Style Questionnaire – 100 items (McDevitt & Carey, 1978)	CP
DOTS-R: Dimensions of Temperament Survey Revised – 54 items (Windle & Lerner, 1986)	CP
CCTI: Colorado Childhood Temperament Inventory – 30 items (Rowe & Plomin, 1977)	CB
EAS: EAS Temperament Survey for Children – 20 items (Buss & Plomin, 1984) – T**	CB
CBQ: Children's Behavior Questionnaire – 195 items (Rothbart, Ahadi, & Hershey, 2001)	NB
BIQ: Behavioral Inhibition Questionnaire – 30 items (Bishop, Spence, & McDonald, 2003) – T	BT
TAB: Temperament Assessment Battery – 35 items (Martin, 1999) – T	BIS/BAS
JTCI: Junior Temperament and Character Inventory – 86 items (Constantino et al., 2002)	TC
<b>School age 8-12 years</b>	
MCTQ: Middle Childhood Temperament Questionnaire - 99 items (Hegvik, McDevitt, & Carey, 1982)	CP
STTQ: Shortened Teacher Temperament Questionnaire - 23 items (Keogh, Pullis, & Caldwell 1983)	CP
DOTS-R: Dimensions of Temperament Survey Revised - 54 items (Windle & Lerner, 1986)	CP
SATI: School-Age Temperament Inventory - 38 items (McClowry, 1995)	CP

\* Initials refer to the conceptual models, from which the instruments were derived. CP = Child Psychiatric approach of Thomas and Chess (pp. 8-9); CB = Criteria Based approach of Buss and Plomin (pp. 9-10); ES = Emotion Systems approach by Goldsmith and Campos (pp. 10-11); ND = Neurobiological Developmental approach of Rothbart (pp. 11-12); BT = Bio-Typological approach of Kagan (pp. 12-13); BIS/BAS = Behavioral Inhibition and Approach Systems theory of Gray; TC = Temperament and Character model of Cloninger (pp. 13-14).

\*\* T stands for the availability of a teacher version; the STTQ is specifically devised for teachers.

Laboratory measures typically consist of situations designed to elicit a temperament-related reaction. One of the most extensive laboratory instruments is the Lab-TAB developed by Rothbart and Goldsmith. The Lab-TAB manual (Goldsmith, Reilly et al., 1999; Goldsmith & Rothbart, 1996) specifies the type of trials (episodes) that can be used to assess a variety of temperament dimensions (e.g., fearfulness, anger proneness, persistence). For example, toy retraction and gentle arm restraint are situations for assessing frustration/anger, whereas scary masks or an unpredictable mechanical toy represent objects for trials related to fearfulness assessment. The manual also specifies how children's responses (e.g., smiling, crying) are to be scored and analyzed, for example, by defining parameters related to response latencies, durations, and intensities. An alternative to the Lab-TAB is the Louisville Temperament Assessment Battery (Matheny, 1991). In addition to these instruments, which are designed to assess a wide range of temperament attributes, there are also laboratory procedures for the in-depth assessment of specific infant and child temperament characteristics, such as behavioral inhibition, along with its precursor, high reactivity (e.g., Kagan, 1994; Kagan & Snidman, 2004) or activity level (Meeks Gardner, Grantham-McGregor, Chang, Himes, & Powell, 1995). These and other experimental procedures may also successfully be used to assess infant temperament in a home context (e.g., Kochanska et al., 1998; Seifer et al., 1994).

Laboratory and questionnaire measures have unique advantages and disadvantages, which have been discussed at length (e.g., Kagan & Fox, 2006; Rothbart & Bates, 2006). Suffice it to say that one of the thorniest issues in parental reports is a lack of standardized objectivity (Kagan & Fox, 2006; Seifer et al., 2004). In part, this shortcoming is compensated by the economy of reports, the rich coverage of difficult-to-observe situations, and the evidence that reports possess validity (Rothbart & Bates, 1998). Laboratory measures of temperament, on the other hand, although highly standardized and objective, may capture only a section of the child's behavior—whatever turns out to be observable in a laboratory setting. Laboratory assessments are laborious and therefore usually carried out just once at a given point of measurement, thereby restraining reliability. Similarly, although some of the bias inherent in a single parent's rating may be mitigated by aggregation with the ratings of other observers (e.g., other family members, friends, other caretakers), in practice, aggregation is seldom employed. Use of measures with limited reliabilities will inevitably yield those modest validity correlations between laboratory and parent assessments that are so often bemoaned in the literature (e.g., Goldsmith & Hewitt, 2003).

Once infants grow out of their earliest months of life, they often spend considerable time outside the home, in nursery school, day care, and kindergarten. Thus, a third possibility to assess temperament is to obtain ratings of children's temperament from aggregation of ratings by multiple early childhood professionals. Such ratings offer three distinct advantages. First and foremost, though every observer in isolation is fallible, aggregation over multiple observers tends to enhance observational accuracy. This improvement is due to the aggregation principle, which states that biases of single observ-

ers tend to cancel each other out (Block, 2008). The power of aggregation is not used as effectively in most temperament studies as it might be. Second, in contrast to most parents, early childhood professionals have the possibility of comparing the behavior of a given child to that of many other children over extended periods of time. Third, professionals are not as emotionally involved with the child as parents are. Thus, the ratings of professionals are less likely to be affected by anxieties and hopes that many parents have for their child (Seifer et al., 2004). This third approach has also its limitations, of course. Thus, the particular context of the daycare or kindergarten may affect the ratings, and not all temperament attributes can be equally well observed in these environments. Still, it is an approach worth to be explored in more depth than it has been so far.

### Outlook

Along with other reviews of the child-temperament literature,<sup>1</sup> the current one shows how much research has evolved since the topic of temperament made its forceful comeback into developmental psychology about 25 years ago. Although the general picture is one of progress, we also pointed to several issues that remain unresolved. And there are more, to be sure. As may have transpired from these pages, temperament has many faces, including genes, neurobiological substrates, endophenotypes and overt behavior patterns. How do these various layers of temperament relate to each other? And, given increasing evidence that the “biological make-up” of children can be altered by early and even prenatal experience (Huizink, 2008), should one not consider differentiating between inherited and acquired components of temperament? These are complex issues that only future work will be able to sort out. Among the most intriguing prospects is that, eventually, discoveries in the area can be used to enhance children’s development. One way in which this can happen is by helping children to overcome temperament-related difficulties. For example, it has been shown that preschool children with difficulties relating to executive attention benefit from training exercises (e.g., A. Diamond, Barnett, Thomas, & Munro, 2007; Posner & Rothbart, 2007). This finding is remarkable, given that executive attention-related traits, such as self-discipline, are powerful predictors of school achievement, more powerful than IQ (Duckworth & Seligman, 2005). However, as documented by several studies in section 3 of this overview, sometimes problems arise not so much because of children’s temperaments, as because of lack of fit between the child’s temperamental characteristics and the caretakers’ responses. Thus, another promising area of application, considered by McClowry et al. (2008), consists of new programs designed to train parents and teachers to find rearing practices that are appropriate for a child’s given temperament.

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<sup>1</sup> Next to the relevant chapters in the *Handbook of Child Psychology* (Kagan & Fox, 2006; Rothbart & Bates, 2006) German-speaking readers can find an extensive overview of the field, including its history and practical applications, in Zentner (1998).

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