Theories of Temperament Development

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Abstract

Temperament is defined as biologically-rooted, early-appearing dispositions that shape long-term patterns of socio-emotional development. Much of the research has focused on broad dimensions of emotional reactivity, including positive and negative emotionality, and regulation, marked by effortful control. The article outlines five main research traditions that have approached temperament as both a continuous and categorical construct. For each model, descriptions are provided for the dimensions/category proposed and their defining features, the underlying constitutional bases, and perspectives on temperamental continuity and discontinuity. Next, theoretical and measurement issues are discussed. Finally, we demonstrate how temperament may predict developmental psychopathology through temperament-by-temperament and temperament-by-environment moderations of early risk.

Key words:

Temperament; temperament development, measurements, socio-emotional adjustment, behavioral inhibition, effortful control

Introduction

Temperament has long been viewed as a source of biologically-based individual differences that impact how children interact with, and adapt to, their environments across development, leading to marked individual differences in both normative behavior and in profiles manifesting psychopathology. The landmark roundtable discussion on temperament at the 1985 meeting of the Society for Research in Child Development (Goldsmith et al., 1987) presented the four core models of temperament proposed by Thomas and Chess, Buss and Plomin, Goldsmith, and Rothbart. All four approaches conceptualize temperament as an early-emerging, constitutionally-based, multidimensional construct. The approaches emphasize the stability of temperament as a motivator of behavior, while recognizing that the expression of temperament may change across time (Rothbart & Derryberry, 1981) and contexts (Goldsmith & Campos, 1982). No consensus was reached regarding the conceptual "boundaries" of temperament. For example, Thomas and Chess (1977) confined temperament to observable behavioral styles. Goldsmith and Campos (1982) defined temperament during infancy as the presence of primary emotions. Finally, Rothbart and Derryberry (1981) included cognitive processes as core components of temperament.

Based on findings derived from the four approaches to temperament, a number of researchers have provided an integrative working definition of temperament that can facilitate contemporary research. The definition states that temperament traits reflect early-appearing, biologically-rooted dispositions that encompass negative and positive emotionality, effortful control (EC), and activity levels (Shiner et al., 2012; Zentner & Bates, 2008; Zentner & Shiner, 2012). Each approach highlighted at the roundtable pursues a dimensional approach to temperament, quantifying temperamental variations along a continuous spectrum. In contract,

Kagan (1994) takes a typological approach to temperament. Specifically, he and colleagues identified a temperament category, behavioral inhibition (BI), characterized by hyper-vigilant and withdrawal behavior in response to unfamiliar people and situations in toddlerhood and childhood (Garcia-Coll, et al., 1984; Kagan et al., 1984). Kagan and colleagues (1984) suggested that BI is rooted in individual differences that are evident in early infancy as elevated negative affective and motor reactivity in response to unfamiliar stimuli. These characteristics, in turn, increase the likelihood that the infant will show BI in childhood. Additionally, the biological underpinnings of infant high negative reactivity and child BI are both linked to heightened amygdala reactivity in response to novelty (e.g. Schwartz et al., 2003).

Despite different perspectives taken in defining temperament, the five models have provided a set of multidisciplinary (and complementary) assessment tools and theoretical frameworks for studying temperament and its development. These include parent- and self-report questionnaires, psychophysiological measures, and laboratory observations of behavior. Behavioral genetic approaches to each of these measures have also been used to assess the influence of gene-environment relations in the expression of temperament.

Contemporary temperament research focuses on studying how intrinsic (biological and cognitive) and extrinsic (environmental) processes interact to moderate the continuity of temperament and influence the link between early temperament and subsequent socio-emotional adjustment. The present article will discuss, in three main sections, 1) the five major approaches to temperament (**Table 1**); 2) current theoretical and methodological issues in research on temperament development; and 3) the mechanisms by which documented relations between temperament traits and maladjustment are moderated by other temperament traits (temperament × temperament moderation) and environmental factors (temperament × environment

moderation). We take the perspective that early temperament does not determine developmental outcomes. Rather, temperament traits interact with internal (e.g. neural processes and cognitive control functions) and external (e.g. parenting and family environments) factors to influence individuals' risks and resilience to events and contexts that shape developmental trajectories.

Section I: Theoretical Approaches to Temperament

The Thomas and Chess Approach

The New York Longitudinal Study (NYLS) stands as a landmark in the field of temperament research (Thomas & Chess, 1977). Thomas and Chess conceptualized temperament as reflecting behavioral styles that can be characterized across nine dimensions: activity level, regularity, approach-withdrawal, adaptability, threshold of responsiveness, intensity of reaction, quality of mood, attention span/persistence, and distractibility. Children are categorized into "difficult", "easy", and "slow to warm" types based on their scores on each dimension. For example, a difficult temperament is defined as high in irregularity, withdrawal, negative mood, intensity of reaction, and unadaptability to change. Moreover, Chess and Thomas introduced the concept of "goodness of fit" to describe the temperament-environment interplay and its link to adjustment.

The argument is that optimal development outcomes are more likely to emerge under the conditions of a good fit: the child's temperament is closely matched to the demands, expectations, and opportunities of the environment. Conversely, a mismatch between temperament and environmental characteristics is more likely to result in maladaptive outcomes (Thomas & Chess, 1977). For example, Lerner (1984) reviewed evidence demonstrating that better fit with individual demands in the classroom or at home was associated with higher school

achievement, better child-parent relations, and fewer clinical problems. More recently, Dennis (2006) showed that children demonstrated better emotion regulation, marked by low frustration and high persistence while waiting to open an attractive gift, only when children and their mothers both shared high levels of temperamental approach. The notion of "goodness of fit" provides a model suggesting that rather than directly predict socio-emotional outcomes, temperament and the child's social contexts dynamically moderate each other's influences on socio-emotional behavior.

The Buss and Plomin Approach

Buss and Plomin (1975, 1984) proposed a behavior genetics-oriented model of temperament, proposing that temperament traits have an early onset and are inherited, evolutionary adaptive, present in non-human animals, relatively stable during development and predictive of later behaviors in adulthood. They identified three core dimensions: 1) emotionality (E), the tendency to become upset easily and greatly (considered as equivalent to distress); 2) activity (A), which contains the components of tempo and vigor; and 3) sociability (S), defined as the preference for others' company and the tendency to engage in social interactions. These temperament dimensions are measured by the EAS Temperament Survey (Buss & Plomin, 1984). Buss and Plomin suggested that temperament traits become more differentiated during development (Goldsmith et al, 1987). For example, only a state of general distress is observable in young infants, but three dimensions of emotionality – distress, fear, and anger – can be detected by age 2. In the model, temperament dimensions undergo quantitative changes in their mean levels over time. As the results of neural maturation and increased socialization by the child's environment, emotionality tends to dampen, and activity and sociability are expected to

strengthen over the course of development. However, the underlying structure of temperament remains stable.

To provide support for the heritability of temperament, Buss and Plomin (1984) utilized twin studies to quantify the genetic contributions to individual variance in temperament traits. Monozygotic (MZ) twin pairs showed significantly larger correlations in all three EAS traits versus dizygotic (DZ) twins. Given that MZ twins have two-fold more genetic similarity than DZ twins, the greater phenotypic similarity in MZ twins indicates genetic influences on trait variance (see Saudino, 2009a, for a review). Although Buss and Plomin's conceptualization of temperament dimensions is relatively less influential in contemporary temperament research, the behavioral genetic approach provides an important tool to examine the relative genetic and environmental influences on the stability of, and changes in, temperament overtime. This approach also provides insight into the mechanisms by which genetically-based temperament traits interact with environments to predict socio-emotional competence or maladjustment.

The Goldsmith Approach

Goldsmith and Campos (1982; 1986) defined temperament as individual differences in the propensity to express and experience all primary emotions (e.g. joy, anger, and fear). Individual differences in temperament are reflected in variations in intensive and temporal parameters of behavior, including facial, vocal, and motor expressions. Goldsmith and Campos (1982; 1986) restricted their definition to infant temperament, in order to obtain a relatively "pure" conceptualization of temperament expressions that are not mediated by socialization influences and cognitive processes. The initial definition is also behaviorally-oriented, as behavioral expressions impact infants' interactions with their environments and can provide a

starting point to understanding the biological underpinnings of temperament (Goldsmith & Campos, 1982).

Goldsmith and Campos' (1982) original theory did not emphasize emotion regulation as a defining feature of temperament, as it was assumed that infants do not have the cognitive maturity to recognize and modify their emotions (Gottman, et al., 1997). Emotion regulation refers to the processes by which individuals monitor, evaluates, and modifies their emotional reactions (Thompson, 1994). However, evolving conceptualizations have led Campos et al (2004) to argue that emotion expression and regulation might not be separable, as the observed emotion outputs are likely to have been processed by preexisting regulatory functions, even in infancy.

With the goal of capturing the behavioral expression of temperament, Goldsmith and colleagues developed the Toddler Behavior Assessment Questionnaire, TBAQ (Goldsmith, 1996), and the age-adapted Laboratory Temperament Assessment Battery (Lab-TAB; Goldsmith & Rothbart, 1993), to measure multiple dimensions of temperament (see **Table 1**). Lab-TAB stressed that the context of behavior needs to be considered in the assessment of temperament, as the expression of temperament dimensions are influenced by the eliciting situations (Goldsmith & Campos, 1986; 1990). The Lab-TAB provides a series of standardized behavioral tasks and coding schemes that assess temperament dimensions in emotion-eliciting episodes in the laboratory or at home (Goldsmith & Gagne, 2012). For example, fear is elicited by the approach of a toy spider in toddlers and the approach of a stranger in older children. The elicited facial expressions, gestures, and vocal and motor behaviors are coded in terms of latency, duration, and frequency of occurrence (see Goldsmith and Gagne, 2012, for a full list of temperament dimensions, behavioral tasks and coded variables).

Building on this initial conceptualization of temperament, Goldsmith and colleagues focused on the psychobiological processes underlying emotion reactivity and regulation, examining genetic and environmental influences on observed variations in temperament. For example, Buss and colleagues (2004) combined both Lab-TAB and physiological measurements and found that heightened fearfulness, coded as freezing behavior, in a mildly threatening situation was associated with heightened baseline sympathetic reactivity a week later. This implies a possible association between fearful temperament and reduced physiological regulation. Utilizing twin designs, correlations on a variety of temperament dimensions, including anger proneness and positive affect, were higher between MZ cotwins than DZ cotwins (e.g. Goldsmith et al., 1997; 1999), which were consistent with Buss and Plomin (1984)'s findings. Additionally, data from behavioral genetic studies can be fitted to the "ACE model" to estimate the proportion of individual variance that can be attributed to additive genetic effects (A), shared environmental effects within families (C) and non-shared environmental influences unique to individuals (E). While there were significant genetic influences on temperament variations, Goldsmith and colleagues (1999) also found moderate shared environmental influences on positive affect (smiling, laughter, and soothability). The broader contribution of the behavioral genetic approach to understanding how temperament-by-environment interactions predict behavioral problems will be discussed more fully below.

The Rothbart Approach

The Rothbart model (Rothbart & Derryberry, 1981) provides a more inclusive conceptualization of temperament than the previously reviewed approaches. In particular, this model defines temperament as biologically-rooted individual differences in reactivity and self-regulation in emotional, activational, and attentional processes. Reactivity refers to levels of

biological arousal triggered by changes in internal and external stimulations. Negative affect and surgency are the reactive aspects of temperament, which can be measured by intensity, latency, timing of peak rise and recovery from the initial reaction. Self-regulation refers to the processes that modulate reactivity (Rothbart & Derryberry, 1981) and is reflected in the temperament dimension effortful control (EC).

Taking a dimensional approach, each of the three higher-order dimensions is comprised of several lower-order temperament traits (Rothbart & Bates, 2007). Surgency consists of sociability, motor activity, and expressions of pleasure in anticipation of rewards or during high-intensity/novel activities. Negative affect encompasses discomfort, anger/frustration, sadness, fear, and low soothability. EC refers to the ability to voluntarily suppress a predominant response in order to perform a subdominant response according to environmental demands, detecting errors and planning (Rothbart & Bates, 2007). It is indexed by attention orienting and focusing, inhibitory control, perceptual sensitivity, and showing pleasure in low-intensity activities (Rueda, 2012). Questionnaire measurements under this approach assume heterotypic continuity in temperament development. That is, phenotypic manifestations of a temperament trait may vary across time, but the underlying biological profile is constant (Caspi, 1998). As presented in Rothbart and collegues' age-specific questionnaires, the broad dimensions remain stable, but the specific traits indexing each dimension changes across age groups. For example, EC during early infancy is measured as a form of involuntary attention orienting. As more voluntary forms of control develop later in life, indices of EC come to also encompass attention shifting and focusing (Rueda, 2012).

The Rothbart model is unique among the reviewed approaches in prominently placing regulation as a core component of temperament. EC has been studied with multiple-levels of

analyses, including the aforementioned parent- and self-report questionnaires, as well as computerized cognitive tasks and laboratory observation tasks. Cross-method convergence of EC assessments has been supported (Kochanska et al., 2000; Posner & Rothbart, 2000), and evidence suggests that the broad dimensions of EC are relatively stable (Kochanska et al., 2000). Computerized cognitive tasks of EC typically require children to inhibit predominant responses in order to perform subdominant ones to maximize performance accuracy (e.g. the Stroop task, reviewed in Rueda, 2012). Findings from these tasks demonstrate that EC capacities first emerge at the end of first year of life and continue to improve during late childhood (Rothbart et al., 2007). For example, the ability to detect errors is observable as early as 7 months of age (Berger et al., 2006). Toddlers begin to show good executive attention functions in a spatial conflict task at 2.5 years old, and their ability to resolve conflicts steadily improves between 4 and 7 years (Rueda, 2012). Research adopting these marker tasks in conjunction with neuroimaging measures suggests that the development of EC is subserved by the executive attention network, a neural system consisting of the anterior cingulate gyrus and lateral prefrontal areas that contribute to cognitive and emotional self-regulatory functions (Rothbart et al., 2007).

As noted, the manifestation of temperament may change over time in this model (Rothbart & Bates, 2007). In addition to maturational changes in biological processes subserving negative affect and surgency, observed changes are also directly associated with the growing influence of EC on behavior. As EC develops during toddlerhood, it facilitates voluntarily shifting attention away from distressful stimuli, inhibiting impulses, and self-monitoring behavior. As a result, it exerts "brakes" on unregulated negative emotionality and motor activities (Rothbart & Derryberry, 2002), and enhance children's coping strategies and abilities to adapt to environmental demands. Cross-sectional studies demonstrate negative associations

between aggression and indices of EC (e.g. Frick & Morris, 2004). Longitudinal data also indicate that higher EC predicts fewer experiences of negative emotional arousal, and conversely, elevated negative emotionality predicts lower EC efficiency (reviewed in Eisenberg et al, 2010). As such, it is the continued dynamic and reciprocal interactions between temperamental reactivity and regulation that contribute to observed instability of temperament expression over time (Rothbart & Bates, 2007).

The Kagan Approach

Distinct from approaches that hold a dimensional view of temperament, Kagan and colleagues defined behavioral inhibition (BI) as a temperamental *category* characterized by discrete biological dispositions marked by high psychophysiological reactivity coupled with hyper-vigilance and behavioral withdrawal upon encountering novel people, objects, and events (Kagan et al., 1984). Elevated negative reactivity toward novelty can be observed as early as 4 months (Kagan, 1994). Research on BI focuses on examining the stability of BI and the relation between BI and internalizing symptoms (especially anxiety problems) over time (Kagan & Fox, 2007).

Kagan's approach emphasizes the use of behavioral observations and biological measures, rather than parent-report questionnaires, to study temperament (Kagan, 2003). Based on laboratory observations, 4-month-old infants who displayed elevated motor reactivity and distress toward novel visual and auditory stimuli were categorized as "high reactive" (Kagan & Snidman, 1991) or "high negative" (Fox et al., 2001). BI in young children (from 14 months to before 48 months of age) is examined by coding their latencies to approach and interact with unfamiliar people and objects and an experimenter. Assessment in older children (4 years to school age) focuses on how they play and interact with unfamiliar peers. Hence, Kagan's

approach also focuses on heterotypic continuity of temperament development over time (Fox et al., 2001).

Longitudinal studies suggest that BI displays moderate stability. Kagan and colleagues (summarized in Kagan, 1994) found that the high reactivity seen in 15%-20% of 4-month-old infants is likely to be an antecedent of BI. That is, the trait biases infants to become behaviorally inhibited as toddlers and display social reticence (BI in social situations) in childhood (Kagan et al., 1998). Findings from a series of studies conducted by Kagan's group collectively suggest that although not all high reactive infants remain behaviorally inhibited in childhood, the percentage of high reactive infants who are later categorized with BI is greater than those who were identified as uninhibited (Kagan, 2003). Considerable continuity as well as discontinuity was also exhibited in Fox et al (2001)'s longitudinal study of BI: at 14 months of age, infants who were classified as "high negative" displayed higher levels of BI than those who were identified as "low reactive" or "high positive". The differences between the three groups were not significant at 2 and 4 years of age, although the "high negative" group still had the higher BI scores compared to and "low reactive" and "high positive" groups.

Grounded in cross-species research on the neurobiology of fear responses (LeDoux et al., 1988), Kagan proposed that the neurobiological foundation of BI is rooted in a highly-excitable amygdala, which predisposes children to become hyper-vigilant toward unfamiliar stimuli (Kagan, et al., 1988; Kagan, 2012), as well as contributes to the development and stability of BI (Fox et al., 2005; Kagan et al., 1988). A series of neuroimaging studies indicate that adults who were identified as "high reactive" at 4 months showed greater amygdala responses when presented with neutral unfamiliar faces compared to those who had been "low reactive" (Schwartz et al., 2003, 2011). Moreover, Pérez-Edgar and colleagues (2007) found that,

compared to non-inhibited adolescents, adolescents with sustained BI in childhood showed elevated amygdala response while rating how afraid they were of emotional and neutral faces. The behaviorally inhibited adolescents also showed greater amygdala activation in task conditions involving uncertainty (i.e. rating fearfulness to happy faces).

The central nucleus of the amygdala projects to other subcortical regions that mediate cardiac and neuroendocrine responses. Amygdala hyper-arousal may potentially explain larger heart rate acceleration seen in responses to unfamiliarity, higher levels of baseline heart rates, and higher cortisol levels that are associated with the BI profile (Kagan et al, 1988; Marshall & Stevenson-Hinde, 2001). The hyper-responsive amygdala is also likely to mediate the stability of BI, as the amygdala has extensive connections to cortical areas that contribute to behavioral avoidance and deficient safety learning observed in behaviorally inhibited individuals (Schwartz et al., 2011).

Stable BI across childhood is a risk factor for anxiety disorders, especially social anxiety disorder (SAD, Pérez-Edgar & Fox, 2005a). BI and anxiety disorders have a range of overlapping behavioral, cognitive, and neurological features, including social withdrawal, attention bias to novelty and potential threats, high baseline cortisol levels and amygdala hyper-reactivity (Clauss & Blackford, 2012; Degnan et al., 2010). Indeed, cross-sectional studies showed positive associations between levels of BI and social anxiety. Retrospective evidence suggests that adolescents and adults with anxiety symptoms also reported higher levels of social withdrawal in childhood (reviews: Degnan & Fox, 2007; Degnan et al., 2010). Additionally a recent meta-analysis of prospective longitudinal studies suggested that risk for SAD increases sevenfold for behaviorally inhibited children (Clauss & Blackford, 2012).

However, BI is unlikely to simply be an early manifestation of anxiety disorders. First, the functional impairments and hypersensitivity to social evaluations associated with SAD are not defining features of BI (Clauss & Blackford, 2012). Second, there is only moderate continuity of BI from infancy through childhood, with correlations between testing waves in longitudinal studies ranging from 0.18 to 0.52. Clauss and Blackford (2012)'s meta-analysis revealed that only 43% of behaviorally inhibited children developed SAD. The considerable degree of discontinuity suggests that BI should be considered as a construct distinct from anxiety disorders.

The central tenet of the Kagan's approach argues that early BI does not necessarily predict stability of temperament and later anxiety disorders. Rather, it constrains possible socio-emotional development outcomes: the possibility of behaviorally inhibited children *not* becoming exuberant or developing externalizing problems is greater than the likelihood of those children staying behaviorally inhibited or developing anxiety problems (Kagan, 2003; Kagan & Fox, 2007). Recent research has begun to examine factors and mechanisms that moderate the link between BI and anxiety; these findings will be discussed in later sections.

Section II: Current Methodologies and Issues in Temperament Research

Contemporary temperament research has shifted its focus from debating the defining features and structure of temperament (Goldsmith et al., 1987) to studying developmental trajectories from early temperament to subsequent socio-emotional adjustment outcomes. To summarize the shared viewpoints and new perspectives on temperament since the roundtable discussion, Shiner and colleagues (2012) defined temperament as early-appearing traits in the domains of motor activity, emotion, attention, and self-regulation. Contemporary

conceptualizations of temperament stress that the construct should not be perceived as strictly stable and impermeable to external influences.

First, traits may have different developmental courses, and those that come online later during infancy and childhood (e.g. regulatory traits) may affect the expression of existing traits (e.g. temperamental reactivity) (Rothbart & Derryberry, 1981). Second, assessments of temperament, including the questionnaire instruments developed under the Rothbart approach and laboratory observation tasks (Lab-TAB, Goldsmith & Rothbart, 1993; tasks for identifying BI, Fox et al., 2001) reflect *a priori* conceptualization of heteroptypic continuity in temperament development (Caspi, 1998). That is, age-appropriate questions or eliciting tasks that are adopted to test behaviors take different forms of expression but are thought to evoke the same underlying bases throughout development (Fox & Henderson, 1999). Third, although temperament traits are biologically-based, behavioral genetic research has found only moderate genetic influences. Rather, both genetic and environmental factors, especially nonshared environmental influences, contribute to the stability and change of temperament overtime (Saudino & Wang, 2012). This notion is incorporated in the contemporary definition of temperament, stressing temperament as the product of the continuous influences of genetic, biological and environmental processes throughout development (Shiner et al., 2012).

Issues relating to the structure of temperament

Zentner and Shiner (2012) proposed a hierarchically-organized model of temperament that consists of three higher-order factors: Negative Emotionality, Positive Emotionality, and EC. Under this formulation, BI would be subsumed within the negative emotionality dimension. The on-going debate of whether temperament should be characterized as variations along a spectrum

or qualitative differences across distinct categories has important implications for studying the continuity versus discontinuity of temperament across development.

Support for the typological approach has come from sophisticated modeling analyses (Loken, 2004; Woodward et al., 2000), which replicated Kagan's (1994) categorization of a group of infants who are "high reactive" in response to unfamiliar stimuli. Moreover, accumulating neurological evidence indicates that, in addition to the differences seen in amygdala reactivity toward novel faces between behaviorally inhibited and non-inhibited individuals (Pérez-Edgar et al, 2007; Schwartz et al., 2003; 2011), activations in striatal structures when processing incentive-related cues also differentiate between the BI and non-BI groups (Helfinstein et al., 2012). For example, Guyer and colleagues (2006) found that high and stable BI was associated with increased striatal activations of during anticipation of potential monetary rewards. However, this association was not found when BI was treated as a continuous variable that reflects quantitative variations in a spectrum of BI (Pérez-Edgar et al., 2013). The findings provided additional neurobiological correlates of BI, thus buttressing the typological approach of temperament.

However, Class and Blackford (2012) pointed out that longitudinal studies using discrete BI profiles (e.g. Chronis-Tuscano et al., 2009) and those adopting continuous measures of BI (e.g. Muris et al., 2001) have provided converging results, suggesting that BI predicts greater risks for social anxiety disorders. Hence, both categorical and dimensional conceptualizations could potentially provide useful frameworks to study the link between early temperament and later psychopathology (Clauss & Blackford, 2012).

It is important to recognize that a temperament trait, measured either as a category or along a dimension, is not expressed on its own. Rather, any one trait is influenced by other traits

during development (Zentner & Shiner, 2012). The Rothbart approach underscored the notion that expressions of temperament are influenced by continuous interactions between reactive and regulatory components of systems. As self-regulatory functions emerge later than temperament reactivity, such interactions produce a source of discontinuity in temperament expressions overtime (Rothbart & Bates, 2007). At the neural level, efficiency in regulating reactivity is subserved by the coupling between regions associated with regulation (e.g. the anterior cingulate cortex and the prefrontal cortex) and reactivity (e.g. the amygdala and the striatum) (Dennis, 2010; Henderson & Wachs, 2007). Hence, children characterized with high negative emotionality are likely to have perturbations in functional connectivity between the cortical and subcortical regions, predisposing them to deficient regulatory cognitive functions (e.g. Hardee et al, 2013). The mechanism by which temperament traits moderate each other to influence socio-emotional adjustment outcomes, especially reactivity-by-regulation moderation (Zentner & Bates, 2008), will be discussed in details in the next section.

The influences of cultural values and norms on the perception and response to temperament traits and temperament development are non-negligible. Culture creates a bioecological environment (the ecological system theory, Bronfenbrenner & Morris, 2006) or "developmental niche" (Super & Harkness, 2002) that encompasses children's physical and social environment, caregivers' attitudes and beliefs of childcare practice. Parents' cultural belief system influences how they perceive, evaluate, and respond to their children's temperament, which in turn shape children's temperament development and adjustment (Super & Harkness, 2002). Consistent with this framework, Chen and French (2008)'s contextual-developmental perspective stresses that social interactions with caregivers and peers, and the resulting

regulatory impacts on children's behavior, mediate cultural influences on child temperament development.

Cultural influences on parental perception are reflected in parent-reports of temperament. Cross-culture research comparing infant temperament in the United States (individualist values) and Russia (mixed values of individualism and collectivism) using the Infant Behavior Questionnaire-Revised (IBQ-R, Gartstein & Rothbart, 2003) found that Russian infants scored lower on regulatory functioning than American infants (Gartstein, et al., 2003). Additionally, different infant temperament structures were found between the two cultures, such that Russian parents rated their children as higher on negative emotionality and lower on surgency/positive affectivity compared to ratings from American parents (Gartstein et al., 2005).

The impacts of immigration and involvement in the host culture (i.e. acculturation) on parental perception of infant temperament is demonstrated in Gartstein et al (2009), who examined the impact of acculturation among Russian families immigrated to either the US or Israel. In the US, greater adherence to Russian culture was correlated with higher ratings of child positive emotionality. In contrast, greater parental involvement of Russian culture was linked to lower child positive emotionality for Russian immigrants in Israel. Moreover, Russian-Israeli parents with greater acculturation to the host culture perceived their children as higher on regulatory abilities indexed by duration of orienting and persistence of attention. The study illustrates the role context, as a reflection of cultural expectations, might shift parental perception of what traits are adaptive. These perceptions might then affect parental practice, which in turn impacts both their children's temperament development and the parent's perception of their child's temperament (Gartstein et al., 2009). Taken together, the cross-cultural studies support the presence of cultural difference in temperamental reactivity and regulation. One important

mediator of cultural influences on children's temperament development is likely rooted in more proximal external influences to children such as parental attitudes and practice. (Chen et al., 2012).

Issues relating to measurement approaches

Advances in the understanding of temperament and its influence on development are dependent on measurement methodologies. Assessments target naturally-occurring behaviors reported by caregivers, behaviors elicited by laboratory-controlled tasks, and neurophysiological correlates of these behaviors (Goldsmith & Gagne, 2012; Rothbart & Bates, 2007). Temperament models differ in their methodologies of choice, with dimensional approaches largely relying on caregivers' reports, as well as naturalistic and laboratory observations, while Kagan's categorical approach tends to capitalize on laboratory observations and neurophysiological measurements (Kagan & Fox, 2007). Regardless of these subtle variations in focus, temperament research has stressed the necessity of adopting a multi-method perspective. Multiple measurement approaches complement each other to overcome limitations of a specific method, and together they provide insights into unique aspects of temperament.

Caregiver reports have been criticized for being unreliable, invalid, and limited in the information provided. Kagan and Fox (2007) summarized the sources of biases and limitations. These include: 1) caregivers tend to avoid reporting behaviors that they believe are socially-undesirable. 2) Their interpretations of the offspring's behavior are also biased by their own characteristics and experiences. 3) Human participants are inclined to maintain consistency in their descriptions. That is, parents might report their child is high on a trait while disregarding behaviors that are inconsistent with the trait. Additionally, 4) questions can only tap into

observable behaviors that are associated with a specific trait, leaving the biological underpinnings of the behaviors unmeasured. Hence, important mechanisms underlying a trait that are not discernible in overt behavior could be overlooked (Dennis et al., 2012).

Rothbart and Bates (2007), however, argued that parent reports provide unique information on children's general behavioral tendencies across different situations. Furthermore, measurement validity should be evaluated in a continuum rather than absolute rejection or support. For example, Bates and Bayles (1984) found that measurement biases did not exceed the objective components in accounting for the variances in parents' reports, supporting for the value of such measurement.

Laboratory observations allow for relatively objective assessments of micro-level information on latency, duration, and frequency of facial, vocal, and gestural responses to specific elicitors that are inaccessible to verbal reports and neurological measures. However, their general limitations include the fact that behavioral coding might be subject to experimenters' biases, observations may lack ecological validity, and the episodes may elicit emotional states rather than measuring temperament traits (Goldsmith & Gagne, 2012). Despite these limitations, laboratory observations, particularly the Lab-TAB battery (Goldsmith & Rothbart, 1993), allow for flexibility in behavioral coding and data reduction compared to questionnaire assessments (Goldsmith & Gagne, 2012).

Target emotional and behavioral responses can be coded at both macro- (e.g. raters' impressions) and micro-levels (e.g. changes of affect across short intervals). The conventional approach is to aggregate behavioral parameters (e.g. intensity, latency, and behavioral frequency) across episodes that are designed to measure one temperament dimension. Alternatively, specific affective responses can be evaluated according to individual eliciting contexts. Adopting the

latter, more nuanced, data analyses technique, recent research has explored novel domains of temperament.

One example is research on the dysregulated fear profile. Buss (2011) adopted a multilevel modeling approach to depict children's changes in fear behaviors across episodes that are low, moderate, and high in threat. The analyses identified a "dysregulated fear" profile, characterized by high levels of fear in low threat and benign contexts (e.g. playing with puppets and a clown). This is different from the analytic method used to identify BI, where behavioral parameters are aggregated across episodes. Dysregulated fear showed stability from age 3 to 5, and the profile uniquely predicts maternal- and teacher-reports of social wariness and anxious symptoms after controlling for BI (Buss, 2011). In a follow-up study, Buss and colleagues (2013) found that children characterized with dysregulated fear were 4 times more likely to show social anxiety symptoms at the transition to kindergarten compared with other fearful children. These findings suggested that fearful temperament may be a heterogeneous construct. In particular, dysregulated fear may be a temperament type distinct from BI that is specifically associated with a developmental trajectory to social anxiety. Buss and colleagues' research underscored the importance of capitalizing on existing observational assessments to evaluate how temperament traits interact with contextual factors to shape outcomes (Shiner et al., 2012).

Moreover, laboratory observations enable the investigation of more fine-grained temperament traits that might not be identifiable from caregivers' reports on general behavioral tendencies observed in everyday life. Kochanska and colleagues' laboratory assessment measures five components of EC: delaying, slowing down motor activity, suppressing activity to signal, effortful attention, and lowering voice (Kochanska et al., 2000). These can be categorized into "cool" EC (e.g. effortful attention), referring to cognitive functions assessed in emotionally

neutral settings, and "hot" EC (e.g. delaying), which taps into the abilities to control emotional reactivity and impulses. While model fitting has supported the one-factor structure of EC (Allan & Lonigan, 2011; Sulik et al., 2010; Wiebe et al., 2011; but see Brock et al., 2009), Hongwanishkul and colleagues (2005) found that the two types of regulatory processes engage different neural processes. Moreover, the distinction between "cool" and "hot" EC functions might be differentially related to developmental outcomes (King et al., 2013). For example, Kim and colleagues (2013) found that "cool" tasks that recruit effortful attention predicted academic abilities but not behavioral problems, whereas "hot" tasks that requires the regulation of emotion predicted behavioral problems but not academic performance. Therefore, it might be fruitful to incorporate both types of behavioral assessments to account for heterogeneity within EC and improve specificity in predicting later adjustment.

Behavioral genetics, as a theoretical and empirical approach, has made prominent contributions to the understanding of the constitutional basis of temperament (Goldsmith et al., 1987). More importantly, longitudinal behavioral genetic designs enable one to examine the relative strength of genetic and environmental influences on the continuity or instability of temperament across age (Saudino, 2009a). Using twin and adoption designs, the contributions of genetic, shared, and nonshared environmental effects can be evaluated at one age point or across development. There is consistent evidence of a genetic basis for a large variety of temperament constructs, including anger/frustration, BI, activity level, EC, and positive affect (Gagne et al., 2009; Saudino, 2009a). Longitudinal twin studies suggest that genetic factors contribute to the continuity of temperament traits, whereas changes in temperament traits over time were mediated by both genetic and environmental factors, especially the environmental influences that are unique to individuals (Saudino, 2009a).

In addition to informing the source of stability and change in temperament, the behavioral genetics approach provides a tool to examine the cross-method and cross-situation validity of temperament measures. For example, regarding assessments of activity level, Saudino (2009b) found that there are overlapping as well as method-specific genetic effects for parental reports and mechanical recordings of activity levels. Moreover, there were also different genetic influences for activity levels assessed at home versus the laboratory (Saudino & Zapfe, 2008). These findings suggest that different instruments and measurement contexts may tap into distinct etiology of observed behaviors. Therefore, caution must be taken when making generalizations across findings gathered from different measurement tools under different contexts. This also raises issues for using age-adapted instruments, as new genetic effects might emerge simply because different behaviors are now being assessed.

Section III Temperament and Developmental Psychopathology

Temperament is commonly studied in relation to the etiology of psychopathology or socio-emotional maladjustment. A temperament trait may act as a risk or resilience factor that predisposes individuals to psychopathology or protects them from disorder (Lengua & Wachs, 2012). Additionally, temperament is associated with adjustment outcomes through its influence on individuals' experiences with external environments and their exposure to risks or protective factors (Lengua & Wachs, 2012). This section discusses the relation of temperament to two broad domains of psychopathology in youths: internalizing symptoms, including anxiety and mood disorders, and externalizing symptoms, including aggression and oppositional defiant problems.

One view on the possible mechanisms linking temperament and psychopathology argues that certain temperament traits have a linear effect on adjustment outcomes. For example, stable BI has been shown to be a risk factor for anxiety problems (Pérez-Edgar & Fox, 2005a), and EC has found to be negatively associated with both externalizing and internalizing symptoms (Eisenberg et al., 2010). However, two theoretical considerations contradict the simple direct effects. First, cultural context may interact with temperament to influence later adjustment (Chen et al., 2012 for reviews). Research on BI supported the contextual-development model (Chen & French, 2008), emphasizing that social evaluations and attitudes toward temperament traits regulate children's behavior and mediate cultural influences on adjustment. For example, BI was found to associate with greater maternal warmth and acceptance in Chinese children, whereas Canadian children with BI experienced more maternal rejection (Chen et al., 1998). Furthermore, studies have shown that early BI predicted social and academic competence in middle childhood and adolescents among Chinese children (Chen et al., 1999; 2009a). Hence, in contrast to findings from Western societies, greater social acceptance of BI in China might have facilitated children's socio-emotional development. However, Chen et al (2009b) also found that learning difficulties and mood problem emerged in inhibited Chinese children in urban areas, likely to be due to the increased influence of Western culture.

A direct link between temperament and adjustment was also inconsistent with the developmental psychopathology perspective. This framework stresses that temperament is an etiological factor should be studied in interactive systems, in order to reflect the complex, transactional nature of developmental processes, in which adjustment outcomes are the result of successive adaptations that build upon one other (Sroufe, 2009). The mechanisms of temperament-by-temperament interactions and temperament-by-environment interactions in

predicting psychopathological symptoms (Zentner & Bates, 2008) will be addressed in the current section.

Temperament × temperament moderation

The framework of temperament-by-temperament moderation is rooted in the Rothbart approach to temperament, which highlights that the interplay between reactive and self-regulatory components of temperament in shaping developmental trajectories. One example of how temperament traits might predispose individuals to psychopathology can be found in research examining the link between BI (as negative reactivity) and anxiety symptoms, and how this link might be moderated by components of EC. EC, as noted, is a self-regulatory function that encompasses executive attention and inhibitory control (Rueda et al., 2005).

BI is associated with increased attention towards potentially threatening stimuli. For example, Pérez-Edgar and Fox (2005b) showed that shy children biased their attention to negative cues in an emotional Stroop task. Attention plays a gatekeeping role in psychological processing by selecting information for further processing (Posner & Rothbart, 2007). Attention bias to threat is likely to elicit a cascade effect on subsequent information processing, leading individuals to encode and interpret relatively neutral social information as threatening, which in turn produces maladaptive behaviors such as social withdrawal. These processes influence each other through a feedback loop, contributing to the formation of a response repertoire that perpetuates and strengthens anxious behaviors overtime. This process is likely to be more acute in behaviorally inhibited children who are at risk for anxiety problems (Pérez-Edgar, 2012). Indeed, longitudinal studies indicate that childhood BI strongly predicts subsequent social withdrawal only in adolescents and children displaying attention biases to threat (Pérez-Edgar et

al., 2010a, b; 2011), suggesting that attention bias acts as a 'tether' to predispose children with BI to a developmental trajectory marked by elevated anxiety symptoms (Pérez-Edgar et al., 2014).

Executive attention control, as an EC function, facilitates voluntary shifts of attention from threat and a subsequent focus on more positive cues, which may in turn allow for better self-regulation of emotion and behavior (Lonigan & Vasey, 2009). Eisenberg et al (1998) found that shy children with poor attention shifting skills showed more shyness and internalizing symptoms two years later than shy children with greater attention shifting. Furthermore, White and colleagues (2011) demonstrated that the ability to flexibly shift attention to meet task demands protected children with early childhood BI from anxiety symptoms assessed at 4-5 years of age.

Inhibitory control and response monitoring are two additional EC components that may impact the expression of temperamental reactivity. Inhibitory control is the ability to withhold predominant responses in order to activate subdominant ones. Response monitoring involves detecting errors and carrying out compensatory behavior to modify subsequent responses (McDermott & Fox, 2010; Rothbart & Bates, 2007). Response monitoring works together with inhibitory control to allow individuals to flexibly adapt to situation-specific demands (McDermott & Fox, 2010). These two capacities are typically assessed using cognitive tasks that require participants to inhibit prepotent response tendencies (e.g. Go/NoGo, flanker, and Stroop paradigms). Inhibitory control is measured via accuracy rates, whereas response monitoring can be indexed by postererror reaction time slowing (Davies et al., 2004).

While better inhibitory control and response monitoring is associated with reduced externalizing and internalizing symptoms in a broad sense (Eisenberg et al., 2010, review), high

levels of these EC abilities in behaviorally inhibited children increase their risks for the developing anxiety problems (Degnan & Fox, 2007, review; Thorell et al., 2004). Studies with children (Lahat et al, in press) and adolescents (McDermott et al., 2009) with a history of BI demonstrated that those youths who also showed increased response monitoring were more likely to have anxiety disorders than children with lower levels of response monitoring. White and colleagues (2011) also found that inhibitory control acts as an additional vulnerability factor in behaviorally inhibited children.

To explain this temperament × temperament interaction, fear and BI are conceptualized as an involuntary control system that constrains behavioral approach to threat or unfamiliar stimuli (Rothbart & Sheese, 2007). When this involuntary control function is combined with high voluntary control systems such as response monitoring and inhibitory control, it may increase behavioral rigidity and inability to adjust to environmental demands (Derryberry & Rothbart, 1997). In other words, for behaviorally inhibited children who are already hyper-vigilant to potential threats in social contexts, excessive concern about negative feedback and associated overregulation are likely to exacerbate withdrawal behavior and enhance the vulnerability to internalizing symptoms such as rumination and social phobia (Fox, 2010).

While different components of EC might play different roles in moderating the relation between BI and anxiety, EC as a broad construct is associated with reduced externalizing behaviors, especially in children with high negative emotionality and impulsivity (Eisenberg et al., 2010). Negative emotionality, including anger and frustration when goal-achieving behavior is obstructed, is associated with externalizing problems (Eisenberg et al., 2010). Children with lower EC might be less efficient in regulating their anger, which would in turn lead to externalizing problems such as aggression (Eisenberg et al., 2000). Eisenberg and colleagues

(2009) found that high levels of impulsivity and anger, in combination with low inhibitory control, predicted externalizing symptoms two years later. More recently, Moran and colleagues (2013) demonstrated that high frustration displayed in 3-year-olds when they were prevented access to a desirable toy predicted more externalizing problems 9 months later only in children who had low EC.

However, the interaction between negative emotionality and EC has not been consistently found (e.g. Belsky et al., 2001; Olson et al., 2005). It should be noted that how and when EC is measured needs to be taken into account. Self-regulatory capacities are likely to come online later in development, hence, its moderating effects on the link between negative reactivity and externalizing problems might not be observable in infants (Belsky et al., 2001). Additionally, performance on "hot" control tasks such as delay of gratification might reflect both reactive and regulatory aspects of affect, hence increasing the difficulty inferring whether a direct or interaction effect is found.

Temperament × environment moderation

The direct effects of environmental factors on the development of psychopathology are modest. More substantial influences may instead be found in the interactions between temperament and the environment (Rubin et al., 2009). The conceptualization of these interactive effects is in line with the mechanisms associated with gene-by-environment interplay illustrated by the behavioral genetics approach. Shiner and Caspi (2012) provide a framework to explain how temperament might shape how individuals experience and adapt to their environments by building on genetic foundations (Moffitt, 2005; Nigg, 2006).

The first mechanism is learning. That is, temperament traits shape how children perceive and react to positive and negative reinforcements from the environment (Shiner & Caspi, 2012).

For example, threat-related attention biases may predispose behaviorally inhibited children to perceive negative aspects of the environment as more salient (Pérez-Edgar et al., 2014; Todd et al., 2012) and facilitate the learning of negative associations linked to their behavior (Shiner & Caspi, 2012). Thus, early BI, by influencing this learning bias, may lead to the emergence and maintenance of anxiety symptoms (Pérez-Edgar et al., 2011).

The second mechanism is environmental elicitation, suggesting that individual differences in children's temperament elicit different parenting behaviors. Rubin and colleagues' (2009) transactional model posits that social withdrawal in behaviorally inhibited children may evoke parental over-control. Parents perceive their inhibited children as socially vulnerable. Thus, they display overly protective or intrusive parenting behaviors to alleviate their children's social discomfort, even in low-threat situations. These parenting strategies limit children's opportunities to attain social competency and decreases their feelings of self-efficacy in social interactions, which in turn, increases their risks for social anxiety disorders (Rubin et al., 1999). Indeed parental over-control has been found to moderate the link between early BI and anxiety symptoms in early childhood (Rubin et al., 2002), mid-childhood (Hane et al., 2008), and adolescence (Lewis-Morrarty et al., 2012).

Environmental selection refers to the mechanisms by which children actively select specific niches in their environments that are compatible with their temperament, which may in turn influence their exposure to risks (Shiner & Caspi, 2012). Rubin and colleagues (2006) found that behaviorally inhibited children are more likely to have best friends who are also more socially withdrawn and victimized compared to the best friends of non-inhibited children. Although the friendship increases inhibited children's social involvement, their friendships tend to be of lower quality (Rubin et al., 2006). Such dyads may perpetuate social withdrawal, leading

to continued rejection from larger peer groups (Degan et al., 2010). Research supports the proposition that both poor friendship quality and peer rejection exacerbate social withdrawal and social anxiety problems (Gazelle & Ladd, 2003; Shanahan et al., 2008).

The fourth mechanism, environmental construal, could also explain the maintenance of social withdrawal and the development of internalizing symptoms in inhibited children. Environmental construal refers to the processes by which temperament shapes individuals' exposure to aversive or promotive experiences through effects on social cognition (Shiner & Caspi, 2012). Based on the repeated experience of social rejections, children may develop an attributional schema characterized by self-blame for negative experiences (Rubin et al., 2008), as well as avoidant coping strategies in response to rejections (Wichmann et al., 2004). These attributional and coping styles may form a self-reinforcing cycle that leads to continued withdrawal and internalizing symptoms, such as depression and anxiety (Garnefski et al., 2005; Rubin et al., 2009).

These mechanisms of temperament-by-environment interactions do not suggest whether or how certain temperament traits make individuals more susceptible to aversive or supportive social environments. A number of theoretical models have been proposed (Lengua & Wachs, 2012; Reiss et al., 2013). The goodness-of-fit model originating from Thomas and Chess' (1977) temperament approach emphasizes that children whose temperament matches the characteristics of their environment will have better adjustment outcomes than those who have a poorer fit. Lagacé-Séguin and Coplan (2005) found that maternal coaching, a parenting style characterized by the ability to detect and respond constructively to the child's emotions (especially negative emotions), was associated with greater pro-social behavior in preschool among behaviorally dysregulated children. However, for well-regulated children, maternal coaching predicted greater

anxiety. It is likely that the same parenting style becomes over-solicitous for well-regulated children, hence exacerbating any underlying social wariness (Rubin et al., 2001). The model highlights the proposition that a particular rearing environment might be beneficial for children with a certain temperament trait but detrimental for children with another trait depending on the goodness of fit (Lengua & Wachs, 2012).

The traditional diathesis-stress model suggests that given the same amount of environmental adversity, temperamentally at-risk children will develop more adjustment problems compare to children without the risks. Negative emotionality, including anger/frustration and fearful temperament, is considered to be a direct risk factor for both externalizing and internalizing symptoms (Lengua, 2002). In addition, Bates and colleagues (2012) reviewed evidence suggesting that negative emotionality might aggravate the negative effects of parenting on children's socio-emotional development. For example, Williams and colleagues (2009) found that the permissive parenting style predicted more internalizing symptoms only in behaviorally inhibited children versus uninhibited children. Moreover, a rejecting parenting style led to increased externalizing symptoms in high-frustration but not low-frustration children (Lengua, 2008). To date, a large number of studies (reviewed in Rothbart & Bates, 2007) have demonstrated that temperament dimensions might pose biologically-based diathesis that triggers psychopathology in adverse environments, such as inappropriate parenting.

Extending from the diathesis-stress model, the differential susceptibility model (Belsky & Pluess, 2009; Ellis & Boyce, 2011) has gained increased attention. The model argues that both negative and favorable environments should be considered in studying the development of psychopathology. Belsky and Pluess (2009) argue that temperamentally at-risk individuals may not only be more affected by negative experiences, but could also benefit the most from

supportive environments. They suggest that negative emotionality and impulsivity are likely to be phenotypic markers of individual differences in their susceptibility to contextual influences. Pluess and Belsky (2009) found that, compared to children with "easy" temperament, children with high negative emotionality displayed more behavioral problems during the transition to schools if they experienced early low-quality daycare, but they showed fewer problems if they received high-quality daycare. More recently, Cassidy and colleagues (2011) demonstrated that temperamental irritability influences infants' sensitivity to maternal attachment styles. Irritability is associated with less attachment security. However, at the same time, the beneficial effects of an intervention on attachment were significantly greater for highly irritable infants than moderately irritable infants. The differential susceptibility model underscores the importance of studying phenotypic and genetic markers of sensitivity to environmental influences, as well as both risk and resilient contextual factors for socio-emotional development.

General Conclusions

Theoretical approaches to temperament have not reached a full consensus regarding the inclusive criteria and structure of temperament. Working definitions of temperament incorporate the domains of affectivity, self-regulatory processes, and motor activity in the conceptualization of temperament (Shiner et al., 2012). There is solid agreement that temperament is essentially a multi-level construct, which is observable via behavioral and neurobiological measurements, and is continually influenced by genetic, biological, cognitive, and environmental factors. Research on the association between temperament and psychopathology has benefited from both the developmental psychopathology and behavioral genetic perspectives. They provide frameworks to study temperament as a biologically-based risk or resilience factor that influences individuals'

trajectory to certain socio-emotional adjustment outcomes through complex interactive processes involving individuals' own cognition, affect, and their external developmental contexts. Different temperament traits impose inherent vulnerability (e.g. high emotionality) or resilience (high EC) mechanisms that influence outcomes by moderating individuals' exposure to negative or promotive environments, constraining what environmental characteristics are beneficial or harmful to special temperament traits, and affecting individuals' level of susceptibility to both aversive and favorable environmental influences. These dynamic interactive processes support the fundamental notion that temperament does not determine developmental outcomes. Rather, it sets the complex foundation on which multiple actors come together to shape developmental outcomes (Kagan, 2003).

Table 1. Summaries of the 5 theoretical approaches to temperament.

	Defining Features	Dimension(s) / Type(s)	Underlying Biological Mechanisms	Major Instrument(s)	Key reading(s)
Thomas & Chess	• Represent stylistic components of behavior	Dimensions: • Activity level • Regularity • Approach-withdrawal • Adaptability • Threshold of responsiveness • Intensity of reaction • Quality of mood • Attention span / persistence • Distractibility Types: • Difficult • Easy • Slow to warm up	Not discussed	1-3 years old: The Toddler Temperament Scale (TTS; Fullard, McDevitt, & Carey, 1984); 3-7 years old: The Behavioral Style Questionnaire (BSQ, McDevitt & Carey, 1978); 8-to 12 years old: The Middle Childhood Temperament Questionnaire (MCTQ, Hegvik, McDevitt, & Carey, 1982).	Thomas and Chess (1977)
Buss & Plomin	• Inherited traits • Evolutionary adaptive • Present in our phylogenetically-related species. • Early-emerging and relatively stable in childhood	Dimensions: • Emotionality • Activity • Sociability • Impulsivity (dropped from the original proposal due to failure to find genetic	Temperament dimensions have genetic bases.	EAS Temperament Survey (EAS, Buss & Plomin, 1984)	Buss and Plomin (1975) Buss and Plomin, (1984)

	• Preserved in adulthood	bases)			
Goldsmith	• An emotional phenomenon; • Related to individual differences; • Behavioral tendencies rather than actual observable emotional behavior; • Does not contain cognitive and perceptual components; • Has cross-situational generality and short-term stability rather than being transitory.	Assessed in Lab-TAB: • Activity Level • Positive Affect • Fear • Anger • Sadness • Shyness • Approach • Persistence • Inhibitory Control	Temperament dimensions are genetically influenced	Toddler Behavior Assessment Questionnaire (TBAQ, Goldsmith, 1996); Laboratory Temperament Assessment Battery (Lab-TAB, Goldsmith & Rothbart, 1993)	Goldsmith and Campos (1982, 1986);
Rothbart	• Biologically based • Contain reactive and regulatory aspects	Dimensions: • Negative affect • Surgency • Effortful control	The attention network: encompasses theanterior cingulate cortext and the lateral prefrontal regions	3-12 months: The Infant Behavior Questionnaire (IBQ, Rothbart, 1981); 18-36 months: The Early Childhood Behavior Questionnaire (ECBQ, Putnam, Gartstein, & Rothbart, 2006); 3-7 years: The Children's Behavior Questionnaire (CBQ, Rothbart et al., 2001); 7-10 years: The Temperament in Middle Children Questionnaire (TMCQ, Simonds & Rothbart, 2004);	Rothbart and Derryberry (1981) Rothbart and Bates (2006)

				9-15 years: The Early Adolescent Temperament Questionnaire (EATQ, Capaldi & Rothbart, 1992)	
Kagan	• Biologically based and early emerging • Defined a specific temperament category characterizes children who show elevated physiological reactivity, hyper-vigilance and withdrawal upon encountering novel stimuli (behavior inhibition)	Type: behavior inhibition	Hyper-responsive amygdala	Not developed	Kagan (1994); Kagan and Fox (2007)

Relevant Website:

Mary Rothbart's Temperament Questionnaires.

http://www.bowdoin.edu/~sputnam/rothbart-temperament-questionnaires/instrument-descriptions/ (accessed 13.09.15.).

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