

2-1-2013

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Original Citation

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DOI: 10.1037/a0029536

Citation, in APA format:

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The authors would like to acknowledge the numerous research assistants whose many hours of data collection and processing were instrumental in the completion of these studies. The efforts made by Brittney Keilman-Wyatt, Katie Laws, Amy Kaitschuck, Katherine Siler, Sarah Vadnais, Lauren Rodman, and Minh Tran are particularly noteworthy. Finally, we gratefully acknowledge Samuel Putnam, M. Christine Lovejoy, and Brad Sagarin for their thoughtful comments on earlier versions of the final manuscript.

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Abstract

Sub-disciplines within psychology frequently examine self-regulation from different frameworks despite conceptually similar definitions of constructs. In the current study, similarities and differences between effortful control, based on the psychobiological model of temperament (Rothbart, Derryberry, & Posner, 1994), and executive functioning are examined and empirically tested in three studies (N = 509). Structural equation modeling indicated that effortful control and executive functioning are strongly associated and overlapping constructs (Study 1). Additionally, results indicated that effortful control is related to the executive function of updating/monitoring information in working memory, but not inhibition (Studies 2 and 3). Study 3 also demonstrates that better updating/monitoring information in working memory and better effortful control were uniquely linked to lower dispositional negative affect, whereas the executive function of low/poor inhibition was uniquely associated with an increased tendency to express negative affect. Furthermore, dispositional negative affect mediated the links between effortful control and, separately, the executive function of updating/monitoring information in working memory and the tendency to express negative affect. The theoretical implications of these findings are discussed, and a potential framework for guiding future work directed at integrating and differentiating aspects of self-regulation is suggested.

Keywords: Executive Function, Emotion Regulation, Temperament, Effortful Control, Negative Affect, Working Memory

Integrating and Differentiating Aspects of Self-Regulation: Effortful Control, Executive Functioning, and Links to Negative Affectivity

Self-regulation broadly refers to the ability to regulate behavior, emotion, and cognition (Karoly, 1993). Across many domains, self-regulation has been identified as a contributor to adaptive and adverse outcomes in children, adolescents, and adults. For example, children's self-regulation has been implicated in developmental psychopathology (e.g., Nigg, 2000; Dahl & Conway, 2009), with compromised self-regulation placing children and adolescents at risk for externalizing problems (e.g., Bridgett, Valentino, & Hayden, In Press; Eisenberg, Spinrad, & Eggum, 2010). In adulthood, poor self-regulation has been implicated in depressive and anxiety disorders (e.g., Airaksinen, Larsson, & Forsell, 2005; Carver, Johnson, & Joorman, 2008). Other studies have noted connections between self-regulation and obesity (e.g., Gunstad, Paul, Cohen, Tate, Spitznagel, & Gordon, 2007), sexual risk taking behaviors, and substance abuse (e.g., Crockett, Raffaelli, & Shen, 2006; Quinn & Kim, 2010). On the other hand, better self-regulation has been linked with children's increased social competence (e.g., Eisenberg et al., 1997; Spinrad et al., 2006), and in young adults, with more intimate interpersonal relationships and higher self-esteem (e.g., Busch & Hofer, 2012). Additionally, better caregiver self-regulation has been associated with parenting practices that promote improved outcomes for children (e.g., Bridgett et al., 2011; Deater-Deckard, Sewell, Petrill, & Thompson, 2010). Thus, collectively, prior work highlights the importance of self-regulation for understanding human behavior.

Although self-regulation has been implicated in numerous outcomes, different sub-disciplines within the field of psychology frequently approach the study of self-regulation from diverse frameworks. For example, developmental investigators frequently study self-regulation from a temperament framework using measures of effortful control (Rothbart, Derryberry, &

Posner, 1994; Rothbart, Ellis, & Posner, 2011; Rueda, Posner, & Rothbart, 2005), whereas clinical, cognitive, and neuroscience investigators frequently study self-regulation from an executive function (EF)¹ framework (Blair & Ursache, 2011; Gyurak, et al., 2009). Despite conceptual overlap between effortful control and executive functioning some investigators have argued for a distinction between them. For example, Blair and Ursache (2011; See also Blair & Razza, 2007; Liew, 2012) argue that executive attention, the network underlying effortful control, involves quick, automatic processes whereas EF involves slower, more effortful and deliberate processes. Other investigators have argued that there is substantial overlap between effortful control and EF. For instance, some have noted that specific EFs, such as working memory, are carried out by the same networks in the brain that comprise the executive attention network (e.g., Rueda, Posner, & Rothbart, 2011). Some investigators have even suggested that effortful control and EF largely overlap and have recently called for integrated approaches to the study of self-regulation (Zhou, Chen, & Main, 2011).

Although there are diverse opinions regarding the conceptual differences or similarities between effortful control and EF, there are relatively few empirical tests examining the inter-relatedness of these constructs, which are needed as important next steps in refining self-regulation at the construct, conceptual, and theoretical levels. Therefore, in the current investigation, we present three studies, each using structural equation modeling to test associations between effortful control and EF. In the third study we also examine links between effortful control, EFs, and the experience and expression of negative affect.

Conceptual Underpinnings

Effortful control has been defined as the ability to inhibit a dominant, prepotent response in order to perform a sub-dominant, less salient response and to detect errors (Rothbart & Bates,

2006). Consistent with its origins in Rothbart and colleagues' (Rothbart, Derryberry, & Posner, 1994) psychobiological model of temperament, effortful control has been widely examined in the developmental literature. From the psychobiological framework, temperament is defined as constitutionally-based individual differences in the domains of reactivity, including emotional reactivity, and regulation (i.e., processes that modulate reactivity), that are influenced across time by aspects of the environment, heredity, and maturation (Rothbart & Derryberry, 1981). Effortful control represents the self-regulatory aspect within the psychobiological model, and serves to modulate reactivity (i.e., emotion) and behavior. Conceptually, effortful control broadly encompasses the abilities to focus attention and to activate and inhibit behavior when necessary. Although the precise composition of the higher-order factor of effortful control varies slightly across ages, studies examining the factor structure of effortful control have found that the higher-order construct frequently consists of attention shifting, activation control, effortful attention, and/or inhibitory control (Evans & Rothbart, 2007; Putnam, Gartstein, & Rothbart, 2006). Consistent with conceptual descriptions of effortful control as a singular construct, these factor analytic findings, as well as similar research using behavioral measures of effortful control (e.g., Sulik et al., 2010) suggest that effortful control is a unitary construct on the basis that all subcomponents load together on a single factor.

EF reflects higher-level cognitive processes, identified as being important for the self-regulation of behavior and emotion (Gyurak, et al., 2009; Patrick, Blair, & Maggs, 2008), which help individuals engage in organized, goal-oriented behavior (Friedman, et al., 2008; McCabe, Roediger, McDaniel, Balota, & Hambrick, 2010; Miyake, et al., 2000). Despite the recognized importance of executive functioning for self-regulation, there has been debate as to the best characterization of EF, with two views consistently emerging. Some investigators have

conceptualized EF as a unitary construct (e.g., Baddeley, 1998), emphasizing a central executive, or executive control system that guides behavior and cognition, and directs attentional resources (Baddeley, 2003; Norman and Shallice, 1986). However, other investigators, on the basis of factor analytic work, have noted that executive functioning is comprised of distinct, but interrelated processes (Miyake et al., 2000). Conceptualizations of EFs as a finite set of interrelated processes have typically noted three core components: shifting, inhibition, and updating/monitoring information in working memory. Shifting represents the ability to flexibly reallocate attention between multiple tasks or mental sets, whereas inhibition is the ability to inhibit a dominant, over-learned response in favor of a less dominant response. Finally, updating/monitoring information in working memory consists of the abilities to monitor and code new information and then to actively mentally manipulate such information, including integrating new information with prior information, as needed to accomplish a given task (Miyake et al., 2000). Both models of EF have received support in the literature.

Based on conceptual descriptions of effortful control and EF there is broad similarity between these constructs. At a finer-grained level, effortful control closely resembles characterizations of the EF of inhibition. Furthermore, the executive attention network, which underlies effective effortful control, has been described as being responsible for monitoring and resolving conflicts (e.g., Rueda et al., 2011), which resembles descriptions of the EF of updating/monitoring information in working memory. Similarly, factor analytic work has also identified effortful control subcomponents, such as effortful attention (i.e. the ability to allocate and focus attentional resources), which also resembles descriptions of the EF of updating/monitoring information in working memory. However, one conceptual difference does

emerge. Whereas effortful control is considered to be a unitary construct, some models of EF emphasize distinct, but inter-related processes.

Neurobiological Substrates

Rothbart, Posner, and colleagues (e.g., Rothbart, Sheese, & Posner, 2007) have noted that effortful control is under the influence of the executive attention network. Neuroimaging work indicates that tasks requiring executive attention activate a common brain network (i.e. the executive attention network) consisting of the anterior cingulate gyrus and areas in the prefrontal cortex (Botvinick, Nystrom, Fissell, Carter, & Cohen, 1999; Fan, Flombaum, McCandliss, Thomas, & Posner, 2003). Like efforts to characterize the neurobiological mechanisms of effortful control, there has been considerable interest in the biological mechanisms underlying EF. As with effortful control, the anterior cingulate gyrus and areas in the prefrontal cortex have been implicated in executive functioning (Koechlin & Summerfield, 2007; Lenartowicz, & McIntosh, 2005; de Pisapia & Braver, 2006).

Two lines of genetic research also support similarities between EF and effortful control. First, behavioral-genetic investigations have pointed to substantial genetic contributions to both executive attention and effortful control (Lemery-Chalfant, Doelger, & Goldsmith, 2008; Yamagata, Takahashi, Kijima, Maekawa, Ono, & Ando, 2005), as well as EFs (e.g., Friedman et al., 2008), supporting the genetic origins of these constructs. Second, molecular genetic investigations have also identified similar genetic links, such as the dopamine D4 receptor gene, that contribute to effortful control (e.g., Fan, Fossella, Sommer, & Posner, 2003) as well as to performance during EF tasks requiring inhibition (e.g., Barnes, Dean, Nandam, O'Connell, & Bellgrove, 2011). Likewise, other studies have noted that the catechol-o-methyl transferase gene contributes to the functioning of the executive attention network that underlies effortful control

(e.g., Blasi et al., 2005) and to performance during tasks requiring working memory (e.g., Krug et al., 2009). Collectively, neurobiological and genetic evidence suggests notable similarities between effortful control and EFs.

Developmental Course

The executive attention network and effortful control come online at the end of the first year of life (Rothbart, Sheese, Rueda, & Posner, 2011), with earlier attentional processes supporting their emergence (e.g., Bridgett, et al., 2011; Gartstein, Bridgett, Young, Pankseep, & Power, In Press). By 18 to 24 months of age, effortful control can be measured using questionnaires (e.g., Gartstein, Bridgett, & Low, In Press; Putnam et al., 2006) and structured laboratory tasks (e.g., Kochanska, Murray, & Harlan, 2000). Subsequently, young children's effortful control improves steadily between early toddlerhood and preschool age (e.g., Chang & Burns, 2005), with continued improvement of children's effortful control into the school-age years and beyond (e.g., Lengua, 2006). Similarly, EFs appear to have a protracted developmental course beginning in early childhood and extending into adulthood (e.g., Best, Miller, & Jones, 2009; Bridgett & Mayes, 2011; Huizinga, Dolan, & van der Molen, 2006; Prencipe, Kesek, Cohen, Lamm, Lewis, & Zelazo, 2011; Williams, Ponesse, Schachar, Logan, & Tannock, 1999). Thus, in addition to other similarities, EFs and effortful control appear to share similar developmental trajectories.

Outcomes/Correlates

In addition to other parallels (e.g., conceptual, neurobiological, and developmental), EFs and effortful control have consistently been associated with similar outcomes. For example, both self-regulation constructs have been associated with externalizing and internalizing problems as well as academic achievement (e.g., Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009;

Eisenberg et al., 2009; Hofer, Eisenberg, & Reiser, 2010; Hughes & Ensor, 2011; Murray & Kochanska, 2002; Valiente, Lemery-Chalfant, Swanson, & Reiser, 2008). Effortful control and EFs are also important for the effective regulation of emotion. Studies have consistently noted negative associations between effortful control, including attentional precursors of effortful control, and dispositional negative affectivity (e.g., Bridgett et al., 2009; Eisenberg, Fabes, Bernzweig, & Karbon, 1993; Moriya & Tanno, 2008; Putnam, Rothbart, & Gartstein, 2008; Rothbart, Ahadi, Hershey, & Fisher, 2001). Similar to findings relating effortful control to negative affectivity, previous investigations have noted the importance of EFs, such as working memory processes, for the effective regulation of emotion and emotional experience (e.g., Hofmann, Friese, Schmeichel, & Baddeley, 2011; Schmeichel, Volokhov, & Demaree, 2008), and specifically negative affectivity (Schretlen, van der Hulst, Pearlson, & Gordon, 2010; Williams, Suchy, & Kraybill, 2010).

In contrast to working memory, linked more specifically to the experience of negative affect, some studies have noted that the EF of inhibition may be specifically important for regulating expressions of negative affect. For example, adults may use inhibition to refrain from expressing more automatic negative reactions toward socially marginalized groups of people (Zelazo & Cunningham, 2007). Likewise, Carlson and Wang (2007) noted that young children with better inhibition had fewer/less intense expressions of negative affect in response to receiving a disappointing gift. Finally, during experimental manipulations, there is evidence suggesting that those with better inhibition are better able to suppress displays of negative emotions (e.g., von Hippel & Gonsalkorale, 2005), but may still experience negative affect (e.g., Gross & Levenson, 1997; Gross, 1998a). These findings support dissociation, at least in some circumstances, between the experience and expression of emotion along with processes that may

serve to regulate them (also see Gross, John, & Richards, 2000). Thus, the available evidence suggests that different, but potentially related, self-regulation processes may play unique roles in the regulation of emotion.

Gross' (1998b; McRae, Ochsner, & Gross, 2011) process model of emotion regulation may help explain how inter-related self-regulatory processes differentially influence negative affect. Within the process model of emotion regulation, two strategies, employed at different stages of emotion regulation, are potentially relevant for the current investigation. Antecedent emotion regulation strategies (i.e. strategies used before or soon after an emotion is experienced), such as redirecting attention and cognitive reappraisal, help regulate emotion by altering the emotional significance of a given situation (Gross & Thompson, 2007). Findings that better working memory and effortful control are associated with lower dispositional negative affect (e.g., Moriya & Tanno, 2008; Putnam et al., 2008; Williams et al., 2010) might reflect better capacity for reappraisal soon after experiencing an emotional response through the use of effortful control and/or working memory processes, thereby reducing the general tendency to experience negative affect (see Hofman et al., 2011 for more discussion). This possibility has been supported by work demonstrating that individuals with better working memory who were exposed to emotional stimuli had less intense emotional reactions due to their ability to appraise such stimuli in an unemotional manner (Schmeichel et al., 2008).

The second relevant emotion regulation strategy within the process model is response modulation, which includes processes that regulate emotional expression (Gross & Thompson, 2007). Evidence suggests that the EF of inhibition might contribute to the regulation of expressions of negative affect such that those with better inhibition express less negative affect (Carlson & Wang, 2007), potentially differentiating it from other self-regulatory processes (e.g.,

the EF of working memory and/or effortful control). While existing work suggests that effortful control and EFs may have ties with emotion regulation, studies have not yet simultaneously considered the effects of multiple, inter-related aspects of self-regulation on the dispositional tendency to experience negative affect and to express negative affect, which could provide some additional support for models of emotion regulation (e.g., Gross, 1998b). Furthermore, examining the contribution of EFs and effortful control to aspects of emotion within a single study would provide the opportunity to examine how these self-regulation constructs are similar or differentiated based on associations with potentially common correlates.

The Current Investigation

In light of the distinct similarities between executive functioning and effortful control, in the current investigation, three studies are presented that examine the associations between these constructs. Study 3 also considers links between EFs, effortful control, and the tendencies to experience and express negative affect. Across studies, we selected measures that are typically used within different sub-disciplines of psychology. In particular, we selected measures of EF that were developed for use in both research and clinical settings. In addition, we used structural equation modeling (SEM) to test hypotheses. This analytic approach estimates measurement error more accurately than traditional approaches (e.g., correlation and regression; Tomarken & Waller, 2005) and takes into account associations between independent variables.

Study 1

The goal of Study 1 was to demonstrate that effortful control and general EF, consistent with conceptualizations of EF as a unitary construct (e.g., Baddeley, 2003; Norman & Shallice, 1986), are strongly associated, substantially overlapping constructs.

Method

Participants and Procedure. Young adults ($N = 236$; 110 male, 126 female) from a large Midwestern university participated in the study. Participants ranged from 18 to 30 years ($M = 19.47$; $SD = 2.06$) of age, and most self-identified as Caucasian (61%; Black, 21%; Asian, 9%; Hispanic 7%; other, 2%). Participants completed the measures described below via an online website that presented questionnaires in a random order across participants. Participants received course credit for an introductory psychology course for their participation.

Measures.

Effortful Control. Participants completed the short form of the Adult Temperament Questionnaire (ATQ-SF; Evans & Rothbart, 2007), which included the subscales that comprise the effortful control factor. The ATQ-SF is a 77-item self-report questionnaire (Rothbart, Ahadi, & Evans, 2000) developed to assess adult temperament within the framework of the psychobiological model (Rothbart et al., 1994). This measure was selected on the basis of its theoretical underpinnings, as well as connections with other measures of effortful control used in younger populations within the tradition of the psychobiological model (e.g., Children's Behavior Questionnaire; Rothbart, Ahadi, Hershey, & Fisher, 2001).

The effortful control factor of the ATQ-SF is comprised of the following subscales: effortful attention, inhibitory control, and activation control. Effortful attention is comprised of items that assess the ability to focus and flexibly use attention (e.g., "When I am trying to focus my attention, I am easily distracted," reverse scored). Inhibitory control is the ability to suppress unfavorable or inappropriate behavior (e.g., "It is easy for me to hold back my laughter in a situation when laughter wouldn't be appropriate") and activation control is the ability to perform a particular action even when there is a strong desire to avoid the task (e.g., "I can keep performing a task even when I would rather not do it"; Evans & Rothbart, 2007). In the current

investigation, a latent factor of effortful control ($\alpha = .70$) was formed using the effortful attention, inhibitory control, and activation control subscales, with higher scores reflecting better effortful control.

Executive Function. Two broad indices, the metacognition index and the behavioral regulation index, from the Behavior Rating Inventory of Executive Function (BRIEF; Roth, Isquith, & Gioia, 2005), adult version, were utilized as indicators of the EF factor. The BRIEF is a 75-item self-report measure on which participants are asked to respond to each statement (e.g., “I am impulsive”) by indicating whether or not each behavior has been a problem for them during the past month on a scale ranging from 1 (“the behavior is never a problem”) to 3 (“the behavior is often a problem”). The metacognition index (MI) assesses the ability to effectively and efficiently solve problems, and to actively sustain task completion goals and activities in working memory. The behavioral regulation index (BRI) assesses the ability to exercise self-regulation of emotion and behavior, including inhibition, flexible use of attention, and the self-monitoring of thoughts and actions. Good psychometric properties (i.e. validity and reliability) of the BRIEF have been reported (e.g., Roth et al., 2005) and in the current study, the internal consistency of the EF factor was excellent ($\alpha = .87$). The BRIEF was selected for Study 1 as age-appropriate versions have been used in child, adolescent, and adult populations for research and clinical purposes to examine problematic executive functioning. For the purposes of the current study, items were reverse scored such that higher scores indicated better EF.

Results and Discussion

Analytic approach. EQS 6.1 (Bentler, 2004), a widely used SEM program, was used to examine the association between EF and effortful control using a maximum likelihood estimation approach. Prior to modeling the association between EF and effortful control, a model

wherein the association between EF and effortful control was constrained to zero was estimated to facilitate comparison against the unconstrained model, in which the association between EF and effortful was estimated². Consistent with recommendations to evaluate the fit of SEM models, the following fit indices were used in the current investigation: Chi-Square Goodness of Fit Index, Comparative Fit Index (CFI; Bentler, 1990), Standardized Root Mean-Square Residual (SRMSR; Joreskog & Sorbom, 1981), and the Root Mean-Square Error of Approximation (RMSEA; Steiger, 1990). Finally, the constrained versus unconstrained model was compared using a chi-square difference test.

SEM results³. Consistent with expectations, all zero-order associations were in the anticipated direction, with effects indicating moderate to strong associations (See Table 1 for descriptive statistics and Table 2 for zero-order associations between variables). The initial SEM model, in which the association between EF and effortful control was constrained to be zero, was a poor fit to the data: $\chi^2(5) = 143.97, p < .05, CFI = 0.72, SRMR = 0.29, RMSEA = 0.34$ (90% CI: 0.29 to 0.39). In contrast, for the model wherein the association between EF and effortful control was not constrained, adequate model fit was obtained: $\chi^2(4) = 11.15, p < .05, CFI = 0.99, SRMR = .022, RMSEA = .09$ (90% CI: 0.03 to 0.15). Consistent with expectations, a strong association was observed between effortful control and EF, $z = 5.31, p < .001$ (See Figure 1). Further supporting the overlap between EF and effortful control, the chi-square difference test, statistically examining the fit of the unconstrained model against the constrained mode, was significant, $\Delta\chi^2(1) = 132.82, p < .01$.

Discussion. These findings suggest that there is a substantial degree of overlap between effortful control and EF. Nonetheless, there are some limitations of Study 1. First, self-report questionnaires were employed to assess both effortful control and EF. Next, only young adults

enrolled in introductory psychology courses were included, which may limit the generalizability of the findings. Finally, in Study 1, EF was measured as a unitary construct (Baddeley, 2003; Norman & Shallice, 1986). However, some have argued that EF is comprised of distinct, but inter-related components (e.g., Miyake et al., 2000). Studies 2 and 3 address these limitations.

Study 2

Given the limitation of relying upon only self-report measures in Study 1, as well as only examining EF solely from the perspective that EF is a unitary construct (e.g., Baddeley, 2003; Norman & Shallice, 1986), in Study 2 we included individually administered measures of two specific EFs, inhibition and updating/monitoring information in working memory. Measurement of these two EF processes in Study 2 is consistent with conceptualizations of executive functioning as a set of separate, but inter-related processes (e.g., Miyake et al., 2000). Furthermore, a community sample of participants was used in Study 2, addressing one of the limitations of Study 1.

In Study 2, we expected better effortful control to be associated with faster reaction times and fewer errors on a Stroop-like task, which measures the EF of inhibition. Because some components of effortful control (e.g., effortful attention) conceptually resemble updating/monitoring information in working memory, we also anticipated that higher effortful control would be associated with better performance on individually administered EF tests of working memory. Finally, consistent with studies that have observed more modest associations between measures of effortful control when different measurement methods have been used (e.g., Eisenberg et al., 2003; Gusdorf et al., 2011; Valiente et al., 2003), more modest associations between the EF tasks and the self-report measure of effortful control used in Study 2 were anticipated.

Method

Participants & procedure. Participants in Study 2 consisted of 85 postpartum women recruited to participate in a longitudinal study examining the effects of maternal self-regulation on infant emotional development. Participants were a mean of 26.67 years old ($SD = 6.66$) and were recruited from a rural county through a large OBGYN practice (61%), or through flyers posted in local communities and birth announcements placed in a local newspaper (39%). Participants primarily self-identified their ethnicity as Caucasian (70.2%), Hispanic (13.1%), and African-American (10.7%); the remaining participants (6%) identified as being of other ethnic origins. The mean educational attainment was 14.53 years ($SD = 2.78$), and the mean family income-to-needs ratio was 2.43 ($SD = 1.93$). Two weeks prior to the first laboratory visit, women were mailed a measure of effortful control to complete and were asked to bring the completed measure with them to the laboratory. At four months postpartum, all participants attended a laboratory session and completed individually administered measures of executive function. All participants received \$50.00 for their participation.

Measures.

Adult Temperament Questionnaire. The ATQ-SF effortful control factor ($\alpha = .76$), consisting of subscales of effortful attention, activation control, and inhibitory control was used to assess effortful control in Study 2 (See Study 1 for more details on this measure).

Executive Functions. To measure updating/monitoring of information in working memory with “externally” presented stimuli, the letter-number sequencing subtest from the Wechsler Adult Intelligence Scale, 4th Edition (WAIS-IV; Wechsler, 2008) was used. The latent variable was formed using the total score and longest recalled span. During this task, participants were presented with increasingly longer series of mixed letters and numbers, at 1 second

intervals, and then had to repeat the series back to the administrator such that numbers were presented first in order from lowest to highest, followed by the letters in alphabetical order. This measure was selected because it is a commonly used indicator of working memory in clinical settings, and because the letter-number sequencing subtest from the Wechsler Adult Intelligence Scale, 3rd Edition (Wechsler, 1997), the predecessor of the WAIS-IV, was found to load with traditionally experimental working memory tasks (e.g., n-back and operation span; Shelton, Elliott, Calamia, & Gouvier, 2009). Higher scores and longer spans reflect better working memory.

To form a second latent variable of “internally” generated information requiring updating/monitoring information in working memory, the verbal fluency test from the Delis-Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001) was used. Three indicators from this measure, letter fluency, category fluency, and category switching accuracy, were used as indicators of the latent variable. These measures were selected based on evidence that working memory is the process that underlies performance on verbal fluency measures similar to the one employed in the current study (see Unsworth, Spillers, & Brewer, 2011). These D-KEFS verbal fluency measures were also selected given other work noting that they loaded onto a working memory factor (e.g., Latzman & Markon, 2010), and because the D-KEFS measures have been standardized to aid in clinical decision making regarding EF capacities in such settings.

Completion of the letter fluency condition required participants to say as many words as possible that started with a specific letter within a 60 second time frame. This was done with the letters “F”, “A”, and “S”, each in separate trials that were administered one immediately after the other. Per standardized administration procedures, participants were instructed that they could

not use the names of people, places, or numbers, that they could only use each response once, and that they could not use the same response with different endings. Completion of the category fluency condition required participants to first say as many animals as possible in one 60 second condition, and then in a second 60 second condition, say as many boy's names as possible. During the category switching condition, participants were asked to switch back and forth between naming a fruit, and then a piece of furniture. Category switching is a single 60 second trial, with category switching accuracy reflecting the number of accurate category changes made within the specified time frame. Although less restrictive than the letter fluency condition, participants were instructed not to repeat the same object or name during the category and category fluency conditions. Given the nature of the task, updating/monitoring information in working memory is required to monitor and keep active words that had already been used, to access new items, and to keep active the other rules governing each aspect of the task (Rosen & Engle, 1997; Unsworth et al., 2011). Higher scores on these verbal fluency tasks are indicative of better updating/monitoring information in working memory.

Finally, several indices, inhibition time, inhibition-switching time, and the sum of errors committed during both the inhibition and inhibition-switching tasks, from a second D-KEFS (Delis et al., 2001) measure, the color-word interference test, were used to form a latent factor of the EF of Inhibition. The inhibition task is a traditional Stroop-like task wherein participants have to inhibit reading a color word, and instead, say the name of the color in which the word is printed. The inhibition-switching task requires switching between reading the color word, and naming the color in which the color word is printed. Longer times to complete these tasks, and more errors (e.g., reading the color word instead of naming the color) indicate more difficulties with inhibition.

Results and Discussion

Results. The general analytical approach described in Study 1 was also used in Study 2. SEM, using EQS 6.1 (Bentler, 2004) was used to examine associations between the EFs of inhibition, updating/monitoring information in working memory⁴, and effortful control (See Table 3 for descriptive statistics and Table 4 for associations between variables). The initial model, wherein associations between EFs and effortful control were constrained to be zero fit adequately: $\chi^2(41) = 59.02, p < .05, CFI = 0.94, SRMR = 0.11, RMSEA = 0.07$ (95% CI: 0.02 to 0.11). Although the initial model was an adequate fit, the model without associations between EFs and effortful control being constrained was a significant improvement, $\Delta\chi^2(2) = 6.60, p < .05$, and an overall good fit: $\chi^2(39) = 52.42, p > .05, CFI = 0.96, SRMR = 0.065, RMSEA = .06$ (95% CI: 0.00 to 0.10). In the unconstrained model, the EFs of inhibition and working memory were significantly associated, $z = -3.33, p < .01$. Furthermore, better working memory was associated with higher effortful control, $z = 2.06, p < .05$. However, while in the anticipated direction, inhibition and effortful control were not significantly associated, $z = -1.69, p > .05$ (See Figure 2 for the final SEM Model).

Discussion. Study 2 employed multiple methods (i.e. self-report effortful control and individually administered neuropsychological measures of EF), using a community sample. Study 2 also examined associations between effortful control and two different aspects of EF. As in Study 1 and consistent with our expectations, updating/monitoring information in working memory was significantly associated with effortful control. However, contrary to our expectation, the EF of inhibition was not significantly associated with effortful control, perhaps due to limited statistical power. Furthermore, although findings in Study 2 were largely consistent with the findings of Study 1, neither of these studies examined potential correlates of

effortful control and EF. Therefore in Study 3, we tested the association between EFs and effortful control and their potential links with negative affectivity.

Study 3

In Study 3, a measurement approach similar to that which was used in Study 2 was implemented with a larger sample. As in study 2, we predicted that better updating/monitoring information in working memory would be associated with better effortful control. In addition, in Study 3 we examined associations between effortful control, EFs, and the tendency to experience and express negative affect. This is central to questions regarding the similarities and differences between effortful control and EFs insomuch as overlapping constructs should be associated with common outcomes. Based on prior work (e.g., Hofmann et al., 2011; Putnam et al., 2008; Rothbart et al., 2001; Schretlen et al., 2010), and based on associations between effortful control and the EF of updating/monitoring information in working memory observed in Study 2, we anticipated that better updating/monitoring information in working memory and effortful control would be associated with lower dispositional negative affect. Given evidence that emotional expression can be differentiated from the experience of emotion (Gross et al., 2000), and that the EF of inhibition may be important for inhibiting emotional expression (e.g., Carlson & Wang, 2007; von Hippel & Gonsalkorale, 2005), it was expected that lower inhibition, indicated by longer completion times and more errors during the Stroop-like task, would be associated with the greater tendency to express negative affect.

Two hypotheses regarding mediated effects were also examined. Because the experience of negative affect should predict the expression of negative affect (Gross et al., 2000), and because effortful control and updating/monitoring information in working memory may be related to dispositional negative affect (Hoffman et al., 2011; Putnam et al., 2008; Williams et

al., 2010), but not necessarily to the tendency to express negative affect, these self-regulatory processes might not be directly associated with the expression of negative affect when dispositional negative affect is simultaneously considered. This possibility is consistent with the process model of emotion regulation (Gross, 1998b) inasmuch as effortful control and/or working memory are potentially important for more antecedent emotion regulation strategies (Schmeichel et al., 2008) that occur before strategies employed for response modulation (e.g., inhibition). As such, it was anticipated that updating/monitoring information in working memory and effortful control would be indirectly associated, through dispositional negative affect, with the expression of negative affect.

Method

Participants & Procedure. Participants consisted of 188 young adults (67.7% female, 32.3% male) between the ages of 18 and 29 years ($M = 19.85$ years, $SD = 2.05$) enrolled in psychology courses at a large Midwestern university. Of those participants who specified their ethnicity, a slight majority (54.3%) were Caucasian, 28.8% self-identified as African-American, 11.4% self-identified as Hispanic/Latino, 1.6% self-identified as Asian, 1.1% self-identified as Filipino, and 2.7% self-identified as being various other ethnicities. Participants completed a single individual session in the lab where they completed questionnaire measures interspersed with individually administered measures of EF and negative affectivity. For their participation, all participants obtained course credit and were entered into a drawing for \$75.

Measures

Effortful Control and Executive Functions. Effortful control was measured using the ATQ-SF (See Study 1 for description), with effortful attention, inhibitory control, and activation control used as indicators of the effortful control latent variable ($\alpha = .73$). The EFs of

updating/monitoring information in working memory and inhibition were assessed using only the D-KEFS. The verbal fluency measures and color-word interference measures, previously described in Study 2, were used to form the latent variables of updating/monitoring information in working memory and inhibition, respectively.

Dispositional Negative Affect and Expression of Negative Affect. The latent variable of dispositional negative affect consisted of the ATQ-SF (Evans & Rothbart, 2007) negative affect scale and the NEO-FFI neuroticism scale ($\alpha = .76$). The ATQ-SF negative affect scale consists of subscales that consist of the dispositional temperament characteristics of fear, sadness, discomfort and frustration. The NEO-FFI (NEO-FFI; Costa & McCrae, 1992) is a brief 60-item measure that captures the Big Five dimensions of personality, including neuroticism. Similar to the ATQ-SF subscales comprising negative affect, items comprising the neuroticism scale reflect dispositional tendencies to experience fear, sadness, and anger. The ATQ-SF negative affect scale and the NEO-FFI neuroticism scale were selected as indicators of the dispositional tendency to experience negative affect based on theoretical and empirical work indicating that negative affect/neuroticism reflect core dispositional tendencies to experience negative emotion (Digman, 1990; Evans & Rothbart, 2007; Tellegen, 1985; Watson & Clark, 1992) and because these scales have demonstrated a strong association in prior work (e.g. Evans & Rothbart, 2007).

The expression of negative affect factor ($\alpha = .77$) was comprised of two scales, negative expressivity and impulse strength, from the Berkeley Expressivity Questionnaire (BEQ; Gross & John, 1995). The BEQ was developed based on a model of emotional expression and generation (Gross & Munoz, 1995) to capture the expression of specific emotions, as well as the strength of the impulse to express specific emotions when they are experienced. Items comprising the

impulse strength scale (e.g., “There have been times when I have not been able to stop crying even though I tried to stop” and “I am sometimes unable to hide my feelings even though I would like to”) reflect the tendency to have difficulties stopping an emotional impulse. Items comprising the negative expressivity scale reflect the tendency to express negative emotions (e.g., “It is difficult for me to hide my fear” and reverse scored, “I’ve learned it is better to suppress my anger than to show it”).

Results and Discussion

Results⁵. See Table 5 for the descriptive statistics for variables used in the SEM analysis. EQS 6.1 (Bentler, 2004) was used to simultaneously test the hypotheses specified in the current study using SEM (See Table 6 for associations). The SEM model was a good fit to the data, $\chi^2(55) = 84.17, p < .05, CFI = 0.95, SRMR = .053, RMSEA = .054$ (95% CI: 0.029 to 0.075). Better inhibition (i.e. less time to complete the color-word and color-word switching tasks, and fewer errors during completion of these tasks) was associated with better ability to update/monitor information in working memory, $z = -3.14, p < .05$. Findings with regard to hypothesized associations between factors of effortful control and the EFs of inhibition and updating/monitoring information in working memory were consistent with findings obtained in Study 2. Effortful control demonstrated a robust association with updating/monitoring information in working memory, $z = 2.64, p < .05$. However, the association between effortful control and the EF of inhibition, while in the anticipated direction, was not significant, $z = -1.14, p > .05$ (See Figure 3 for the factor loadings of the indicators in the model and see Figure 4 for the pathways between latent variables).

Consistent with hypotheses, better effortful control, $z = -6.14, p < .05$, and updating/monitoring information in working memory, $z = -1.99, p < .05$, were associated with

lower dispositional negative affect. However, neither effortful control, $z = 0.59, p > .05$, nor updating/monitoring information in working memory, $z = -0.01, p > .05$, were associated with the tendency to express negative affectivity. On the other hand, while the EF of inhibition was not associated with the dispositional tendency to experience negative affect, $z = -1.18, p > .05$, poorer inhibition was associated with the tendency to express more negative affect, $z = 2.29, p < .05$. Effortful control and updating/monitoring information in working memory accounted for 56% of the variance in dispositional negative affect; 50% of the variance in the expression of negative affect was accounted for in the model.

Finally, the potential indirect (i.e. mediated) effects of effortful control and updating/monitoring information in working memory on the expression of negative affect through dispositional negative affect were tested using the effect decomposition feature of the EQS 6.1 SEM software. Results of tests of indirect effects indicated that effortful control, $z = -3.22, p < .05$, and updating/monitoring information in working memory, $z = -1.75, p < .05$, were indirectly linked to the tendency to express negative affect through the dispositional tendency to experience negative affect.

Discussion. As was observed in Study 2, in Study 3, updating/monitoring information in working memory was significantly associated with effortful control. Associations in both Studies 2 and 3 were of approximately the same magnitude as associations between parent-report and laboratory measures of effortful control that have been noted in the developmental literature (Eisenberg et al., 2003; Gusdorf et al., 2011; Valiente et al., 2003). However, in both studies, the EF of inhibition was not significantly associated with effortful control.

Study 3 also extended Study 2. Both effortful control and updating/monitoring information in working memory were associated with the dispositional experience of negative

affect whereas the EF of inhibition was associated with the tendency to express negative affect. These findings further support the broader pattern of results that suggest greater similarity between the EF of updating/monitoring information in working memory and effortful control, and the distinction of the EF of inhibition from these other self-regulatory processes. As anticipated, dispositional negative affect mediated the association between effortful control and updating/monitoring information in working memory and expression of negative affect.

General Discussion

In the current investigation, we examined similarities between two self-regulation constructs: effortful control and executive functioning. Prior investigators have noted that effortful control and EFs have conceptual, neurobiological, and developmental similarities, as well as similarities in terms of common correlates (e.g., Zhou et al., 2012). The present investigation provides additional and direct evidence of the overlap between these constructs. In Study 1 we found a strong association between effortful control and EF. In Studies 2 and 3 effortful control was associated with the EF of updating/monitoring information in working memory, but not the EF of inhibition. Finally, in Study 3, we demonstrated that effortful control and the EF of updating/monitoring information in working memory were associated with the experience of negative affect, whereas the EF of inhibition was only associated with the expression of negative affect.

These findings have several notable implications. First, the findings support the view that effortful control and EF are largely overlapping constructs, potentially challenging the distinctions that are sometimes made between them. In particular, our findings in Studies 2 and 3 are consistent with Rueda et al.'s (2011) statement that the executive attention network, underlying effortful control, is comprised of networks that carry out some EFs, such as working

memory. Although associations between the EF of updating/monitoring information in working memory and effortful control in Studies 2 and 3 were more modest than the association between EF and effortful control in Study 1, this was anticipated based on the use of different methods to assess EFs and effortful control. Importantly, the magnitude of these associations was similar to that which has been observed between parent-report and laboratory measures of effortful control described in the developmental literature (Eisenberg et al., 2003; Gusdorf et al., 2011; Valiente et al., 2003). Inasmuch as the magnitude of associations between effortful control and updating/monitoring information in working memory noted in the current investigation parallel the magnitude of associations between parent report and laboratory measures of effortful control in children (i.e. same construct, different measurement approaches), additional support is provided for the overlap of updating/monitoring information in working memory and effortful control.

Next, the overlap between executive functioning and effortful control identified in the current investigation (e.g., Study 1) has important theoretical implications. Whereas effortful control is an aspect of temperament (Rothbart, et al., 1994), EFs are typically not referred to as temperament characteristics. However, because EFs emerge early in life (Kalhut, et al., 2009; Pennequin, et al., 2010), are constitutionally-based (i.e. are biologically-based, heritable processes; Lenroot, et al., 2009), and change over time as a function of maturation and the environment (e.g., Bridgett & Mayes, 2011; Rhoades, Greenberg, Lanza, & Blair, 2011), attributes that are encompassed within the concept of temperament based on the psychobiological model (Rothbart et al., 1994), EFs also may be considered aspects of temperament. Thus, in light of our findings supporting the overlap between executive functioning and effortful control, other comparisons between these constructs (e.g., Zhou et al.,

2012), and investigations, such as those noted above, that have carefully examined the nature of executive functioning, theoretical integration of these self-regulatory constructs within a temperament framework may be appropriate.

Although several anticipated effects were observed, non-significant associations between effortful control and the EF of inhibition were obtained in Studies 2 and 3. These findings are inconsistent with some investigations that have identified associations between aspects of effortful control and inhibition (e.g., Carlson & Moses, 2001; Ellis, Rothbart, & Posner, 2004), yet other investigations, similar to our findings, have found small or no associations (e.g., Muris, van der Pennen, Sigmond, & Mayer, 2008; Verstraeten, Vasey, Claes, & Bijttebier, 2010). One potential explanation for these inconsistencies is that effortful control and working memory overlap more so than inhibition in young adults. This possibility is consistent with research that has identified common brain networks underlying effortful control and working memory (Hester & Garavan, 2005; McCabe, et al., 2010; Rueda et al., 2011). Similarly, from a developmental perspective, the inhibitory aspects of effortful control may be more prominent in children. This may be due to the greater salience of inhibitory processes earlier in development, or due to effortful control measurement approaches, as laboratory-based measures used with children focus primarily on inhibitory processes (e.g., Kochanska et al., 2000). Likewise, because parents are often raters of their children's effortful control in developmental studies, it may be the case that failures of inhibition are more noticeable, resulting in ratings of effortful control that are less likely to capture more internal self-regulatory processes (e.g., working memory), rendering stronger associations between effortful control and laboratory measures that capture inhibition. Future studies should examine these and other potential explanations for the dissociation between effortful control and the EF of inhibition observed in this investigation.

In addition to associations between EFs and effortful control, Study 3 examined the implications of simultaneously considering multiple aspects of self-regulation for understanding the tendencies to experience and express negative affect. This approach permitted testing a model demonstrating that different, albeit related, self-regulation constructs may be uniquely associated with the experience and expression of emotion. Consistent with what might be expected based on the process model of emotion regulation (Gross, 1998b), and on prior work (e.g., Hofmann et al., 2011; Levens & Gotlib, 2010; Moriya & Tanno, 2008; Putnam et al., 2008; Schmeichel et al., 2008; Schretlen et al., 2010; Williams et al., 2010), findings indicated that effortful control and the EF of updating/monitoring information in working memory were related to dispositional negative affect, but not directly associated with the tendency to express negative affect. These results suggest that working memory and effortful control may contribute to the regulation of the experience of negative affect, perhaps through cognitive reappraisal (Hofmann et al., 2011). In contrast, the EF of inhibition was only associated with the tendency to express negative affect, suggesting that the EF of inhibition may only contribute to the regulation of the outward expression of negative affect. This interpretation is consistent with prior work suggesting that the EF of inhibition is important for regulating expressions of emotion (e.g., Carlson & Wang, 2007). Nevertheless, while the current study statistically modeled associations between self-regulation (i.e. EFs and effortful control) and negative affect from the perspective that self-regulation of emotion occurs in adults in a top-down manner (see Ray & Zald, 2012 for discussion of top-down vs. bottom-up control processes), another potential interpretation of these findings is that negative affectivity disrupted EFs and effortful control. Such a possibility is consistent with a small, but notable body of research demonstrating, primarily in children, the potential disruption of later self-regulation and related processes (e.g., attention) by earlier

negative affect (Bridgett et al., 2009; Leve et al., In Press; Stifter & Spinrad, 2002). This potential explanation should be considered in future investigations.

Finally, in the broader context of the current investigation, findings obtained in Study 3 are important for two reasons. First, our findings make potentially important connections with theory related to the self-regulation of emotion, providing a basis for understanding the potentially unique roles that inter-related self-regulatory systems may play in emotion regulation. Second, these findings contribute to understanding how effortful control, working memory processes, and inhibition might be integrated and differentiated. That is, consistent with a measurement perspective, we were able to show that working memory and effortful control operate as similar constructs because they not only demonstrate associations with one another, but they also demonstrate similar patterns of association, and dissociation, with potential correlates.

Methodological Implications

Prior studies examining processes potentially important for the regulation of negative affect and/or the expression of negative affect have frequently examined only one self- or emotion-regulation-related process (e.g., working memory or inhibition). In the current investigation, multiple inter-related aspects of self-regulation were examined, and a distinction was made between the dispositional tendency to experience negative affect and the tendency to express negative affect. Based on zero-order correlations, the EF of updating/monitoring information in working memory and effortful control were consistently associated with indicators of dispositional negative affect as well as the tendency to express negative affect. However, when modeled simultaneously using SEM, it was evident that both effortful control and the EF of updating/monitoring information in working memory were only indirectly

associated with the expression of negative affect. This serves as an example of the importance of simultaneously measuring and modeling multiple aspects of self-regulation as failing to do so increases the possibility of missing theoretically important effects. While work that seeks to isolate specific self-regulation processes and the influence of such processes on the regulation of behavior and emotion is important (e.g., Carlson & Wang, 2007; Schmeichel et al., 2008; Levens & Gotlib, 2010), future work could build on the current investigation by simultaneously considering different, but inter-related self-regulation processes in models of emotional and behavioral regulation. Such work will contribute important information regarding self-regulation that is potentially distinct from work that seeks to isolate specific processes.

Another strength of the current investigation was the measurement approach wherein all three studies included measures of EF that can be used in both research and clinical applications. Because of this approach, findings in the current investigation potentially make stronger connections between findings regarding effortful control and clinical findings regarding executive functioning, enhancing the translational implications of the findings in this study. However, it should also be noted that there are a number of additional methods available for assessing EFs in clinical and research settings, and future studies may want to consider incorporating additional methods of assessing EFs. Similarly, different measures of effortful control/executive attention, such as the Attention Network Test (Fan, McCandliss, Sommer, Raz, & Posner, 2002), could be used along with self-report and neuropsychological measures of EFs and/or self-report measures of effortful control.

Conclusion, Limitations, and Future Directions

The current investigation has a number of important strengths, such as 1) the use of a multi-method approach for assessing aspects of self-regulation, 2) the integration of multiple

theoretical frameworks (i.e., Gross, 1998b; Miyake et al., 2000; Rothbart, Derryberry, & Posner, 1994), and 3) the use of SEM to simultaneously test hypotheses while better accounting for measurement error (see Tomarken & Waller, 2005). Furthermore, the current investigation reported three separate studies that converged in terms of conclusions regarding connections between effortful control and EFs in young adults. Our findings provide further support for the idea that effortful control and certain aspects of executive functioning are overlapping constructs, and we join the call to develop integrated approaches to the study of self-regulation (e.g., Zhou et al., 2012). Here, we also suggest, and in the current study used, a framework that can be implemented to potentially aid in the development of integrated approaches to self-regulation. Specifically, when two (or more) aspects of self-regulation converge along conceptual, biological, and developmental lines, share common correlates, and when empirical connections are established, conceptual and theoretical integration may be warranted. Certainly, before such integration is established, it is important to consider measurement issues. As in the current investigation, similar methods of measurement are likely to yield stronger associations between (e.g., Study 1) and within (e.g., Studies 2 and 3) constructs than when different methods are employed. While mixed methods may at times yield more modest associations, these associations are particularly important when other converging evidence is available, and findings are replicated.

Despite the strengths of the current study, there are also several limitations that should be addressed in future work. In Studies 2 and 3, two aspects of EF, inhibition and updating/monitoring information in working memory, as proposed by Miyake et al. (2000) were examined. However, attention shifting, the third component of the EF model proposed by Miyake et al., which is also considered to be a core aspect of EF (Latzman & Markon, 2010;

Miyake et al.), was not considered. Similarly, in some studies, attentional shifting has been noted as one aspect of the broader, unitary effortful control construct (e.g., Putnam et al., 2006). On the other hand, other studies (e.g., Hofer, Eisenberg, & Reiser, 2010; Rothbart et al., 2001; Rothbart & Bates, 2006) have found that attention shifting did not load with, or was not related to, other aspects of effortful control. Thus, it appears that attention shifting is not consistently considered to be a component of effortful control. The ATQ-SF (Evans & Rothbart, 2007) effortful control factor, used in the current study, does not have an attention shifting component, which, in part, was one reason why the EF of attention shifting was not considered. Nevertheless, future work should consider including attention shifting, examining its potentially unique associations with other aspects of self-regulation to provide important additional steps towards integrating and differentiating aspects of self-regulation. Furthermore, given that prior work has noted associations between attentional shifting and negative affect (e.g., Compton, 2000; Eisenberg, Shepard, Fabes, Murphy, & Guthrie, 1998; Johnson, 2009), future work should examine the potentially unique role of this aspect of self-regulation in the regulation of emotion.

It is also important to note that while some findings reported in the current study are potentially consistent with what might be anticipated based on the process model of emotion regulation (Gross 1998b; Gross & Thompson, 2007), only participant reports of greater or lesser tendencies to experience and express negative affect were examined as opposed to placing participants in emotion-eliciting situations. The benefit of this approach was that it captured participants' tendencies to experience and express negative affect in day-to-day situations. The use of self-report measures is also consistent with measurement methods frequently employed to examine questions regarding temperament and/or personality (Gartstein et al., In Press). Nevertheless, addressing the limitation of solely relying upon self-report for examination of

negative affect represents an important avenue for further investigation. For example, future work might consider incorporating laboratory tasks that elicit negative affect (e.g., frustration) as a means to determine if better inhibition translates into fewer expressions of negative affect (see Carlson & Wang, 2007, for an example), in the context of a model that also includes the dispositional tendency to experience negative affect and multiple self-regulatory constructs.

Finally, the current study gathered information concurrently, not longitudinally, and examined associations between effortful control and EF only in young adults. It will be important for future investigations to employ longitudinal methods, and to examine associations between similar, and potentially overlapping aspects of self-regulation across the entire lifespan (See Zhou et al. 2012 for a similar suggestion). Despite the limitations noted above, the current investigation makes an important contribution by linking different areas within psychology that have focused, in part, on understanding self-regulation. The approach and findings reported here provide a useful framework for future investigations aimed at refining theoretical approaches to the study of self-regulation, and provide some evidence that different, but related aspects of self-regulation may play differential roles in the regulation of emotion.

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Footnotes

1. Throughout we use EF to refer to executive function and EFs to refer to executive functions, depending on the context.
2. We appreciate an anonymous reviewer who made the suggestion to compare nested models in the manner reported.
3. In all studies reported in the current investigation, prior to SEM analyses, variables were examined for normality (Tabachnick & Fidell, 2007). Based on the recommendations made by Tabachnick and Fidell (2007), a z-test (i.e. Skew/Std. Error of Skew) was used to determine if the degree of skew for each variable used in the SEM model was significantly different from zero. All variables that demonstrated significant skew were transformed using either a square-root or a log transformation if the results of the z-test were greater than or equal to 2 or less than or equal to -2 (Curran, West, & Finch, 1996; Tabachnick & Fidell, 2007). Transformed and non-transformed variables are reported in tables associated with each specific study.
4. Prior to analyzing the full model, the fit of a single working memory factor, two correlated working memory factors, and a second order working memory factor, with two lower order latent variables was examined. The single working memory factor was a poor fit to the data, $\chi^2(5) = 78.20, p < .05, CFI = .76, RMSEA = .42$. In comparison, a correlated two factor model was a significant improvement in fit, $\Delta \chi^2(1) = 65.85, p < .05$, but still a relatively unacceptable overall fit to the data, $\chi^2(4) = 12.35, p < .05, CFI = .93, RMSEA = .16$. Relative to the correlated two factor model, a single higher order working memory factor, with two lower order latent working memory factors, $\chi^2(3) = 5.19, p > .05, CFI = .96, RMSEA = .09$, was a significant improvement in fit, $\Delta \chi^2(1) =$

7.16, $p < .05$. Given these findings, a single higher order working memory factor was specified in the full SEM.

5. As was done in Studies 1 and 2, a model wherein pathways between EFs and effortful control were constrained to be zero was compared against the unconstrained model. For these analyses, negative affectivity variables were not included. The constrained model was a reasonable fit to the data: $\chi^2(26) = 36.61$, $p < .10$, CFI = 0.96, SRMR = 0.08, RMSEA = 0.05. However, the unconstrained model, $\chi^2(24) = 26.73$, $p > .05$, CFI = 0.99, SRMR = 0.05, RMSEA = 0.02, was a significant improvement in fit, $\Delta \chi^2(2) = 9.88$, $p < .01$, providing further support for the overlap between EFs and effortful control.

Table 1

Study 1 Descriptive Statistics for Variables used in the Structural Equation Model

Variable	Mean (SD)	Skew	S.E. of Skew	<i>z</i>	T. ¹ Mean (SD)	T. Skew	T. S.E. of Skew	<i>z</i>
ATQ Inhibitory Control	4.09 (0.72)	0.47	0.157	3.00**	2.01 (0.18)	0.18	0.157	1.15
ATQ Activation Control	4.55 (0.91)	0.14	0.157	0.86	NA	NA	NA	NA
ATQ Effortful Attention	4.22 (1.06)	-0.06	0.157	0.39	NA	NA	NA	NA
BRIEF-SR BRI ²	2.08 (0.32)	-0.67	0.157	-4.27**	1.25 (0.09)	-0.27	0.157	-1.72
BRIEF-SR MI ³	2.01 (0.35)	-0.58	0.157	-3.63**	1.23 (0.10)	-0.21	0.157	-1.35

1. T = Transformed

2. Behavioral Regulation Index

3. Metacognitive Index

* $p < .05$; ** $p < .01$

Table 2

Zero-Order Associations between Observed Variables in Study 1

Variable	1	2	3	4
1. ATQ Inhibitory Control				
2. ATQ Activation Control	.28**			
3. ATQ Effortful Attention	.39**	.52**		
4. BRIEF Behavioral Regulation Index	.36**	.41**	.48**	
5. BRIEF Metacognitive Index	.32**	.58**	.57**	.78**

** $p < .01$

Table 3

Study 2 Descriptive Statistics for Variables used in the Structural Equation Model

Variable	Mean (SD)	Skew	S.E. of Skew	<i>z</i>	T. ¹ Mean (SD)	T. Skew	T. S.E. of Skew	<i>z</i>
ATQ Inhibitory Control	4.51 (0.89)	- 0.18	0.266	- 0.69	NA	NA	NA	NA
ATQ Activation Control	5.14 (0.91)	- 0.60	0.266	- 2.26*	1.81 (0.28)	- 0.16	0.266	- 0.61
ATQ Effortful Attention	4.87 (1.10)	- 0.33	0.266	- 1.24*	NA	NA	NA	NA
DKEFS Inhibition Time	49.21 (10.69)	1.68	0.263	6.38**	1.68 (0.09)	0.42	0.263	1.57
DKEFS Inhibition Switch Time	55.98 (11.77)	0.93	0.263	3.54**	1.74 (0.09)	0.26	0.263	0.99
DKEFS Total Errors ²	4.49 (3.72)	1.05	0.263	3.99**	0.62 (0.34)	- 0.51	0.263	- 1.94
DKEFS Letter Fluency	37.57 (9.65)	0.12	0.263	0.46	NA	NA	NA	NA
DKEFS Category Fluency	41.54 (8.97)	0.39	0.263	1.48	NA	NA	NA	NA
DKEFS Cat. Switching Accuracy	13.14 (3.33)	0.18	0.263	0.68	NA	NA	NA	NA
Letter-Number Seq. Score	19.29 (2.74)	- 0.26	0.263	0.99	NA	NA	NA	NA
Letter-Number Seq. Longest String	5.43 (1.03)	0.20	0.263	0.76	NA	NA	NA	NA

1. T = Transformed

2. DKEFS Total Errors consists of errors (e.g., reading the word instead of naming the color) made during the Inhibition and Inhibition Switch trials.

* $p < .05$; ** $p < .01$

Table 4

Zero Order Associations between Observed Variables in Study 2

Variable	1	2	3	4	5	6	7	8	9	10
1. ATQ Inhibitory Control										
2. ATQ Activation Control	.40**									
3. ATQ Effortful Attention	.64**	.57**								
4. D-KEFS Inhibition Time	-.08	-.16	-.10							
5. D-KEFS Inhibition Switching Time	-.14	-.19 ⁺	-.22*	.52**						
6. D-KEFS Inhibition/ Inhibition Switching Errors	-.15	-.25*	-.15	.41**	.45**					
7. D-KEFS Letter Fluency Total Correct	.20 ⁺	.01	.21 ⁺	-.33*	-.41**	-.38**				
8. D-KEFS Category Fluency Total Correct	.19 ⁺	.15	.19 ⁺	-.43**	-.34**	-.38**	.61**			
9. D-KEFS Category Switching Accuracy	.19 ⁺	.04	.15	-.53**	-.42**	-.32**	.59**	.66**		
10. LNS Total Score	.25*	.01	.25*	-.30**	-.33**	-.40**	.40**	.25*	.39**	
11. LNS Longest Correct Span	.23*	-.08	.21 ⁺	-.13	-.25*	-.25**	.41**	.18	.30**	.76**

+ $p < .10$; * $p < .05$; ** $p < .01$

Table 5

Study 3 Descriptive Statistics for Variables used in the Structural Equation Model

Variable	Mean (SD)	Skew	S.E. of Skew	<i>z</i>	T. ¹ Mean (SD)	T. Skew	T. S.E. of Skew	<i>z</i>
NEOFFI Neuroticism	2.70 (0.67)	0.12	0.177	0.67	NA	NA	NA	NA
ATQ Negative Affect	3.76 (0.69)	0.02	0.177	0.11	NA	NA	NA	NA
BEQ Neg. Expressivity	3.67 (0.79)	-0.22	0.177	-1.24	NA	NA	NA	NA
BEQ Impulse Strength	4.39 (1.21)	-0.07	0.178	-0.39	NA	NA	NA	NA
ATQ Inhibitory Control	4.17 (0.86)	0.39	0.177	2.20*	2.03 (0.21)	0.06	0.177	0.34
ATQ Activation Control	4.82 (0.88)	-0.39	0.177	-2.20*	1.68 (0.26)	0.05	0.177	0.28
ATQ Effortful Attention	4.12 (1.06)	0.40	0.177	2.26*	2.01 (0.26)	0.00	0.177	0.02
DKEFS Inhibition Time	48.35 (11.71)	1.21	0.177	6.84**	1.67 (0.10)	0.39	0.177	2.20*
DKEFS Inhibition Switch Time	54.73 (11.17)	1.14	0.177	6.44**	1.73 (0.08)	0.40	0.177	2.26*
DKEFS Total Errors ²	4.78 (4.95)	2.46	0.178	13.82**	0.63 (0.34)	-0.06	0.178	-0.34
DKEFS Letter Fluency	36.82 (9.74)	0.19	0.177	1.07	NA	NA	NA	NA
DKEFS Category Fluency	39.40 (8.06)	-0.08	0.177	0.45	NA	NA	NA	NA
DKEFS Cat. Switching Accuracy	11.97 (2.54)	-0.37	0.177	-2.09*	2.44 (0.46)	0.33	0.177	1.86

1. T = Transformed

2. DKEFS Total Errors consists of errors (e.g., reading the word instead of naming the color) made during the Inhibition and Inhibition Switch trials.

* $p < .05$; ** $p < .01$

Table 6

Zero Order Associations between Observed Variables in Study 3

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. NEOFFI Neuroticism												
2. ATQ Negative Affect	.62**											
3. BEQ Negative Expressivity	.33**	.39**										
4. BEQ Impulse Strength	.42**	.39**	.54**									
5. ATQ Inhibitory Control	-.38**	-.39**	-.33**	-.32**								
6. ATQ Activation Control	-.41**	-.31**	-.13 ⁺	-.04	.38**							
7. ATQ Effortful Attention	-.47**	-.44**	-.32**	-.20**	.53**	.52**						
8. D-KEFS Inhibition Time	.09	.13 ⁺	.15*	.18*	-.10	-.03	-.08					
9. D-KEFS Inhibition Switching Time	-.02	.07	.16*	.19*	-.12 ⁺	-.02	-.06	.63**				
10. D-KEFS Inhibition/ Inhibition Switching Errors	-.05	-.09	.07	.06	-.06	-.02	.04	.34**	.39**			
11. D-KEFS Letter Fluency Total Correct	-.13 ⁺	-.16*	-.14 ⁺	-.22**	.12 ⁺	.08	.19**	-.24**	-.26**	-.09		
12. D-KEFS Category Fluency Total Correct	-.26**	-.24**	-.20**	-.14 ⁺	.10	.08	.21**	-.20**	-.13 ⁺	.08	.42**	
13. D-KEFS Category Switching Accuracy	-.18*	-.04	-.08	-.15*	-.01	.07	.13 ⁺	-.27**	-.30**	-.14 ⁺	.28**	.27**

+ $p < .10$; * $p < .05$; ** $p < .01$

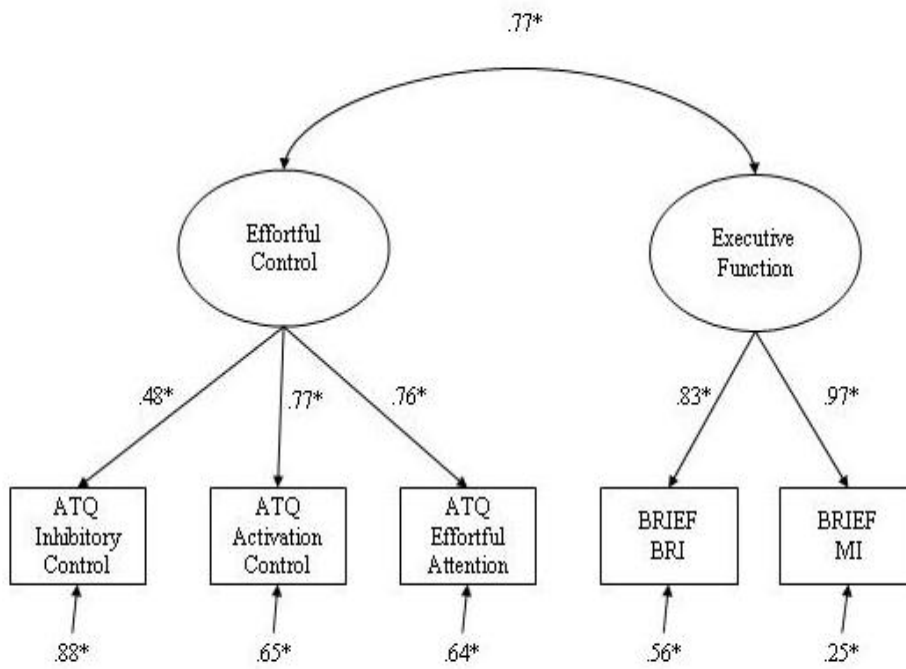


Figure 1. Study 1 structural equation model depicting association between effortful and executive function. Standardized coefficients are displayed.

* $p < .05$

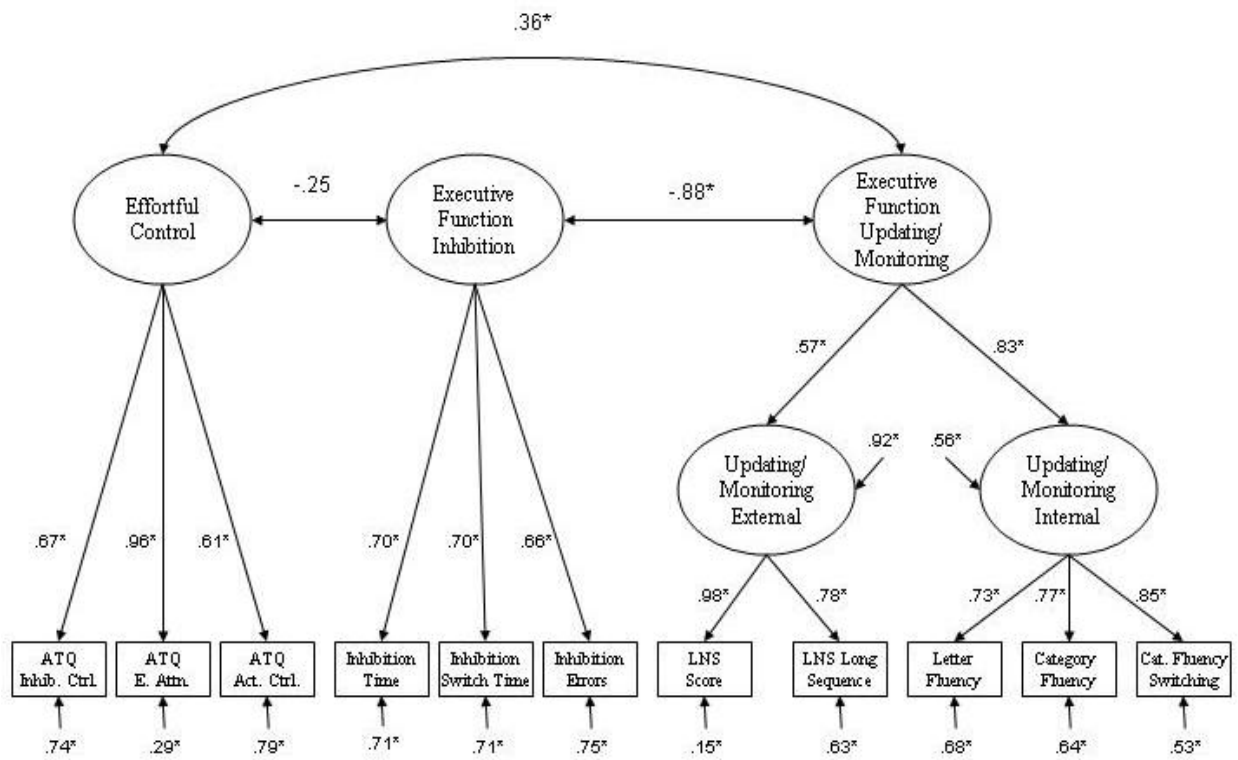


Figure 2. Study 2 structural equation model depicting association between effortful control and the executive functions of updating/monitoring information in working memory and inhibition. Standardized coefficients are displayed.

* $p < .05$

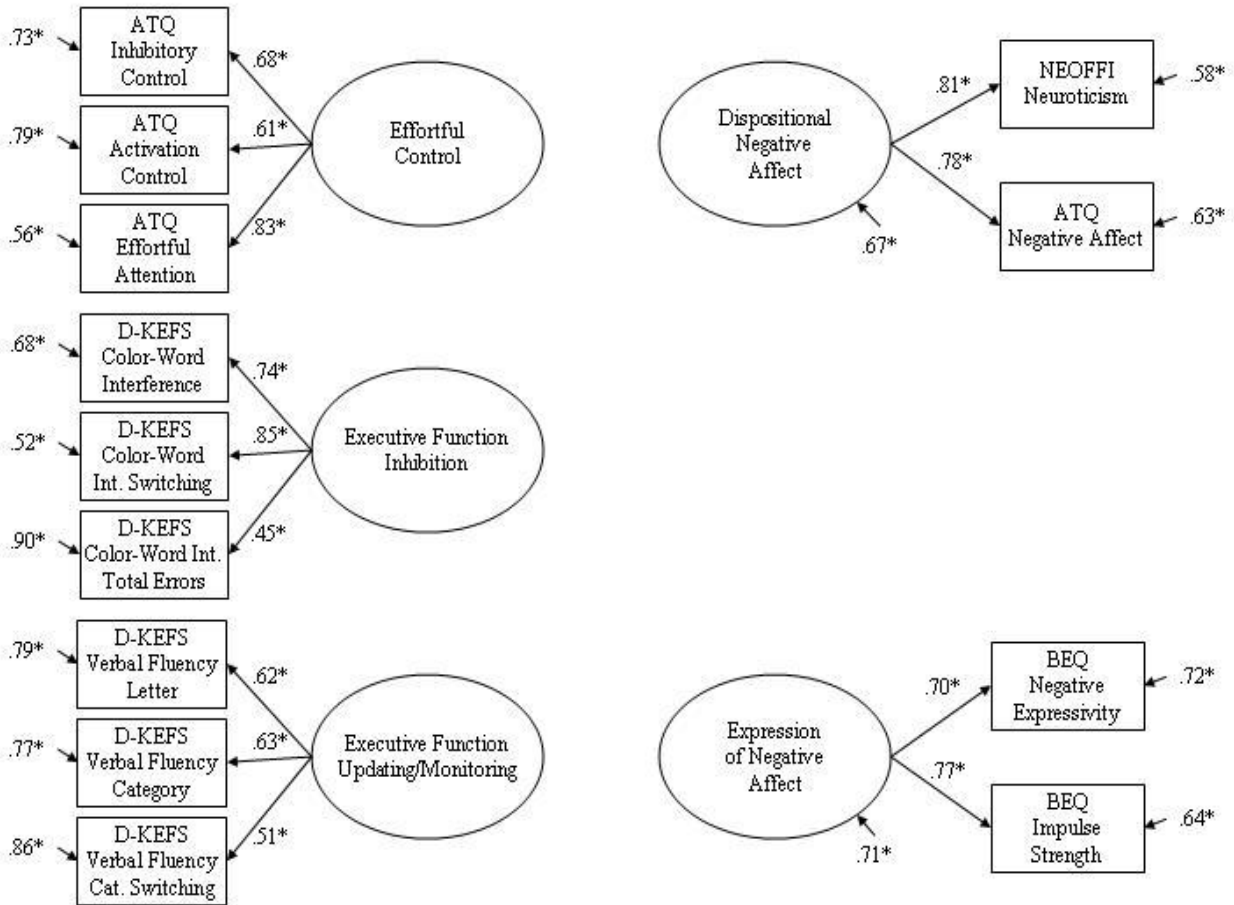


Figure 3. Observed variables, factor loadings, and error variances for the structural equation model testing the association between effortful control and executive function constructs, and between self-regulation and the dispositional tendency to experience negative affect and the tendency to express negative affect. Only standardized coefficients are displayed.

* $p < .05$

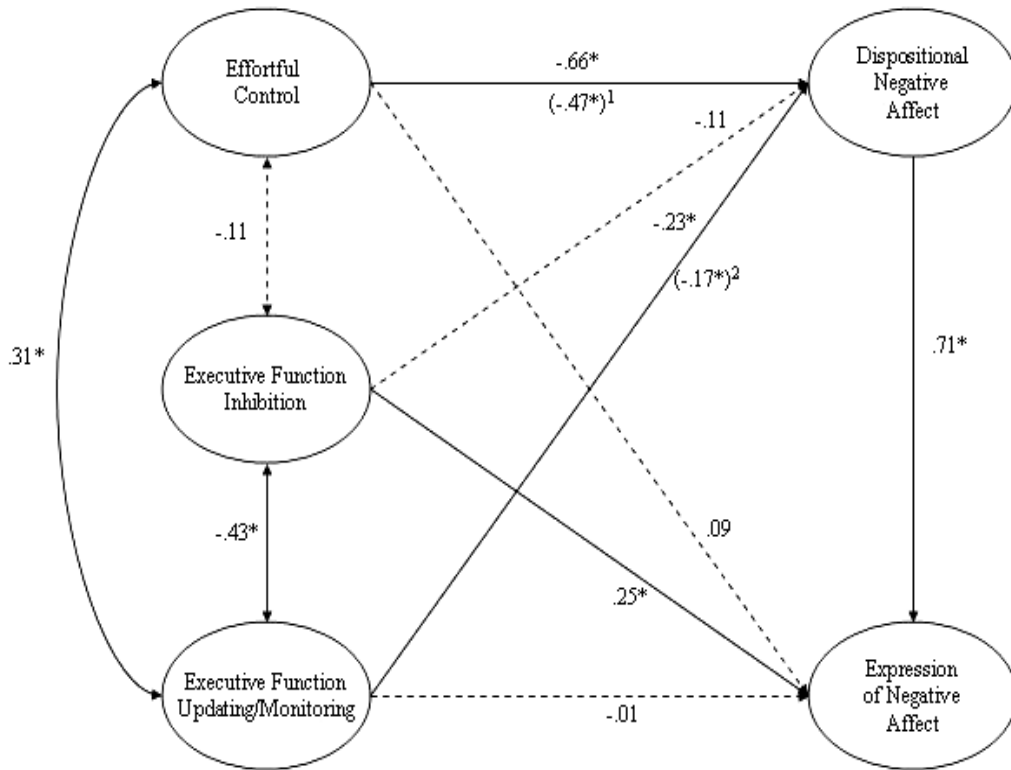


Figure 4. Structural equation model, depicting standardized coefficients between latent variables, testing associations between effortful control and the executive functions of updating/monitoring information in working memory and inhibition, and between self-regulation and the dispositional tendency to experience negative affect and the tendency to express negative affect.

1. Standardized coefficient for the indirect effect of effortful control on the expression of negative affect.
2. Standardized coefficient for the indirect effect of updating/monitoring information in working memory on the expression of negative affect.

* $p < .05$