As modern-era research on temperament approaches its 50th anniversary, it is worth remembering some of the forces that propelled temperament into the mainstream of research in psychology, psychiatry, neuroscience, and genetics. Broadly, the emergence of modern temperament research owes to two strands of study with somewhat different goals and emphases. One strand has its origin in child psychology and psychiatry. As described by Rothbart (Chapter 1, this volume), precursors of this tradition included Gesell (1928), Shirley (1933), Bergman and Escalona (1949; Escalona, 1968), and Meili (1957). However, the systematic study of infant and child temperament was not to take off until Thomas and Chess launched their highly influential New York Longitudinal Study, first extensively described 50 years ago in *Behavioral Individuality in Early Childhood* (Thomas, Chess, Birch, Hertzig, & Korn, 1963).

Somewhat paradoxically, the authors initially did not see themselves as temperament researchers. Rather, they set out to study “primary reaction patterns” that could be seen in infants. Their interest was in studying the implications of individual differences in these early patterns for normal and abnormal psychological development, and in exploring the clinical benefits of seeing the child as an autonomous agent (rather than merely as a reflection of parental influences). It was only later that the researchers adopted the term *temperament*. With its background in child psychiatry and pediatrics, this work paved the way for developmentally oriented work on temperament—an almost entirely new genre of temperament research (Rothbart, Chapter 1, this volume). The second strand had more in common with traditional temperament research, notably in its interest in the hereditary, constitutional, neurobiological, and evolutionary origins of temperament. As described in detail by Zuckerman (Chapter 3, this volume), this strand owed much to the foundational contributions of, among others, Kretschmer (1925), Sheldon and Stevens (1942), Diamond (1957), Eysenck (1967), Gray (1973), Zuckerman (1979), and Strelau (1983).

In 1975, A. H. Buss and Plomin provided an influential blend of these two largely unrelated strands of research (Buss & Plomin, 1975; see also Rowe & Plomin, 1977). Placing research on the heritability and biology of adult temperament and the study of child temperament under one roof galvanized the field and helped to forge the identity of the field of temperament as it is known today.
The first works describing and reviewing the results of this modern era of temperament research appeared toward the late 1980s and early 1990s (Carey & McDevitt, 1989; Goldsmith et al., 1987; Kohnstamm, 1986; Kohnstamm, Bates, & Rothbart, 1989; Plomin & Dunn, 1986; Strelau & Angleitner, 1991).

Since that time, temperament research has seen an unprecedented expansion, owing in part to its relevance across disciplines, including neuroscience, psychiatry, behavioral and molecular genetics, pediatrics, psychopharmacology, prevention science, counseling, and school psychology. Figure 32.1 illustrates this dramatic growth of temperament-related publications between 1970 and 2010, relative to the growth in publications on attachment and personality. The figure plots the percentage of growth in number of publications, in 5-year intervals, relative to the year 1970. Although the number of publications across the whole time period is higher for attachment (863 to 4,624) and personality (2,509 to 7,479) than it is for temperament (38 to 867), what is striking about the growth in temperament-related publications is its exponential nature. It is clear from this chart that an integrative volume on the current state of research in temperament was long overdue. In what follows, we attempt to provide an integrative view of some of the most important developments described in the previous 31 chapters. Specifically, our overview revolves around five major themes that relate to the meaning, structure, etiology, development, and applications of temperament. We trace progress across these areas, highlight key findings, discuss challenges, and point to possible solutions, as well as future developments.

**The Meaning of Temperament**

How tricky it can be to define psychological constructs as if they were quasi-material entities is illustrated by a recent survey, in which 33 world authorities in emotion research responded to a request to define the construct of emotion. The degree of consensus was disappointing (Izard, 2007). An alternative, and possibly more effective approach, is to define a construct by what the field intends to study. Temperament can be characterized as a field engaged in a comprehensive, concerted effort to identify early appearing, enduring behavioral phenotypes with a presumed biological basis; to examine their role in psychological development; and to explore their relevance for treatment. In the modern era, biological predispositions are increasingly described in terms of neurogenetic mechanisms (e.g., serotonin

![Figure 32.1](image-url)
ment research and concepts on early development of temperament and neuroscience sets it apart from personality, which has always referred to a broader range of individual differences in later periods of development, or from attachment, with its focus on early interpersonal experience. However, this volume points to several interconnections across these areas. In the wake of advances in personality trait taxonomies, including the three-factor model (e.g., Tellegen, 1985) and the Five-Factor Model (Goldberg, 1990), personality psychologists have become increasingly interested in the biological signatures and the early childhood manifestations of these higher-order traits (see Mervielde & De Pauw, Chapter 2, and Shiner & Caspi, Chapter 24, this volume).

There is nonetheless an important difference between research on child temperament and investigations into the appearance of broad personality factors. The former endorsed a bottom-up approach, focusing on individual differences that can be observed across infancy and toddlerhood, such as individual differences in circumscribed responses to novelty, vocalizing, and smiling, attentional focusing, ability to delay gratification, vigor, and duration of motor movement. The latter adopted a top-down approach in looking for early signs of broad personality traits (Lamb, Chuang, Wessels, Broberg, & Hwang, 2002). These differences notwithstanding, a certain measure of integration has been achieved in recent years (Rothbart, 2011; Shiner & DeYoung, in press).

Most attachment researchers, in turn, acknowledge today that attachment security cannot be monotonically attributed to parental beliefs (e.g., internal working models) or behaviors (e.g., maternal sensitivity). Rather, the relationship patterns that emerge between parents and children are more appropriately conceptualized as outcomes of a complex interplay among genetic predispositions, infant temperament, and parenting, as discussed by van IJzendoorn and Bakermans-Kranenburg (Chapter 19, this volume). Conversely, temperament researchers have come to realize that there is no such thing as a purely biological trait, and that the role of temperamental dispositions in psychological development depends on their interactions with a host of environmental variables (Bates, Schermerhorn, & Petersen, Chapter 20, and Lengua & Wachs, Chapter 25, this
The developments traced in these three chapters in this volume mark a welcome departure from the quasi-ideological battle between two seemingly irreconcilable views of early psychological development that separated temperament and attachment research for several decades.

The Structure of Temperament

Research on the structure of temperament strives to identify basic temperament dimensions and types. Compared to the typological tradition, with its ancient Greco-Roman roots, research on temperament dimensions is much more recent, in part due to its roots in psychometrics (Rothbart, Chapter 1, this volume). Influenced by the pioneering work of Heymans and Wiersma (1906), this line of work endorsed a multidimensional view of temperament, yet this was not a forgone direction to take. Indeed, in popular parlance, temperament is often referred to as a unidimensional quality that people have more or less of, not unlike intelligence or self-esteem. Thus, in several languages, individuals are characterized as differing in amount of temperament. If having met a new person, someone exclaims “Quel tempérament!” in French, this is generally understood as an expression of admiration for the person’s vitality, vigor, and strength of will, salted with connotations of potential moodiness, willfulness, or intensity. This same meaning of temperament is also found in German, Italian, Spanish, and English, although English variants of the term place a stronger emphasis on capriciousness and volatility (e.g., temperamental and temper).

An illustrious embodiment of a person “full of temperament” may be seen in Carmen, the protagonist of Bizet’s famous opera (Figure 32.2). It is hard to fathom what would happen if Carmen were to be miraculously transported into one of today’s temperament laboratories. It is certain, however, that she would not be seen as “scoring high on temperament.” Rather, Carmen would be seen as scoring high on different dimensions instead. In terms of the three higher-order temperament traits described by Rothbart (Chapter 1, this volume) and Zuckerman (Chapter 3, this volume), Carmen’s energy and enthusiasm would earn her high scores on positive emotionality; her moodiness and intensity, high scores on negative emotionality; and her willpower, high scores on effortful control. Thus, Carmen’s temperament would stand out for its cross-dimensional potency—a high-voltage phenomenon worthy of study to those in search of a general personality factor (e.g., Muzek, 2007).

Temperament Dimensions

Research on temperament dimensions has predominantly relied on factor analysis, sometimes in combination with behavioral observations guided by a theoretical rationale about the nature of temperament. Not surprisingly, this led to competing models of the dimensional structure of temperament that hampered progress in temperament research. Yet the differences in the number and type of dimensions have recently been found to be more apparent than real. Thus, Zentner and Bates (2008) found that a taxonomy based on six temperament dimensions could serve as an integrative model for most dimensions and scales of child temperament. The research described by Mervielde and De Pauw (Chapter 2, this volume) takes this work a step further by analyzing the structure of child temperament traits across questionnaires from the models of Rothbart (2011), Buss and Plomin (1975), and Thomas and Chess (1977). The authors found that the questionnaires converged on a set of
traits, similar to those identified by Zentner and Bates (2008).

There is now also a higher level of integration regarding adult temperament, as described by Zuckerman (Chapter 3, this volume). To an extent, the childhood traits converge with the adult temperament traits. Traits with the broadest support across ages and models are discussed in detail in a series of chapters: behavioral inhibition (Kagan, Chapter 4, this volume); activity (Strelau & Zawadzki, Chapter 5, this volume); positive emotionality (Putnam, Chapter 6, this volume); anger and irritability (Deater-Deckard & Wang, Chapter 7, this volume); effortful control (Rueda, Chapter 8, this volume); and empathy and prosocial traits (Knafo & Israel, Chapter 9, this volume). Further convergence is emerging in studies with animals, in which most of these temperament characteristics have been found, as described in Barr, Chapter 13, this volume. Table 32.1 provides an overview of these dimensions, including some closely related variants.

As a caveat, it is important to keep in mind that some of the traits have more research on record than others to commend them as basic temperament traits. Thus, compared with most other characteristics, the status of empathy and sensory sensitivity as distinct temperament dimensions is less well established by research. However, we also need to look forward. Thus, we found empathy to be intriguing enough to be included in Part II of this handbook with a dedicated chapter. Sensory sensitivity is touched upon

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### TABLE 32.1. An Integrative Taxonomic Map of Temperament Traits

<table>
<thead>
<tr>
<th>Super-factors</th>
<th>Basic traits</th>
<th>Capsule definitions</th>
<th>Related dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative Emotionality (Neuroticism)</td>
<td>Behavioral inhibition</td>
<td>Inhibition of behavior in response to novel unfamiliar people and situations</td>
<td>Fearfulness, harm avoidance, anxious temperament</td>
</tr>
<tr>
<td></td>
<td>Trait anxiety</td>
<td>Inhibition to novel unfamiliar people and situations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anger</td>
<td>Aggressive or irritated behavior in response to painful and/or frustrating input</td>
<td>Irritability, frustration</td>
</tr>
<tr>
<td></td>
<td>High-intensity pleasure</td>
<td>Propensity to positive emotions, including pleasure, positive anticipation, and excitement in social interaction</td>
<td>Exuberance, hyperthymia, sensation seeking, high-intensity pleasure</td>
</tr>
<tr>
<td>Positive Emotionality (Extraversion)</td>
<td>Low-intensity pleasure</td>
<td>Ability to experience delight in response to sensuous gratification and comfort</td>
<td>Consummatory hedonia, low-intensity pleasure</td>
</tr>
<tr>
<td></td>
<td>Activity level</td>
<td>Frequency, briskness, and vigor of motor movement; intolerance to enforced idleness</td>
<td>Briskness, tempo</td>
</tr>
<tr>
<td></td>
<td>Attention/persistence</td>
<td>Capacity for attentional focusing and control as basis for persistence</td>
<td>Self-control, willpower, impulsivity (–), undercontrol (–)</td>
</tr>
<tr>
<td></td>
<td>Inhibitory control</td>
<td>Ability to inhibit a dominant response and/or activate a subdominant response, to plan, and to detect errors</td>
<td>Delay of gratification</td>
</tr>
<tr>
<td>Effortful Control (Constraint)</td>
<td>Sensory sensitivity</td>
<td>Amount of stimulation needed to evoke a sensory response (e.g., tactile, olfactory, gustatory)</td>
<td>Perceptual sensitivity, threshold, high sensitivity, sensory defensiveness</td>
</tr>
<tr>
<td></td>
<td>Empathy/affiliativeness</td>
<td>Disposition to recognize and value salient social cues as a basis for affiliative reward</td>
<td>Cuddliness, kindness, reward dependence</td>
</tr>
</tbody>
</table>
by Mervielde and De Pauw (Chapter 2, this volume) and Aron (Chapter 31, this volume) and will be briefly discussed at the end of this section.

Although the traits in Table 32.1 have been studied with different methodologies, including questionnaire/interview approaches (Gartstein, Bridgett, & Low, Chapter 10, this volume), objective behavioral approaches (Goldsmith & Gagne, Chapter 11, this volume), and neuroscience-based approaches (Calkins & Swingler, Chapter 12, this volume), much of the evidence in their support has come from questionnaire ratings subjected to factor analysis. The latter tends to promote a vision of temperament consisting of broad, context-independent factors, whereas behavioral and physiological methods more often lead to greater focus on specific, context-dependent facets of temperament. Although the two foci are different, they are not incompatible if one looks at temperament as a hierarchically organized structure. Thus, specific behaviors or lower-level facets of temperament traits tend to covary, and the covariation among those traits can be condensed into higher-order factors with greater breadth by means of data reduction techniques (Shiner & DeYoung, in press). Most of the traits compiled in Table 32.1 represent higher-order factors, or families of temperament characteristics, rather than highly specific temperament dispositions.

Broad traits are taxonomically useful because they provide a structure for organizing, integrating, and comparing diffuse empirical findings obtained through a bewildering array of measures and concepts, often carrying different names but measuring constructs with considerable overlap (Caspí, 1998). However, broad constructs may not always represent the best level of analysis for research in temperament. One limitation of overarching temperament constructs is that important predictive relationships may be lost. For example, impulse control in toddlers has been found to predict good performance in most executive function–related tasks at age 17 years, but underperformance in some (Friedman, Miyake, Robinson, & Hewitt, 2011). Another risk is that broad traits may obscure temperament’s neural etiology (see Kagan, Chapter 4, and Goldsmith & Gagne, Chapter 11, this volume). Thus, the factor positive emotionality almost certainly includes at least two subfacets with differing neurobiological underpinnings. These are sometimes referred to as low- versus high-intensity pleasure (Rothbart, 2011) or as appetitive versus consummatory hedonism (Putnam, Chapter 6, and Depue & Fu, Chapter 18, this volume). However, even this distinction probably fails to capture the richness of dispositional positive affect. Goldsmith and Gagne (Chapter 11, this volume) make several suggestions about how a greater particularization of positive emotionality may be achieved, for example, by drawing on models that focus on positive emotion (Shiota, Keltner, & John, 2006).

Within the context of the higher-order traits, researchers have attempted to examine the extent of relatedness or organization of the traits. For example, activity is sometimes seen as a ramification of surgency or extraversion (hence the dashed line between positive emotionality and activity in Table 32.1) Mervielde and De Pauw (Chapter 2, this volume) found that activity is an important, separate temperament dimension until about middle childhood, at which point it tends to fuse with extraversion. In contrast, according to Strelau’s model, activity level preserves a status as an independent temperament characteristic through adulthood (Strelau & Zawadzki, Chapter 5, this volume). Other adult temperament models, with origins in dimensional models of mood and emotion, have also frequently posited an independent activity-like dimension, labeled activation or arousal (Mehrabian, 1996; Thayer, Newman, & McClain, 1994; see also Clark & Watson, 2008). The situation is clearer with negative emotionality, which is generally found to ramify into behavioral inhibition and anger, and possibly sadness, although the latter has only begun to be looked at from a temperament perspective (Klein, Dyson, Kujawa, & Kotov, Chapter 26, this volume).

All of the traits discussed thus far have an obvious emotive component. The important role of emotion across most temperament traits was noted long ago (Allport, 1937; Goldsmith & Campos, 1982), and continues to be emphasized in current-day conceptions of temperament (Goldsmith & Gagne, Chapter 11, this volume). In contrast, effortful control represents a more recent but increasingly consequential area of research.
on “regulatory” aspects of temperament, including concepts such as “self-control,” “inhibitory control,” “persistence,” “constraint,” or “willpower” (in this volume, see Rothbart, Chapter 1; Rueda, Chapter 8; White, Lamm, Helfinstein, & Fox, Chapter 17; Depue & Fu, Chapter 18). Empirically, effortful control and its affiliates are highly inversely correlated with impulsivity, suggesting that effortful control is, in effect, impulse control. Some authors make a distinction between the two. In the latter view, impulsivity is a heterogeneous characteristic, possibly the result of a temperament × temperament interaction. Thus, impulsivity may be seen as the expression of an accelerator (positive emotionality) that is not contained in an appropriate breaking system (inhibitory control). However, since it is at present unclear whether impulsivity is anything more (or less) than the reverse of effortful control, we subsume it under constraint in Table 32.1.

Although there is consensus that effortful control and its affiliates comprise a basic dimension of temperament, several authors have noted its peculiarity relative to other temperamental traits (e.g., Carver, 2005). For example, it does not seem to have an obvious link to an emotional or motivational system and it is also a relatively late-emerging temperament characteristic, not fully expressed until about the third year of life. One view is that constraint acts as a superordinate disposition that determines the probability of elicitation of the affective traits and their neurochemical bases, such as the dopaminergic circuitry underlying incentive-motivated behavior and positive affect (e.g., corticotropin-releasing hormone [CRH] in the potentiation of anxiety, μORs in the mediation of affiliative reward). It has been suggested that this disposition may be linked to serotonergic functioning, but evidence is conflicting (e.g., Carver, Johnson, & Joormann, 2008). The understanding of effortful control as a superordinate system to emotive temperaments is consistent with Rothbart’s view that effortful control modulates behavioral manifestations of the lower-level incentive and threat sensitivities (Rothbart & Derryberry, 1981). A question rarely addressed, however, is what would make control effortful? From a biological, mechanistic point of view, some individuals would be predisposed to act planfully and control impulses naturally and, indeed, effortlessly. What may be effortful, then, is the training required to strengthen this temperament. As suggested by Baumeister, self-control or “willpower” may operate like a muscle: fatigued by overuse and strengthened with practice (Baumeister & Tierney, 2012).

Another intriguing feature of effortful control is its affinity with skills traditionally catalogued under the heading cognition. Initially, temperament and cognitive functioning (as summarized in IQ scores) were seen as clearly separate, nonoverlapping constructs. However, as shown by Rueda (Chapter 8, this volume), temperamental and cognitive control may have a common origin in the executive attention network—a neurocognitive system involved in the regulation and coordination of action in novel or challenging situations, in the detection and correction of errors, and in the suppression of habitual (or automatic) responses. In this view, the executive attention network is seen as a neural substrate supporting constraint or effortful control, as well as more traditionally cognitive skills such as working memory (Posner & Rothbart, 2007). A number of findings are consistent with this view. Succeeding in an impulse control task during toddlerhood significantly predicted higher IQ scores at age 16 (Friedman et al., 2011). Limitations in working memory have been found to relate to adult introversion, albeit in a complex way (Lieberman & Rosenthal, 2001). Resistance to interference in the classical Stroop color-naming task (a form of inhibitory control) has been shown to correlate substantially with measures of personality, and with resiliency in girls and control in boys (Block, 2005). As research on control advances, the nature of constraint, including its independence from or interdependence with the emotive temperaments, as well as its connectedness with cognitive functioning, should lead to more clarity as to how constraint or effortful control may be best conceptualized.

Compared with the preceding characteristics, empathy and other traits relating to the recognition of social cues and affiliative reward have been considered from a temperament perspective only in recent years (Knafo & Israel, Chapter 9, and Depue & Fu, Chapter 18, this volume); thus, they are
less established by research. In contrast, sensory sensitivity is relatively well studied but has proved difficult to characterize and classify. Possibly this is because it seems to include two separate, though possibly related facets, namely, (1) sensitivity to aversive stimuli such as loud noises or scratchy clothes, which are captured in the sensory discomfort construct (Kochanska, Coy, Tjebkes, & Husarek, 1998; Rothbart, 2011); and (2) the ability to react to sensory stimuli of low stimulative value, captured by the notion of perceptual sensitivity (Goldsmith, 1996; Rothbart, 2011), which has been allocated to effortful control by Rothbart. The commonalities between perceptual sensitivity and effortful control may not be immediately obvious. However, they are easier to understand if one looks at their possible common basis in the capacity for error detection, a function of the executive attention network that involves the anterior cingulate and other frontal brain areas (Posner & Rothbart, 2007). Related constructs such as threshold (Thomas & Chess, 1977), sensory defensiveness (Goldsmith, Van Hulle, Arneson, Schreiber, & Gernsbacher, 2006), or high sensitivity (Aron, 1996) probably represent mixtures of both aspects of sensitivity (Aron, Chapter 31, this volume; see also Zentner & Bates, 2008).

**Temperament Types**

Like the heroine of Bizet’s opera, people can be characterized in terms of a mixture or pattern of several temperamental attributes. For example, some preschoolers with high levels of anger score low in self-control, whereas other children with high levels of anger have high concomitant levels of control. To researchers accustomed to thinking in dimensional terms, the example of the high-anger, high-control child may seem somewhat incongruous because when questionnaire measures are factor-analyzed, there is a moderately negative relationship between the anger and control dimensions, as there is between negative emotionality and effortful control (Deater-Deckard & Wang, Chapter 7, and Rueda, Chapter 8, this volume). Yet dispositional anger and willpower can be entrenched in one and the same individual, as in the case of authoritarian personalities (Altemeyer, 1998). Thus, implications of a given temperament trait are not monotonic; rather, they depend on the presence of other attributes in an individual’s temperament profile.

That the connection between a temperament trait and psychosocial adjustment can be lessened or strengthened through the presence or absence of other temperamental attributes is shown in several examples from the recent literature. Notably, when the developmental trajectories of children high in temperamental negative emotionality and low in effortful control are compared with children who are high in both, well-regulated and prosocial behaviors are more prevalent among the latter (e.g., Eisenberg, Smith, & Spinrad, 2011; Rothbart & Bates, 2006; Verstraeten, Vasey, Raes, & Bijttebier, 2009). In turn, behaviorally inhibited children high in inhibitory control may be at increased risk for developing anxiety disorders (White, McDermott, Degnan, Henderson, & Fox, 2011). Still other studies found that a high level of negative emotionality predisposes to depressive symptoms, in particular when it is coupled with low positive emotionality (Klein et al., Chapter 26, this volume).

Although not conceived as such, research on temperament types is, in effect, a natural extension of work on temperament × temperament interactions. The number of possible combinations of temperamental attributes being incalculable, it makes sense to discern “typical” combinations, that is, those occurring with above average frequency. The literature on temperamental types has a long history dating back to Galen and earlier, as described by Rothbart (Chapter 1, this volume) and Kagan (Chapter 4, this volume). Yet modern-era temperament typologies are very different from those expounded in works such as Kretschmer’s *Physique and Character* (1925) or Sheldon and Stevens’s *The Varieties of Temperament* (1942). The focus on morphology or body build has been relinquished and supplanted with an emphasis on the early identification and developmental significance of temperament constellations. This was evident from Thomas and Chess’s (1977) threefold temperament typology that distinguished between difficult, slow to warm up, and easy children. More recently, a related triadic scheme has identified undercontrolled, overcontrolled, and resilient children (e.g., Asendorpf &
van Aken, 1999; Caspi & Silva, 1995; Hart, Burock, London, Atkins, & Bonilla-Santiago, 2005). On the basis of these studies, the three types can be described with the following distinctive attributes:

**Undercontrolled child**: willful, restless, inattentive, impulsive, and emotionally volatile

**Overcontrolled child**: shy, compliant, quiet, and self-critical

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

Because the more recent studies on types were based on samples of preschoolers or older children, the infant precursors to these three types remain to be elucidated. It is not clear, however, how temperament typologies ought to be derived during infancy. Kagan (Chapter 4, this volume) has described one model of infant types focused on variations in behavioral inhibition. Kagan's identification of infant temperament types was based on the assumption that amygdalar hyperreactivity might play a pivotal role in determining behavioral inhibition. A combination of previous research and behavioral observations led him to hypothesize that motor unrest and crying might be two potential early infancy markers of amygdalar hyperreactivity. In his work, he found that about 20% of 4-month-old infants react irritably to the unexpected appearance of unfamiliar visual, auditory, or olfactory stimuli, whereas about 40% of the infants reacted without signs of distress (Kagan & Snidman, 2004). As described in detail by Kagan (Chapter 4, this volume), the developmental pathways of the two types in early infancy differed in several respects, including behavioral, emotional, psychophysiological, and neurobiological characteristics (see also White et al., Chapter 17, this volume).

Future research on temperament types faces intriguing questions. While it is relatively straightforward to identify types from questionnaire ratings by means of cluster or inverse factor analysis, there are at present no established procedures for identifying early infancy temperament types or developmentally meaningful temperament × temperament interactions. **Taxometrics**—a set of statistical procedures used to determine whether the latent structure of a construct is continuous or categorical (i.e., taxonic; Schmidt, Kotov, & Joiner, 2004)—can be used to examine whether quantitative indices of a phenotype are subtended by qualitative latent structure. Kagan and colleagues found that this was the case for high- and low-reactive infants (Woodward, Lenzenberger, Kagan, Snidman, & Arcus, 2000). However, the technique can only confirm, not identify, types.

A further question that has been raised particularly by advocates of a dimensional approach is the added value of types over dimensions. In other words, if researchers were to endorse exclusively a dimensional approach, would this prevent them from gaining important insights into the nature of temperament and its implications for psychological development and adjustment? In part, the answer to this question depends on how types are defined. In a recent follow-up of preschoolers from the Munich Logic Study, only the upper 8% in terms of preschool inhibition exhibited internalizing problems at age 23 years. If the outcomes were analyzed with respect to inhibition in the upper 15% of the preschoolers, most of the effects vanished (Asendorpf, Denissen, & van Aken, 2008). This finding does suggest that ignoring extreme groups may come at a cost, perhaps precisely because individuals at the extreme ends of a distribution share a number of attributes that are not shared by individuals at less extreme ends. Furthermore, the growing evidence on temperament × temperament interactions indicates that prediction and understanding can sometimes be improved by looking at combinations of temperamental attributes, rather than at temperament dimensions in isolation.

Finally, it has also been noted that the merits of typological approaches cannot be described on statistical grounds exclusively (e.g., amount of variance explained) and that some of the advantages of typologies result from a more natural and genuinely psychological way of studying individuals such as the practive of conceputalizing the latter as persons rather than variables (Caspi, Roberts, & Shiner, 2005; Hart, Atkins, & Fegley, 2003). In summary, then, both dimensional and typological approaches offer unique advantages for furthering our understanding of the structure of temperament.
The Etiology of Temperament: Nature and Nurture

Etiology, that is, the study of causation or origination of phenomena, has been a particularly challenging area of temperament research. At the dawn of modern-era research on temperament, Thomas and Chess (1977) described several possible causes of the temperamental features they observed in young children, notably prenatal, postnatal, and genetic influences. In doing so, they acknowledged the importance of both inherited and environmentally induced pre-, peri-, and postnatal factors in shaping a child’s temperament. However, research on temperament’s etiology was not one of their research priorities. The interest in etiology became apparent in several articles and volumes, published in the late 1980s, that focused on heritability estimates for temperament traits, as derived from behavior genetic studies (Kohnstamm et al., 1989; Plomin & Dunn, 1986).

Since then, several key developments have significantly expanded our insights into the origin of temperamental differences: research on prenatal precursors of temperament differences, refinement of behavior genetic methods, the application of molecular genetic research to the study of temperament, and research on the neurobiological structures and processes associated with temperament. Perhaps most important, there is now a clearer understanding of the ways in which postnatal environmental factors impinge on temperamental predispositions, whether neurogenetically or prenatally determined.

Behavior Genetics of Temperament

Advances in behavioral or quantitative genetics have allowed researchers to move beyond simple heritability estimates of temperament to address more sophisticated questions. Somewhat paradoxically, one of the richest contributions of behavior genetics has been in particularizing environmental influences on temperament, such as the relative contribution of the shared and nonshared environment on various temperament traits. More important, behavior genetics methodology, such as longitudinal quantitative genetic analyses that explore genetic and environmental contributions to phenotypic continuity and change across age, can now examine more complex questions than was possible in the past. For example, recent findings on the genetics of temperament allow for the possibility that certain traits may be expressed or muted only later in life, conceivably up to old age, either through new genes turning on, or as a result of gene × environment interactions precipitated by incisive life events (Saudino & Wang, Chapter 16, this volume).

These methods inform us about developmental processes by assessing the extent to which genetic and environmental effects on a trait persist across age, and whether new genetic and environmental influences emerge across time. Studies of early temperament typically find that stability is due to genetic factors, and change is largely environmental; however, for some dimensions, there is also evidence of genetic contributions to developmental change, as detailed in Saudino and Wang (Chapter 16, this volume). Increasing evidence suggests that the link between temperament and behavior problems is in part driven by genetic influences (Klein et al., Chapter 26, and Tackett, Martel, & Kushner, Chapter 27, this volume). These findings are important because they suggest that temperament may convey a genetic risk for maladaptive outcomes and point to temperament dimensions as possible endophenotypes for clinical disorders.

Recent work on gene × environment interactions and correlations has led to an important insight, namely, that the environments children experience (e.g., parenting) partly reflect genetically influenced temperaments, indicating genotype–environment correlations. This work has allowed researchers to look at outcomes typically attributed to environmental factors in a different light. For example, prevailing wisdom has it that divorce causes children’s disruptive behavior. Yet, Block, Block, and Gjerde (1986) found that male toddlers’ restless and impulsive behavior preceded parental divorce by many years. A possible interpretation of this finding in terms of genotype–environment correlations is that the boys’ behavior, with the stresses on family life it entails, could have been a cause rather than a consequence of divorce. Despite progress in behavior genetics methodology, several methodological problems that stand in the way of further progress include measure- and context-specific effects (Saudino & Wang, Chapter 16, this volume).
Neurogenetics of Temperament

Behavior genetics, however advanced, has the limitation that it cannot identify specific genes that may be responsible for individual differences in temperament. This gap in our knowledge is now being progressively filled by molecular genetics. The excitement around this area of research is understandable because it opens up the possibility of specifying the genetic material that codes for individual differences in both neurochemistry and temperament. Indeed, using the allelic association strategy described by Saudino and Wang (Chapter 16, this volume), researchers have been able to identify certain polymorphisms that appear to play a role in the etiology of temperament. Even so, the variance in temperaments explained by allelic variation is scarcely impressive. There are several reasons for this circumstance.

First, temperament is a complex behavioral phenotype, unlike circumscribed developmental disabilities, such as trisomy, which results from having three copies of chromosome 18 in each cell in the body instead of the usual two copies. The extra genetic material disrupts the normal course of development, causing the characteristic features of trisomy 18. In cases such as these, a genetic variant explains a large portion of the variance in the behavior phenotype, but temperament researchers face a more sobering situation in which many genes explain a modest part of the variance in phenotypic features.

Second, the neural structures and mechanisms subserving temperament are more likely to involve brain circuitries than specific brain areas or receptor densities at given brain sites. Although there is evidence to suggest a role for the amygdala in behavioral inhibition and trait anxiety (see Kagan, Chapter 4, and Depue & Fu, Chapter 18, this volume), a hyperresponsive amygdala may have different temperamental expressions, depending on its connectivity to other areas. For example, several studies suggest that the prefrontal cortex, particularly the anterior cingulate cortex (ACC), has a role in suppressing the amygdala's natural response in negatively valenced situations (White et al., Chapter 17, this volume). Consistent with this work, it has been found that heightened amygdala activation relates to trait anxiety, chiefly in those individuals with weak connections between the prefrontal cortex and the amygdala. In individuals with strong connections, the prefrontal cortex seems to suppress amygdala activation successfully following an upsetting experience or emotion, thereby facilitating recovery from it (Kim & Whalen, 2009). Thus, the circuitry modulating amygdala reactivity via inhibitory feedback from the prefrontal cortex during times of emotional stress may play a critical role in trait anxiety. A behavioral parallel to this interaction may be seen in the previously discussed finding that children high in negative reactivity are more likely to suffer negative consequences when they are also low in effortful control.

Third, the understanding of genetic effects on temperament remains incomplete as long as the specific neural functions that mediate these effects are not known. As described in Part IV of this volume, here is now mounting evidence that functional polymorphisms are implicated in temperamental differences. On the other hand, there is increasing evidence that neurobiological structures and neurochemical signaling pathways are implicated in temperamental differences. Some examples include a role for the amygdala and possibly also for the bed nucleus of the stria terminalis (BNST) in behavioral inhibition and trait anxiety, with 5-HT and CRH playing an important role on the level of neurochemical transmission. The prefrontal and anterior cingulate cortex have been shown to play a role in attentional and emotional control, and there is also a certain consensus that the ventral striatum is involved in exuberance, with DA being one of the key neurotransmitters regulating activation in this brain site (White et al., Chapter 17, and Depue & Fu, Chapter 18, this volume).

Yet, what remains unclear is how alleles or functional polymorphisms impart on temperament through their effect on neurochemistry and neuroanatomy. Modeling of such interconnectivities might specify, for example, how the HTR1A-1019G allele influences trait anxiety by modulating 5-HT synaptic autoreceptor expression in the amygdala (see, e.g., Bodgan et al., in press; Hariri, 2009). Elaborating a comprehensive neuroscientific theory of temperament will require advances in instrumentation. At present, the detailed dynamics of neural processes, including neurotransmitter activity, remains hidden from the scanner and can be inferred only indirectly. This could change...
in a few years, when several promising techniques, such as hyperpolarization with para-hydrogen (Adams et al., 2009), will have sufficiently progressed to let researchers measure the dynamics of neural activity with unprecedented precision (see Smith, 2012, for a review of these techniques). Technical innovations in neuroimaging combined with the refinement of temperament measures will enhance our understanding of the neurogenetics of temperament.

Acquired Biology and the Role of Epigenetics

By the time temperament can be reliably assessed as a relatively enduring trait, the development of neural circuitries subtending temperament has not simply executed a genetic script: It has also been shaped by experience. As has become increasingly clear in recent years, the brain is sensitive to both adversity and opportunity, resulting in changes to metabolic, endocrine, and neuro-regulatory pathways, especially in a period of high brain plasticity such as infancy. As we now know, these processes start before birth in response to factors such as maternal stress, depression, or substance abuse, with potential “programming” effects on the brain, such as a hyperresponsiveness of the hypothalamus–pituitary–adrenal (HPA) axis (Huizink, Chapter 15, this volume). In the postnatal period, nutritional deficiencies, environmental lead, and parental neglect can all affect the infant’s brain and alter the nature and course of temperament (Lengua & Wachs, Chapter 25, this volume).

What is more, the genetic activity itself may be altered as a result of postnatal influences. Such alterations are currently being intensely investigated across disciplines under the heading of epigenetics—the study of changes in gene activity that occur without any changes in the structure of the gene’s DNA. After birth, the transduction of environmental influences into neurochemical and neurobiological signatures can work through epigenesis. For example, Meaney (2010) found that the gene encoding the corticosteroid receptor in rats carries different epigenetic marks, or modifications, in the brains of the offspring of negligent compared with nurturant mothers. As a result, the gene is less active in the neglected offspring, lessening the corticoid receptors that reduce stress responses, even in rats with high corticosteroid receptor DNA. In humans, the glucocorticoid receptor gene has shown increased methylation in human cord-blood DNA from newborns of depressed or anxious mothers (Oberlander et al., 2008).

Thus, in the postnatal period, exogenous life events can modulate gene expression of structural proteins, receptors, and signaling molecules, thereby establishing a basic neural foundation underlying the type of emotional behavior we call temperament. Indeed, there is accumulating evidence to suggest that the neurobiological legacy forged by these early processes can have long-lasting effects (Hillage, Herbert, Goodyer, & Murray, 2007; Heim, Newport, Mletzko, Miller, & Nemeroff, 2008; McGowan et al., 2009), thereby contributing to the stability of temperamental qualities that is typically observed after about age 3, as we shall see next.

Temperament and Development

An understanding of the role of temperament in development was hampered for a long time because of the scarcity of large-scale longitudinal studies extending from birth to adulthood (e.g., Kagan & Zentner, 1996). Over the past decade, a few such studies have sufficiently matured to give researchers the opportunity to examine adolescent and adult outcomes of early childhood temperament. Because previous chapters have extensively covered short- to medium-term longitudinal studies describing outcomes of early temperament (in this volume, see Shiner & Caspi, Chapter 24; Lengua & Wachs, Chapter 25; Klein et al., Chapter 26; Tackett et al., Chapter 27), the emphasis in this concluding chapter is on long-term longitudinal studies describing adolescent and adult outcomes of early temperament. When we say “early temperament,” we mean temperament assessed in infancy and toddlerhood up until age 3.

Most of the evidence for the predictive power of early childhood temperament has been found for two traits, or syndromes, on which this review focuses. The first temperament component broadly relates to impaired impulse control and includes constructs such as “temperamental difficulty,” “undercontrol,” impulsivity, and inattention. These
constructs are not identical, to be sure, but they share important features (Duckworth & Kern, 2011). The second temperament component relates to behavioral inhibition and related dimensions, such as fearfulness and social anxiety. Tables 32.2a and 32.2b list prospective longitudinal studies relating to adolescent and/or adult outcomes of both types of infant and/or toddler temperament. The majority of studies assessed early temperament based on examiner observations and/or objective behavioral coding; exceptions are the New York Longitudinal Study, the Fullerton Longitudinal Study, and the Uppsala Longitudinal Study, in which same and cross-informant questionnaire ratings were used to assess infant temperament. We should note that Tables 32.2a and 32.2b list but a few notable predictor and outcome variables. For more complete information on design and methodology, the reader is referred to the references listed in the right-hand columns of these tables.

Connections between Early Childhood Temperament and Adolescent/Adult Outcomes

Long-Term Outcomes of Impulse Control

The Dunedin Multidisciplinary Health and Development Study followed a cohort of slightly over 1,000 children from birth to the age of 32 years. Among its many measures was an assessment of the degree of self-control in 3-year-old children. The study showed that preschool degree of self-control predicted physical health, substance dependence, personal finances, and criminal offending outcomes at age 32 years (Moffitt et al., 2011). Because results are by far more trustworthy if they replicate across studies (Ledgerwood & Sherman, 2012), it is worth noting that similar findings have emerged from another important long-term longitudinal study, the Mauritius Child and Health Study, in which children’s temperamental attributes at age 3 were rated by examiners on the island of Mauritius. It provides additional evidence that low levels of fearfulness and inhibition, and high levels of stimulation seeking, are a risk for the subsequent development of a psychopathic personality in adulthood (Glenn, Raine, Venables, & Mednick, 2007). Comparable findings emerged from another classic long-term study, the Block and Block Longitudinal Project (Block, 1993, 2006), which had a smaller sample but included a rich set of assessments. Participants were recruited in preschool while attending either a parent cooperative or a university-run nursery school. The sample members were assessed at various ages, beginning at age 3 and including assessments at ages 14, 18, and 23. At each age, participants were seen on multiple occasions, by multiple observers, and rated on overcontrol, undercontrol, and resiliency as they completed a wide variety of tasks. The most relevant dimension in the present context is undercontrol, an expression for “unbridled impulsivity” (Block & Kremen, 1996, p. 351). There was a significant degree of continuity with respect to undercontrol from ages 3 to 23 years (Block, 2006). In addition, undercontrolled 3-year-old children, whose most salient traits include impulsivity and inattention, were at a higher risk to develop a variety of externalizing problem outcomes, including drug abuse and narcissism, across adolescence and young adulthood (Block, 1993; Carlson & Gjerde, 2009). Because narcissism shares some features with antisocial personality, this outcome is somewhat comparable with findings from the Dunedin and Mauritius studies.

In the Colorado Longitudinal Twin Study, over 600 toddlers were measured at their homes at ages 14, 20, 24, and 36 months on a “don’t touch a toy” prohibition task (Friedman et al., 2011). On the basis of latent class growth analysis, the toddlers were allocated to one of two groups: high control or low control. At age 17, participants were measured on a battery of nine computerized executive function tasks administered in the laboratory. The two groups differed significantly and sizably on overall executive function performance at age 17.

The Fullerton Longitudinal Study, launched in 1979, chronicled the development of 109 children and their families from infancy through age 17 years by using same and cross-informant ratings (Guerin, Gottfried, Oliver, & Thomas, 2003). Infant temperament was measured through parental ratings on the Infant Characteristics Questionnaire (Bates, Freeland, & Lounsbury, 1979) and, at age 17 years, participants pro-
vided self-ratings on the Youth Self-Report. “Difficult” infant temperament (fussy, unadaptable) predicted modest but significant amounts of variance in both externalizing and internalizing behavior problems at age 17 years. Interestingly, and in line with the findings from the Colorado Study, difficult infant temperament was also predictive of diminished intellectual functioning and school achievement in late adolescence (Guerin et al., 2003).

Similar findings emerged from the New York Longitudinal Study, which followed 133 children from early infancy to early adulthood. Notably, toddler temperamental difficulty, a combination of negative mood, slow adaptability, and highly intense reactions, as inferred from interviews with parents, was reported to be significantly related to interview ratings of adult maladjustment, a generic outcome variable including negative self-evaluation and problems in scholastic and social functioning (Thomas & Chess, 1986). Three additional long-term studies starting somewhat later than age 3 also showed that preschoolers’ impaired impulse control predicted an aggressive–externalizing personality in adulthood (Asendorpf et al., 2008; Deal, Halverson, Havill, & Martin, 2005; Mischel et al., 2011).

**Long-Term Outcomes of Behavioral Inhibition**

Some of the long-term connections of infancy and toddler behavioral inhibition and related constructs emerged from the studies just reviewed, which had also measured inhibition and shyness at age 3. Thus, in the Dunedin Study, inhibited children reported more harm avoidance and less social potency and positive emotionality at both ages 18 and 26, and at age 26 they were described by informants as less extraverted (Caspi et al., 2003). The inhibited children were also more likely to be depressed and had more often attempted suicide compared
with the well-adjusted children (Caspi et al., 1996). In a recent follow-up of the Uppsala Longitudinal Study, significant correlations emerged between toddler shyness and adult social anxiety, as well as depressive symptoms, at age 21 years (Bohlin & Hagekull, 2009).

The most extensive evidence for the early appearance and long-term implications of this temperamental disposition comes from the Harvard Longitudinal Study. The early infancy assessments and the inclusion of a wide array of psychophysiological and neurobiological measurements make this work particularly interesting. Some infants show high levels of negative reactivity to unknown objects, people, or locations, typically expressed by an increase in motor activity and negative affect, such as crying. This pattern of reactivity is related to behavioral inhibition and anxious behavior later in childhood and adolescence (Kagan, Chapter 4, this volume). Of note is also the predictive relationship between behavioral inhibition assessed in toddlerhood by maternal ratings and social anxiety disorder found in a related study by Fox and colleagues (Chronis-Tuscano et al., 2009; in this volume, see White et al., Chapter 17; Klein et al., Chapter 26).

Weight is added to these findings from an unlikely source. In 1950, the Swiss psychologist Richard Meili launched the Bernese Longitudinal Study to examine infancy origins of later personality differences. He began by studying 3- to 4-month-old infants’ responses to unfamiliar stimuli, such as a black ball swung in front of an infant’s visual field (Meili, 1957). After having infants’ behaviors filmed and coded from record on 4 separate days, he found the reactivity to novel objects to be relatively stable (Pulver, 1959). In one of the few passages of his work ever translated into English, he summarized his findings as follows: “[I] discovered a difference between responses to an object in children between three and four months of age; some after initial inhibition rapidly resumed a calm expression, relaxed and sometimes smiled; others remained tense, moved irritably and began to cry” (Meili, 1963/1968, p. 245). He interpreted the infants’ reactions in terms of differences in the ease of processing novel objects—a dimension Meili (1957) deemed to be “characterologically relevant.” On this assumption, he followed these children into adolescence. He found moderate-to-high correlations between tenseness between 3 and 4 months, and multiple inhibition and shyness measures at ages 7 and 15 years (Meili & Meili-Dworetzki, 1972).

Taken collectively, the long-term studies reviewed here indicate that two traits appearing in infancy and toddlerhood, impulsivity/inattention and behavioral inhibition, are predictive of outcomes extending well into adolescence and adulthood. Crucially, links have been documented repeatedly by independent investigators working in different time periods, across different geographic locations, and using different methodologies within and across studies.

### TABLE 32.2b. Temperamental Factors Predicting Adolescent and Adult Personality and Psychopathology: Inhibition/Fearfulness

<table>
<thead>
<tr>
<th>Longitudinal study</th>
<th>Infant/toddler temperament</th>
<th>Adolescent/adult outcome</th>
<th>Key references</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvard Longitudinal Study</td>
<td>High reactivity, 4 months</td>
<td>Trait anxiety, 15 years Amygdala hyperresponsiveness, 21 years</td>
<td>Kagan et al. (2007) Schwartz et al. (in press)</td>
</tr>
<tr>
<td>Bernese Longitudinal Study</td>
<td>Infant irritability, 3 to 4 months</td>
<td>Shyness, 15 years</td>
<td>Meili &amp; Meili-Dworetzki (1972)</td>
</tr>
<tr>
<td>Uppsala Longitudinal Study</td>
<td>Shyness, 20 months</td>
<td>Social anxiety, depressive symptoms, 21 years</td>
<td>Bohlin &amp; Hagekull (2009)</td>
</tr>
<tr>
<td>Dunedin Multidisciplinary Health and Development Study</td>
<td>Inhibition, 3 years</td>
<td>Depression, 18 years Harm avoidance, indecision, 26 years</td>
<td>Caspi et al. (1996) Caspi et al. (2003)</td>
</tr>
</tbody>
</table>
Mechanisms Underlying the Links between Early Temperament and Adult Outcomes

An important question for researchers is how to interpret the previously reported empirical connections both quantitatively and qualitatively. Although the connections are statistically significant, well replicated, and quite impressive given the long time intervals, the effect sizes are modest. Thus, the links need to be cast in probabilistic terms. Impulsive, undercontrolled toddlers can develop in many different ways, but some ways are more likely than others. This fact is easier to understand today than it was 20 years ago, thanks to novel insights into the processes underpinning stability and change.

A particularly important finding to emerge from behavioral genetics research is that genetic factors contribute substantially to measures of the environments of individuals, as detailed by Saudino and Wang (Chapter 16, this volume). Because environments have no DNA, the most plausible interpretation is that genetically influenced traits frame and shape the environments in their own image, as it were. How this is possible is fleshed out by Shiner and Caspi (Chapter 24, this volume), who discuss several processes through which temperament can shape environments in its own image. Through environmental elicitation, a child’s temperament shapes the responses he or she evokes from adults and peers, and those reactions may in turn reinforce the child’s temperament. Coplan and Bullock (Chapter 21, this volume) review the ways that children’s temperament traits predict the responses of their peers toward them. Environmental selection describes a process through which a child seeks out an environment that is consistent with his or her temperament. Thus, a child with high levels of attention and self-control may choose to spend time reading and learning about new topics, and those activities may further strengthen the child’s capacities for attention and self-regulation.

Environmental construal relates to temperament imposing a “meaning structure” on events (Rothbart, 2011). Depending on their temperaments, young children interpret and experience similar environments in profoundly different ways from birth. This may happen through a selective perceptual bias that gives more salience to certain components of the environment compared with others, or through a different interpretation of the same components of the environment. Thus, as opposed to the low-reactive infant, the high-reactive infant tends to focus on the threatening components of his or her environment. Because perceiving the world as a threatening place exacerbates the initial disposition to fearful reactions, this can only operate to reinforce the temperamental bias.

Although these processes go a long way in explaining why, in numerous cases, there is a certain inertia to temperament, temperament determines neither the environment nor the child’s development. Three relatively recent lines of research help us to understand why a range of different outcomes is possible given the identical temperament. First, interactions between temperament dispositions and contextual factors can strengthen or weaken a child’s temperament qualities, thereby promoting varied positive or negative adjustment outcomes (Bates et al., Chapter 20, and Lengua & Wachs, Chapter 25, this volume). Within the context of normal development, Kochanska’s research on moral and conscience development has shown that the same parenting practices that promote the development of children’s moral integrity and sense of justice in one type of child are unhelpful for another type of child. Thus, fearful children develop internalized self-controls best when they have mothers who use gentle child disciplinary strategies, whereas fearless children develop best with mothers who are warm and responsive, yet firmer in their interactions (Kochanska & Aksan, 2006).

Second, as described by van IJzendoorn and Bakermans-Kranenburg (Chapter 19, this volume), research has found certain temperamental dispositions to be particularly susceptible to environmental influences. This finding is generally referred to as differential susceptibility, which is not simply another expression for vulnerability. Rather, it denotes temperamental dispositions that confer particularly negative development in response to bad environments, but also exceptionally positive development in response to good environments. On the other extreme are temperamental qualities that appear to make children psychologically less permeable to environmen-
tal effects. These children will be protected from adverse environments but may in turn benefit less from enriching ones. These two different types of children have been poetically characterized as orchid and dandelion children, as discussed by van IJzendoorn and Bakermans-Kranenburg (Chapter 19, this volume). This new line of research raises the intriguing possibility that mutability or immutability in response to events may be a feature of temperament itself.

Third, the child’s environment transcends the family. It includes the powerful sibling and peer context (Coplan & Bullock, Chapter 21, this volume). On a broader level, the context is woven from norms, laws, values, beliefs, customs, and traditions that define an entire cultural context. Chen, Yang, and Fu (Chapter 22, this volume) discuss how these cultural components of the environment can interact with the child’s temperament. Peers and adults tend to perceive, evaluate, and respond to a child’s temperamental characteristics through the lenses of their culture’s value system. Such evaluations and responses affect the child’s self-concept and behaviors, thereby affecting developmental patterns. For example, in Canadian samples, inhibition was found to evoke negative maternal attitudes and reactions, such as punishment orientation and rejection. However, the trend was the opposite in China, where inhibition was associated with warm and accepting maternal attitudes. Similarly, Canadian peers saw the subdued behaviors of inhibited children as deficient, but Chinese peers looked at them in a positive way, as signs of courteousness and readiness for social engagement. Consistent with these results, a recent study demonstrated that the same genotype—a serotonin receptor polymorphism (5-HTR1A)—is associated with different cognitive styles in Korea and in the United States (holistic vs. analytic), thus adding weight to the notion that the same genotype may have different, sometimes contrasting, phenotypic expressions depending on the context (Kim et al., 2010). Other factors that interact with temperament are social class and gender. Although interactions between temperament and low income or poverty are discussed by Lengua and Wachs (Chapter 25, this volume), and the literature on temperament and gender is reviewed by Else-Quest (Chapter 23, this volume), these domains deserve more attention in the future.

In summary, developmental work on temperament has greatly expanded our understanding of social, emotional, and personality development. Initially, the most perceptible shift was from an emphasis on the parent and other environmental factors to the child. More recently, however, the environment has resurfaced as an important factor in child development, albeit in a form that is very different from the one-size-fits-all understanding of the effects of parenting proclaimed in the 1960s and 1970s (e.g., Baumrind, 1967). This contemporary understanding of parenting and other environmental influences has more in common with the emergence of personalized medicine, that is, the customization of healthcare that involves tailoring practices to the individual patient by use of genetic or other information.

**Temperament Research in the Public Interest**

This volume provides strong evidence for the role of temperament in shaping risks for school failure (Duckworth & Allred, Chapter 30, this volume), depressive and anxiety symptoms (Klein et al., Chapter 26, this volume), and behavior problems, including serious antisocial behavior (Tackett et al., Chapter 27, this volume). In recognition of these findings and the fact that temperamental risk factors can be assessed as early as the second and third years of life, the field has come to appreciate the implications of its findings for prevention, intervention, and policymaking. As forcefully put by Moffitt and colleagues in their study on life outcomes of early impulsivity:

> It was possible to disentangle the effects of children’s self-control from effects of variation in the children’s intelligence, social class, and home lives of their families, thereby singling out self-control as a clear target for intervention policy. Joining earlier longitudinal follow-ups . . . , our findings imply that innovative policies that put self-control center stage might reduce a panoply of costs that now heavily burden citizens and governments. Differences between children in self-control predicted their adult outcomes approximately as well as low
intelligence and low social class origins, which are known to be extremely difficult to improve through intervention. (2011, p. 2697)

The idea of relying on certain behavioral markers for the purposes of screening and intervention is not new, of course. There is a copious literature on the possibilities for identifying at-risk children early in life, in particular those at risk for developing externalizing problems because they are hard to overlook (e.g., Conduct Problems Prevention Research Group, 2011). However, as we show next, temperament research has much to offer to this time-honored tradition of preventive science and practice.

**Temperament in Childhood Prevention and Intervention**

Temperament research offers at least four ways of strengthening current practices in prevention and intervention. First, most approaches to prevention and intervention target children during school age, although some programs have moved their initial assessments back to preschool. The move from school age back to preschool age or kindergarten recognizes that early intervention is key to the prevention of behavior disorders, particularly externalizing behaviors. The assessment procedures resulting from recent research on temperament can be applied to children of a younger age, including toddlers. The possibility of identifying at-risk behavioral patterns earlier than has been customary has the potential of making prevention more effective. Thus, the research described in this handbook gives a new meaning to what “early intervention” can be.

Second, temperament concepts and measures cover a relatively broad spectrum of traits, ranging from dispositional anger and fear to impairments in persistence and attention. These traits are relevant to both social functioning and academic competence, outcomes that have tended to be targeted separately. Thus, whereas behavioral inhibition carries a greater risk for predisposing children to low self-esteem and impaired social functioning (Coplan & Bullock, Chapter 21, this volume), effortful control and its affiliated constructs of constraint and self-control bear quite directly on behaviors required for scholastic achievement (Duckworth & Allred, Chapter 30, this volume). In other words, temperament concepts and measures not only provide the possibility of an earlier at-risk assessment compared with other screening tools, but also lend themselves to a more comprehensive screening of behavioral risk factors.

Third, early childhood temperament, though modestly predictive of later behavior problems, refers to variations within the normal range. Thus, temperament concepts avoid the overtly diagnostic or even pathologizing vocabulary that is characteristic of widely used screening tools. Interventions can capitalize on the benign vocabulary offered by temperament research and theory, and can frame its programs in terms of, for example, enhancing “character literacy” rather than preventing psychopathology or violence. Although this may seem like a minor change in labeling, it could go a long way toward ensuring parents’ and teachers’ acceptance of a given prevention or intervention. Few parents like to see their child as a potential criminal or depressive, whereas most parents would agree that character building is as important as passing exams. More important, avoiding unfavorable labeling of a child may prevent parents, teachers, counselors, and other child professionals from building up negative expectations that may end in self-fulfilling prophecies.

Fourth, the field of child temperament tends to spur personalized interventions, that is, practices that are tailored to the individual child's behavioral phenotype, as described by McClowry and Collins (Chapter 29, this volume). This development marks a departure from one-size-fits-all approaches that are characteristic of many prevention programs. Although certain practices and exercises can be effectively applied to all children, preventive science can ill afford to ignore the fact that what helps certain children may be unhelpful or even counterproductive for others. This development has an interesting parallel with the recent advent of personalized medicine. Knowing which genes are involved in a particular patient’s disease can allow treatments to be deployed with greater precision. Thus, targeted therapies aimed at specific cancer-causing mutations, including Gleevec (imatinib) for chronic myelogenous leukemia and
Herceptin (trastuzumab) for some types of breast cancer, have been highly successful. Relatedly, a better understanding of which temperamental dispositions are involved in a given behavior disorder should allow clinicians to deploy prevention tools and treatments with greater effectiveness.

In summary, there are many ways in which the research covered in this handbook could enrich early intervention and prevention programs, thus making a difference for children’s scholastic achievement and mental health. However, to build a bridge between basic research on temperament and practice effectively, more needs to be done. One problem is that despite the large number of temperament measures described in Part III of the handbook, hardly any instruments have been normed and standardized. This limits their usefulness as screening tools for purposes of prevention and intervention, although they can be readily used in temperament research. There are currently few temperament inventories with relatively extensive norms (N > 1,000). One is the Revised Temperament Assessment Battery for Children (TABC-R), which has norms from a U.S. sample (Martin & Bridger, 1999). It measures negative emotionality, activity, and persistence (based on New York Longitudinal Study concepts), from which composite scores of inhibition and impulsivity can be derived. Another instrument is the Integrative Child Temperament Inventory (ICTI), a 30-item measure of frustration, behavioral inhibition, attention/persistence, activity, and sensory sensitivity. It has been normed for use in Germany (Zentner & Ihrig, 2010), the United States, and the United Kingdom (Zentner & Wang, in press).

Yet even the most sensitive diagnostic tools are of limited value if they cannot be matched with putting in place effective interventions in the case of a risk diagnosis. McClowry and Collins (Chapter 29, this volume), Duckworth and Allred (Chapter 30, this volume), and Aron (Chapter 31, this volume) all describe a range of such possible interventions, showing how much the field has moved beyond the parent guidance originally envisaged by Chess and Thomas (1986; see also Carey & McDevitt, 1989). Even so, the integration of temperament concepts into intervention practices still leaves much room for improvement. At present, only very few temperament-inclusive interventions have demonstrated efficacy in reducing problem behaviors and enhancing adaptation in a variety of settings. One is the Cool Little Kids program for temperamentally inhibited preschool children (Kennedy, R apee, & Edwards, 2009). Coplan, Schneider, Matheson, and Graham (2010) recently introduced an intervention called “Play Skills,” also designed for very inhibited preschoolers, and reported promising results. INSIGHTS into Children’s Temperament (McClowry, Snow, Tamis-LeMonda, & Rodriguez, 2010) is a more comprehensive intervention program based on an assessment of the child’s entire temperamental profile; this intervention has been shown to be effective in two randomized controlled trials (see McClowry & Collins, Chapter 29, this volume).

An important point to keep in mind is that rather than being stand-alone programs, temperament-based interventions can be integrated into existing child development initiatives. In part, this is already happening, albeit somewhat unknowingly and invisibly. For example, several interventions enhance children’s self-control and other self-regulatory abilities, which are facets of effortful control (Rueda, Chapter 8, this volume). Indeed, Duckworth and Allred (Chapter 30, this volume) ask with good reason: “The salutary effects of effortful control, and evidence that rank-order and mean-level change are possible, raise the question, what can schools and teachers do to encourage its development?” These authors describe several programs of prevention and intervention, such as Tools of the Mind, PATHS, and the Chicago School Readiness Program, which have shown good results in reducing problem behaviors related to deficits in effortful control. Also, forms of training, such as computerized and noncomputerized games, have been shown to improve the executive functions of preschoolers and school-age children (Diamond & Lee, 2011; see also Rueda, Chapter 8, and Goldsmith & Gagne, Chapter 11, this volume). In addition, there is growing interest in using classmates to deliver targeted group or schoolwide programs that teach and encourage more effective coping with anger and aggression (Deater-Deckard & Wang, Chapter 7, this volume). Finally, temperament-inclusive
interventions could also play a significant role in preventing health problems such as obesity (Hampson & Vollrath, Chapter 28, this volume).

Thus, there is clearly scope for improving the level of integration between the temperament and intervention literature. One advantage of bridging the two is that intervention could start earlier than is presently the case. For example, behavioral inhibition and deficits in effortful control are risk factors that can be discerned and measured as early as in toddlerhood (in this volume, see Kagan, Chapter 4; Rueda, Chapter 8; Gartstein et al., Chapter, 10; Goldsmith & Gagne, Chapter 11). This is important in the light of evidence showing that temperament predicts performance in reading and numerical tasks (e.g., Coplan, Barber, & Lagace-Seguin, 1999; Fuhs, Wyant, & Day, 2011). Thus, current temperament concepts can facilitate the deployment of interventions at an age when the relatively high degree of brain and behavioral plasticity makes successful outcomes more likely.

**Temperament in Psychotherapy**

C. G. Jung’s views in *Psychological Types* (1923) triggered Freud’s scorn (see Paskaukas, 1995, p. 424), but are consistent with current thinking about applications of temperament research and personalized interventions more generally. An extravert needs action and company to feel well, but being forced constantly to socialize, attend parties and office functions, and be deprived of a measure of solitude will likely throw an introverted type out of balance. In and of itself, this notion is hardly original. What makes it controversial is its clash with current-day Western ideals for gregariousness and a general preference for action over contemplation. Indeed, most parents, teachers, psychotherapists, and psychiatrists would risk being accused of acting irresponsibly were they to encourage children or patients to cut down on socializing and make time for extensive periods of solitude.

Easily overlooked, however, is that the desirability of extraversion is variable across cultural context and historical period. In 19th-century England, restraint and a measure of eccentricity passed as signs of class and nobility. The legendary character Phileas Fogg, before attempting to circumnavigate the world in 80 days (Verne, 1874), lived a happy life as a bachelor, carrying out his daily activities with mathematical precision in London’s Savile Row. Even in the contemporary reader, the character does not arouse serious psychiatric suspicions because there is an appreciation for the fit between the person and his time. More important, and as discussed by Chen and colleagues (Chapter 22, this volume), to keep to oneself is considered normal, and sometimes even a desirable sign of wisdom in other cultural contexts.

Another example is self-control, whose virtues are currently emphasized and contrasted with the perils of impulsivity (Baumeister & Tierney, 2012). Although self-control has been demonstrably linked to several positive outcomes, in certain contexts, it may also impose certain limitations on exploratory and creative behavior (Block, 2006). Steve Jobs, for many an epitome of entrepreneurial creativity, experimented with drugs in his youth, drove a car without a license plate, and was notoriously emotional in his handling of employees (Isaacs, 2011)—hardly signs of the kind of self-control that preventive programs strive to promote in children.

Even neuroticism had its ups and downs. The author of a recent *New York Times* essay looks back at a time when “being neurotic meant something more than merely being anxious. . . . It meant being interesting (if sometimes exasperating) at a time when psychoanalysis reigned in intellectual circles and Woody Allen reigned in movie houses” (Carey, 2012). MacDonald (Chapter 14, this volume) takes an evolutionary approach to understanding the costs and benefits associated with various temperamental characteristics. The concept of *fluctuating selection* posits that both ends of any of the basic temperamental dimensions were “selected” because each end is associated with both evolutionary costs and fitness benefits, depending on environmental circumstances. Thus, it is only through the preservation of variation in temperament that evolutionary fitness can be maintained (see also K. Akiskal & Akiskal, 2005).

Although the kinds of temperamental traits that make life harder or easier vary according to cultural and historical contexts, the clinical benefits of this realization
are limited. No time machine can transport a patient into an epoch that might have provided a better fit to his temperament. And although people do occasionally relocate to places that suit their temperament better than the previous one, this is not often practicable. As a consequence, when temperament gets in the way of social or professional functioning, means for enhancing behavioral flexibility will be the most sensible choice. This can be achieved through the previously described intervention programs or other established forms of psychotherapy.

Aron (Chapter 31, this volume) offers a number of suggestions for ways that clinicians can address patients’ varied temperaments effectively in the context of therapy. She argues that a temperament perspective offers significant advantages to treatment: It may improve assessment, reduce misdiagnosis, help build a therapeutic alliance, improve the efficiency of treatment, and nurture patients’ self-esteem by helping them to value their individual differences. Another important recognition has been that temperament can predict which type of psychotherapy will be most effective (Klein et al., Chapter 26, this volume), and may be traced to Kretschmer on one hand, and Axelrod and other eminent neuropsychopharmacologists on the other (Healy, 2002). For example, drawing on Kretschmer’s (1925) notion that endogenous psychoses are exaggerated forms of normal temperament, Akiskal views temperament as the earliest clinically observable phenotypic expressions of an underlying genetic diathesis for mood disorder distinctions (H. Akiskal & Akiskal, 1992). He distinguishes five major “subaffective temperaments”: cyclothymic, dysthymic, hyperthymic, irritable, and anxious (H. Akiskal, Akiskal, Haykal, Manning, & Connor, 2005). This conception of temperament as a subclinical phenotype is related to the continuum/spectrum framework of temperament–psychopathology links discussed by Klein and colleagues (Chapter 26). The psychiatric approach to temperament also has a stronger emphasis on psychopharmacology. Although both strands look at the role of temperament in psychopathology, the connections between the two strands are not as strong as they might be. Yet, a tighter connection between these domains would have obvious advantages.

First, several temperament measures used in psychiatric research, such as those developed by Akiskal and Cloninger, overlap considerably with the mainstream temperament concepts and measures discussed in Part II (see Table 32.1; Zuckerman, Chapter 3, this volume). A taxonomic integration of these models could make research on temperament and psychopathology more cumulative and incremental. Thus, the serotonin transporter allele(s) has been linked to “cyclothym-

<table>
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<th>Temperament</th>
<th>IPT</th>
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<tr>
<td>Novelty seeking</td>
<td>.22*</td>
<td>.09</td>
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<tr>
<td>Harm avoidance</td>
<td>.37***</td>
<td>-.17</td>
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<tr>
<td>Persistence</td>
<td>.06</td>
<td>.18</td>
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<tr>
<td>Reward dependence</td>
<td>.24</td>
<td>.22*</td>
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Note. Based on Joyce et al. (2007). CBT, cognitive-behavioral therapy; IPT, interpersonal psychotherapy. *p < .05; p < .01; ***p < .001.
mic” and “anxious” temperament (Rihmer, Akiskal, Rihmer, & Akiskal, 2010), “harm avoidance” (Wu et al., 2010), and “neuroticism” (see Depue & Fu, Chapter 18, this volume). In effect, these findings likely represent variants of one and the same relationship. Yet use of different terminologies creates the appearance of three different types of results—an instantiation of the jangle fallacy, that is, the obfuscation of similarity in constructs and results by the use of different terms (Block, 1995).

Second, a temperament diagnosis could help to predict which patients will respond best to a given psychotropic agent. Currently, the edge that psychotropic agents have over placebos in treating anxiety, depression, impulsivity, or rigidity is scarcely impressive (e.g., Kirsch, Deacon, Huedo-Medina, Moore, & Johnson, 2008). One reason is that psychotropic medication efficacy has been shown to vary widely from patient to patient (Simon & Perlis, 2010). Understanding and predicting that variation could have considerable benefits for both doctors and patients. The current recommendation in psychiatry is to try a given drug first, then to switch to another compound if there is no response or side effects occur. If the second drug fails, a third one might be tried, and so on. The inability to match a patient with a drug often sends both the doctor and patient on a protracted odyssey until a compound that works is found.

There are several hypotheses about individuals’ differential responsiveness to antidepressive and antipsychotic agents, including purely metabolic ones (Simon & Perlis, 2010). But there is also recognition that individuals’ may respond differentially because of different neuroaffective bases of their personalities. For example, Joyce, Mulder, and Cloninger (1994) showed that people with certain temperamental profiles were more likely to respond to drugs acting on the serotonin system, whereas others responded to drugs acting on the norepinephrine system. More recently, Phan, Lee, and Coccaro (2011) found that patients’ scores on harm avoidance predicted effectiveness of selective serotonin reuptake inhibitors (SSRIs) in treating depression. Thus, as a proxy for the neural basis of personality, temperament concepts could help clinicians to find the effective compound for a given individual right away. To be sure, the evidence for the differential effectiveness of drugs, depending on the temperamental characteristics of patients, is in its infancy.

Finally, the rapid progress in our understanding of brain–temperament relationships might ultimately facilitate the development of targeted psychotropic drugs. For example, some recent findings suggest that axonal disintegration may play an important role in trait anxiety because the former tends to disrupt connectivity across brain sites involved in anxiety regulation (Westley, Bjørnebekk, Grydeland, Fjell, & Walhovd, 2011). Thus, compounds that can halt or reverse axonal neuropathology might also have an anxiolytic effect. In summary, as we enter into the new era of personalized pharmacotherapy (Gurwitz, Lunshof, & Altman, 2006), a tighter integration of temperament research in psychopharmacology and in biological and molecular psychiatry seems an obvious step to take.

Some Caveats Regarding Temperament-Inclusive Interventions

Although there are clear advantages of integrating temperament research, measures, and concepts into current forms of prevention, intervention, and treatment, there is also a certain potential for misuse. First, interventionists should be mindful of interventions’ dependence on value systems, as pointed out before. Furthermore, although temperament could play a salutary role in psychiatry, and perhaps in medicine more generally, the concept of temperament should not itself be medicalized. Although most readers of this volume will appreciate that calling a trait, such as impulsivity, temperament does not imply a clear-cut biological etiology, in popular parlance, the term often stands informally for behavioral tendencies with a neural or genetic cause, such as a chemical imbalance in the brain. From here it is only a small step to the claim that because temperament is a result of chemical imbalances or badly routed synapses, the behaviors can only be rectified by pharmacological intervention. Capitalizing on this informal (and incorrect) use of the term temperament, interest groups such as drug companies would only be too happy to see temperament concepts spreading across the
helping professions, thus broadening the market for their lines of product.

Another sensitive area is jurisdiction. The obvious worry is that temperament concepts, wrongly understood as implying biological determinism, could be misused to exculpate individuals for criminal offenses or other harmful actions. In this view, some unfortunate individuals act the way nature intends them to act. Indeed, this view may wrongly suggest that these individuals should themselves be seen as helpless victims of a temperament generated by a brain malfunction, such as a deficiency of positively charged sodium ions along the membranes of axons in the prefrontal cortex or the nucleus accumbens (see Gazzaniga, 2011, for a recent discussion of problems in using biological determinism in the courtroom).

Conclusion

Overseeing the incredibly rich, diverse, and rigorous research compiled in this volume has been a heartening experience. Even so, one can see that research on temperament is very much a work in progress. As noted by Pavlov long ago, there is a proper sequence to research priorities that cannot be circumvented: “From the very beginning of your work, school yourselves to severe gradualness in the accumulation of knowledge. . . . Never begin the subsequent without mastering the preceding” (1936, p. 369). Before attempting to crack the code of temperament’s ultimate workings, the field had first to establish a system for describing, characterizing, and classifying the phenomenon of interest. This work has in itself been fruitful, leading to a comprehensive system for the classification and measurement of normal individual differences in emotive and regulatory behaviors, currently unmatched by any other conceptual or assessment instrumentarium for the period of infancy and toddlerhood (Parts II and III, this volume).

In parallel, it began to gradually expand its research into the antecedents and consequences of temperamental qualities showing that individual differences in temperament have appreciable predictive validity regarding personality, psychopathology, and interpersonal functioning, as well as health and occupational achievement, as is detailed in Parts V and VI of this volume. From this foundation, the field is now in a better position to embrace Pavlov’s second piece of advice: “[T]ry not to stay on the surface of the facts. . . . Try to penetrate to the secret of their occurrence, persistently search for the laws which govern them” (p. 369). The new developments traced in this handbook show that this is now happening.

Because the focus of the volume is inherently developmental, we have not singled out the role of temperament in specific age periods (infancy, childhood, adolescence, adulthood). Thus, the chapters in Part II delineate basic temperament traits across the lifespan, from infancy to adulthood. Moreover, this volume has two chapters specifically devoted to temperament in adults (Zuckerman, Chapter 3; Depue & Yu, Chapter 18). Even so, not all areas in adult temperament research have equally been covered, and more could have been added on models relating to affective styles (Davidson, 2000), the behavioral inhibition and activation systems in temperament (Carver, 2005), or other two-dimensional models of temperament (Clark & Watson, 2008). Similarly, infancy’s somewhat special role in temperament research has been touched upon in many chapters of this volume. Still, it may deserve more special treatment, especially with respect to uses of temperament concepts in pediatrics.

Finally, although this volume addressed links between temperament and developmental psychopathology in Klein and colleagues, Chapter 26, and Tackett and colleagues, Chapter 27, a previous section in this chapter has pointed to other ways in which temperament concepts and measures could be profitably integrated into biological psychiatry and psychopharmacology. A chapter dedicated specifically to these latter areas would undoubtedly enrich this volume and contribute to bridging the current gap between temperament research in biological psychiatry and psychopharmacology on the one hand, and research on temperament in clinical psychology and developmental psychopathology on the other.

The unknown unknowns are, by definition, unknown. There is little doubt that these unknowns will be brought to our attention. This we can only welcome and embrace. Incongruous findings or secluded research initiatives have often acted as a source of
creativity and progress. Several chapters in this volume point to currently neglected questions, whose examination may enrich the area in important and unexpected ways. Despite its incompleteness, we hope that the new level of integration achieved with this volume is substantial enough to spur the research insights and alliances required to meet the challenges that lie ahead.

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