4 Effortful Control in Adolescence: Individual Differences within a Unique Developmental Window

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Abstract
Individual differences in emotional reactivity emerge in the first months of life. In some infants, this is marked by a fearful withdrawal from the uncertainty of the larger world, while other infants display a joyful embrace. While early reactivity can shape behavior over time, it is not immutable. The child can come to shape, or regulate, these initial emotional tendencies, allowing him to meet individual goals and conform to societal expectations of behavior. This chapter focuses on effortful control as a key component of an individual’s regulatory arsenal. It explores the role of effortful control in helping individuals navigate the exceedingly complex social and emotional world confronted in adolescence, highlighting the behavioral, cognitive, and neural mechanisms at play.

In many ways, psychology, as a science, has chosen for itself a rather difficult target of study relative to its empirical peers. Like the chemist examining atomic structures, the psychologist is faced with a complex, multi-unit structure whose elements interact in surprising, nonlinear fashion. Much like the biologist peering at a cell, the psychologist is chasing an evolving, growing organism whose transformations reflect both quantitative and
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qualitative change. However, unlike the atom or the cell, the human is able to observe, judge, and willfully change previous patterns of behavior. Thus, the psychologist must be nimble in the attempt to measure a construct even as the object of study is employing *that very construct* to modify its behavioral manifestation. Developmental psychology, in particular, must capture a rapid rate of change, the insistent shift from external to internal mechanisms of control, and the expanding universe of forces that shape the developmental trajectory of an individual child.

This chapter focuses on one mechanism by which children come to shape their own behavior, their understanding of the world around them, and the paths by which they navigate their environment — effortful control. The discussion defines and characterizes the current understanding of effortful control as both a temperamental trait and a regulatory mechanism that emerges over the course of childhood. The emphasis is on individual differences in the efficacy and deployment of effortful control, particularly as it reflects a core component of temperament. Throughout, the focus is on the unique role effortful control may play in behavior during adolescence as individuals confront tasks that increasingly reflect the challenges of adulthood while relying on regulatory mechanisms that are neither fully mature nor stable in their deployment. In doing so, the chapter also highlights the strength of bringing together converging data from multiple sources and levels of analysis.

**Effortful Control as a Core Component of Temperament**

**Temperament Encompasses Both Reactivity and Regulation**

Individual differences in behavior are evident from the first days of life. Some infants spend their days in relative serenity soaking in environmental stimuli and, eventually, reaching out to engage with a larger world. Other infants, in contrast, feel bombarded by the multitude of sensory inputs that surround them. They respond by pulling back and displaying strong, unmistakable signs of negative affect. These two groups of infants are displaying the earliest temperament markers of emotional reactivity, their initial automatic response to the environment. This is the affective and behavioral style that they will carry with them as they navigate an ever-expanding social world (Kagan, 2012; Rothbart, 2012). Temperamental reactivity emerges in the first months of life, shows relative stability across contexts and time, and serves as the initial biological building block for the later emergence of personality from childhood into adolescence and then adulthood (Rothbart, Ahadi, & Evans, 2000).
Figure 4.1. This simplified model depicts the multilayered processes that impact longitudinal trajectories into adolescence. Here, effortful and reactive control mechanisms work in response to initial affective and motivational forces to shape behavior within the ecological context of functioning. When flexible and able to adapt to shifting resources and demands, effortful control can work to enhance adaptive functioning. When coupled with poor social supports and extreme affective inputs, variations in effortful control may lead to over- or undercontrolled patterns of behavior.

This is not to say, however, that early temperamental reactivity is immutable. The individual child’s environment, socialization pressures brought to bear by parents and peers, as well as internal psychological processes all work to shape initial biases. Indeed, temperament-linked individual differences in the ability to regulate emerge as early as the second year of life. Regulatory mechanisms (e.g., effortful control) work to modulate initial responses in light of individual goals or concerns. Thus, specific developmental trajectories are shaped by the interplay between initial reactivity and subsequent regulation. The specific direction of these trajectories (e.g., toward or away from the social world) are rooted in motivational systems that categorize the environment as appetitive or aversive and energize behavior accordingly (Quevedo, Benning, Gunnar, & Dahl, 2009). The discussion that follows will highlight the individual components of this model, illustrated in Figure 4.1.

The Construct of Effortful Control
Effortful control can be defined as the ability to inhibit a dominant response in the service of performing a subdominant response (Rothbart & Rueda,
2005). For example, a child playing ‘Simon says’ must carefully regulate her behavior in order to perform (or avoid performing) as needed. Effortful control is also invoked when individuals must detect errors during, or must engage in planning in anticipation of, performance. Effortful control is seen as a core tool in the child’s arsenal needed to both self-regulate and integrate oneself as an adaptive member of the larger social environment. Thus individual differences in effortful control have been associated with the emergence of conscience and empathy (Kochanska, Murray, & Coy, 1997), levels of academic success (Checa & Rueda, 2011), and the quality and quantity of peer relationships (Valiente, Lemery-Chalfant, Swanson, & Reiser, 2008).

**Effortful versus Reactive Control**

In characterizing effortful control, a distinction is often made with reactive control. Reactive control (Eisenberg & Spinrad, 2004) encompasses the child’s implicit evaluation of objects or events as aversive or rewarding. Reactive control is motivated by immediate incentives and is sufficiently spontaneous that it is not considered deliberate (Martel & Nigg, 2006). This implicit evaluation then triggers relatively automatic or reflexive response strategies, which can indicate approach or withdrawal behavior (Rueda, 2012). Effortful control brings to bear more deliberate or conscious processing, interpretation, and manipulation of these initial reactive tendencies (Rothbart & Bates, 2007).

**The Emergence of Effortful Control**

Individual differences in reactivity are evident from the first weeks of life (Kagan, Snidman, Kahn, & Towsley, 2007). In contrast, regulatory mechanisms are slower to emerge (Posner & Rothbart, 2000), can be somewhat crude in the initial application (Posner, Rothbart, & Thomas-Thrapp, 1998), and are initially dependent on external forces (Bernier, Carlson, & Whipple, 2010). For example, a three-month-old may show regular patterns of high negative affect but the first glimmers of self-regulation may not appear until close to the first birthday (Posner et al., 1998). In many cases, regulation will require an adult or older child who can intervene and introduce a new focus of attention (Fox & Calkins, 2003). This might involve, for example, providing a child with a new toy just as a dangerous object is removed from his grasp.

On a practical level, the researcher examining the interplay between reactivity and regulation in infancy and early childhood can take advantage of bold behavioral responses on the part of the child. Emotional responses to distressing cues involve clear markers, such as crying and turning away.
Regulatory mechanisms, even when invoked, are relatively slow and only partially effective—allowing us to capture variability across individuals and time. In contrast, in the older child or adolescent emotional and cognitive responses to salient stimuli can be quite subtle or completely hidden from the researcher’s glare (Luna & Sweeney, 2004). Indeed, many of the standard laboratory tasks used with young children to measure reactivity and effortful control (e.g., Please wait 5 minutes before eating a treat) are no longer developmentally appropriate past the very early elementary school period (Rueda, 2012).

**Effortful Control in Adolescence**

As a field we have focused on the initial stabilization or coalescing of effortful control in early to middle childhood (Rosso, Young, Femia, & Yurgelun-Todd, 2004). This limited scope leaves unexplored a critical period during which effortful control skills are expanded, applied to more complex and long-term goals, and subjected to new pressures that accompany the expanding experiential environment for adolescents. Effortful control skills can be seen as the “mediator between genetic predispositions, early experience, and adult functioning” (Fonagy & Target, 2002). Without a focus on the specific application of effortful control skills on the unique demands of adolescence, the link to the final component of this triad is missing.

In adolescence, effortful control is called on to modulate behaviors that are growing in both specificity and complexity. Effortful control mechanisms are often characterized as broad, context-free tools that are brought to bear across a complex spectrum of behaviors and tendencies. In this sense, the self-regulation strategies of mental contrasting (Oettingen, 1999, 2012) and implementation intentions (Gollwitzer, 1999; Gollwitzer & Oettingen, 2011) qualify as effortful control, even though their effects on behavior change are based on non-effortful, automatic processes. However, as discussed in the following sections, the individual and environmental contexts of regulation may play a very important role in the observed relation between effortful control skills and developmental outcomes.

**Attention in Effortful Control and Socioemotional Development**

**Attention as Gatekeeper in Social Development**

The centrality of attention in development grows out of its role as a specific brain-based mechanism whose core function is to influence the operation of other mechanisms—by choosing the focus of attention for further processing, by maintaining this focus as needed, and by disengaging from...
the focus of attention when it no longer serves current goals (Posner & Rothbart, 2007). The earliest forms of self-regulation and effortful control are rooted in the ability to disengage, shift gaze, and reorient on a new focus of attention (Rothbart, Posner, & Rosicky, 1994).

If this view is correct, early life individual differences in attention should be associated with diverging trajectories of socioemotional development during early childhood—potentially extending into adolescence. Since attention mechanisms can link early traits to later broad patterns of functioning, they can be considered a “developmental tether.” Developmental tethers bind children to specific developmental trajectories. From our lab’s perspective, developmental tethers grow out of the child’s individual early traits or biases. These biases then provoke an environmental response. The child processes and interprets these responses and frames subsequent behaviors based on the conclusions drawn. This can become cyclical, growing progressively more entrenched (and at times biased) with each successive iteration, and setting the trajectory for socioemotional development. This process may be particularly acute in children at temperamental risk for socioemotional difficulties.

As a first examination of attention as a developmental tether (Pérez-Edgar, McDermott et al., 2010), my colleagues and I had nine-month-old infants watch an engaging video of Sesame Street. We then intermittently presented a bulls-eye in the periphery of their visual field. Based on how engaged they remained with the video, infants were characterized for high or low levels of sustained attention. We followed the children until adolescence, periodically assessing social behavior with unfamiliar peers in our lab. Infants with low levels of sustained attention showed increasing levels of social withdrawal and discomfort through age 14 years. In addition, initial social difficulties as toddlers (14 months) predicted adolescent social behavior only in the children with low levels of sustained attention, thus tethering the child to his initial biases. The observed developmental trajectories may be a reflection of the important gatekeeping role that attention plays in day-to-day psychological processes.

**Mechanisms of Attention**

Attention is a complex, multifaceted neuropsychological process. Posner’s model of attention (Posner, Rothbart, Sheese, & Voelker, 2012) has suggested three core areas of functioning that allow a child moving through her busy environment to notice an important event (alerting), shift attention to the event (orienting), and then decide if she needs to act (executive). The alerting system is tasked with obtaining and maintaining an alert state,
is subserved by midbrain structure with strong interconnectivity between frontal and parietal regions, and is linked to norepinephrine functioning. The second, orienting system is thought to select sensory events for further processing, is linked to inferior and superior parietal systems, and is linked to cholinergic activity. The orienting system plays an important role in early self-regulation as it is evident in the first year of life and is a core tool for modulating emotion. Appearing later in development is the executive attention system. This system is called in to resolve conflict among responses, is linked to prefrontal (including the anterior cingulate cortex, ACC) activity, and is closely aligned with dopaminergic functioning. This system is thought to reflect the effortful control behaviors researchers observe in older children. Indeed, poor executive attention is associated with lower levels of effortful control (Ellis, Rothbart, & Posner, 2004). Over time, initial attempts at reactive control supported by the orienting system are subsumed by effortful control mechanisms and the executive attention system. This transition provides the individual with greater flexibility in responding to environmental stimuli and a wider range of options when needing to regulate. Unlike the younger child, the adolescent’s orienting system can recruit the executive system to meet a challenge, as needed (Shulman et al., 2009).

**Neural and Psychophysiological Underpinnings of Effortful Control**

A number of empirical tasks have been designed to assess effortful control. These include the Stroop color-word task (Stroop, 1935) and its emotional variants (Pérez-Edgar & Fox, 2003), the Go–No Go task (Casey et al., 1997), the spatial conflict task (Gerardi-Caulton, 2000), and the flanker task (Ericsson, 1995). Each task was initially designed for use with adults from the perspective of cognitive psychology or neuropsychology. This heritage can cause difficulty when trying to modify tasks for use with very young children (Pérez-Edgar & Bar-Haim, 2010). However, adolescents are often fully capable of meeting the behavioral demands placed on them by these tasks. In addition, these tasks are amenable for use with psychophysiological and imaging techniques (Fox, Hane, & Pérez-Edgar, 2006). Since adolescents are relatively good at masking their affective or cognitive responses to our laboratory tasks, in vivo noninvasive methods are particularly useful in revealing underlying patterns of reactivity and regulation (Luna & Sweeney, 2004; Taber-Thomas & Pérez-Edgar, in press).
Response Inhibition

One core component of effortful control is the ability to withhold a prepotent response, which is often assessed with the Go–No Go or flanker task. The inhibitory effort exerted is reflected in the N2 component of the event-related potential (ERP). ERPs capture the electrical activity of the brain time-locked to the precise presentation of a specific stimulus or response. The N2 is noted approximately 200 ms after stimulus presentation and is maximal at medial-frontal electrode sites. The amplitude of the N2 is often taken to reflect underlying levels of conflict monitoring (Donkers & van Boxtel, 2004) or response inhibition (Folstein & Van Petten, 2008). Under ideal performance conditions, the N2 reaches adult levels by mid- to late adolescence (Ladouceur, Dahl, & Carter, 2007) and is used to index the availability and efficacy of cognitive functions that underlie control processes.

Performance Monitoring

A second ERP component often used to capture individual differences in effortful control is the event-related negativity (ERN). The ERN indexes the individual’s ability to detect errors and monitor ongoing performance. This, in turn, is thought to allow children to flexibly assess performance, adapt to changing demands, or shift behavior in order to increase the probability of goal attainment. The ERN is observed 50–150 ms after a child makes a response and is maximal in medial-frontal electrode sites (Falkenstein, Hoormann, Christ, & Hohnsbein, 2000). In the process of completing a task, the ERN is thought to signal conflict monitoring after an error response is made, while the N2 reflects conflict monitoring before a correct response. The general consensus is that larger ERN and N2 amplitudes necessarily reflect “better” functioning. However, as discussed later in the chapter, individual differences in temperament can shift the relation between these two ERP components and psychological outcomes.

Functional Neural Systems Underlying Effortful Control

ERPs are unique in their ability to closely track the chronometry of processing. However, ERPs can only grossly approximate the location of the neural generators triggering the evident differences in ERP components. Conversely, localization is more clearly revealed with technology such as functional magnetic resonance imaging (fMRI). The fMRI environment can be quite difficult for very young children as it is quite noisy, can seem overwhelming, and requires minimal movement (often less than 3 mm) during data collection (Pérez-Edgar & Bar-Haim, 2010). This limits the
use of fMRI technology with young children. Luckily, by middle childhood and adolescence, children can often easily tolerate these demands, allowing researchers the first opportunity to extensively explore the neural correlates of effortful control.

The behavioral dichotomy between emotional reactivity and effortful regulation is paralleled by separate neural systems for emotional arousal and motivation versus effortful or executive control (Dennis, O’Toole, & DeCicco, 2013). The reactive system is centered on an interconnected network that includes the amygdala, insula, striatum, and medial orbital frontal cortex (mOFC). The effortful or executive control system is centered on more cortical regions including the lateral prefrontal cortex (lPFC), medial PFC, lateral OFC, and the ACC.

The ACC, in particular, subserves cognitive control functions associated with monitoring the effectiveness, efficiency, and meaning of behavior and performance. The dorsal ACC is considered a transition zone in the fronto-limbic network (Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004), linking together the emotional processing of objects and events rooted in the limbic system with the regulatory mechanisms of the frontal cortex. As such, activity in the ACC may be involved in effortful control processes brought to bear in challenging contexts, helping the adolescent monitor and resolve conflicts while navigating the environment. The ventral ACC is connected to the amygdala, mOFC, nucleus accumbens, hypothalamus, and anterior insula (Bush, Luu, & Posner, 2000). This neuroanatomical architecture is consistent with an important role for the ACC in assessing the salience of emotional and motivational information.

**Integrating Affective and Cognitive Processes in Adolescence**

Within the executive functioning literature, a distinction is often made between “cool” and “hot” environments and tasks (Zelazo, Qu, & Müller, 2005). Cool environments are emotionally neutral and can be considered a baseline measure of performance under ideal conditions. Hot environments, in contrast, are emotionally charged and often involve highly salient motivational components. This can include rewards or punishments based on level of performance (e.g., the adolescent must perform well in order to avoid giving a dreaded speech), the use of emotionally salient stimuli (e.g., emotion faces used as stimuli in a Go–No Go task), or the presence of an emotional trigger (e.g., a critical audience observing performance).

Adolescents often exhibit adult levels of performance in cool tasks (Prencipe et al., 2011), suggesting that the underlying effortful control skills are mature. However, performance often breaks down under hot
conditions. This seeming regression in skill level may reflect the system’s inability to maintain high levels of performance in a core task (e.g., sorting pictures) while simultaneously regulating the reactive response generated by the affective pressures of the task (e.g., avoiding the dreaded speech; Taber-Thomas & Pérez-Edgar, in press).

At the neural level, adolescence reflects a unique disequilibrium between regulatory and reactive neural mechanisms. Somerville and Casey (2010) have suggested that pubertal, hormonal, and neuroendocrine forces shape reactive mechanisms, such that they show a rapid increase in sensitivity, peaking in adolescence, which then subsides over time – creating an inverted U-shaped curve. Unfortunately, the regulatory mechanisms centered in the PFC that are needed to reign in initial reactive tendencies are not yet mature as they have a protracted maturational progression compared to other neuropsychological functions (Gogtay et al., 2004). Detecting and processing novel and salient cues may overwhelm regulatory capacities, exerting a stronger influence on behavior for adolescents, relative to children and adults (Figner, Mackinlay, Wilkening, & Weber, 2009).

Ernst and Fudge (2009) capture this imbalance within their triadic model. Illustrated using a triangle, each corner of the triangle reflects underlying regulatory and reactive neural systems. The model has regulatory capacities at its peak. The base corners of the triangle are assigned to approach motivations and avoidance motivations, respectively. Throughout development, the goal is for the peak of the triangle to keep the base in balance. However, in adolescence, the pull of approach and reward mechanisms may be particularly strong, overwhelming the regulatory peak of the triangle. As a result, the triangle tips in the direction of this corner of the base. With the continuing stabilization and growth of regulatory mechanisms, the balance is restored as the individual transitions into young adulthood (Taber-Thomas & Pérez-Edgar, in press).

This imbalance can be seen at the neural level. Galvan et al. (2006) observed children, adolescents, and adults as they performed a monetary reward task within the fMRI environment. They found that adolescents reacted comparably to adults in the nucleus accumbens, a subregion of the striatum. The nucleus accumbens is active when individuals are working to translate motivation into action. In contrast, when examining activation levels in the PFC, the adolescents were more comparable to the children in the sample. The fundamental imbalance between motivation and regulation may be the root foundation for the impulsive, risky, and emotionally volatile behavior that we often view as the hallmark of adolescence. While the societal emphasis on _Sturm und Drang_ may be an exaggeration, this stereotype
may be rooted in this underlying imbalance. In adolescence, individuals can often articulate a clear understanding of the potential consequences of their behavior (Steinberg, 2008), reflecting improvement in the ability to imagine hypothetical scenarios and extrapolate consequences. However, implementation becomes more difficult in the heat of real-life choices in emotionally evocative contexts. Thus, the thoughtful adolescent who can recite driving safety rules becomes an aggressive speeder when out with friends.

**Effortful Control in the Unique Context of Adolescence**

From an evolutionary perspective, adolescence may by necessity be marked by risk-taking, impulsiveness, and new heights of creativity. These traits impart the necessary motivation and brashness needed to leave the home base, explore new territories, and establish independent family units (Spear, 2004). The difficulty lies in the intersection of ancient evolutionary engines and modern societal constraints.

**Effortful Control and Socialization in Adolescence**

Adaptive developmental outcomes, defined as the ability to successfully navigate and integrate into the surrounding social world, depend not only on the ability to regulate but also the ability to realize what behaviors need to be regulated. Universal, biologically based mechanisms of regulation are shaped to conform to the cultural norms of the society in which the child is embedded (Rothbart, 2007). The successful adolescent is able to mold or modulate initial temperamental biases to fit the demands and expectations of the specific culture he finds himself in. It is in the temperament-culture mismatch, much like a temperament-parenting mismatch (Mangelsdorf, Gunnar, Kestenbaum, Lang, & Andreas, 1990), that one can find the roots of dysfunction. This becomes most evident in adolescence as societal expectations become more stringent and more closely aligned with adult patterns of behavior.

Effortful control may facilitate environmental efforts to socialize the child to cultural expectations (Posner & Rothbart, 2009). For example, young children are often given greater latitude from adults when judging their ability to target and modulate behaviors deemed inappropriate or socially undesirable. The two-year-old who, after seeing a plate of cookies, rushes to grab one, or two, or three is told to wait his turn and share with others. However, on the whole, the cookie-grabber can be considered charming and a bit funny. The twelve-year-old who engages in the same behavior
is considered rude and deviant. Children entering into adolescence are increasingly expected to independently regulate underlying tendencies and also more closely reflect ideal patterns of adult behavior (Steinberg, 2008). A child who can bring to bear effortful control skills when extrapolating another’s mental state (theory of mind) to anticipate their responses to behavior may be able to better conform to social expectations (Carlson, Moses, & Breton, 2002). This initial example of the plate of cookies reflects a relatively minor and ephemeral transgression of societal norms. However, the adolescent is also now, more than before, dealing with much larger issues calling for both short-term and long-term regulation of behavior.

**Impulse versus Investment in Adolescence**

Consider the famous marshmallow task (Mischel, Shoda, & Rodriguez, 1989) in which a young child is presented with a delicious treat. He is asked to wait patiently and refrain from eating the treat with the expectation that he will receive two marshmallows if he survives the ordeal. A large literature base suggests that children who can refrain from eating the marshmallow display greater cognitive, academic, and social outcomes in both the short and long terms (Casey et al., 2011). Presumably, this reflects underlying effortful control skills linked to inhibitory control and attention regulation. This task is marked by a tangible, visible goal and a short (although unknown to the child) time frame. With adolescence, goals are often intangible, have a much longer time frame, and involve opportunities with a much larger impact on future outcomes.

For example, we can substitute for the marshmallow the potential for admissions to a highly selective college or university. The time frame extends from 15 minutes to multiple years. This window encompasses the span of time during which the adolescent must first recognize the goal, navigate academic and social pressures as he attempts to build the academic record needed for admissions, and, finally, years later, actually submit an application. The eventual reward is a relatively ephemeral notice of admission. This process requires that the adolescent delay gratification, inhibit impulsive behavior, and carefully plan and organize activities across multiple domains (Yucel et al., 2012).

The adolescent is asked to repeatedly confront the impulsive choice and the investment dilemma (Davey, Yucel, & Allen, 2008). In the impulsive choice, the adolescent must decide between the proximal reward (an invitation to a great party) and the distal costs (a university’s rejection letter). For the investment dilemma, the adolescent must weigh the proximal cost (missing the party to go to the library) versus distal rewards (receiving an
acceptance letter). A student who fails to navigate these choices early in his academic career cannot simply reverse course years later. It must be an early and sustained course of action during a time period where the goals are distant and intangible and the current competing interests may be engaging, immediate, and concrete. Both behavioral and neuroimaging research show that adolescents are particularly attuned to salient environmental stimuli and cues (Ernst & Spear, 2009), suggesting that powerful effortful control mechanisms are needed to keep the adolescent on track.

**Effortful Control and the Independence of Adolescents**

Across adolescence, there is also an increase in the diversity or variability of the contexts under which adolescents must regulate their behavior. Adolescence often represents the first time we are given real freedom to actively choose and shape our environments (Steinberg et al., 2006). Thus, the increasing complexity of the targets of regulation is coupled with an explosion in the potential goals and contexts that regulation must take place. The adolescent must intentionally set goals that can be supported by subsequent automatic or reactive processes. Since many of these goals have a long time horizon (e.g., university admissions), the adolescents must be able to monitor the ongoing progress he is making toward the goal and have the flexibility to shift underlying strategies based on feedback over time. These course corrections are made outside of the immediate context or environment that generated the central goal. As noted earlier, regulation in childhood often involves objectives that are immediate, tangible, and close at hand.

**Individual Differences in the Impact of Effortful Control on Development**

The discussion to this point has held closely to the proposition that higher levels of effortful control, and the underlying skills leading to effortful control, are necessarily positive influences on the course of development. This is indeed generally the case. However, as with most aspects of development, the impact of a particular skill or trait must be assessed within the context in which it is manifested.

For example, the ability to monitor performance for errors and adjust subsequent behavior accordingly is a hallmark of mature behavior and is thought to underlie observed improvement in task performance with age. Children who are diagnosed with attention deficit hyperactivity disorder (ADHD) or who show high levels of impulsive behavior have deficits in performance and error monitoring (Nigg, Goldsmith, & Sachek, 2004).
At the neural level, this is often reflected in smaller ERNs (Liotti, Pliszka, Perez, Kothmann, & Woldorff, 2005) or less ACC activation (van Veen & Carter, 2002) during computer-based tasks, such as the flanker task. In this context, increases in performance monitoring over time are often treated as milestones of improving developmental outcomes.

However, this pattern of increased monitoring leading to better outcomes may not carry over to children prone to anxiety. For example, Fox, Henderson, Rubin, Calkins, and Schmidt (2001) recruited a large sample of four-month-old infants with high levels of negative reactivity to novel sensory stimuli. Negative reactivity in infancy increases the risk for social difficulties in childhood (Fox et al., 2001) and elevated anxiety in adolescence (Chronis-Tuscano et al., 2009). At age 15, adolescents completed a traditional flanker task (McDermott et al., 2009). Temperamental risk was positively associated with ERN amplitudes in adolescence. Importantly, elevated ERN amplitudes were associated with increased levels of clinical anxiety among the participants with the highest levels of social difficulties. Henderson (2010) found a similar pattern with the N2 in shy 9–13-year-olds. These psychophysiological findings are in line with an fMRI study indicating that adolescents with a childhood history of temperamental risk for anxiety show altered neural responses to salient cues only when they are indicative of the adolescent’s performance (Bar-Haim et al., 2009; Helfinstein et al., 2011).

These data suggest that heightened error monitoring in anxiety-prone children may reflect an overcontrolled behavioral style. Here, the subcomponents of effortful control, rather than freeing the child to flexibly and nimbly respond to environmental demands, may lock the child into a rigid response pattern (Wong et al., 2006). Coupled with biased patterns of attention, discussed earlier, this regulatory style may set the stage for biased cognitions that lead to anxiety and social withdrawal. Indeed, children and adolescents with the ability to flexibly shift attention (White, McDermott, Degnan, Henderson, & Fox, 2011), who have high overall levels of attentional control (Sportel, Nauta, de Hullu, de Jong, & Hartman, 2011), or do not show an attention bias toward threat (Pérez-Edgar, Bar-Haim, et al., 2010; Pérez-Edgar et al., 2011) are buffered from the observed link between early temperament and anxiety. These data suggest that the individual subcomponents of effortful control may play independent roles in moderating the long-term impact of early temperamental reactivity (Henderson, Pine, & Fox, 2015). However, no studies to date have followed this potential differentiation from childhood into adolescence, leaving a gap in the literature.
Levels of effortful control are also associated with broad patterns of externalizing behavior, such as aggression. Researchers often make the distinction between proactive and reactive aggression (Dodge, 1991). Proactive aggression is marked by the deliberate aggressive acts against others that are goal oriented and planned. Reactive aggression, in contrast, is often impulsive and driven by the perception of immediate threat. This distinction appears to map onto our general understanding of the interplay between reactive and effortful control in self-regulation (Frick & Morris, 2004). That is, low levels of effortful control are associated with greater reactive aggression, particularly in children prone to high levels of anger (Eisenberg, Champion, & Ma, 2004). This may be due to poor emotional regulation and the inability to inhibit initial reactive tendencies. In contrast, high levels of effortful control are associated with proactive aggression, when coupled with contextual factors that encourage aggressive behavior (Rathert, Fite, & Gaertner, 2011). Here, goal setting, planning, and performance monitoring are drawn on in support of planful acts of aggression.

There may be an optimal level of behavioral or effortful control that is sensitive to the vulnerabilities and strengths of the individual and helps optimize adaptation to shifting environmental demands. Adolescents with high levels of negative reactivity, a rigid reactive regulatory style, and over-controlled effortful regulation may be vulnerable to anxiety. Counterparts with high levels of surgency, an equally rigid reactive regulatory style, and an undercontrolled effortful control style may show difficulties in the form of aggression. The increased pressures faced by adolescents may trigger the emergence of maladaptive tendencies rooted in patterns of inflexible under- or overcontrol, leading to the documented spike in psychopathology within this age range (see Figure 4.1).

**Outstanding Issues**

Kagan (2008) has suggested that “contemporary scientists resemble children who can only read six words trying to read a Harry Potter novel” (p. 162). This characterization can be applied to our attempts to study effortful control into adolescence. While an impressively wide array of research has worked to delineate and explain the emergence of effortful control in infancy and toddlerhood, we know relatively little of its role in the transition to adolescence and adulthood. Thus, there are a number of outstanding issues or questions that must be addressed.

First, we as researchers must create empirical methods that can capture the evolution of reactivity and regulation as children confront the increasing pressures and expectation of adolescence. This is particularly difficult given
that with age the two systems become on the surface so intertwined that one wonders if reactivity and regulation can ever be separately addressed.

Thus, the second challenge is to incorporate measures at multiple levels of analysis, across multiple contexts, in order to create multidimensional profiles of reactivity and regulation in action. The use of both behavioral and biological measures in tandem may prove crucial. As seen here, taking into account changes in affective context and temperamental differences across individuals may be particularly important.

Finally, longitudinal studies must encompass a broader time frame extending into adolescence so that we can capture the long-term stability or dynamism of effortful control.

Given the unique challenges of adolescence, we do not know if our current understanding of effortful control in this time window is transient in nature, responding to the unique stressors of adolescence, or a marker of long-term patterns of functioning. Indeed, we do not know how (or if) individual differences in the efficacy of effortful control in adolescence shape subsequent life patterns. The promise holds in seeing effortful control as one dimension of an intricately assembled system working at the level of individual and context to alter the course of development.

REFERENCES


