EFFORTFUL CONTROL, EXECUTIVE INHIBITION, AND PERSONALITY DYSFUNCTION: BRIDGING TEMPERAMENT, NEUROCOGNITION, AND PSYCHOPATHOLOGY

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DISSERTATION

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Abstract

Personality dysfunction results, in part, from maladaptive interactions among temperamental factors, neurocognitive deficits, and environmental influences (Linehan, 1993; Zelkowitz et al. 2001). Posner and Rothbart (2002; 2003) posited a developmental psychobiological model that emphasizes a particular temperament dimension, effortful control, in the development subsequent later personality dysfunction. Nigg (2000) asserted that behaviors associated with effortful control depend on executive inhibition, which refers to the intentional modulation of a dominant response in order to achieve one's goals. Poor effortful control among adult borderline personality disorder patients is associated with inefficiency in the executive attention network, a coordinated neural circuit involved in resolving conflict among stimuli and correcting errors (Posner et al., 2002). Executive inhibition subsumes the notion of executive attention efficiency (Fan, McCandliss, Fossella, Flombaum, & Posner, 2005) and consists of three facets that are putatively distinct: interference control, behavioral inhibition, and cognitive inhibition.

The present study sought to extend Posner and Rothbart's model by examining the role of effortful control and executive inhibition in an array of dysfunctional personality traits. Following the taxonomy outlined by Nigg (2000), 112 nonclinical adult participants completed six experimental measures of executive inhibition, as well as questionnaires about personality dysfunction and effortful control. Our results were not consistent with the hypothesized inhibition facet structure and suggested that inhibition is a unidimensional construct. This finding is consistent with past work demonstrating a nonaffective constraint neurobehavioral system underpinned by serotonin function (Depue & Collins, 1999).

We found modest support for the link between effortful control and personality dysfunction. Effortful control was not closely associated with executive inhibition as we predicted and relationships between personality dysfunction and effortful control were not mediated by executive inhibition, suggesting that self-reported effortful control does not adequately capture inhibitory capacity. Executive inhibitory deficits were linked with many personality dysfunction traits, including aggression, manipulativeness, mistrust, and entitlement. Performance on inhibition measures suggested particular involvement of anterior cingulate cortex in personality dysfunction. This study provides preliminary support for the role of executive inhibition deficits in a diversity of dysfunctional personality traits.

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The definition, classification, and etiology of personality disorders (PDs) are topics of current debate (Lenzenweger & Clarkin, 2005). Overwhelming evidence indicates that the dominant psychiatric nosology, the DSM-IV (American Psychiatric Association, 1994), which divides personality disturbance into ten separate PD diagnoses, fails to correspond with empirical classification research and has excessive overlap among diagnostic criteria (Krueger, 2005; Livesley, 2001a; O'Connor, 2005). Despite this failure of psychiatric taxonomy, the DSM-IV has stimulated further interest in the classification and etiology of PDs, and diverse personality disorder theoreticians and researchers increasingly agree on the phenomenological features that define personality dysfunction. In an attempt to describe the range of personality disturbance – independent of theory – Parker and colleagues (2002) identified a host of dysfunctions common to PDs, a subset of which include: lack of cooperation, lack of empathy, failure to form and maintain interpersonal relationships, failure to learn from experience, poor emotion regulation, impulsivity, inflexibility, immorality, self-defeating behaviors, low self-directedness, lack of humor, and tenuous stability under stress. These features align well with Millon's (1986) characterization of individuals with PDs as interpersonally unstable, interpersonally inflexible, and caught in self-defeating circles of behavior. Integrating across theoretical perspectives, Livesley (1998; 2001b) identified two core dimensions of personality disturbance: chronic interpersonal dysfunction and problems with self or identity.

Dimensional classification of personality disorders has been proposed as an alternative approach to the DSM-IV system, and some researchers have posited that the five-factor model (FFM) of personality may provide the foundation of such a classification system (Clark, 2007; Trull & Durrett, 2005). Simultaneous analysis of the latent structure underlying questionnaires measuring normal and maladaptive personality traits converges on the FFM, suggesting that this model adequately describes the structure of personality variation in the normal range and at the extremes of these trait dimensions (Markon, Krueger, & Watson, 2005). Factor analyses of the Dimensional Assessment of Personality Pathology (DAPP; Livesley, 2006) and the Schedule for Nonadaptive and Adaptive Personality (SNAP; Clark, 1993) fail to recapture the DSM-IV PD taxonomy (Livesley, 2006), but these measures do discern dimensions of dysfunction, such as callousness, oppositionality, and identity problems, which are not well captured by DSM-IV PD diagnostic criteria. Apropos of the viability of the FFM for PD classification, the superstructure of both the DAPP and the SNAP align well with the FFM, and despite being developed independently, these measures cover virtually identical content domains (Clark & Livesley, 2002). Thus, extant self-report questionnaires that tap maladaptive extreme variations in personality traits (e.g., extremely high neuroticism) have been proposed as viable alternatives to the current categorical classification system offered by the DSM-IV.

Although the FFM seems to provide an adequate taxonomy of trait adjectives (e.g., “friendly,” “tense,” “sociable”), the model has served primarily as a descriptive taxonomy for personality scientists, rather than yielding specific predictions or positing underlying neurobiological substrates of personality. Attempts to link the FFM with

DSM-IV personality disorders have typically yielded tens of predictions about the correlation of particular FFM facets with particular PD features, essentially establishing a descriptive concordance between the FFM and DSM-IV (see Widiger, Trull, Clarkin, Sanderson, & Costa, 2002, for an example). However, personality disorder researchers have long noted that the DSM-IV PD classification structure should not serve as the gold standard against which assessment tools are judged (Clark, 2007), so the import of FFM-DSM-IV associations is unclear. Twin studies of personality dimensions consistently find that genetic inheritance accounts for roughly 50% of the variation in traits measured by major personality inventories, such as the NEO Personality Inventory—Revised (see Yamagata et al., 2006, for a review), and preliminary evidence supports the heritability of extreme trait variations underlying personality dysfunction (Coolidge, Thede, & Jang, 2001; Nigg & Goldsmith, 1994). Nevertheless, top-down trait models have traditionally been invested in developing adequate psychometric inventories with predictive validity, rather than focusing on neural and genomic underpinnings of personality structure (see Jacobs et al., 2006; Jang et al., 2001; and Manuck et al., 1998, for exceptions).

In contrast to descriptive taxonomies, some theorists have developed models of personality structure based upon evidence for distinct neurobiological systems that regulate particular aspects of behavior (Depue & Collins, 1999; Depue & Lenzenweger, 2005; Siever & Davis, 1991). Other researchers have attempted to identify specific neurological or neuropsychological deficits that underlie personality dysfunction (Fertuck, Lenzenweger, & Clarkin, 2005; Posner et al., 2002). Relative to descriptive taxonomies such as the FFM, psychobiological approaches to personality dysfunction research increase the probability of identifying core mechanisms that cause and maintain

PDs. In addition, biologically-oriented approaches may help to identify endophenotypes (i.e., basic biological or performance deficits that are co-heritable with disorders and present in some unaffected family members) that would allow researchers to identify candidate genes for aspects of personality dysfunction (Gottesman & Gould, 2003; New & Siever, 2003).

Effortful Control and Executive Attention Deficits in Personality Dysfunction

One recent psychobiological approach to personality dysfunction – particularly borderline personality disorder – proposes that personality dysfunction is in part attributable to temperamental differences in negative emotionality and effortful control (Posner et al., 2002; Posner et al., 2003; Posner & Rothbart, 2000). Mary Rothbart and colleagues (Rothbart, Ahadi, & Evans, 2000) have developed a rich temperament classification system that identifies negative emotionality, surgency/extraversion, and effortful control as core dimensions of childhood temperament. Temperament is defined as individual differences in self-regulation and emotional, attentional, and motor reactivity, which emerge early in life and are assumed to be due to genetic inheritance (Rothbart & Derryberry, 2002). Posner and colleagues (2003) assert that borderline patients are characterized by high negative emotionality, which describes persons who are prone to frustration, worry, sadness, and fear. Additionally, borderline patients are thought to have poor effortful control, which is defined as "the ability to suppress a dominant response in order to perform a subdominant response" (Rothbart, Ellis, Rueda, & Posner, 2003, p. 1114). Facets underlying the construct of effortful control include attentional focusing, inhibitory control, low intensity pleasure, and perceptual sensitivity

(Rothbart, Ahadi, Hershey, & Fisher, 2001). However, behavioral inhibition and deliberate attentional control are considered the primary functions of effortful control (Muris & Ollendick, 2005).

Consistent with Posner and colleagues' hypotheses, adult borderline patients reported high negative emotionality and poor effortful control relative to a normative college cohort (Posner et al., 2002). These researchers asserted that poor effortful control in BPD may reflect an underlying deficit in the executive attention network, a coordinated neural circuit involved in planning actions, resolving conflict among stimuli, and correcting errors based on feedback (Norman & Shallice, 1986). Indeed, borderline patients were slower to resolve conflicting stimuli on a validated reaction time-based test of executive attention efficiency (Posner et al., 2002). A substantial volume of temperament research in infants, children, and adolescents documents that poor effortful control is associated with features of personality dysfunction, such as impulsivity, unstable interpersonal relationships, and poor development of conscience (Eisenberg, Smith, Sadovsky, & Spinrad, 2004). Moreover, ample evidence indicates that personality dysfunction begins in childhood or adolescence for many individuals (Bemporad, Smith, Hanson, & Cicchetti, 1982; Bernstein, Cohen, Skodol, Bezirganian, & Brook, 1996). Thus, poor effortful control in childhood may set the stage for adult personality dysfunction and clinical personality disorder (not limited to borderline PD). First, the normative and abnormal development of effortful control in childhood and adolescence are described. Second, behavioral manifestations of effortful control in adulthood are explored.

Normative Development of Effortful Control

Effortful control follows a developmental course, with the first signs of deliberate attentional control and conflict resolution emerging around 18 months of age. Prior to this age, children have little ability to inhibit dominant responses and tend to be driven by reactive responses to external stimuli, immediate needs, and affective distress (Rueda, Posner, & Rothbart, 2004). At 18 months, most children display simple executive attention skills, such as resolving ambiguous spatial locations based on contextual clues. Around 30 months of age, children display a significant decrease in reaction time resolving ambiguous spatial locations, a task known to activate focally the executive attention network. Contemporaneous with this shift, parents report improved inhibition of maladaptive behavior on command, better emotion regulation, and lower negative emotionality in their infants, which are considered to be the earliest indications of effortful control (Kochanska, Murray, & Harlan, 2000; Rothbart et al., 2003).

Effortful control and the executive attention network develop over the next several years, as evidenced by linear improvements in reaction time and accuracy on laboratory tasks requiring resolution of conflicting stimuli (e.g., Stroop task) or ambiguous visual locations. The executive attention network reaches maturity around age seven, after which children's performance on laboratory measures of executive attention is indistinguishable from that of adults (Rueda, Fan, et al., 2004). Diamond and Taylor (1996) found linear improvements in children's ability to execute a rule that required inhibition of the dominant response and execution of a subdominant response between the ages of 3.5 and 7. Indeed, children under the age of four are largely unable to succeed in games such as "Simon Says", which requires effortful inhibition of dominant behavioral responses (Reed, Pien, & Rothbart, 1984). Interindividual differences in effortful control developmental trajectories – particularly inhibitory control and attention focusing skills – are relatively stable over the course of development, with ratings of effortful control at 22 months closely predicting effortful control at 45 months (Kochanska & Knaack, 2003; Murphy, Eisenberg, Fabes, Shepard, & Guthrie, 1999).

The development of effortful control coincides with various developmental outcomes related to emotion regulation and inhibition and activation of social behaviors. A major component of adaptive emotion regulation involves refocusing attention away from the source of discomfort, which is an ability closely tied to effortful control. For example, children who were able to distract themselves from the source of frustration during a laboratory task displayed lower levels of negative emotions than children who were unable to disengage attention from their frustration (Calkins & Johnson, 1998). Similarly, Calkins and colleagues (Calkins, Dedmon, Gill, Lomax, & Johnson, 2002) found that infants reported to be fussy by caregivers displayed low attention regulation during a frustrating task and were also poor at maintaining attentional focus on a laboratory measure of sustained attention. Higher effortful control was also associated with lower expressed anger among infants under the age of three during a frustrating situation (Kochanska et al., 2000). In short, attentional flexibility, which is a core function of the executive attention network, provides a means to regulate negative emotionality.

Further, attentional flexibility provides a mechanism by which children delay gratification of immediate needs or desires (Eisenberg et al., 2004). Children who used deliberate distraction to delay playing with an interesting toy were more successful than children who used other strategies (Raver, Blackburn, Bancroft, & Torp, 1999). Mischel and colleagues (Mischel, Shoda, & Peake, 1988) found that adolescents' frustration tolerance when they are unable to effect a desired outcome was well predicted by their ability to delay gratification in the preschool years. In addition to better delay of gratification, children high in effortful control are more compliant with caregiver requests to suppress dominant responses, such as a parent asking his daughter not to hit her brother despite being frustrated (Kochanska, Coy, & Murray, 2001). Indeed, inhibition of socially undesirable behaviors is critical to adaptive socialization in childhood and adolescence, and effortful control plays a major role in this developmental process.

In addition to emotion regulation and responsiveness to social demands, effortful control is important in the development of conscience and empathy in childhood. Kochanska and colleagues (Kochanska, Murray, & Coy, 1997) found that effortful control at ages two through four predicted internalization of conscience at age five, as reflected by better internalization of authority figure rules (e.g., not playing with a particular toy even when the adult who made the rule is not present) and higher concern about the morality (i.e., whether an action is right or wrong) of one's actions. In terms of empathy development, Guthrie and colleagues (1997) found that five- to eight-year-old children high on effortful control were attuned to the painful emotional experience of another person, whereas children who scored low on effortful control tended to focus on their own distress in response to another's emotional pain. In this study, children's facial expressions were monitored while watching an emotionally-charged video about a young girl burned in a fire who was teased for her appearance. Children rated by their parents as low on effortful control displayed less facial sadness during the video and expressed less sympathy for the girl's experience and greater personal distress following the video. On the other hand, high effortful control was associated with lower personal distress, as well as greater sympathy and display of sadness in response to the video (Guthrie et al., 1997).

The simultaneous presence of lower personal distress and higher display of sadness suggests that effortful control is associated with the ability to attend to the emotional experience of another person while maintaining an emotional distinction between self and other (perhaps through modulation of executive attention). These data are consonant with other research on self- and parent-reports of empathy during childhood, which finds that early effortful control predicts later ability to attune to another's pain without becoming overwhelmed by personal reactions to such pain (Murphy et al., 1999; Rothbart, Ahadi, & Hershey, 1994). Appropriate development of empathy, as well as the broader development of awareness to interpersonal cues emitted during social interactions, are crucial to social competence and are strongly influenced by effortful control (Eisenberg et al., 2004). In addition, higher levels of effortful control prospectively predict prosocial behavior (e.g., development of friendships), social competence, and peer perception of social status (Raver et al., 1999).

Children's ability to understand and reason about others' states of mind (i.e., theory of mind) is closely tied to executive attention development (Carlson & Moses, 2001; Sabbagh, Xu, Carlson, Moses, & Lee, 2006). Theory of mind refers to a child's ability to conceptualize mental states in the self and others and to recognize that the experience of the self is not necessarily the experience of another. In a common theory of mind task (Wimmer & Perner, 1983), two puppets, Bert and Ernie, play with a ball. Bert places the ball in a blue container and leaves. Ernie subsequently retrieves the ball and places it in a red container. Children are asked where Bert thinks the ball is as well as where they think the ball is. Around the age of four, children are able to distinguish between their belief and that of the puppet.

Carlson and colleagues (Carlson & Moses, 2001; Carlson, Moses, & Claxton 2004) suggest that executive function skills, particularly inhibitory control and working memory, provide children with the necessary attentional control to evaluate multiple conflicting perspectives and to choose the perspective that reflects an abstracted representation apart from the self. According to Carlson and Moses (2001), "without *some* capacity to distance themselves from current stimuli, [children] would surely never be able to reflect on representations of those stimuli" (p. 1032; italics in original). Indeed, theory of mind likely requires inhibitory control of a dominant response (expressing one's understanding of a situation) and production of a subdominant response (expressing the understanding of another), which is a core function of effortful control. High effortful control is associated with strong theory of mind among children ages three to six (Carlson & Moses, 2001; Sabbagh et al., 2006).

In summary, adaptive development of effortful control is associated with diverse self-regulatory abilities including emotion regulation, morality, prosocial behavior, attention to social cues, and inhibition of maladaptive behavior. Indeed, effortful control likely underlies most of the skills required for mature self-regulation, such as planning behavior to achieve long-term goals (Gollwitzer, Fujita, & Oettingen, 2004) and developing intimate social relationships. Mature adulthood is characterized by balancing and managing multiple responsibilities and relationships with relative flexibility, which requires a high degree of self-regulation (Vohs & Ciarocco, 2004). In short, regulatory skills associated with effortful control and executive attention are manifestly important to the development of mutually rewarding interpersonal relationships and adaptive regulation of negative emotionality across the lifespan.

Failures of effortful control development

In contrast to the adaptive development of executive attention, Posner and Rothbart (2000) argue that developmental failures of executive attention and, more broadly, effortful control are central to the etiology of childhood and adult psychopathology. Indeed, poor effortful control is associated with multiple social and self-regulation deficits in childhood. Children with low effortful control struggle to regulate negative emotions, which results in higher levels of expressed frustration, sadness, and anger. These negative emotions likely reflect failures to disengage attention from the source of affect (Calkins & Johnson, 1998; Kochanska & Knaack, 2003). The negative relationship between effortful control and negative emotionality holds true for adolescents and adults, which suggests that effortful control is important in emotion regulation across the lifespan (Posner & Rothbart, 2000).

Furthermore, children low in effortful control tend to gratify their immediate wants and needs, thereby resulting in poor behavioral inhibition and frequent impulsive behaviors (Sethi, Mischel, Aber, Shoda, & Rodriguez, 2000). According to parent reports, low effortful control children respond poorly to being redirected from a task of interest, often insist on continuing socially inappropriate behavior despite being told "no," and are described as hyperactive (Eisenberg et al., 2004). Caspi and colleagues (Caspi, Henry, McGee, Moffitt, & Silva, 1995) found that teachers' reports of conduct disorder, antisocial behavior, inattention, and hyperactivity among adolescents ages nine to fifteen years were well predicted by lack of control at age five. Indeed, low effortful control at age three is associated with poor social adjustment, antisocial and aggressive behavior, and interpersonal conflict throughout the school years (Caspi, 2000; Newman, Caspi, Moffitt, & Silva, 1997), and number of criminal convictions is prospectively predicted by weak self-control (Pulkkinen & Hamalainen, 1995).

In terms of conscience development, young children with low effortful control display poor understanding of the possible consequences of their actions (e.g., understanding right from wrong or apologizing for wrongdoing), report low concern about others' emotions, and tend to be driven by their own desires, rather than by explicit social rules (Kochanska et al., 1997). Seven-year-olds low in effortful control typically express low guilt in response to their wrongdoing (Rothbart et al., 1994). Poor effortful control may also deleteriously impact the development of empathy (i.e., concern about the emotional experience another person), although low empathy likely does not reflect emotional aloofness. Rather, children with low effortful control tend to become emotionally overaroused when confronted by strong emotional expression of another, which leads to self-concern and self-distress (Eisenberg, Wentzel, & Harris, 1998). As mentioned above, low effortful control children who watched an emotional film that pulled for empathic concern tended to become personally distressed and had difficulty sympathizing with the person in the video (Guthrie et al., 1997). This overarousal likely reflects poor emotion regulation (a major function of the executive attention network) and poor separation of the emotional experience of another from that of the self. Lastly, poor theory of mind has also been reported among children with poor effortful control

(Carlson & Moses, 2001), which suggests that low effortful control may make it difficult for a child to conceptualize differences between the experience of self and other.

Adult Manifestations of Effortful Control: Connecting Temperament and Personality

As described above, effortful control pertains broadly to self-regulatory capacities that have a strong attentional component. Whereas personality research typically focuses on multifaceted, higher-order traits, such as neuroticism and extraversion, temperamental factors are thought to be early-developing basic behavioral tendencies that are largely biological in origin, with significant genetic inheritance (Buss & Plomin, 1984). By virtue of its grounding in temperament, effortful control has been conceptualized and studied primarily in children and adolescents. Recent research supports the developmental and theoretical continuity of personality and temperament constructs (Caspi, Roberts, & Shiner, 2005). Indeed, models of temperament and personality emphasize three common dimensions of interindividual differences: negative emotionality/neuroticism, positive emotionality/extraversion, and constraint/conscientiousness/effortful control (Clark & Watson, 1999; Rothbart & Ahadi, 1994). Extreme temperamental configurations (e.g., high negative emotionality and low effortful control) may set the stage for later personality abnormality and personality disorders (Kernberg & Caligor, 2005).

In terms of adult personality, effortful control is likely most closely associated with the constructs of constraint from Tellegen's three-factor (Tellegen, 1985) personality taxonomy and conscientiousness from the FFM (Watson & Clark, 1993), although effortful control is not synonymous with these constructs. Evans and Rothbart

(2007) extended established childhood temperament measurement scales to adults in order to understand the manifestations of temperament among adults. Effortful control, as measured by the Adult Temperament Questionnaire (ATQ), was moderately associated (r = .64) with conscientiousness, as defined by the FFM, and negatively associated with neuroticism (r = -.41). No other associations between FFM traits and effortful control were observed by Evans and Rothbart (2007).

Although effortful control is associated with FFM conscientiousness, the content domains of these scales are not identical. On the ATQ, effortful control is comprised of three facets: attentional control, inhibitory control, and activation control (Evans & Rothbart, 2007). Attentional control taps an individual's ability to focus closely on a task at hand (freedom from distractibility), as well as the ability to shift one's attention voluntarily in the presence of reward or punishment cues. Inhibitory control describes a person's capacity to inhibit inappropriate responses or behaviors, including inhibiting inappropriate appetitive behaviors (e.g., food cravings or a desire to purchase an item in a store), as well as inhibiting response tendencies that would violate social norms (e.g., speaking out of turn when excited about a topic). Activation control refers to an individual's capacity to engage in a behavior that serves long-term goals when short-term avoidance is the dominant response (e.g., completing an arduous homework assignment on time). In summary, the construct of effortful control centers around the flexible deployment of attention on behalf of higher-order goals or social norms, rather than one's actions being guided by momentary desires or affect.

In contrast, FFM conscientiousness pertains to a broader class of behaviors, including organizational ability, traditionalism, dependability, attention to detail, neatness, impulse control, and ambitiousness. High levels of conscientiousness have been prospectively linked with adaptive social outcomes, including vocational achievement, work satisfaction, and financial security (Roberts, Caspi, & Moffitt, 2003). In addition, conscientiousness is associated with longevity (Friedman et al., 1993), likely because individuals with lower conscientiousness are more likely to engage in unhealthy behaviors such as tobacco use, unhealthy eating, risky sex, and violence (Bogg & Roberts, 2004). Although conscientiousness has been linked with theory-consistent behaviors, such as marital stability (Tucker, Kressin, Spiro, & Ruscio, 1998) and occupational achievement (Roberts et al., 2003), such research consistently indicates that subdividing conscientiousness into facets leads to more specific, robust predictions. For example, among established employees, self-reported achievement orientation was positively associated with job performance, whereas orderliness was associated with job performance among new employees (Stewart, 1999).

Although many researchers agree on the existence of five major personality factors (Neuroticism, Extraversion, Conscientiousness, Openness to Experience, and Agreeableness), less agreement has been reached about the underlying facet structures of these factors (Saucier & Ostendorf, 1999). The facet structure of conscientiousness has proven particularly problematic, in part because of the diversity of behaviors and traits subsumed under this construct (Costa & McCrae, 1998). Costa and McCrae (1998) identified six facets of conscientiousness in the NEO Personality Inventory – Revised (NEO-PI-R; Costa & McCrae, 1992), which they divided into inhibitive and proactive components. Proactive conscientiousness is characterized by achievement striving, competence, and dutifulness, whereas inhibitive conscientiousness is characterized by orderliness, self-discipline, and deliberation.

In order to derive a viable facet structure for conscientiousness that synthesizes conceptions among researchers and across personality measures, Roberts and colleagues (Roberts, Chernyshenko, Stark, & Goldberg, 2005) factor analyzed conscientiousness-related scales drawn from seven major personality inventories. Their results supported the presence of six facets underlying conscientiousness: industriousness, order, self-control, responsibility, traditionalism, and virtue. Of these facets, self-control most closely relates to attentional flexibility abilities underlying effortful control. Individuals with low self-control are described as "impulsive, spontaneous, easily distracted, and careless" (Roberts et al., 2005, p. 122), whereas high self-control is associated with patience and an ability to inhibit gratification. Although not as directly related, other facets of conscientiousness may depend upon effortful control. Behaviors associated with the responsibility facet (e.g., cooperativeness, dependability, and generosity) may depend upon inhibition of immediate responses in order to engage more prosocial behavior. For example, when unfairly ridiculed by one's boss, an immediate response might be to become angry, quit the job, and walk out, but long-term goals such as financial stability and vocational achievement are incompatible with such behavior. Thus, an individual described as responsible and dependable by others would probably inhibit her angry response to receiving such negative feedback, choosing instead to vent to a friend about the experience after work. In short, as with children, the core processes of attention and inhibition that underlie effortful control may provide the basis for development of prosocial, moral behavior among adults.

As mentioned above, effortful control is theoretically related to Tellegen's (1985) notion of constraint, which is characterized by planfulness, harm avoidance, traditionalism, and cautiousness. On Tellegen's Multidimensional Personality Questionnaire (Tellegen & Waller, in press), Constraint is a higher-order dimension underpinned by Control, Harm Avoidance, and Traditionalism subscales. Effortful control is likely most closely linked to the Control subscale, which is defined by goal-oriented planning, ability to restrain inappropriate behaviors, and low impulsivity. Traditionalism and Harm Avoidance pertain to social values and sensation seeking, respectively, which are not directly connected with the notion of effortful control.

Although Control (and its superfactor, Constraint) is moderately associated with FFM Conscientiousness (Church, 1994), no studies to date have examined the empirical associations among FFM and MPQ facets, in part because of the unstable Conscientiousness facet structure noted above (Roberts et al., 2005). Nevertheless, in view of the similar content of the MPQ Control and FFM Self-Control subscales, it is likely that these two subscales are highly associated with each other and are particularly relevant to Rothbart's notion of effortful control. Consistent with this notion, MPQ Control is negatively associated with MPQ Negative Emotionality (Patrick, Curtin, & Tellegen, 2002) and the magnitude of this association was similar to that observed between the ATQ Effortful Control and FFM Neuroticism (Evans & Rothbart, 2007).

Neural Basis of Effortful Control

As described above, Posner and colleagues (2002) found evidence for lower effortful control and higher negative emotionality among borderline patients relative to normal controls. They also corroborated the hypothesis that poor executive attention efficiency was more common among borderline patients and that such inefficiency was linked to low effortful control. More broadly, Rueda and colleagues (Rueda, Rothbart, & Posner, 2004) have asserted that effortful control can be conceptualized as, "the efficiency with which the executive attention network operates in naturalistic settings" (p. 289). Indeed, children who performed better on experimental measures of executive attention were rated as having higher effortful control by parents (Gerardi-Caulton, 2000). Available neuroimaging research indicates that the executive attention network continues to develop until age seven and permits deliberate shifting of attention on behalf of self-regulatory goals (Eisenberg et al., 2004; Posner et al., 2003). Structurally, the executive attention network includes anterior cingulate cortex (ACC), lateral prefrontal cortex, and the basal ganglia (Posner & Rothbart, 2007), although ACC has been described as the central node in the network (Raz & Buhle, 2006). Neuromodulation of this network occurs primarily via dopamine (Rueda, Posner, & Rothbart, 2004).

ACC is centrally involved in several self-regulatory functions of attention, including resolution of conflicting stimuli (e.g., Stroop task), subjective experience of pain (Rainville, Duncan, Price, Carrier, & Bushnell, 1997), and emotion regulation (Bush, Luu, & Posner, 2000). Although the function of ACC is not entirely clear, available research indicates that ACC monitors the activation of competing response tendencies, particularly when one response is habitual or prepotent, but a second, subdominant response is called for (Braver, Barch, Gray, Molfese, & Snyder, 2001). When a prepotent, but inappropriate, response is executed (e.g., swearing when one strikes one’s thumb with a hammer despite there being a young child in the room), ACC shows particularly strong activation, which may serve to monitor and correct ongoing behavior (Carter et al., 1998; Kiehl, Liddle, & Hopfinger, 2000; MacDonald, Cohen, Stenger, & Carter, 2000).

Early focal lesions of ACC are associated with poor behavioral regulation in social situations, emotional dysregulation (abnormally intense emotions), and impaired decision making throughout the lifespan (Anderson, Damasio, Tranel, & Damasio, 2000). In terms of ACC's role in emotion regulation, individuals instructed to reduce negative affect using cognitive reappraisal following exposure to upsetting photographs displayed higher activation of anterior cingulate and ventral prefrontal cortex as well as lower amygdala activation (Ochsner, Bunge, Gruss, & Gabrieli, 2002). Indeed, ACC has major neural connections with the limbic system and serves to regulate emotion centers such as the amygdala (Davidson, Putnam, & Lareson, 2000). When hypnotic suggestions for pain reduction were offered to participants whose hands were submerged in painfully hot water, activation of the executive attention network was highly correlated with subjective reports of pain, whereas objective stimulus intensity was coded by primary somatosensory cortex (Rainville et al., 1997). Affective and nonaffective subregions of ACC have been identified using neuroimaging of interference control tasks that are selectively responsive to affective and nonaffective material, respectively (Whalen et al., 1998; Bush et al., 1998). Available evidence suggests a reciprocal suppression relationship between these subdivisions, such that the affective subdivision (and associated limbic structures) is suppressed during cognitive interference control tasks (e.g., determining the direction of a central arrow in a flanker task), whereas the cognitive subdivision during is suppressed during an emotionally-salient interference control task (e.g., counting the number of repetitions of the word “murder” printed on a computer screen) (Drevets & Raichle, 1998).

Although executive attention was deficient among borderline patients studied by Posner and colleagues (2002), non-psychiatric individuals matched with borderline patients on their levels of negative emotionality and effortful control did not show the same magnitude of executive attention deficiencies, suggesting that temperamental differences (albeit measured in adulthood) did not account fully for the observed attention deficiency (Posner et al., 2002). Executive attention inefficiency among borderline patients was negatively correlated with effortful control, although the magnitude of this relationship was small to medium ($r = -.29$; Posner et al., 2002), suggesting that other neurocognitive abilities may underlie effortful control.

Rothbart and Posner (2000) have primarily explored the link between effortful control and the executive attention network, but the neurocognitive processes underlying behaviors associated with effortful control are likely more diverse. As outlined by Nigg (2000), behaviors associated with effortful control depend on executive inhibition capacities, which refers to the intentional modulation or suppression of a dominant response in order to achieve goals or to follow social rules. Nigg (2000) advocated for distinctions among four types of executive inhibition related to effortful control: interference control, cognitive inhibition, behavioral inhibition, and oculomotor inhibition. Interference control refers to preventing interference from competing stimuli in order to make a desired response (Dempster & Corkill, 1999). The Stroop effect is perhaps the best known paradigmatic laboratory task of interference control, on which participants are asked to name the color of a word when the word itself is a different color (e.g., saying “red” when a presented with the word “green” in red print). Such tasks are closely associated with the executive attention network, particularly ACC, as well as dorsolateral prefrontal cortex (DLPFC; Cabeza & Nyberg, 1997).

Cognitive inhibition refers to the suppression of distracting or irrelevant information in order to maintain attentional focus and working memory. One prominent experimental paradigm of cognitive inhibition, directed forgetting (Bjork, 1972), instructs participants to read and remember a list of words. Participants are then told to forget that entire list and to devote all of their attention to another list. After reading both lists, participants are then instructed to recall all words from either list. In most variations, participants have greater difficulty recalling the words that they were instructed to forget relative to to-be-remembered words (see Hourihan & Taylor, 2006). Neuroimaging research from a similar experimental paradigm, the think/no think procedure (Anderson & Green, 2001), revealed that DLPFC and ventrolateral prefrontal cortex (VLPFC) were particularly activated during no-think trials (when participants were instructed to suppress thinking about an association between two words), whereas right hippocampal activation was associated with successful forgetting of no-think word pairs (Anderson et al., 2004).

Behavioral inhibition refers to the suppression of a dominant or prepared behavioral response. For example, when insulted by a peer, an adolescent’s dominant response might be to punch the peer, although the consequences of such an action would be negative. Thus, the act of hitting another person is inhibited in the service of avoiding punishment from authority figures and developing positive peer relationships. Perhaps the best explored laboratory paradigm of behavioral inhibition is the Go-No Go task (e.g., Casey et al., 1997). In a common form of this test, participants are instructed to press the space bar as quickly as possible when they see any letter on the screen other than “X.” If an “X” appears on the screen, the participant must not press the space bar. The task is structured such that 75% or more of trials require pressing the space bar, leading to a dominant, prepared response for behavioral action. When an “X” appears, participants must inhibit their dominant response in order not to press the space bar. Behavioral inhibition in the Go-No Go task is linked to activation in VLPFC, ACC, superior parietal cortex, and inferior frontal cortex (Casey et al., 1997).

Lastly, oculomotor inhibition describes the ability to deliberately inhibit a reflexive saccade. In an antisaccade task, participants must execute a saccade in a direction away from the appearance of a new stimulus on the screen, which normally attracts visual attention (Nigg, 2000). This response requires prefrontal inhibition of a prepared response to look at a novel stimulus. Oculomotor inhibition relies upon orbitofrontal cortex and the frontal eye fields (Spinella, 2002).

Although Nigg (2000) provided a useful taxonomy of executive inhibition capacities thought to underlie effortful control, only one study has examined whether the four types of executive inhibition are empirically distinct. Friedman and Miyake (2006) gathered multiple experimental measures thought to tap various forms of executive inhibition and used structural equation modeling to model latent variables representing the executive inhibition taxonomy provided by Nigg (2000). Confirmatory factor analytic models indicated that cognitive inhibition was distinct from and uncorrelated with other forms of executive inhibition, whereas oculomotor inhibition was subsumed under behavioral inhibition. Interference control and behavioral inhibition were distinct constructs that were moderately correlated with one another (r = .67; Friedman, &

Miyake, 2006). Despite Nigg's (2000) assertion that multiple forms of executive inhibition are part of the effortful control construct, subsequent temperament research has examined only the association between effortful control and interference control (e.g., Rothbart, Ellis, Rueda, & Posner, 2003; Rueda et al., 2004).

A related literature on self-regulation among adults may bear on the neural basis of effortful control. Self-regulation refers to the use of higher order cognitive processes to regulate one's thoughts, feelings, or behavior, particularly when a discrepancy is identified between a desired outcome and one's current status (Vohs & Baumeister, 2004). Said differently, self-regulation refers to supervisory awareness and control over the contents and products of the mind (Banfield, Wyland, Macrae, Munte, & Heatherton, 2004). Much like effortful control, self-regulation depends on a supervisory attentional system (Norman & Shallice, 1986) to monitor, modulate, and inhibit ongoing mental activity. Banfield and colleagues (2004) reviewed three frontal lobe regions critical for normative self-regulation among adults, and these regions overlap largely with those outlined by Nigg (2000) as central to executive inhibition and effortful control.

First, dorsolateral prefrontal cortex (DLPFC) is implicated in working memory, selecting task-appropriate behaviors among behavioral options, and maintaining information about the demands of a task that requires cognitive control (MacDonald et al., 2000). DLPFC is also important in tasks that require sustained attention, selective attention, and switching attention from one stimulus to another (Chao & Knight, 1998), and this region shows sustained activation during tasks that require focused attention and cognitive control (Mitchell et al., 2007). DLPFC lesions are associated with poor planning, judgment, and insight as well as apathy and flat affect (Dimitrov et al., 1999).

Second, Banfield and colleagues (2004) reviewed the involvement of anterior cingulate cortex (ACC) in self-regulation, which has been discussed in detail above. In contrast to DLPFC, activity in the ACC increases transiently in response to the degree of conflict present during a task and ACC is probably involved more in ongoing monitoring and correction of inappropriate responses (MacDonald et al., 2000). Using a go-no go task, Durston and colleagues (2002) demonstrated that ACC activation increased on no-go trials as a function the number of preceding go trials, such that a large number of go trials prior to a no-go trial resulted in high ACC activation during a no go trial.

Banfield and colleagues (2004) also suggested that ventromedial prefrontal cortex, particularly orbitofrontal cortex (OFC), is involved in the control and inhibition of behavioral and emotional output. OFC is implicated in the ability to alter one's behavior in response to social and emotional signals. Lesions to the ventromedial prefrontal cortex frequently result in marked changes in personality and behavior. Individuals with such lesions are often impulsive, emotionally labile, and show inappropriate affect (Stuss & Alexander, 2000). Some individuals with lesions in the OFC are particularly violent and aggressive and may exhibit emotional callousness similar to psychopathic persons (Blair & Cipolotti, 2000; Grafman et al., 1996). Among individuals with relatively intact OFC functioning, this region appears to be important for monitoring rewards and punishments (e.g., winning or losing money) that occur because of one's behavior (O'Dougherty, Kringelbach, Rolls, Hornak, & Andrews, 2001). More broadly, Bechara, Damasio, and Damasio (2000) argued that ventromedial prefrontal cortex is crucial for integrating emotional and somatic inputs in order to make decisions and to predict the consequences of those decisions, particularly when affective information is salient.

Although executive inhibition tasks involve a diverse set of frontal cortical areas, a common nonaffective constraint system may underpin executive inhibition abilities. Depue and colleagues (Depue, 1995; Depue & Spoont, 1986; Depue & Lenzenweger, 2005) have asserted that serotonin acting at many sites in the brain modulates the threshold at which an organism responds to a stimulus with behavior, emotion, or cognition, thereby providing a constraint system implicated in self-regulation. As described by Depue and Collins (1999), nonaffective constraint is orthogonal to motivational systems (i.e., appetitive or aversive motivation) that influence organism behavior. Ample research documents the role of poor serotonin functioning in aggressive and violent behaviors (Gollan, Lee, & Coccaro, 2005), irritability (Spoont, 1992), and depression (Malison et al., 1999). Nonaffective constraint has been linked most closely to the Control subscale of MPQ Constraint (Lenzenweger et al., 2005), and empirical research documents the correlation between MPQ Control and serotonin turnover (Depue, 1995). As described above, effortful control and MPQ control are likely linked, suggesting by association that nonaffective constraint and effortful control are related constructs. Although nonaffective constraint is likely not isomorphic with effortful control or executive inhibition, Depue and Collins (1999) provide a compelling argument that serotonin functioning may underlie diverse abilities associated with executive inhibition.

Executive Functioning and Personality Dysfunction

Extant neuroimaging and neuropsychological studies point to a diversity of impairments in executive functioning among patients with some personality disorders.

Although the definition of “executive functioning” has been the subject of much debate (e.g., Barkley, 2001), executive functions include inhibiting responses, selectively ignoring some information to maintain focus, planning, maintaining and updating working memory in order to complete a task, and setting goals (Esslinger, 1996). Executive inhibition represents a particular aspect of the larger construct of executive functioning (Nigg, 2000). Fertuck and colleagues’ (2006) review of executive neurocognition in borderline personality disorder indicated that BPD patients showed impairments in interference control as measured by a flanker task (Eriksen & Eriksen, 1974), which requires the participant to determine the direction of a central arrow when surrounding arrows point in the same (congruent) or opposite (incongruent) direction (Posner et al., 2002). Borderline patients also show preferential encoding of BPD-salient words (e.g., “abandonment”) relative to neutral or positive words in a directed forgetting paradigm (Korfine & Hooley, 2000), suggesting possible impairment in cognitive inhibition. Lastly, in terms of executive inhibition, set-shifting on the Wisconsin Card Sorting Test was impaired among borderline patients, suggesting that BPD patients have difficulty altering their behavior in response to changing contingencies (Lenzenweger, Fertuck, Clarkin, & Kernberg, 2004).

Deficits in executive neurocognition have also been observed among individuals diagnosed with antisocial personality disorder (ASPD) and conduct disorder. In particular, impulsive, antisocial behavior has been linked to diverse frontal dysfunctions in DLPFC, OFC, and ACC (Foster, Hillbrand, & Silverstein, 1993; Moffitt, 1993; Morgan & Lilienfeld, 2000). Psychopathic individuals, in addition to exhibiting antisocial, impulsive behavior, are characterized as emotionally callous, manipulative, and shallow (Hare, 1991). Neurocognitive deficits in psychopathy are more focal than those observed among individuals with conduct disorder or ASPD. Blair and colleagues (2006) found a focal deficit in OFC functioning among psychopathic individuals, who performed poorly on a task in which reward contingencies were frequently altered between decision trials. Individuals with schizotypal personality disorder fail to maintain set and show higher perseverative errors on the Wisconsin Card Sorting Test, suggesting limitations in working memory and frontal cortical functioning, respectively (Lenzenweger & Korfine, 1994; Gooding et al., 1999).

Consistent with the connection between prefrontal functioning and personality, Mathiesen and Weinryb (2004) found that individuals with prefrontal injury were characterized by borderline personality organization on a dimensional measure of personality dysfunction because of their impulsivity, aggressiveness, poor affect regulation, and unstable identity. Executive neurocognition in other personality disorders (e.g., dependent or histrionic) identified by the DSM-IV remains understudied. Recently, however, Coolidge, Thede, and Jang (2004) presented preliminary twin study data which suggest that executive function deficits are highly heritable and that personality disorders are co-heritable with such deficits. Parents rated their monozygotic or dizygotic twins (mean age was 10.1 years) on measures of executive functioning (specifically organizational problems, perseveration, poor planning, and difficulties making decisions) and personality disorders, as defined by DSM-IV. Executive functioning and personality disorders were found to be moderately to highly heritable in this sample (median h^2 for PDs was .69, whereas h^2 for executive functioning was .77). Bivariate heritability estimates between executive functioning and personality disorders ranged from .27 for schizoid PD to .64 for histrionic PD, although no relationship was observed between executive functioning and narcissistic, schizotypal, and obsessive-compulsive PDs. Coolidge and colleagues (2004) suggest that personality disorders may reflect behavioral manifestations of executive function deficits, which include difficulties with decision making, inhibition, planning, and behavioral flexibility.

The present study

The present study sought to extend the position of Posner and Rothbart (2000), who emphasized the centrality of self-regulatory deficiencies in the development of psychopathology. More specifically, Posner and Rothbart (2003) developed a psychobiological theory of personality dysfunction, particularly borderline personality disorder, which asserts that high negative emotionality and poor effortful control (executive attention) may be causal agents in the development of BPD. As described above, poor development of effortful control in childhood and adolescence has been linked with a number of interpersonal and emotional deficiencies, including poor affect regulation, difficulty forming and maintaining interpersonal relationships, and poor development of empathy and conscience (Eisenberg et al., 2004). Poor effortful control in childhood may be a precursor of adult personality dysfunction (Posner & Rothbart, 2000), and the interpersonal and affective deficits associated with low effortful control are characteristic of personality disorders in adulthood (Parker et al., 2002). Nevertheless, the theoretical and developmental continuity between effortful control and adult personality dysfunction remains understudied and the work of Posner and colleagues (2002; 2004) has focused only on borderline personality disorder, not other forms of personality dysfunction (e.g., dependent personality). Moreover, specific neurocognitive abilities underlying effortful control have not been fully explored. Posner and colleagues (2000; 2002) have established a link between effortful control and the executive attention network, which is implicated in interference control, but effortful control is likely underpinned by multiple types of executive inhibition (Nigg, 2000).

The present study sought to explicate the link between effortful control, executive inhibition, and personality dysfunction among young adults. Following Nigg (2000), three facets of executive inhibition were measured: interference control, behavioral inhibition, and cognitive inhibition. Oculomotor inhibition (Nigg, 2000) was not be measured in this study (e.g., using an antisaccade task) because recent empirical research indicated that this facet is a variant of behavioral inhibition, not a distinct executive inhibitory process (Friedman & Miyake, 2004). Where possible, laboratory tasks informed by neuroimaging research were selected in order to permit conjectures about possible links to functional neuroanatomy, which may facilitate identification of biological markers (or possibly endophenotypes) of PDs in future research (for a similar discussion of the utility of neuroimaging-based tasks in schizophrenia, see Jonides & Nee, 2005).

To date, studies of the association between personality dysfunction and executive functioning deficits have sampled primarily from individuals diagnosed with one or more DSM-oriented personality disorders. Consequently, although a number of executive functioning deficits have been observed for some personality disorders, such as borderline (Fertuck et al., 2006) and antisocial (Blair et al., 2006) personality, little is known about executive inhibitory capacity among individuals with levels of personality dysfunction that fall below diagnostic threshold. More importantly, individuals sampled from a psychiatric population may be systematically unrepresentative of the general population because of treatment history, institutionalization, medication use, functional impairment, and psychiatric comorbidity (i.e., Berkson's bias; for a related discussion of schizophrenia research, see Lenzenweger, 1998). Indeed, as described above, Posner and colleagues (2002) found that individuals with similar levels of effortful control and negative emotionality to borderline patients did not exhibit the same degree of executive attention impairment, suggesting that borderline patients were particularly extreme in some unobserved respects. Lastly, personality disorder psychiatric samples are necessarily tied to the diagnostic criteria of the DSM, which have been widely criticized for their excessive boundary overlap, heterogeneity, and limited construct validity (Krueger, 2005). In view of these limitations, the present study selected individuals from a general college population who were not selected for personality dysfunction.

Because of the theoretical and empirical linkage between negative emotionality and effortful control in children and adults (Evans & Rothbart, 2007; Rothbart et al., 2000), each facet of executive inhibition was measured by one nonaffective and one affective task. Attempts to exert effortful control may be ineffective in the presence of strong emotions that overpower executive inhibitory abilities (Rothbart, Derryberry, & Hershey, 2000), and poor emotion regulation is a common feature of many, if not all, personality disorders (Parker et al., 2002). Although available literature for borderline personality disorder indicates the presence of executive inhibition deficits for nonaffective material (Fertuck et al., 2006), it remains unknown whether emotionally-salient stimuli would result in executive inhibition deficits of larger magnitude, and the salience of affective stimuli in inhibitory tasks has not been studied for other forms of personality dysfunction. Depue and Lenzenweger (2005) have suggested that personality dysfunction results from the interaction of multiple neurobehavioral systems. Thus, in their model, the efficiency of the nonaffective constraint system in regulating mental contents may depend on the strength of the negative emotionality system. Poor nonaffective constraint and high negative emotionality may be a potent combination for personality dysfunction because little inhibitory control can be exerted over powerful, distressing feelings.

The present study sought to test two primary hypotheses: 1) self-reported effortful control provides an approximate metric of executive inhibitory control (Nigg, 2000), and 2) executive inhibitory deficits are common to the spectrum of personality dysfunction traits (Posner & Rothbart, 2000; 2003). We hypothesized that poor executive inhibition performance in the domains of interference control, behavioral inhibition, and cognitive inhibition (Nigg, 2000) would be positively associated with nearly all personality dysfunction traits measured by a well-established self-report scale (Clark, Wu, Simms, and Casilla, in press). We expected that traits associated with obsessive-compulsive personality dysfunction, including perfectionism, excessive devotion to work, and rigidity surrounding ethical and moral matters (APA, 1994), would be an exception to this pattern, as they are probably characterized by high effortful control. With regard to the affective valence of experimental tasks, we expected that the magnitude of associations between executive inhibition and personality dysfunction would be larger for affective tasks than for nonaffective tasks.

Methods

Participants

Participants were 112 undergraduate students (69 female, 43 male) enrolled in psychology courses at a northeastern university who completed the experiment in exchange for course credit. The average age of participants was 19.22 (*SD* = 1.82). Ethnic composition of the sample was 68% Caucasian, 17% Asian, 6% African-American, 6% Latino, and 3% Other. Participants enrolled in the experiment through an online scheduling system that provided a brief description of the study and its requirements. Participants were required to give their informed consent to participate, and were treated in accordance with the "Ethical Principles of Psychologists and Code of Conduct" (American Psychological Association, 2002).

Materials

Adult Temperament Questionnaire – Effortful Control Scale (Evans & Rothbart, 2007). This self-report measure consists of 35 items rated on a 7-point Likert-type scale (1 = “extremely untrue”, 7 = “extremely true”). Three subscales comprise this scale: Inhibitory Control (11 items), Activation Control (12 items), and Attentional Control (12 items), which are described above. Evans and Rothbart (2007) demonstrated adequate to good internal consistency for effortful control subscales (Cronbach’s alpha ranged from .66-.88). In addition, effortful control was associated with the five-factor model of personality in theoretically-predicted directions (Evans & Rothbart, 2007), suggesting adequate convergent and discriminant validity. As we did not have differential predictions for subscales, the ATQ-EC total score was used as the primary measure of effortful control. Cronbach’s alpha for the total score was .89 in the present sample.

Personality Dysfunction: Schedule for Nonadaptive and Adaptive Personality – Second Edition (Clark, Simms, Wu, & Casillas, in press). This self-report test consists of 390 true-false items that tap a broad range of dysfunctional personality traits. Twelve trait scales (factor analytically-derived) are measured by this instrument: Aggression, Dependency, Detachment, Eccentric Perceptions, Entitlement, Exhibitionism, Impulsivity, Manipulativeness, Mistrust, Propriety, Self-Harm, and Workaholism. Internal consistency for SNAP-2 subscales is strong (Clark, 1993) and test-retest reliability is high (Simms & Clark, 2006). The SNAP-2 has been extensively validated in clinical and nonclinical populations (Clark et al., in press) and its ability to identify clinically significant personality dysfunction and to differentiate among personality disorders has been documented (Morey et al., 2003). Cronbach's alphas for the trait scales ranged from .76 (Manipulativeness) to .87 (Detachment) in the present sample.

Nonspecific Psychological Distress. Nonspecific psychological distress, particularly current anxiety and depression, was measured by the K10, a 10-item self-report measure developed to screen for current distress (Kessler et al., 2002). This instrument has demonstrated strong sensitivity and specificity rates for current psychotic, anxiety, or mood disorder as assessed by a semistructured psychiatric interview (Andrews & Slade, 2001). Questions ask about anxiety and depressed mood symptoms in the last 30 days, and items are rated on a 5-point Likert-type scale (0 = none of the time, 4 = all of the time). Internal consistency for the K10 is high (Cronbach's alpha = .93; Kessler et al., 2002). Cronbach's alpha in the present sample was .86.

State Anxiety. State anxiety was measured by the State Anxiety Scale from the State-Trait Anxiety Inventory (STAI; Spielberger, 1983). The STAI-State is a well-validated 20-item self-report instrument that has high internal consistency (Cronbach's alpha = 0.90; Ramanaiah, Franzen, & Schill, 1983), but low test-retest reliability (r_{tt} = 0.35; Spielberger et al., 1970). Questions on the STAI-State are phrased in terms of how the person feels at the present moment, and participants rate the intensity of each anxiety symptom on a 4-point Likert-type scale. Cronbach's alpha in the present sample was .94.

Interference Control: Flanker Test (Eriksen & Eriksen, 1974; Posner et al., 2002). For this task, participants viewed trials of five horizontal arrows and were required to press a key corresponding to the direction of the center arrow (left or right). Participants were instructed to make this determination as quickly as possible. Half of the trials presented arrows on either side of the center arrow that pointed in the same direction ("congruent" trials), whereas the flanking arrows on the other trials pointed in the opposite direction ("incongruent" trials). Incongruent trials generate stimulus conflict that activates the executive attention network, particularly ACC and DLPFC (Raz, 2006). Reaction times and response errors were the dependent variables of interest for this task.

This study adapted the flanker paradigm developed by Casey et al. (2000), in which the frequency of incompatible trials was parametrically manipulated in order to differentially activate regions hypothesized to be involved in the task. Participants completed 160 behavioral trials in two conditions: mostly congruent and mostly incongruent. Stimulus presentation was be split into blocks of 40 trials per condition. In mostly congruent blocks, 70% of trials were congruent; in mostly incongruent blocks, 70% of trials were incongruent. The direction of the central arrow was 50% left and 50% right. Following Casey and colleagues (2000), four blocks of forty trials were presented in ABBA order, where A is a mostly congruent block and B is a mostly incongruent block. Flanker stimuli were displayed for 1000ms each with a 500ms interstimulus interval.

Interference Control: Emotional Flanker Test (Horstmann & Bauland, 2006; Horstmann, Borgstedt, & Heumann, 2006). This computerized task extended the classic flanker task (Eriksen, 1973) by using pictures of emotional faces as stimuli. Participants were asked to determine the emotional valence of the central face (e.g., happy) regardless of the valence of surrounding faces. On congruent trials, the central face had the same emotional expression (e.g., angry) as flanking stimuli, whereas for incongruent trials, the central face did not match the emotion of surrounding faces. Prior research has demonstrated that reaction times to incongruent trials with happy targets (i.e., the central stimulus) and angry flankers are significantly longer, which may indicate that distraction due to angry flankers is difficult to inhibit (Horstmann et al., 2006). In addition, target faces displaying negative emotions are less prone to flanker interference, suggesting that negative emotions constrict the focus of attention (Fenske & Eastwood, 2003).

In the present study, participants were exposed to facial stimuli depicting four expressions: Angry, Sad, Happy, and Neutral. Fifty percent of trials were congruent for expression, whereas 50% of trials differed in the target and flanker emotions. Four models were used for the facial pictures, but only one model was displayed per trial. Participants viewed 288 stimuli in six blocks of 48 trials and there was a 30-second break between the third and fourth blocks. Trials were displayed for 1500ms each, followed by a 500ms interstimulus interval. Participants pressed one key if the central face matched a particular emotional expression (e.g., Angry) and another key if the central face matched the paired emotion (e.g., Sad). Two emotions were depicted for each block, with all six possible combinations of emotions comprising the blocks. For each block, 50% of targets depicted one emotion and 50% depicted the other, resulting in 12 congruent and 12 incongruent trials for each emotion. Reaction times and response errors were the dependent variables of interest for this task.

Behavioral Inhibition: Go-No Go Test (Casey et al., 1997; Durston et al., 2002). For this task, participants viewed single letter trials and were required to press a key (i.e., "go") or to withhold a key press (i.e., "no go"). When a letter other than 'X' was presented, participants were instructed to press the space bar as quickly as possible. When an 'X' appeared, participants were instructed not to press the space bar (i.e., "no go"). Letters were presented for 500ms followed by a 1500 interstimulus interval (Casey et al., 1997) and the frequency of no go trials was fixed at 20% within a block in order to promote a tendency to perform a key press. Extending the work of Durston and colleagues (2002), the number of go trials preceding a no go trial was parametrically manipulated within each block to create varying levels of difficulty. No go trials were preceded by one, three, five, or seven go trials, and difficulty withholding key presses on no go trials was thought to increase as a function of the number of preceding go trials. ACC, VLPFC, and superior parietal cortex exhibit greater activation as the number of preceding go trials increases (Durston et al., 2002). Trials of varying difficulty were randomized within the trial block. Participants completed three blocks of 64 trials with two 30-second breaks. The frequency of key presses on no go trials was the primary dependent variable.

Behavioral Inhibition: Emotional Go-No Go Test (Hare et al., 2005). This task adapted the basic structure of a go-no go task (as described above), but emotionally expressive faces were used instead of letters (see Hare et al., 2005). The emotional go-no go task developed by Hare and colleagues (2005) presented participants with neutral, fearful, or happy faces. In one condition, participants were asked to perform a key press when they saw fearful faces, but to withhold a response for happy or neutral faces. In the other condition, participants responded to happy or neutral faces, but withheld responses to fearful faces. Amygdalar and ACC activity increased in response to fearful faces, consistent with previous research (Whalen et al., 1998), and the degree of increased activity in the amygdala was associated with slower reaction times (r = .46; Hare et al., 2005). Inferior frontal gyrus and ACC were activated preferentially during no-go trials.

In the present implementation of the emotional go-no go task, participants viewed trials with one of four facial expressions: angry, fearful, happy, and neutral. Whereas fearful expressions activate the amygdala (Whalen et al., 1998), angry faces are associated with increased activity in ACC and orbitofrontal cortex (Blair et al., 1999). Participants completed six blocks with one of eight response instructions: angry go/neutral no go, neutral go/angry no go, fearful go/neutral no go, neutral go/fearful no go, angry go/fearful no go, fearful go/angry no go, happy go/fearful no go, and fearful go/happy no go. Whereas all possible combinations of fear, anger, and neutral emotions were included, happy was paired only with fear in order to reduce task duration. Blocks will consist of 48 trials (36 go, 12 no go) and stimuli were presented for 500ms with a 1500ms interstimulus interval. The order of trials was be randomized within each block. One 60-second break occurred between the third and fourth blocks. The frequency of key presses on no go trials was the primary dependent variable.

Cognitive Inhibition: Recent Probes Task (Nelson, Reuter-Lorenz, Sylvester, Jonides, & Smith, 2003). This task measured participants' ability to inhibit the effects of proactive interference (i.e., difficulty remembering a set of information because of information learned previously) as well as interference due to making particular responses on previous trials. For each trial, participants viewed a set of four lower case letters for 1500ms, which they were to remember. A 3,000ms retention interval followed, then a 1500ms single letter probe was presented, followed by a 2000ms interval before the next trial. The probe letter matched one of the four letters to be remembered on 50% of the trials (positive trials) and did not match any of the letters on 50% of the trials (negative trials). Participants were asked to indicate as quickly as possible whether the probe letter was or was not part of the to-be-remembered letters. For negative trials, however, four types of single-letter probes were possible, each comprising 12.5% (one-fourth of 50%). Negative, unfamiliar probe letters were not present on either of the two preceding trials. Negative, familiar probes were present on the preceding trial, but not two trials prior. Negative, highly familiar probes were present on both of the two preceding trials. Negative, response-conflict probes were positive probes from the previous trial. The following is an example of a response-conflict trial: 1) the letters "l d s f" are presented in the preceding trial, 2) "d" is presented as the probe (requiring a positive response), 3) the letters "k m p o" are presented in the current trial, and 4) "d" is presented as the probe (requiring a negative response).

Nelson and colleagues (2003) demonstrated that familiar and highly familiar negative probes were associated with lower accuracy on familiarity judgments and longer reaction times, and such probes were focally activated the inferior frontal gyrus (IFG). In contrast, although response-conflict negative probes were also associated with lower accuracy and longer reaction times, ACC, but not IFG, was activated during such trials. In the present implementation, participants completed 72 trials in two blocks. One 60-second break occurred between the blocks. Reaction times and response errors were the dependent variables of interest for this task.

Cognitive Inhibition: Directed Forgetting (Bjork, 1989). The present study extended the directed forgetting approach of Korfine and Hooley (2000), who examined directed forgetting of borderline-salient words among borderline patients and nonpatient controls. Two lists of 24 words consisting of eight positive words, eight negative words, and eight neutral words per list were drawn from the Affective Norms for English Words (Bradley & Lang, 1999). Negative and positive words were balanced for arousal level, emotional valence, and word frequency. Neutral words had low normative ratings for arousal and emotional valence. Participants were asked to memorize a list of words that they would later recall, and they viewed each word for six seconds (Basden, Basden, & Gregano, 1993). After viewing the first list, a contrived computer error appeared indicating that the experiment had crashed. The experimenter then told participants to forget those words, as the experiment had failed. Participants were then asked to remember a different list of words. After viewing the second list, participants completed a distractor task in which they counted backwards by threes starting with the number 300 (Korfine & Hooley, 2000). Participants were asked to recall all items from both lists, regardless of having been told to forget the first list. Thereafter, a recognition memory task was be completed in which participants viewed 96 words, 48 of which came from the original stimulus set. Participants pressed one key for familiar words and another key for unfamiliar words. Participants were then debriefed about the purpose of the deception. The number of words recalled from the three affective categories of the to-be-forgotten list served as the primary dependent.

Procedure

Participants were run individually by a single experimenter in one 120-minute session. In advance of the experiment, participants were asked to refrain from consumption of alcohol and illicit drugs for at least 24 hours, as well as caffeine and nicotine for 8 hours. Participants were informed that individuals whose performance on speeded measures could be deleteriously affected by substance use would terminated from the experiment. All participants completed a breathalyzer test prior to the experiment, which tested for blood alcohol concentration. Breathalyzer results indicated that all participants had 0.00 BAC at the time of the experiment. The experimenter secured written informed consent from each participant and provided the following oral information about the study:

> We are interested in learning about the connection between personality and performance on computer-based measures of cognitive functioning. You will be asked to complete a few personality questionnaires. You will also complete tests on the computer that require you to react quickly to stimuli presented on the screen. Stimuli will consist of symbols or faces and faces will have different expressions, such as happiness and sadness. Lastly, you'll be asked to remember lists of words or letters and to recall those later.

All tasks were administered using a 17-inch computer display and keyboard, and experimental tasks were controlled using the E-Prime 2.0 software suite (Psychology Software Tools, Inc., 2007). Participants responded on a high-speed USB keyboard that had 1ms response precision. Participants first completed the STAI-State measure in order to record their baseline state anxiety. Previous research has demonstrated that performance on consecutive measures of executive neurocognition declines (Schmeichel, 2007). Thus, to mitigate such depletion, self-report and experimental measures were interleaved with one another in four pseudorandomized orders. Prior to completing each experimental task, participants read instructions about task requirements. For measures requiring speeded response, participants completed an untimed introduction to each task and were given feedback about their performance in order to ensure that each task was understood properly prior to gathering reaction time data.

Upon completion of all measures, participants were thanked for participating and were debriefed about the purpose of the experiment.

Results

Level of personality dysfunction in the present sample

SNAP-2 trait scale scores in the current sample were compared against published norms (Clark et al., in press) to determine the level of personality dysfunction. *T* scores for each scale are listed in Table 1. Examination of SNAP-2 scores in the present sample indicated a moderate level of personality dysfunction. Sixty-seven percent of participants had a clinical elevation ($T > 65$) on at least one trait scale, 46% had clinical elevations on two or more scales, and 12% were clinically elevated on three or more scales. The most common clinical elevations were Manipulativeness (29%), Dependency (21%), Self-Harm (15%), Mistrust (15%), Workaholism (15%), and Exhibitionism (14%).

Insert Table 1 about here

Relationships between effortful control and personality dysfunction

We hypothesized that effortful control would be negatively associated with most dysfunctional personality traits measured by the SNAP-2. In order to test the relationship between effortful control and personality dysfunction, bivariate correlations for each SNAP-2 trait scale were computed: Aggression $r = -.01$; Dependency $r = -.44$; Detachment $r = -.05$; Eccentric Perceptions $r = -.02$ Entitlement $r = .01$; Exhibitionism $r = -.07$; Impulsivity $r = -.29$; Manipulativeness $r = -.37$ Mistrust $r = -.03$; Propriety $r = .17$; Self-Harm $r = -.13$; Workaholism $r = .44$. All correlations were partialed for current psychopathology and state anxiety. Coefficients of $|r| > .19$ were significant at $p < .05$ ($df = 106$). Thus, we found some support for our hypothesis: effortful control was significantly associated with Dependency, Impulsivity, Manipulativeness, and Workaholism.

Measuring executive inhibition performance

Analytic approach

Generalized linear mixed models (GLMMs) were utilized to analyze performance on executive inhibition tasks. These models are an extension of the general linear model (GLM; Cohen, Cohen, West, & Aiken, 2003) that permit an arbitrary probability distribution of the dependent variable (e.g., Poisson), whereas the GLM assumes that the dependent variable is normally distributed. In addition, GLMMs permit correlation of within-subjects errors and tolerate missing data well, thereby providing an ideal solution for repeated measures analysis (Fox, 2008) that circumvents many of the pitfalls of less sophisticated methods, such as MANOVA (Singer & Willett, 2003). Within-subjects error structures for all analyses were assumed to conform a compound symmetry covariance pattern, which models a constant variance and covariance across trials (two random parameters). This error structure was chosen because trials were not expected to conform to structures that include autocorrelation as a function of temporal proximity (e.g., first-order autoregressive structure). GLMMs were estimated using PROC GLIMMIX in SAS 9.1.3 (SAS Institute, Cary, NC).

Flanker Task

Response accuracy statistics were initially examined to ensure that participants who did not understand the task demands were excluded from analyses. Seven participants had high percentages of inaccurate responses (30% or more) and/or frequent inaccurate responses to incongruent trials (59% of more), suggesting that they did not fully understand the task at hand. In order to corroborate this concern, inaccurate responses were analyzed using a binary logistic GLMM (Fox, 2008). Examination of studentized residuals from the GLMM supported the decision to exclude these seven participants: for all seven, over 40 of 160 total responses (25%) had studentized residuals of 2 or greater, suggesting outlier scores. In addition, box plots and stem-and-leaf plots were utilized to examine response validity on reaction times for the Flanker task. This analysis revealed two participants with many reaction times falling below 100ms, which may have occurred because they held down a certain response key, responded randomly, or misunderstood the task. Both participants also had high rates of invalid responding and were thus dropped from further analysis. In total, nine participants were excluded due to invalid responding, leaving 103 participants for subsequent flanker analyses.

A binary logistic GLMM modeled the effect of trial type (incongruent vs. congruent) and block type (70% congruent block vs. 70% incongruent block), as well as the two-way interaction, on response accuracy. There was a significant main effect of trial type on response accuracy, $F(1, 102) = 62.06$, $p < .0001$, which indicated that the response errors were 2.5 times more likely on incongruent trials than congruent trials (OR = 2.57). We also found a significant main effect of block type, $F(1, 102) = 9.72$, $p = .002$, such that 42% more errors were made in congruent blocks than incongruent blocks (OR = 1.42). However, the analysis failed to find a significant interaction between block type and trial type, $F(1, 102) = .17$, $p = .68$.

A repeated-measures mixed-model ANOVA of flanker reaction times found significant main effects of trial type and block type, as well as a two-way interaction between these factors. The significant main effect of trial type ($F[1, 102] = 370.78$, $p < .0001$) indicated that that participants were significantly slower when responding to incongruent trials than congruent trials (see Figure 1). Additionally, reaction times during congruent blocks were significantly slower than incongruent blocks, $F(1, 102) = 69.62$, $p < .001$. However, these main effects were qualified by a significant interaction between trial type and block type, $F(1, 102) = 15.40$, $p < .001$. Follow-up simple effects tests indicated that the effect of block type was significant for both incongruent and congruent trials (ps < .01), but the magnitude of the RT difference was greater for incongruent trials (14ms vs. 5ms; Figure 1).

Insert Figure 1 about here

Executive inhibition performance on the Flanker task was measured by two scores: 1) the frequency of inaccurate responses on incongruent trials, controlling for congruent trial errors, and 2) the mean reaction time (RT) for incongruent trials, controlling for mean congruent trial RT. The executive inhibition index for response accuracy (Flanker: Incongruent Errors) was derived by regressing the number of incongruent errors on congruent errors using a Poisson GLMM and calculating residual values for each participant. The RT inhibition index (Flanker: Incongruent RT) was calculated by regressing mean incongruent RT on mean congruent RT in a mixed model and calculating residual values for each participant, consistent with past research on similar tasks (Fan, Flombaum, McCandliss, Thomas, & Posner, 2003).

Go-No Go Task

For the Go-No Go task, the primary outcome of interest was the number of responses to no go trials, which reflect failures of behavioral inhibition. One individual had 32 commission errors (out of a possible 48 [67%]) and was excluded from analyses because he/she did not seem to understand the task, leaving 111 participants. A binary logistic GLMM with compound symmetry within-subjects error covariance structure was computed to determine the effect of the number of preceding go trials (1, 3, 5, or 7) on no-go errors. We found a significant effect of block type on the probability of no-go commission errors, $F(3, 330) = 12.41$, $p < .0001$. Follow-up contrasts indicated that commission errors occurred, on average, 57% ($OR = 1.57$) more often on no go trials preceded by one go trial compared to no go trials preceded by three, five, or seven go trials, $t(330) = 6.06$, $p < .0001$. There were no significant differences among error rates for no gos preceded by three, five, or seven go trials (Tukey-Kramer *p*s > .10; see Figure 2). Errors may have been particularly prevalent for the no gos preceded by one go trial because participants did not anticipate having to withhold a response, as the average number of go-trials preceding no-go trials was four. These results indicate that behavioral inhibition in the Go-No Go task was best measured by no go commission errors preceded by one go trial, which were particularly difficult, so the proportion of commission errors for such trials was retained as the executive inhibition index for this measure.

Insert Figure 2 about here

Recent Probes Task

Response accuracy statistics for the Recent Probes task were initially examined to ensure that participants who did not understand the task demands were excluded from analyses. Three participants exhibited mean response accuracies in the range of 53-59%, suggesting that they were performing little better than chance (50%). To corroborate this finding, inaccurate responses were analyzed using a binary logistic GLMM and studentized residuals were extracted from the model. For the three questionable participants, residuals were 2 or larger for 30 or more of the 72 total trials, suggesting outlier scores. Given this evidence of invalid responding, these three participants were excluded, leaving 109 participants for further Recent Probes task analyses.

We hypothesized that response accuracy would be lower and reaction times would be slower for familiar, highly familiar, and response interference trials, as these trials created proactive interference relative to unfamiliar trials. A binary logistic GLMM was utilized to model the effect of trial type (unfamiliar, familiar, highly familiar, and response interference) on negative trial response accuracy. Average accuracy levels across trial types are reported in Table 2. The GLMM revealed a significant effect of trial type, $F(3, 324) = 12.90$ $p < .0001$. A follow-up planned contrast corroborated our hypothesis of proactive interference: participants made significantly more errors on familiar, highly familiar, and response interference trials than on unfamiliar trials, $t(324) = 5.43$, $p < .0001$, $OR = 2.93$. Tukey-Kramer post hoc tests indicated response errors were significantly more likely for response interference trials than highly familiar trials, $t(324) = 2.65$, *adj* $p = .04$, $OR = 1.5$, but no other pairwise comparisons among trial types were significant, *adj* ps > .10.

The effect of trial type (unfamiliar, familiar, highly familiar, and response interference) on negative trial reaction time was tested using a normal GLMM with compound symmetry error structure. Mean reaction times across trial types are reported in Table 2. The GLMM revealed a significant effect of trial type on reaction time, $F(3, 324) = 20.96$, $p < .0001$. A follow-up planned contrast corroborated our hypothesis of proactive interference: participants responded significantly more quickly to unfamiliar probes than familiar, highly familiar, and response interference probes, $t(324) = 7.48$, $p < .0001$. Tukey-Kramer post hoc tests found no significant differences among familiar, highly familiar, and response interference trials, *adj* ps > .05.

Insert Table 2 about here

Executive inhibition on the Recent Probes task was measured by two scores: 1) the frequency of errors on familiar and highly familiar negative probe trials, controlling for errors on unfamiliar trials (Recent Probes: Familiar Probe Errors), and 2) the mean RT for familiar and highly familiar negative probe trials, controlling for mean unfamiliar probe RT (Recent Probes: Familiar Probe RTs). These indices were derived by regressing familiar probe performance on unfamiliar probe performance and extracting residual scores for each participant.

Emotional Flanker Task

Emotional flanker response accuracy statistics were initially examined to screen out participants who did not understand the demands of the task. Three participants had high percentages of inaccurate responses (25% or more), suggesting questionable performance. Examination of studentized residuals from a binary logistic GLMM of response accuracy corroborates this concern: all three had 80 or more responses (out of 288 trials) with studentized residuals of 2 or greater, suggesting outlier scores. Thus, 109 participants were retained for emotional flanker analyses.

A three-way binary logistic GLMM modeled the effect of target emotion (happy, sad, angry, and neutral), emotion pair (i.e., the comparator for the target emotion, such as sad-angry), and flanker congruence (congruent vs. incongruent), as well as the target emotion x congruence and emotion pair x congruence interactions, on response accuracy. The effect of emotion pair was nested within target emotion (e.g., the effect of emotion pair for angry targets included angry-sad, angry-happy, and angry-neutral). Results from the GLMM indicated a significant main effect of target emotion on accuracy, $F(3, 324) = 31.82$, $p < .0001$. Follow-up Tukey-Kramer tests indicated that inaccurate responses were most common for angry and sad (which did not differ in error rates), but were significantly less common for happy and neutral faces, with neutral having the lowest error rate (*adj p*s < .001; see Figure 3). However, the main effect of target emotion was qualified by a significant nested main effect of emotion pair, $F(8, 864) = 20.90$, $p < .0001$. Follow-up simple effects tests indicated that emotion pair had a significant effect on accuracy for angry ($F[2, 864] = 42.23$, $p < .0001$) and sad ($F[2, 864] = 44.14$, $p < .0001$) targets, but not happy or neutral targets (*p*s > .10). Tukey-Kramer post-hoc tests were performed to understand the effect of emotion pair on accuracy for angry and sad target emotions. For angry targets, inaccurate responses were significantly more likely when paired with sad faces than with happy faces ($t[864] = 7.40$, $OR = 1.95$, *adj.* $p < .0001$) or neutral faces ($t[864] = 7.88$, $OR = 2.07$, *adj.* $p < .0001$), but error rates did not differ between angry-happy and angry-neutral conditions ($p = .86$). For sad targets, error rates were significantly higher in the sad-angry condition than in sad-neutral ($t[864] = 7.26$, $OR = 1.93$, adj. $p < .0001$) and sad-happy ($t[864] = 8.29$, $OR = 2.19$, adj. $p < .0001$) conditions (see Figure 3).

Insert Figure 3 about here

There was a significant main effect of congruence, $F(1, 108) = 12.96$, $p < .001$, such that inaccurate responses were significantly more common on incongruent trials, regardless of target emotion and emotion pair ($OR = 1.16$). Lastly, we failed to find significant interactions between emotion pair and congruence ($F[8, 428] = 1.06$, $p = .39$) or between target emotion and congruence ($F[3, 324] = 1.69$, $p = .17$), indicating that the effect of congruence did not depend on the particular emotions involved. The failure to target emotion-by-congruence and emotion pair-by-congruence interactions is consistent with the conclusion that incongruent trials caused more errors, but the target and comparator emotions did not influence the magnitude of the incongruence effect.

A three-way mixed-model ANOVA was used to analyze the effect of target emotion (happy, sad, angry, and neutral), emotion pair (i.e., the comparator for the target emotion), and flanker congruence, as well as the target emotion x congruence and emotion pair x congruence interactions, on reaction time. The effect of emotion pair was nested within target emotion. There was a significant main effect of target emotion, $F(3, 324) = 112.52$, $p < .0001$. Follow-up Tukey-Kramer tests indicated that reaction times to angry faces were significantly longer than happy and neutral faces (*adj. p*s < .0001; see Figure 4). Sad reaction times were also significantly greater than happy and neutral RTs (*adj. p*s < .0001). Neutral RTs were significantly longer than happy RTs (*adj. p* < .0001). But RTs for angry and sad did not significantly differ ($p > .10$).

The main effect of target emotion was qualified by a significant nested effect of emotion pair, $F(8, 864) = 134.33$, $p < .0001$. Follow-up simple effects tests indicated that flanker emotion had a significant effect on RT for angry ($F[2, 864] = 269.95$, $p < .0001$), sad ($F[2, 864] = 257.80$, $p < .0001$), and neutral ($F[2, 864] = 7.56$, $p < .001$) targets, but not happy targets. Tukey-Kramer post-hoc tests were conducted to analyze the effect of flanker emotion on RT for angry, sad, and neutral targets and relevant means are plotted in Figure 4. For angry targets, RTs were significantly longer for angry-sad blocks than angry-neutral and angry-happy blocks, *adj. p*s < .0001, but angry-neutral and angry-happy blocks did not differ ($p > .10$). For sad targets, RTs were significantly longer for the sad-angry block than for sad-happy and sad-neutral blocks, *adj. ps* < .0001. Sad-neutral RTs were significantly longer than sad-happy RTs, *adj. p* < .01. For neutral targets, RTs for the neutral-angry block were significantly shorter than for neutral-happy and neutral-sad blocks, *adj. p*s < .01, but neutral-sad and neutral-happy did not differ in their RTs, $p > .10$.

Insert Figure 4 about here

There was a marginally significant main effect of flanker congruence, $F(1, 108) = 3.46$, $p = .07$, such that RTs for incongruent trials ($M = 653.78$, $SD = 197.62$) were slightly longer than congruent trial RTs ($M = 650.49$, $SD = 192.58$), irrespective of target and flanking emotions, but the practical significance of this finding (less than five milliseconds difference) is dubious. Notably, however, we failed to find a target emotion-by-congruence interaction, $F(3, 324) = 1.38$, $p = .25$, suggesting that the magnitude of RT differences among emotions was not qualified by whether trials contained incongruent or congruent flankers. Also, there was not a significant emotion pair by congruence interaction, $F(8, 428) = 0.91$, $p = .51$, suggesting that the effect of trial congruence was not dependent upon the comparator emotion for target emotions.

The failure to find congruence-by-emotion interactions in terms of RT and accuracy suggests that three independent processes affected accuracy and reaction time: 1) incongruent trials led to greater errors and slightly longer RTs, and 2) certain target emotions were more difficult to distinguish than others, and 3) the difficulty of distinguishing some emotions depended on the comparator emotion (i.e., emotion pair) for the block. RT and accuracy data supported the conclusion that the most difficult block was angry-sad.

Given the above results, executive inhibition performance on the Emotional Flanker task was measured by two indices: 1) the frequency of inaccurate responses on incongruent angry trials, controlling for errors on congruent angry trials (Emotional Flanker: Angry Incongruent Errors), and 2) the frequency of inaccurate responses on sad trials, controlling for errors on congruent sad trials (Emotional Flanker: Sad Incongruent Errors). These indices were derived by regressing incongruent errors on congruent errors and calculating residual values for each participant, consistent with past research on similar tasks (Fan et al., 2003). Reaction time-based indices of executive inhibition were not computed for the Emotional Flanker task because RTs on incongruent trials were not significantly longer that congruent trial RTs, suggesting that these data did not measure interference control.

Emotional Go-No Go Task

For the Emotional Go-No Go task, the primary outcome of interest was the number of responses to no-go trials, which reflect failures of behavioral inhibition. Four emotional expressions of interest were examined: angry, fearful, happy, and neutral. As described above, in order to reduce the number of possible combinations of emotion targets and non-targets, happy faces were paired only with fear faces (happy target-fearful nontarget, happy nontarget-fearful target), whereas all possible combinations of neutral, fear, and anger were included as trial blocks. Examination of error rates and studentized residuals across emotions did not suggest any participants that responded invalidly, but three participants' data were lost on this task due to equipment malfunction, leaving 109 for subsequent analyses.

A three-way binary logistic GLMM was used to test the effect of the number of preceding go trials (1, 3, or 5 preceding go trials), no go emotion (angry, fearful, or neutral), and go emotion (angry, fearful, or neutral), which was nested within no go emotion, on response error frequency. Given that happy trials were crossed only with fearful trials, a separate GLMM was tested for this emotion (reported below). The first GLMM included angry, fearful, and neutral trials, which were fully crossed. We failed to find a significant effect of number of preceding trials on commission error rates, F(2,

216) = 1.53, $p = .22$. There was, however, a significant effect of no go emotion on commission errors, $F(2, 202) = 44.73$, $p < .0001$. Follow-up Tukey-Kramer tests indicated that commission errors on fearful no go trials were significantly more common than angry no go errors, $t(202) = 2.51$, $OR = 1.21$, *adj* $p < .05$. Commission errors for both fearful and angry no gos were significantly more common than neutral no go errors (*ORs* = 2.07 and 1.72, respectively; *adj* ps < .0001). Error rates across no go and go emotion combinations are displayed in Figure 5.

Insert Figure 5 about here

The main effect of no go emotion was qualified by a nested main effect of go emotion, $F(3, 173) = 76.29$, $p < .0001$. Follow-up simple effects tests revealed that go emotion had a significant effect on error rate for each no go emotion. For angry no go trials, errors were almost four times more common when the go emotion was fearful than neutral, $t(173) = 11.15$, $p < .0001$, $OR = 3.91$. For fearful no go trials, errors were significantly more common when blocked with fearful gos than in fearful-neutral blocks, $t(173) = 9.41$, $p < .0001$, $OR = 2.56$. Lastly, for neutral no go trials, errors were significantly more common in the neutral-fearful block than in the neutral-angry block, $t(173) = 4.11$, $p < .0001$, $OR = 1.64$.

There was a significant interaction between the number of preceding go trials and the no go emotion, $F(4, 404) = 2.52$, $p = .05$. A simple-effects test revealed that number of preceding go trials affected error rates for angry no gos, $F(2, 404) = 4.65$, $p < .01$. Tukey-Kramer post hoc tests indicated that commission errors for angry no gos were significantly more common when preceded by one go trial than five go trials, $t(404) = 3.05$, $p < .01$, $OR = 1.48$, but there were no significant differences between other levels of preceding go trials, *p*s > .10. We failed to find a significant interaction between number of preceding go trials and go emotion, $F(6, 346) = 0.76$, $p = .60$. These results support the conclusion that inhibition of behavior was particularly difficult for angry and fearful no go trials, especially when these emotions were paired with each other (i.e., angry go-fearful no go, fearful go-angry no go).

For happiness, a two-way GLMM was conducted to analyze happy go-fearful no go and fearful go-happy no go blocks. We failed to find a significant effect of number of preceding go trials on commission error rates, $F(2, 216) = 0.36$, $p = .70$. But there was a significant main effect of no go emotion on error rate, $F(1, 55) = 8{,}76$, $p = .005$, such that commission errors were significantly more common for happy no gos than fearful no gos ($OR = 1.41$), consistent with past research (Hare et al., 2005). We failed to find an interaction between number of preceding trials and target emotion, $F(2, 110) = 1.80$, $p = .17$.

Based on the analyses above, which indicated that inhibition of behavior was especially difficult for angry and fearful targets, executive inhibition performance on this task was measured by two scores: 1) the frequency of commission errors for angry no go trials and 2) the frequency of commission errors for fearful no go trials.

Directed Forgetting

One participant remembered only a single word from both lists (out of a possible 48 words) and reported having completed another list learning experiment earlier in the day. Thus, data for this participant were dropped, leaving data for 110 participants. A two-way Poisson GLMM was used to model the effect of word valence (positive, negative, or neutral) and the list instructions (remember vs. forget) on the number of words recalled. All participants viewed two lists of 24 words, with 8 words of each valence represented in each list, and participants were instructed to forget the first list (see description above). There was a significant main effect of list instructions, $F(1, 109) = 79.5$, $p < .0001$, such that participants remembered more words of each valence in the remember ($M = 2.62$, SD =1.71) than in the forget condition ($M = 1.67$, SD = 1.34). There was also a significant main effect of word valence, $F(2, 218) = 14.96$, $p < .0001$. Tukey-Kramer follow-up tests revealed that participants remembered significantly more negative words ($M = 2.48$, SD = 1.61) than positive words ($M = 2.17$, $SD = 1.55$, *adj.* $p = .05$), whereas neutral words were remembered poorest ($M = 1.79$, $SD = 1.59$, *adj.* ps < .01). We failed to find a significant interaction between list and valence, $F(2, 218) = 0.98$, $p = .38$, indicating that the directed forgetting instructions did not differentially alter the effect of valence on recall.

As described above, recognition memory for both lists was tested by having participants discern unfamiliar from familiar words from a list of 96 words (50% familiar). Response accuracy was recorded to determine the effect of valence and forgetting instructions on recognition memory for familiar words. Data from two participants were excluded because of rather high rates of inaccurate responses (more than 60%, where 50% represents chance), suggesting that they may have misunderstood the task demands.

A two-way binary logistic GLMM was run in order to analyze the effect of forgetting instructions and emotional valence on false negative responses on the recognition task (i.e., familiar words that participants indicated were unfamiliar). We failed to find a main effect of instructions on false negative rates, $F(1, 106) = 1.16$, $p =$

.28. There was, however, a significant main effect of valence on false negatives, $F(2, 212) = 15.08$, $p < .0001$. Tukey-Kramer post hoc tests revealed that false negatives were significantly less common for negative words than for positive ($OR = .71$) and neutral words ($OR = .66$), *adj p*s < .0001. We failed to find an interaction between instructions and valence, $F(2, 212) = 0.30$, $p = .74$. Thus, although participants recalled fewer words from the "forget" list, results from the analysis of false negatives do not support a decrement in recognition memory based on forgetting instructions. Rather, participants were more likely to recognize negative words regardless of forgetting instructions, consistent with past research (e.g., Korfine & Hooley, 2000).

Executive inhibition performance on the Directed Forgetting task was measured by two indices: 1) the number of positive words recalled from the forget list, controlling for positive words recalled on the remember list, and 2) the number of negative words recalled from the forget list, controlling for negative words recalled on the remember list. These indices were derived by regressing forget list words on remember list words calculating residual values for each participant.

Self-reported effortful control as an index of executive inhibition performance

We hypothesized that ATQ-EC total score (effortful control) would provide an approximate measure of executive inhibition performance across experimental tasks. To test this hypothesis, bivariate correlations between task indices and ATQ-EC total score were computed. Correlations were as follows: Flanker Incongruent Errors $r = -.16$, Flanker Incongruent RTs $r = -.26$, Go-No Go No Go Errors (1-Go) $r = -.07$, Recent Probes Familiar Probe Errors $r = -.02$, Recent Probes Familiar Probe RTs $r = .05$, Emotional Flanker Sad Incongruent Errors $r = -.14$, Emotional Flanker Angry Incongruent Errors $r = -.01$, Emotional Go-No Go Fear Incongruent Errors $r = -.24$, Emotional Go-No Go Anger Incongruent Errors $r = .01$, Directed Forgetting Forget Positive Words $r = .13$, Directed Forgetting Forget Negative Words $r = .12$. Correlations of $|r| > .19$ were significant at $p < .05$ ($df = 106$). Thus, we found significant associated for 2 of 11 measures of executive inhibition, providing modest support for our hypothesis.

Relationships between executive inhibition and personality dysfunction

We hypothesized that executive inhibition deficits would be related to a variety of dysfunctional personality traits. Indices from each executive inhibition task that best captured the construct were selected based on task performance data reviewed above. Selected executive inhibition indices for all tasks are described in Table 3, along with the brain regions thought to be involved in task performance. As a coarse test of the viability of our hypothesis, and to ensure a degree of protection against excessive Type I error inflation, set correlation (Cohen, 1993) was used to test the multivariate association between the full set of SNAP-2 trait scales and the set of executive inhibition measures. There was a significant multivariate correlation between personality dysfunction and executive inhibition sets, *Rao* $F(132, 704.42) = 1.25$, $p = .04$, supporting the notion that these constructs are related. Consequently, we conducted simultaneous multiple regression (MR) analyses for each SNAP-2 trait scale.

Insert Table 3 about here

Regressions were conducted using full-information maximum likelihood estimation in Mplus 5.2 (Muthén & Muthén, 2008), which permits for varying patterns of missing data. Examination of bivariate scatterplots did not suggest meaningful relationships between any executive inhibition index and Propriety and Dependency scores. Thus, these traits were excluded from MR analyses, leaving 10 SNAP-2 trait scales. Given that we did not have differential predictions about which executive inhibition facets (and, by extension, particular tasks) would predict personality dysfunction, bivariate scatterplots and added variable plots were used to determine which variables to enter into regression models (see Cohen et al., 2003). This strategy reduces the number of hypothesis tests required and also accurately excludes predictors that do not add substantively to the regression. Standardized regression coefficients are reported, as many of the predictors are residual scores or have no inherently meaningful metric. Four individuals who responded invalidly to the SNAP-2 questionnaire (based on the SNAP-2 Invalidity Index; see Clark et al., in press) were excluded from these analyses. In order to control for current symptoms of psychopathology, K10 and STAI-State scores were combined to yield a composite score (these variables were correlated at $r = .65$), which was included in all regressions.

Parameter estimates and included predictor variables for each trait scale are provided in Table 4. Executive inhibition was significantly associated with SNAP-2 Aggression, Detachment, Eccentric Perceptions, Entitlement, Exhibitionism, Impulsivity, Manipulativeness, Mistrust, Self-Harm, and Workaholism. Aggression was significantly associated with more Go No Go errors, more Recent Probes errors, fewer positive words recalled, and fewer Emotional Flanker anger errors. Detachment was significantly associated with more Flanker incongruent errors and marginally associated with more Recent Probes errors and fewer Go No Go Errors. SNAP-2 Eccentric Perceptions was significantly associated with more anger errors on the Emotional Go-No Go task, as well as marginally fewer fear errors on the Emotional Go-No Go.

Entitlement was associated with more errors on Emotional Flanker sad trials, as well as marginally fewer negative words recalled. Exhibitionism was associated with fewer negative words recalled. Impulsivity was associated with more Go-No Go errors. Manipulativeness was associated with more Go-No Go errors, fewer positive words recalled, and marginally associated with greater RTs on incongruent Flanker trials. Mistrust was related to more errors on incongruent Flanker trials and more errors on Emotional Flanker angry trials. Higher Self-Harm scores were associated with fewer commission errors on Emotional Go-No Go fear trials. Workaholism was related to more errors on Emotional Flanker incongruent anger trials and fewer Go-No Go errors.

Insert Table 4 about here

Executive inhibition as a mediator of effortful control-personality dysfunction relationships

We hypothesized that effortful control would provide an approximate measure of executive inhibition capacity, which in turn, would be associated with personality dysfunction. Path analysis was used to test the hypothesis that executive inhibition performance mediated the relationship between effortful control and personality dysfunction. Given that we expected executive inhibition to be theoretically proximal to effortful control and did not expect executive inhibition to suppress relationships between effortful control and personality dysfunction, mediation models were developed only for significant bivariate effortful control-personality correlations (cf. Baron & Kenny, 1986; Shrout & Bolger, 2002), including SNAP-2 Dependency, Impulsivity, Manipulativeness, and Workaholism. Executive inhibition variables that were significant predictors of particular SNAP-2 trait scales were retained as potential mediators.

Models were constructed and tested using maximum likelihood estimation in Mplus version 5.2 (Muthén & Muthén, 1998-2008). Each model included a direct path from effortful control to the SNAP-2 trait, which tested whether the effect of effortful control on personality dysfunction was perfectly mediated by executive inhibition (Baron & Kenny, 1986). All personality trait scores were regressed on current psychiatric symptomatology (a composite of the K10 and STAI-State measures) to control for the effect of clinical state. Mediation effects were tested by computing the product of the path coefficients composing the indirect effect (i.e., the path from effortful control to executive inhibition and from executive inhibition to the personality trait) divided by the bootstrapped standard error of the product (MacKinnon, Fairchild, & Fritz, 2007). Bootstrapped standard errors were utilized because the underlying distribution of such mediation coefficients is not normally distributed and failure to account for this can reduce statistical power when testing mediation effects (see MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002; Shrout & Bolger, 2002). One thousand bootstrapped samples were utilized to estimate the standard errors of the path coefficients.

In reporting mediation results, we have adopted the widely used notation described by Baron and Kenny (1986): *a* refers to the path from effortful control to the mediator, *b* refers to the path from executive inhibition to the personality trait, *c'* refers to the direct path from effortful control to personality trait after controlling for all mediators, and *ab* refers to the product of the *a* and *b* coefficients, which represents the indirect effect of effortful control on the personality trait via executive inhibition. All reported coefficients were standardized, as the underlying variables did not have an inherently meaningful metric.

Because no executive inhibition indices were associated with Dependency, we did not test for possible mediation of the effortful control-dependency relationship. For Impulsivity, Go-No Go: No Go Errors (1-Go) served as the potential mediator (based on MR analyses above). The effect of effortful control on Impulsivity was not significantly mediated by no go errors, $ab = -.01$, $p = .52$. However, the direct effect of effortful control on Impulsivity remained significant, $c' = -.30$, $p = .01$, as did the direct effect of no go errors, $b = .20$, $p = .04$. The failure to find significant mediation stemmed from the nonsignificant path from effortful control to no go errors, $a = -.07$, $p = .49$.

For Manipulativeness, possible mediators of the effect of effortful control were Flanker: Incongruent RT, Go-No Go: No Go Errors (1-Go), and Directed Forgetting: Forget Positive Words. The effect of effortful control on Manipulativeness was not mediated by no go errors ($ab_1 = -.02$, $p = .50$), positive words recalled ($ab_2 = -.02$, $p = .50$), or incongruent flanker RT ($ab_3 = -.02$, $p = .37$). However, the direct effect of effortful control on Manipulativeness remained significant after controlling for potential mediators, $c' = -.33$, $p < .001$. Additionally, the direct effect of no go errors was significant, $b = .23$, $p = .01$. Mediation by no go errors failed because of a non-significant relationship with effortful control ($a_1 = -.07$, $p = .49$). Positive words recalled were also not associated with effortful control ($a_2 = .13$, $p = .21$), precluding mediation. And although incongruent flanker RT was associated with effortful control (a_3 = -.26, p < .01), the path from incongruent RT to Manipulativeness was nonsignificant (b_3 = .08, p = .34), precluding mediation.

Go-No Go: No Go Errors (1-Go) and Emotional Flanker: Anger Incongruent Errors did not mediate the relationship between effortful control and Workaholism (ab_1 = .02, p = 51 and ab_2 = -.003, p = .91, respectively). The effect of effortful control on Workaholism remained significant after controlling for potential mediators, c' = .44, p < .001. Moreover, the effects of no go errors (b_1 = -.20, p = .02) and anger incongruent errors (b_2 = .18, p = .01) on Workaholism remained significant after controlling for effortful control and current psychiatric symptomatology. Thus, the failure to find a mediation effect for Workaholism was attributable to nonsignificant associations between effortful control and executive inhibition indices (ps = .49 and .90 for no go errors and anger incongruent errors, respectively).

Comparing the predictive strength of affective and nonaffective measures of executive inhibition

We hypothesized that measures of executive inhibition whose stimuli were affectively salient (e.g., facial emotions) would be more closely associated with personality dysfunction than stimuli that were non-affective (e.g., single letters). Two set correlational models (Cohen, 1993) were used to compare the magnitude of association (measured as proportion of generalized variance, $R^2_{Y,X}$) between personality dysfunction and executive inhibition, one for affective tasks and one for non-affective tasks. Estimates of association strength were very similar for affective and non-affective tasks:

$R^2_{Y,X}$(affective) = .50, $R^2_{Y,X}$(non-affective) = .46, which did not support our hypothesis. In order to assess better the incremental utility of affective versus nonaffective tasks, two hierarchical set correlations were computed: adding affective to non-affective tasks and adding to affective to non-affective tasks as they correlate with personality dysfunction (see Cohen, Cohen, West, & Aiken, 2003). We failed to find that affective tasks contributed incrementally over nonaffective tasks, *Rao F* (54, 458.41) = 1.25, p = .12. But nonaffective tasks were incrementally predictive of personality dysfunction over affective tasks, *Rao F*(27, 260.57) = 1.56, p = .04. All set correlations partialed current psychiatric symptomatology from SNAP-2 trait scores. In summary, our results did not support the superiority of affective measures of executive inhibition as correlates of personality dysfunction and suggest that nonaffective measures may provide more information.

Testing the taxonomy of inhibition

We hypothesized that the six executive inhibition tasks measured three facets (following Nigg, 2000): interference control (Flanker and Emotional Flanker), behavioral inhibition (Go-No Go and Emotional Go-No Go), and cognitive inhibition (Recent Probes and Directed Forgetting). Correlations among these tasks did not support this structure (see Table 5). For interference control, we failed to find significant associations between the Flanker and Emotional Flanker tasks. However, incongruent errors and incongruent RTs on the Flanker task were associated (r = .24), and Emotional Flanker sad incongruent errors and angry incongruent errors were correlated (r = .33). As can be seen in Table 5, the two interference control measures correlated more highly with measures of behavioral inhibition (Go-No Go and Emotional Go-No Go) than with each other, calling into question the coherence and distinctiveness of interference control.

Insert Table 5 about here

For behavioral inhibition, we found significant correlations between commission errors on the Go-No Go and Emotional Go-No Go tasks (*r* = .49 and *r* = .29 for fear and anger, respectively). There was also a significant association between fear and anger no go errors on the Emotional Go-No Go task (*r* = .47). The magnitudes of associations among behavioral inhibition indices were generally larger than associations between behavioral inhibition and other putative facets of executive inhibition. Nevertheless, fear and anger no go errors had several significant correlations with interference control and cognitive inhibition indices (significant |*r*s| ranged from .20-.34.).

Associations among cognitive inhibition measures did not support the distinctiveness of this facet. Directed Forgetting scores did not correlate significantly with any other measure of executive inhibition, although there was a positive association between positive and negative words recalled (*r* = .34). Recent Probes: Familiar Probe Errors and Familiar Probe RTs correlated significantly with Emotional Go-No Go: Anger No Go Errors (*r*s = .34 and -.20, respectively). Recent Probes: Familiar Probe Errors and Familiar Probe RTs were also was associated with Flanker: Incongruent RTs (*r*s = .19 and -.24, respectively). No other significantly associations were observed for cognitive inhibitions tasks.

A three-factor confirmatory factor analysis (CFA) tested the hypothesized factorial structure of executive inhibition. Inhibition indices from each of the experimental tasks served as the factor indicators (see Figure 6). Modification indices for the initial model suggested the addition of a residual covariance between Emotional Flanker Angry Incongruent Errors and Emotional Flanker Sad Incongruent Errors. This parameter was added to the model, as these two indices originated from the same task and likely shared some method variance. The three-factor model fit the data adequately: $\chi^2(40) = 46.79$, $p = .21$, CFI = .94, RMSEA = .04, SRMR = .08. However, examination of factor loadings indicated that Recent Probes indicators did not load significantly on cognitive inhibition, and modification indices suggested that Recent Probes: Familiar Probe Errors should load on the behavioral inhibition factor. Refitting the three-factor model with two directed forgetting indices as the indicators for cognitive inhibition resulted in a nonconvergent solution with a Heywood case (negative residual variance for positive words). A Wald test constraining the improper residual variance to zero was nonsignificant, $\chi^2(1) = .006$, $p = .94$. Consequently, this variance estimate was constrained to zero and the model was re-estimated (Chen, Bollan, Paxton, Curran, & Kirby, 2001), but the solution remained nonconvergent and initial parameter estimates indicated that the cognitive inhibition factor failed to cohere, which is consistent with findings from the correlation matrix.

Insert Figure 6 about here

As a result, the cognitive inhibition factor and associated indicators were dropped and Recent Probes: Familiar Probe Errors was moved to the behavioral inhibition factor. The two-factor model (see Figure 7) converged and fit the data well: $\chi^2(18) = 22.49$, $p = .21$, CFI = .95, RMSEA = .05, SRMR = .06. However, the interference control and behavioral inhibition factor were highly correlated, $r = .96$, suggesting that a unifactorial model might be more parsimonious. A one-factor solution converged and fit the data well: $\chi^2(19) = 22.53$, $p = .26$, CFI = .96, RMSEA = .04, SRMR = .06. A chi-square difference test between two-factor and one-factor models was non-significant, $\chi^2_{diff}(1) = .04$, $p = .84$, indicating that the two-factor model did not fit the data better than the one-factor model. Thus, a one-factor model of executive inhibition was accepted (see Figure 8). Notably, however, the proportion of variance accounted by the inhibition factor was quite low for some indicators (e.g., Recent Probes: Familiar Probe Errors R^2=.06), indicating that additional processes likely underlie task performance. Nevertheless, attempts to clarify additional processes using hierarchical and bifactor models based on the hypothesized factor structure (Reise, Morizot, & Hays, 2007) yielded nonconvergent solutions, suggesting model misspecification.

Insert Figures 7 and 8 about here

Discussion

The present study sought to extend the psychobiological approach to personality dysfunction developed by Posner and Rothbart (2003), which posited that deficits in effortful control and executive attention contribute to the development of personality disorders, especially BPD. Our primary aim was to establish a link between effortful control and multiple traits of personality dysfunction that were not limited to BPD per se. Further, we expected that performance on experimental measures of executive inhibition would mediate the relationship between effortful control and personality dysfunction, as executive inhibition (prefrontal and anterior cingulate efficiency) is thought to be the neural substrate of effortful control (Nigg, 2000). Although our sample consisted of nonclinical participants, there was a moderate level of personality dysfunction, consistent with epidemiological studies demonstrating the commonality of personality problems

(Lenzenweger, 2008). Relative to prior studies of personality dysfunction, which have primarily utilized clinical samples or particular diagnoses, our nonclinical sample may have captured a broader and more continuous range of personality dysfunction.

Relationships between effortful control and personality dysfunction

Effortful control was associated with some traits of personality dysfunction measured by the SNAP-2, specifically lower Dependency, lower Impulsivity, lower Manipulativeness, and higher Workaholism. These correlations are consistent with past research (Eisenberg et al., 2004; Rothbart et al., 2000) and suggest that higher effortful control is related to greater perfectionism, achievement focus, self-reliance, self-confidence, cautiousness, and planning, as well as lower risk-taking, approval seeking, and deliberate exploitation of others. With respect to the alignment of SNAP-2 traits with interviewer-rated DSM-IV personality disorder diagnoses, Dependency is most closely associated with Borderline, Avoidant, and Dependent personality disorders; Impulsivity is salient for Antisocial and Borderline diagnoses; Manipulativeness is a component of Antisocial and Narcissistic diagnoses; and Workaholism is associated with Obsessive-Compulsive personality disorder (Clark et al., in press). Notably, self-reported effortful control was not associated with several SNAP-2 personality dysfunction scales that we anticipated, including Aggression, Mistrust, and Self-Harm, all of which are part of the BPD phenotype (Clark et al., in press). Past research has documented a link between BPD diagnosis and lower effortful control (Posner et al., 2002), but the features of BPD that drive this association have not been studied.

One possible reason for our failure to find more robust associations between effortful control and personality dysfunction is that the ATQ-EC may have been unduly prone to response biases. Several items on the ATQ-EC describe socially desirable attributes, such as completing tasks promptly and the ability to keep a secret. This measure also contains many questions that reflect undesirable characteristics, such as avoiding responsibilities to indulge in pleasurable activities and difficulty inhibiting impulse purchases. Indeed, ATQ-EC scores correlated significantly with SNAP-2 Rare Virtues and Deviance scales (*r*s = .30 and -.26, respectively), indicating that responses on this measure were motivated, in part, by a desire to present oneself in a highly favorable light and to deny socially deviant thoughts/behaviors. Thus, the true relationships between effortful control and personality dysfunction may have been obscured by the failings of the ATQ-EQ instrument.

Effortful control as a proxy for executive inhibition

We hypothesized that self-reported effortful control would provide an approximate measure of executive inhibition performance, but our results did not support this notion. Only two of the six executive inhibition tasks were modestly associated with effortful control: incongruent trial errors on the Flanker task and failures to withhold responses to fear faces on the Emotional Go-No Go task. These findings are inconsistent with Nigg's (2000) synthesis of effortful control and executive inhibition, which posited that executive inhibition abilities are neurobiologically proximal indicators of effortful control. Moreover, the associations between effortful control and personality dysfunction were not mediated by executive inhibition, as we expected. Rather, mediation models suggested that self-reported effortful control and indices of executive inhibition performance were largely orthogonal predictors of personality dysfunction.

This study is the first that we are aware of to test the relationship between effortful control and diverse measures of executive inhibition, and our results call into question this association in a young adult population. There are a few possible reasons for our failure to find robust associations between effortful control and executive inhibition. First, the Adult Temperament Questionnaire (Evans & Rothbart, 2007) is a relatively recent instrument, and longitudinal studies demonstrating the developmental continuity of effortful control from childhood to early adulthood have not been conducted. Thus, the ATQ may not measure the same latent trait as childhood and adolescent measures of effortful control (Rothbart et al., 2000), which primarily informed Nigg's (2000) synthesis. Second, measures of executive inhibition in the present study may have failed to capture the essence of the construct. Indeed, past inhibition research has been troubled by poor coherence among different tasks (Friedman & Miyake, 2006), and it has been difficult to improve the construct validity of inhibition when performance-based measures are examined.

Another alternative is that self-reported effortful control does not align with behavioral measures of inhibitory capacity because of the limitations of self-report, which include reliance upon self-reflective capacity and respondents' ability and willingness to report accurately on past behavior (Kagan, Snidman, McManis, Woodward, & Hardway, 2002; Wilson & Dunn, 2004). As mentioned above, our data support the salience of response bias for the ATQ. Reports about personality traits likely reflect judgments about the self in general, rather than a recollection of specific trait-relevant behaviors and experiences (Robinson & Clore, 2002). Consequently, self-reported effortful control may reflect crystallized beliefs about self-control, rather than an index of inhibitory capacity in ecologically valid situations.

In contrast, performance-based measures of personality (e.g., Greenwald & Banaji, 1995), such as the executive inhibition tasks in the present study, directly measure trait-relevant behaviors and do not rely upon insight or self-perception. Performance-based personality measures are often weakly associated with self-report instruments and yield incremental information about the self (Robinson & Neighbors, 2006). Thus, it is possible that executive inhibition performance in the present study provided a more pure indicator of inhibitory capacity, relative to self-reported effortful control.

Relationships between executive inhibition and personality dysfunction

Consistent with our hypothesis, poor executive inhibition was associated with many traits of personality dysfunction on the SNAP-2, including Aggression, Detachment, Eccentric Perceptions, Entitlement, Exhibitionism, Manipulativeness, Mistrust, Self-Harm, and Workaholism. All associations were significant after controlling for current psychopathology, suggesting that they reflect more enduring relationships not attributable to clinical state. Although we expected that affective executive inhibition tasks would be more robustly associated with personality dysfunction relative to nonaffective tasks, our results suggested that nonaffective measures were as relevant, if not more so, to personality dysfunction. This finding suggests that basic cognitive deficits may underlie many personality problems, consistent with past literature implicating impaired executive functioning in personality disorders (e.g., Bazanis et al., 20002; Lenzenweger et al., 2004; Posner et al., 2002).

Executive inhibition tasks were selected, in part, based on available neuroimaging research, which provides information about the structural and functional neuroanatomy of executive control. Our results suggest several brain regions that may be implicated in dysfunctional personality traits, including anterior cingulate cortex, posterior cingulate cortex, orbitofrontal cortex, ventrolateral prefrontal cortex, dorsolateral prefrontal cortex, pars triangularis, caudate nucleus, and amygdala (see Table 3). Clearly, in the absence of any neuroimaging in the present study, conclusions about the functional neuroanatomy of executive inhibition are quite tenuous. Moreover, the above list of includes most of the regions involved in self-regulation, calling into question the utility of such findings (Banfield et al., 2004). Nevertheless, such speculation may promote further studies of the relationship between executive inhibition and personality dysfunction.

Some of the associations between executive inhibition tasks and personality dysfunction suggested functional neuroanatomical relationships that are consistent with past research and modern neurobiological models of self-regulation and emotion regulation (Phillips et al., 2008), whereas other associations were more difficult to interpret. For example, nine of the ten dysfunctional personality traits associated with poor executive inhibition suggested involvement of ACC. As described above, ACC is involved in monitoring competing response tendencies and correcting prepotent, but incorrect, behavior (Braver et al., 2001; Carter et al., 1998; Kiehl et al., 2000; MacDonald et al., 2000). ACC deficits have been observed in borderline personality disorder (de la Fuente et al., 1997; Posner et al., 2002; Silbersweig et al., 2007) and the present results suggest that ACC may related to a wide variety of problematic personality traits. We found that behavioral failures of executive inhibition (e.g., pressing the space bar on no-go trials), rather than response time-based indices, were consistently associated with personality dysfunction. This finding is consonant with past research that implicates ACC as a central node in monitoring and correcting behavioral errors (MacDonald et al., 2000) and suggests that personality dysfunction may be related to poor error monitoring (cf. King-Casas et al., 2008).

Tasks associated with Manipulativeness suggested the involvement of the caudate nucleus and DLPFC. The caudate nucleus, which is part of the ventral striatum, is implicated in reward processing and social evaluation (Balleine et al., 2007; Forbes et al., 2009; King-Casas et al., 2005). DLPFC is implicated in selecting task-appropriate behaviors among behavioral options and planning behaviors to attain goals (Banfield et al., 2004). Thus, it is sensible that the DLPFC and caudate nucleus would be involved in manipulative behaviors, as these reflect using others for personal gain (reward) and planning behavior to attain one’s goals (e.g., exploitation). In contrast to the relative clarity of such neurobiological speculations suggested by the present results, Self-Harm, which is most characteristic of BPD, was associated with *fewer* errors on fear no-go trials, which were thought to tap amygdala and ACC functioning. Although past research has demonstrated the relevance of these regions in BPD, we expected that hyperactivation of amygdala and poor regulation by ACC (Silbersweig et al., 2007; New et al., 2007) would have produced *more* errors on this task, indicating poorer executive inhibition. This finding may have been an artifact of controlling for current psychopathology, but it nevertheless calls into question the coherence of associations between executive inhibition and personality dysfunction.

Latent structure of executive inhibition

Based on the integration of temperament and cognitive neuroscience developed by Nigg (2000), we selected executive inhibition tasks that were hypothesized to tap three putative facets of executive inhibition: interference control (Flanker and Emotional Flanker tasks), behavioral inhibition (Go-No Go and Emotional Go-No Go tasks), and cognitive inhibition (Recent Probes and Emotional Flanker tasks). Notably, however, associations among these tasks did not support the tenability of this facet structure. Confirmatory factor analysis suggested that interference control and behavioral inhibition were one and the same, whereas cognitive inhibition tasks were virtually uncorrelated with other measures of executive inhibition. The best-fitting CFA for executive inhibition tasks was a one-factor model that captured performance on five of the six tasks, but excluded directed forgetting. These results are somewhat consistent with past work by Friedman and Miyake (2006), who tested Nigg's (2000) inhibition taxonomy with a different set of executive inhibition tasks. Using latent variable modeling, these authors found that interference control and behavioral inhibition were highly correlated constructs (r = .67), but both facets were uncorrelated with cognitive inhibition.

In contrast to a model that bifurcates interference control and behavioral inhibition, our results are consistent with Depue and Lenzenweger's (2005) notion that a unified nonaffective constraint system underpinned by serotonergic functioning regulates inhibition. Thus, our failure to find support for Nigg's (2000) taxonomy may have occurred because inhibition is a unitary construct (see also Dempster, 1992). That said, although our data support a one-factor model of executive inhibition, low factor loadings for some tasks suggest that there may be more specific inhibitory capacities that account for task performance.

Our failure to find three facets of executive inhibition may also have occurred because of the task impurity problem (Friedman & Miyake, 2006): inhibition tasks depend on a stimulus to be inhibited (e.g., pressing the space bar or suppressing a word). Task performance may reflect more about the peculiarities of the stimulus than inhibitory ability per se, thereby introducing measurement error. Indeed, past attempts to clarify the latent structure of inhibition have found low correlations among tasks. For example, Friedman and Miyake found low or nil intercorrelations among measures of executive inhibition (*r*s < .23) and used latent variable modeling to compensate for this problem. Shilling and colleagues (2002) addressed the task impurity problem by developing tasks that were as similar as possible to each other in their stimuli, but this approach is problematic, as relationships among inhibition tasks reflect stimulus idiosyncrasies as much as inhibition proper. Our study utilized CFA to distill core inhibition processes, but low correlations among tasks (possibly due to the task impurity problem) may have precluded an adequate resolution of the latent structure of executive inhibition.

The failure to support a multifaceted model of executive inhibition calls into question the taxonomy proposed by Nigg (2000) and also obscures the interpretation of associations between executive inhibition and personality dysfunction, as we could not distill our six experimental tasks into a smaller set of core processes.

Limitations

Several limitations of the present study are notable. First, although executive inhibition tasks were selected based on existing neuroimaging evidence, we did not collect any direct measures of functional neuroanatomy (e.g., fMRI) that could confirm or disconfirm the salience of brain regions thought to tap particular aspects of inhibition (e.g., the role of ACC in the Flanker task). Future neuroimaging or electrophysiological research may help to clarify the neural bases of executive inhibition, which in turn may advance the cognitive neuroscience of personality dysfunction. Second, the present study failed to distill facets underlying executive inhibition (Nigg, 2000), yielding a murky picture of the inhibitory processes contributing to task performance. Consequently, although many personality dysfunction traits were associated with executive inhibition performance, such associations may be spurious, and future research should seek to replicate these findings and to identify the neurobehavioral bases of such associations. Third, effortful control has been studied primarily among children and adolescents, and the adult manifestations of this construct have been discussed (e.g., Caspi et al., 2005), but not well tested. Thus, the use of the ATQ with young adult participants may have prevented a clear alignment of our findings with past developmental studies of child temperament (Rothbart et al., 2000).

Our results were also limited by the exploratory nature of the study. Our intention was to extend the work of Posner and colleagues (2002), who have identified deficits in interference control and effortful control among BPD patients. This study expanded their model by measuring other putative facets of executive inhibition and exploring all dysfunctional personality traits identified by an established self-report measure, the

SNAP-2. In doing so, we had little basis to specify a priori hypotheses about which inhibition facets would correlate with particular personality dysfunction traits, and many of our analyses were necessarily exploratory. Thus, many of our results yielded hypotheses to be tested in future research (e.g., the link between Manipulativeness and the caudate nucleus), and possible spurious associations will be corrected by future attempts to confirm and replicate these findings.

Conclusions and Future Directions

In summary, we found modest support for the association of effortful control with personality dysfunction, but this relationship was not as robust as anticipated. Our results were inconsistent with the notion that effortful control provides a proxy for executive inhibition performance (Nigg, 2000), and relationships between effortful control and personality dysfunction traits were not mediated by executive inhibition. Performance on an array of executive inhibition tasks was associated with a number of personality dysfunction traits, supporting the notion that individuals with personality dysfunction may have cognitive deficits related to prefrontal functioning (Fertuck et al., 2006). Future research is needed to confirm which personality dysfunction traits are most closely associated with executive inhibition deficits and what neural substrates are implicated in such deficits.

Consistent with the idea of a nonaffective constraint neurobehavioral system (Depue & Collins, 1999), our results supported the unidimensionality of executive inhibition, which may be underpinned by serotonin function. Although extant research has documented some of the personality correlates of the serotonin system (e.g., impulsive aggression; Gollan et al., 2005), our results suggest that serotonin function may affect more aspects of personality than have previously been considered (e.g., detachment). Many of the executive inhibition tasks associated with personality dysfunction have previously been shown to rely upon ACC functioning (e.g., Durston et al., 2002), and this region is known to be deficient in BPD (Posner et al., 2002), as well as many other psychiatric disorders, such as posttraumatic stress disorder (Shin et al., 2001). ACC is richly connected with the limbic system (Davidson, Putnam, & Lareson, 2000) and is implicated in correcting behavioral errors (MacDonald et al., 2000). Future research on the behavioral correlates of ACC may help to clarify the function of this region and its relationship to personality dysfunction.

This study provides initial support for a link between executive inhibition deficits and an array of dysfunctional personality traits, extending previous work demonstrating neurocognitive deficits in particular personality disorders, such as borderline PD (Fertuck et al., 2006), antisocial PD (Raine, Lencz, Bihrle, LaCasse, & Colletti, 2000), and schizotypal PD (Lenzenweger, 1998). Additional work is needed to replicate and extend these findings. Basic cognitive deficits (not related to affective function) may underlie personality dysfunction, and cognitive and affective neuroscience paradigms (Caspi & Moffitt, 2006) are ideally suited to clarify the functional neuroanatomy of inhibitory circuits. We hope that future researchers will extend our approach by seeking to identify the neural substrates and personality correlates of executive inhibition, rather than limiting their scope to particular disorders, which occur in the context of enduring personality traits (Westen et al., 2007). With luck, such an approach to cognitive neuroscience may have implications not only for personality dysfunction, but for psychiatric disorders more generally.

Table 1

SNAP-2 trait scale descriptive statistics

SNAP-2 Trait Scale	*M*	*SD*	*Minimum*	*Maximum*
Aggression	52.72	11.37	40.57	92.00
Dependency	55.31	12.10	37.10	88.71
Detachment	47.71	10.11	36.59	80.49
Eccentric Perceptions	52.29	9.89	38.13	78.75
Entitlement	49.28	11.41	26.77	73.82
Exhibitionism	53.49	10.79	34.59	75.14
Impulsivity	51.33	9.84	35.90	79.49
Manipulativeness	57.36	11.83	37.50	90.63
Mistrust	53.37	10.80	38.78	85.12
Propriety	48.98	9.14	29.13	66.09
Self-Harm	51.86	11.94	42.69	96.54
Workaholism	50.29	11.27	30.00	75.95

Note. All values represent *T* scores computed against published scale norms (Clark et al., in press). Normed *T* scores are standardized to have $M = 50$, $SD = 10$. $N = 108$.

Table 2

Recent Probes task performance as a function of trial type

	Response Accuracy (%)		Reaction Time (ms)	
Trial Type	*M*	*SD*	*M*	*SD*
Unfamiliar	96.94	6.57	766.73	257.94
Familiar	92.15	9.95	852.17	308.74
Highly Familiar	92.76	9.96	827.46	293.10
Response Interference	89.33	11.55	819.46	261.67

Table 3

Descriptions of executive inhibition indices and hypothesized brain regions implicated

Executive inhibition index	Description	Brain regions
Flanker: Incongruent Errors	The number of errors committed on incongruent trials, controlling for errors on congruent trials.	Dorsal ACC and DLPFC
Flanker: Incongruent RT	Reaction time on incongruent trials, controlling for congruent trial reaction time	Rostral ACC and DLPFC
Go-No Go: No Go Errors (1-Go)	The number of commission errors on no go trials preceded by one go trial.	ACC, PCC, and VLPFC
Recent Probes: Familiar Probe Errors	The number of errors made on negative familiar probes (includes familiar and highly familiar trials)	Pars triangularis (inferior frontal gyrus)
Recent Probes: Familiar Probe RTs	The reaction time to familiar probes (familiar and highly familiar), controlling for reaction time to unfamiliar probes.	Pars triangularis (inferior frontal gyrus)
Directed Forgetting: Forget Positive Words	Positive words recalled from the forget list, controlling for positive words from the control list.	Caudate nucleus, VLPFC, DLPFC
Directed Forgetting: Forget Negative Words	Negative words recalled from the forget list, controlling for negative words from the control list.	Amygdala, VLPFC, DLPFC
Emotional Go-No Go: Fear No Go Errors	The number of commission errors on fear no go trials	Amygdala and ventral ACC
Emotional Go-No Go: Anger No Go Errors	The number of commission errors on anger no go trials	ACC and OFC
Emotional Flanker: Sad Incongruent Errors	The number of errors committed on sad incongruent trials, controlling for errors on sad congruent trials	Amygdala and ACC
Emotional Flanker: Anger Incongruent Errors	The number of errors committed on anger incongruent trials, controlling for errors on anger congruent trials	ACC and OFC

Table 4

SNAP-2 trait scales as a function of executive inhibition task performance

SNAP-2 Trait Scale (Model R^2)	Predictor	β	$SE\ \beta$	p
Aggression (R^2 = .28)	Go-No Go: No Go Errors (1-Go)	.30	.08	< .001
	Recent Probes Familiar Errors	.20	.09	.03
	Directed Forgetting Positive Words	-.17	.08	.03
	Emotional Flanker Incongruent Anger Errors	-.18	.09	.04
	Current Symptoms of Psychopathology	.24	.08	.001
Detachment (R^2 = .19)	Incongruent Flanker Errors	.24	.09	.007
	Recent Probes Familiar Errors	.15	.08	.06
	Go-No Go: No Go Errors (1-Go)	-.15	.09	.08
	Current Symptoms of Psychopathology	.35	.10	< .001
Eccentric Perceptions (R^2 = .15)	Emotional Go-No Go: Anger No Go Errors	.24	.11	.02
	Emotional Go-No Go: Fear No Go Errors	-.18	.10	.07
	Incongruent Flanker Errors	.14	.09	.12
	Current Symptoms of Psychopathology	.26	.11	.02
Entitlement (R^2 = .11)	Emotional Flanker Incongruent Sad Errors	.30	.08	< .001
	Directed Forgetting Negative Words Recalled	-.15	.09	.10
	Current Symptoms of Psychopathology	-.07	.10	.50

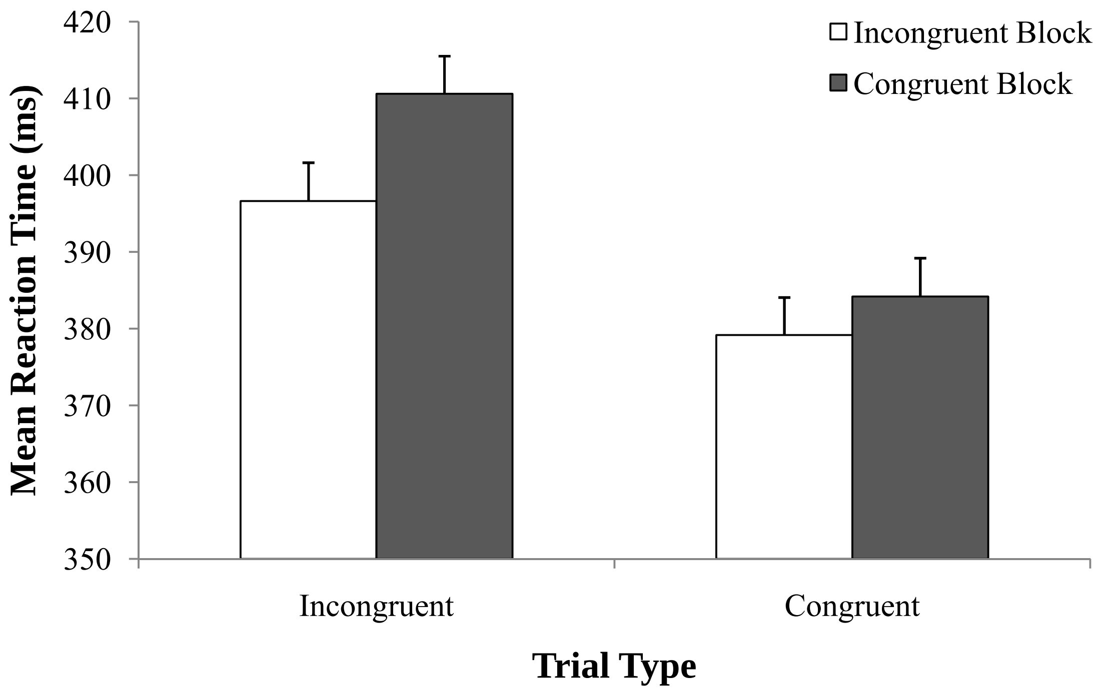
Exhibitionism (R^2 = .05)	Directed Forgetting Negative Words Recalled	-.19	.09	.03
	Emotional Go-No Go: Anger No Go Errors	.16	.11	.15
	Current Symptoms of Psychopathology	.02	.09	.85
Impulsivity (R^2 = .05)	Go-No Go: No Go Errors (1-Go)	.20	.09	.03
	Current Symptoms of Psychopathology	.08	.09	.35
Manipulativeness (R^2 = .21)	Go-No Go: No Go Errors (1-Go)	.22	.08	.01
	Directed Forgetting Positive words Recalled	-.19	.08	.01
	Flanker Incongruent RT	.14	.08	.10
	Current Symptoms of Psychopathology	.29	.08	< .001
Mistrust (R^2 = .29)	Incongruent Flanker Errors	.22	.08	.004
	Emotional Flanker Incongruent Angry Errors	.16	.08	.05
	Current Symptoms of Psychopathology	.44	.08	< .001
Self-Harm (R^2 = .44)	Emotional Go-No Go: Fear No Go Errors	-.19	.09	.03
	Current Symptoms of Psychopathology	.69	.08	< .001
Workaholism (R^2 = .11)	Emotional Flanker Anger Incongruent Errors	.18	.08	.03
	Go-No Go: No Go Errors (1-Go)	-.20	.09	.02
	Current Symptoms of Psychopathology	.25	.10	.02

Table 5

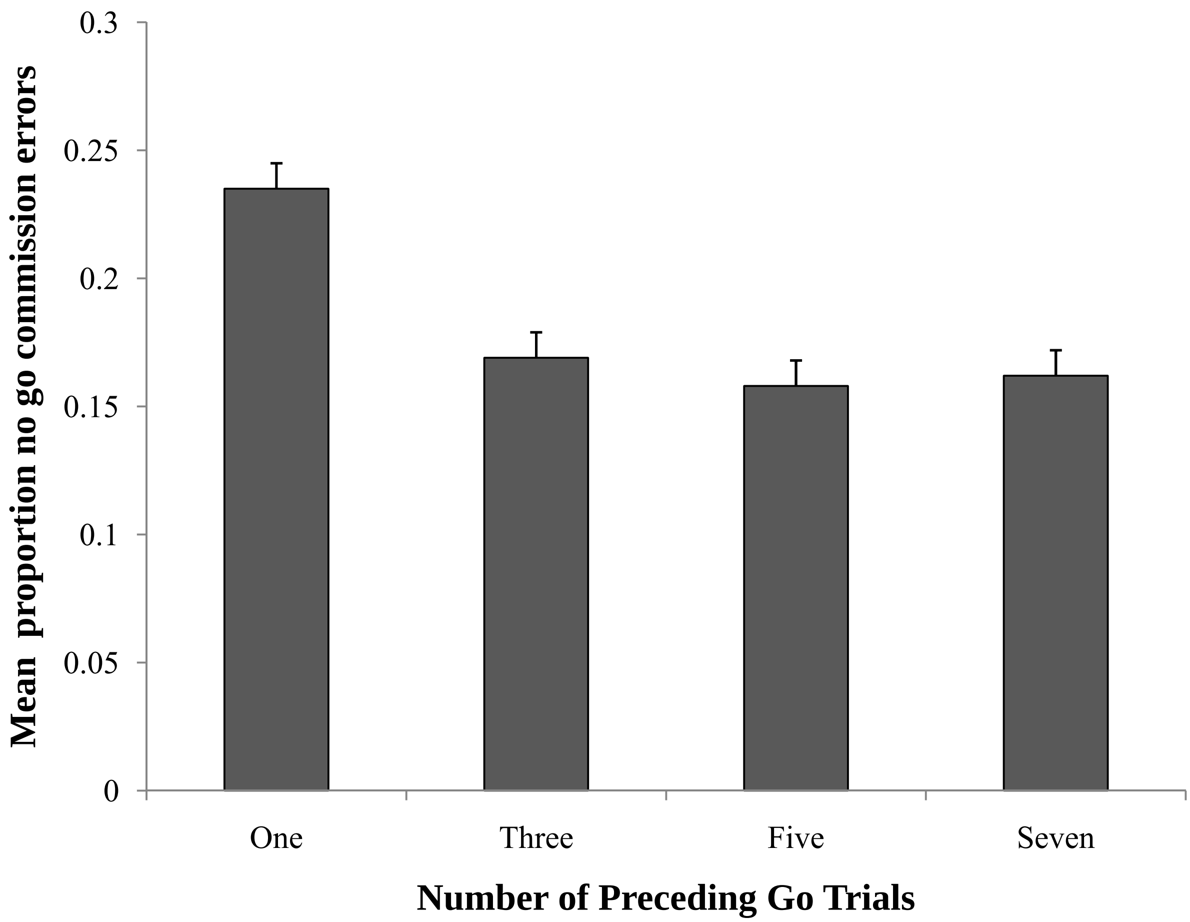
Bivariate correlations among executive inhibition indices

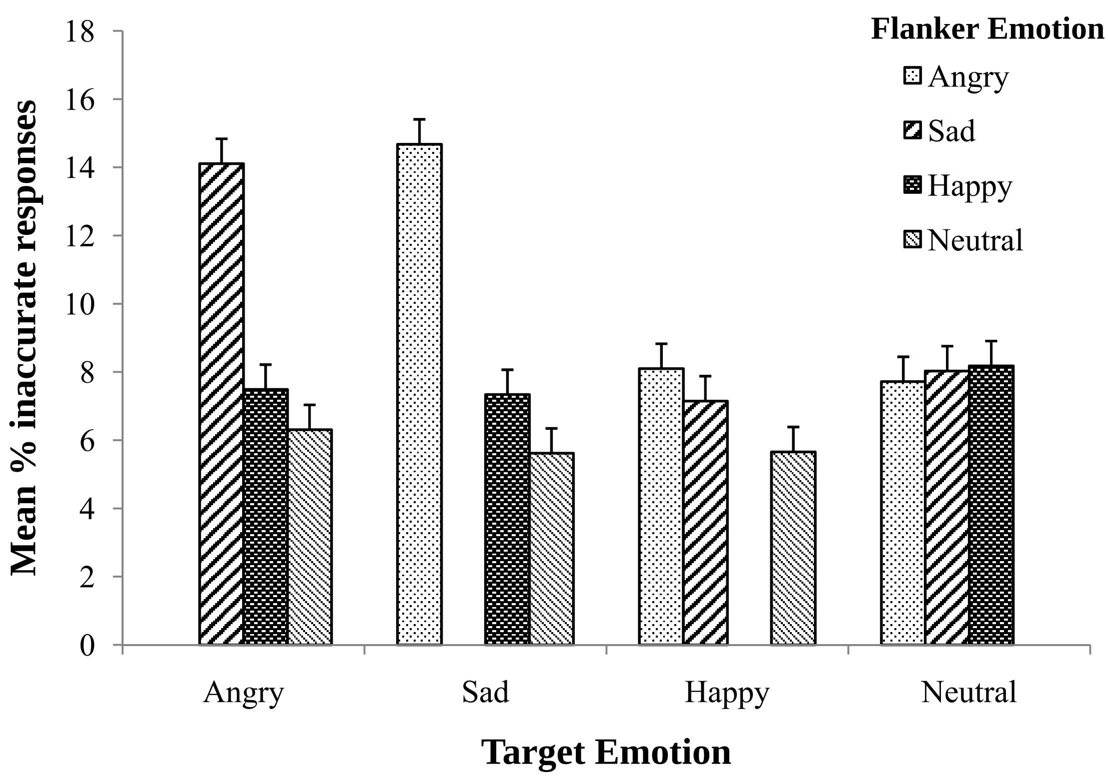
Variable	1	2	3	4	5	6	7	8	9	10	11
1. Flanker: Incongruent Errors	1.0										
2. Flanker: Incongruent RT	.24*	1.0									
3. Emotional Flanker: Sad Incongruent Errors	.01	.06	1.0								
4. Emotional Flanker: Anger Incongruent Errors	.03	.11	.33***	1.0							
5. Go-No Go: No Go Errors (1-Go)	.26**	.07	.12	.11	1.0						
6. Emotional Go-No Go: Fear No Go Errors	.33***	.33***	.22*	.18†	.49***	1.0					
7. Emotional Go-No Go: Anger No Go Errors	.15	.30**	.29**	.23*	.29**	.47***	1.0				
8. Recent Probes: Familiar Probe Errors	-.05	.19*	.07	.15	.04	.15	.34***	1.0			
9. Recent Probes: Familiar Probe RTs	-.03	-.24*	.03	-.01	-.03	-.04	-.21*	-.11	1.0		
10. Directed Forgetting: Forget Positive Words	-.15	-.05	-.05	.00	-.08	-.14	-.03	-.08	.09	1.0	
11. Directed Forgetting: Forget Negative Words	.03	-.07	.02	.04	-.05	.08	.13	.00	.04	.34***	1.0

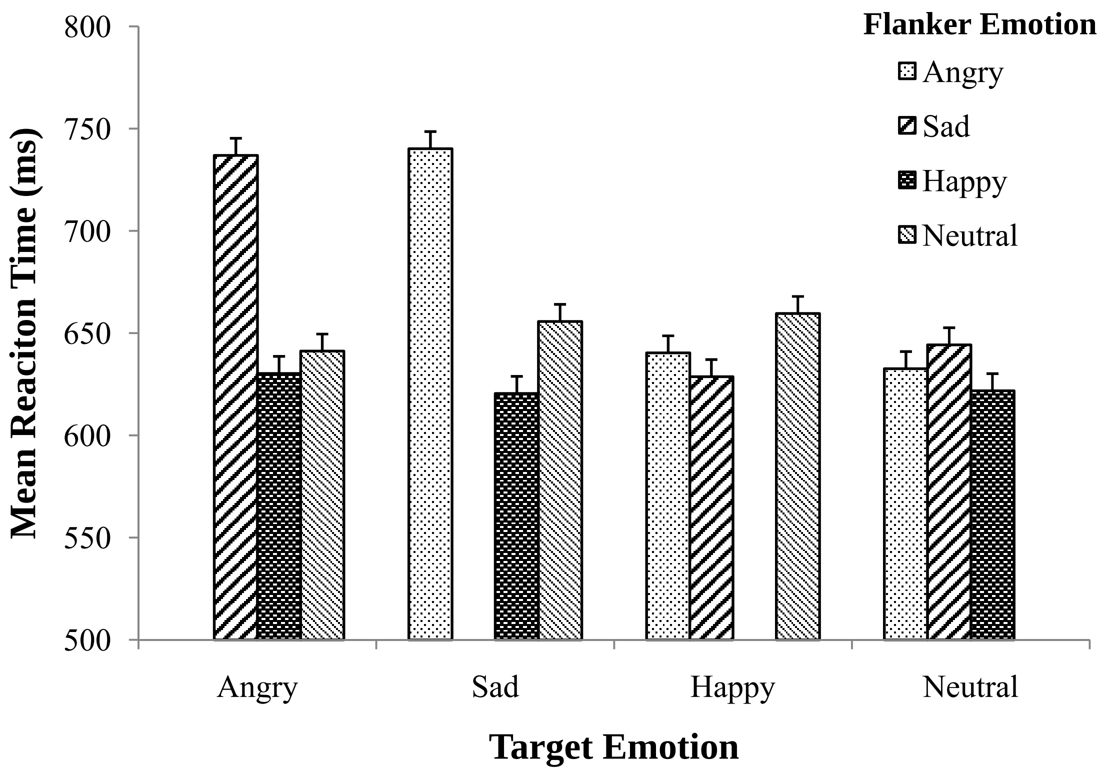
Note. † $p < .10$; * $p \leq .05$; ** $p < .01$; *** $p < .001$.



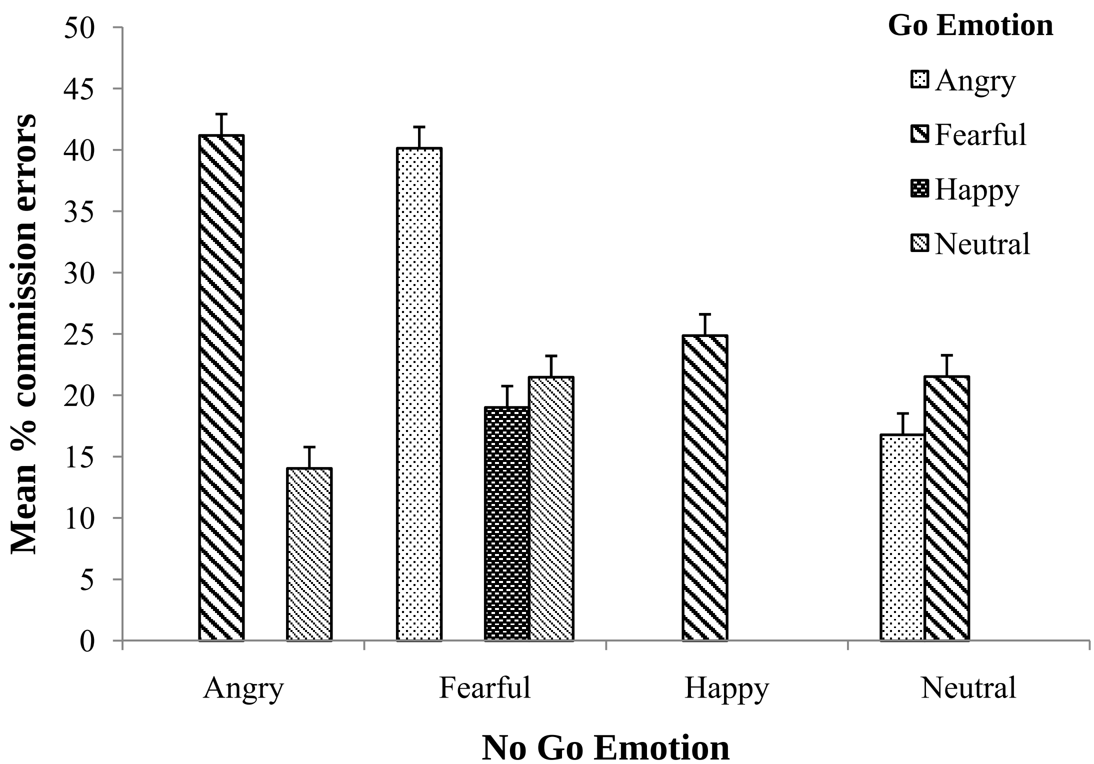
420
410
400
390
380
370
360
350
Mean Reaction Time (ms)
Incongruent Block
Congruent Block
Incongruent
Congruent
Trial Type

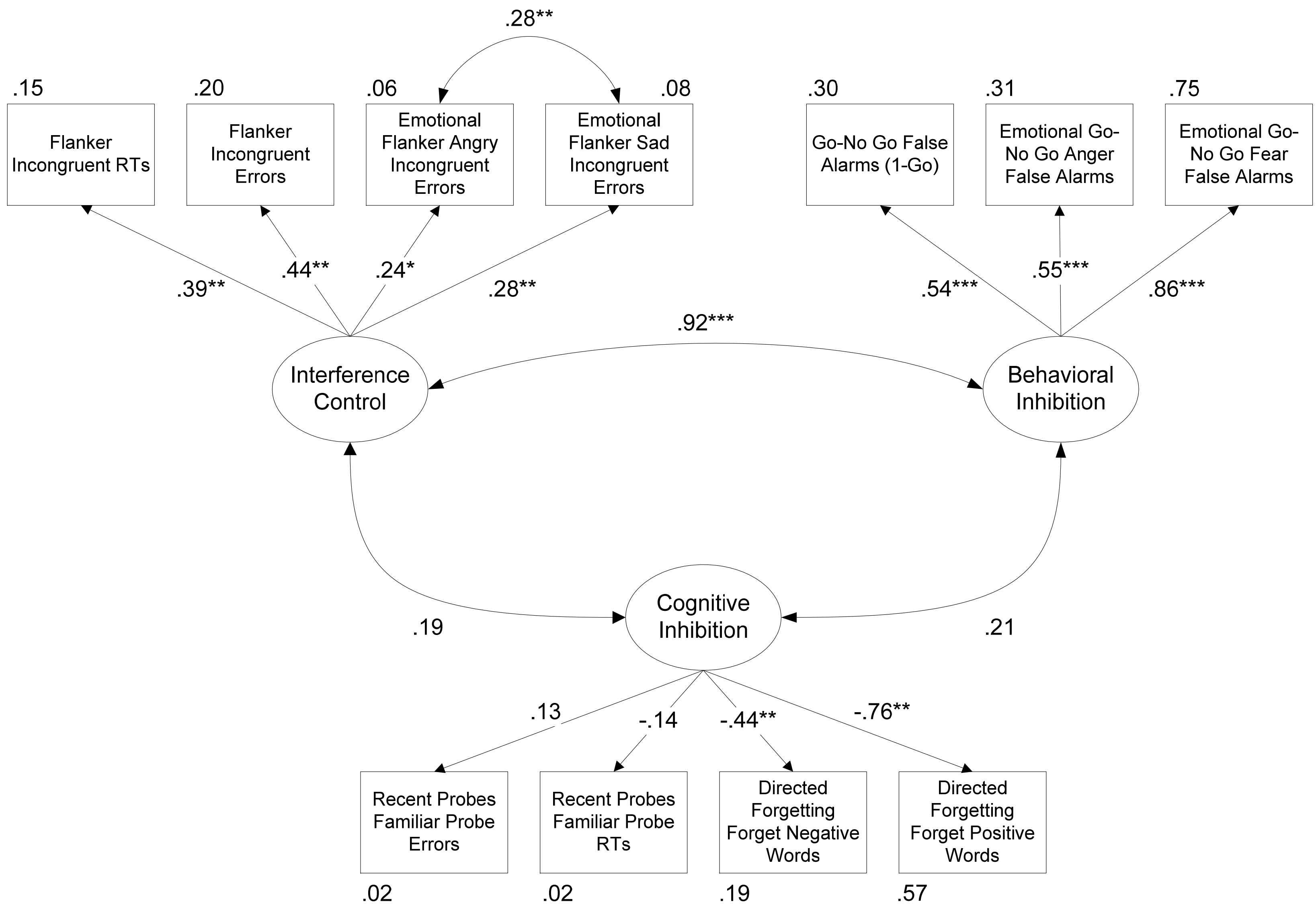

0.3
0.25
0.2
0.15
0.1
0.05
0
Mean proportion no go commission errors
One
Three
Five
Seven
Number of Preceding Go Trials


Flanker Emotion
Angry
Sad
Happy
Neutral
Mean % inaccurate responses
18
16
14
12
10
8
6
4
2
0
Angry
Sad
Happy
Neutral
Target Emotion

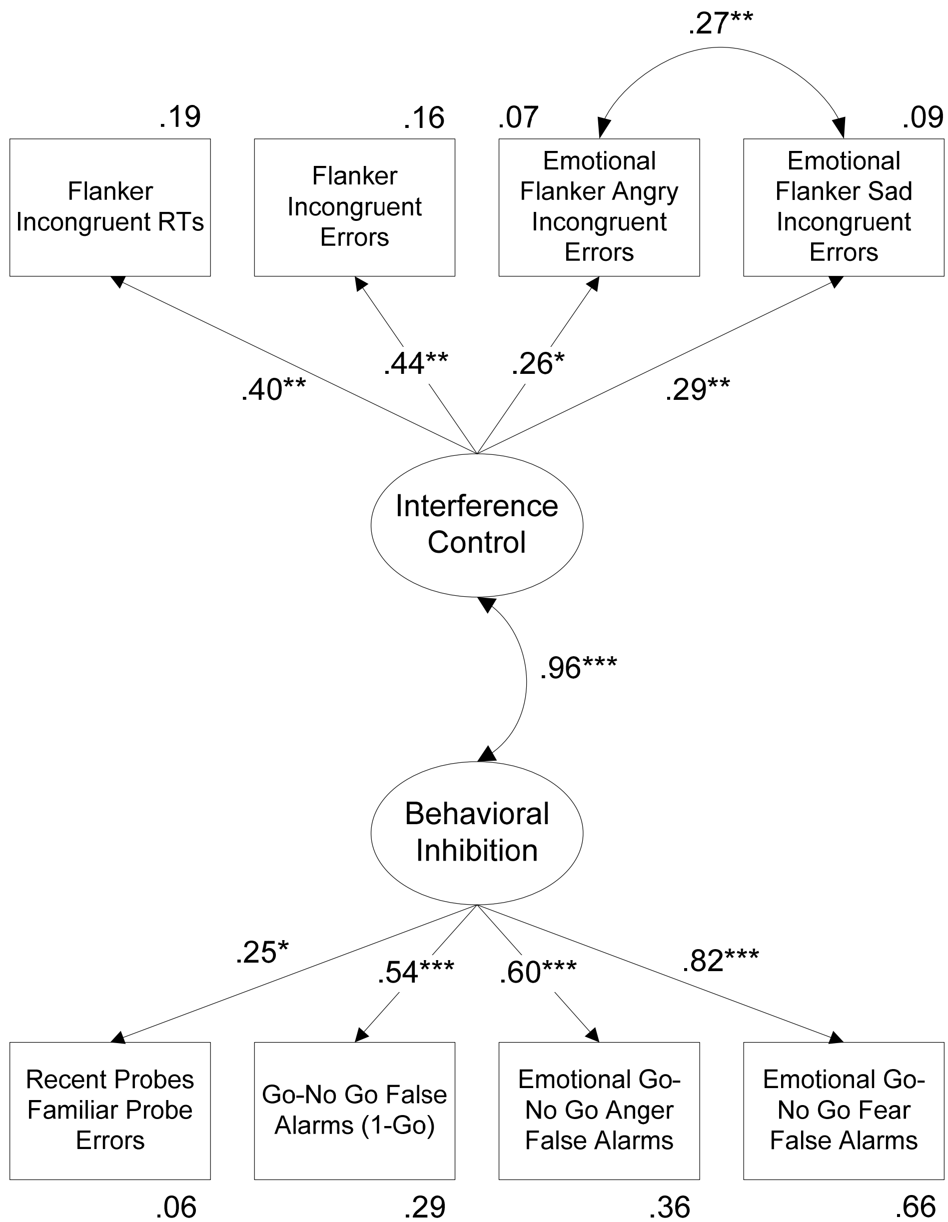


Flanker Emotion
Angry
Sad
Happy
Neutral
Mean Reaciton Time (ms)
800
750
700
650
600
550
500
Angry
Sad
Happy
Neutral
Target Emotion

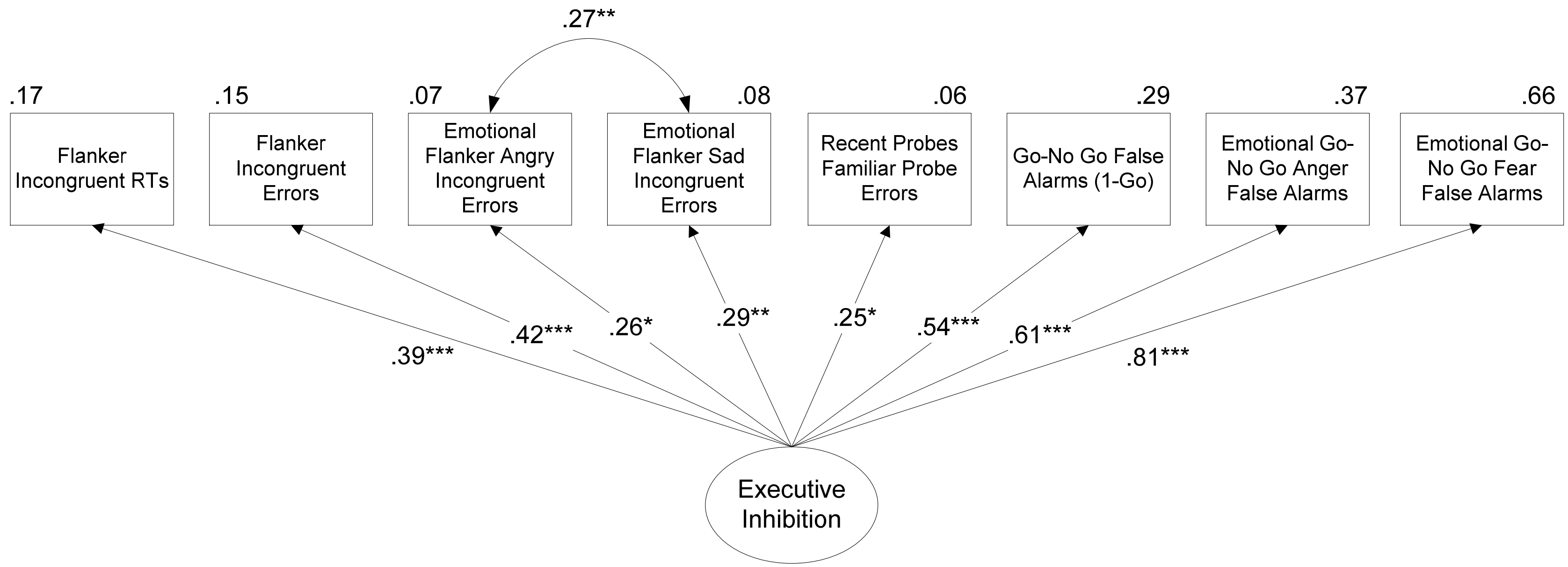

Go Emotion
Angry
Fearful
Happy
Neutral
Mean % commission errors
50
45
40
35
30
25
20
15
10
5
0
Angry
Fearful
Happy
Neutral
No Go Emotion



Note. The numbers adjacent to each executive inhibition index represent the proportion of variance accounted for by the factor model (i.e., R^2).



Note. The numbers adjacent to each executive inhibition index represent the proportion of variance accounted for by the factor model (i.e., R^2).



Note. The numbers adjacent to each executive inhibition index represent the proportion of variance accounted for by the factor model (i.e., R^2).

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