

Individual Differences in Executive Functioning and Their Relationship to Emotional Processes and Responses

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Abstract

The executive functions (including response inhibition, memory updating, and task switching) appear to form the core of higher-order cognitive processes in humans. Relatively little research has been devoted to the role of the executive functions in emotional and motivational processes. The current article surveys evidence on the contributions of individual differences in executive functioning to emotion and emotion regulation in adults. The findings reveal that cognitive ability helps to shape human emotional life and raise new questions about how and why this is so.

Keywords

executive functioning, emotion regulation, inhibition, working memory

Some minds are more nimble than others, insofar as they more capably juggle multiple streams of information, suppress unwanted information from awareness, and shift seamlessly between tasks. Research over the past two decades has found ample evidence that these executive functions undergird performance on numerous cognitive challenges. For example, the capacity to update the contents of working memory contributes to logical reasoning (e.g., Kyllonen & Christal, 1990), dual tasking (e.g., D'Esposito et al., 1995), goal maintenance (e.g., Kane & Engle, 2003), and planning (e.g., Miyake et al., 2000).

But what about emotional processes and responses? Does the nimble-mindedness that enables good performance on cognitive tasks also influence human emotional life? Historically, research on the executive functions has focused on identifying the mechanisms underlying cognitive task performance. More recently, researchers have begun to focus on the interplay of executive functions and emotions (e.g., Gray, 2004). Most of this research has examined the effects of emotions on cognitive performance, and the central question has been: Do emotional states moderate the operation of the executive functions? Many experiments have found that they do. For example, mild negative affect has been found to improve inhibitory control, whereas more intense negative affect undermines it (Pessoa, Padmala, Kenzer, &

Bauer, 2012). Negative emotions also appear to impair memory updating (Curci, Lanciano, Soletti, & Rimé, 2013). Positive emotions can enhance task switching but also increase distractibility (Dreisbach & Goschke, 2004; see also Phillips, Bull, Adams, & Fraser, 2002), depending on whether the positive affect is high versus low in approach motivation (Liu & Wang, 2014).

The current article considers the converse form of influence—namely, the influence of executive functions on emotions. Do individual differences in executive functioning contribute to differences in emotional responding?

Executive Functions

The executive functions are processes associated with the frontal lobes of the brain that coordinate and regulate other processes and brain regions. Researchers have yet to identify a definitive list of the executive functions, but many lists feature response inhibition, forming and implementing plans, switching between tasks, maintaining and updating the contents of memory, and resisting

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interference from distractions as core executive functions. In an influential study, Miyake et al. (2000) invited college students to perform a battery of putative executive-functioning tasks and found evidence for three related but empirically distinct processes underlying performance: information monitoring and *updating*, mental set *shifting*, and *inhibition* of prepotent responses. Subsequent research has revealed that performance on diverse executive-functioning tasks can be boiled down to a common element that appears to contribute to performance across different tasks and across elements that are unique to each function or task (see Miyake & Friedman, 2012). The current article focuses on the respective contributions of individual differences in updating, shifting, and inhibition to emotional processes and responses.

Emotion Regulation

Because the executive functions are thought to coordinate and regulate other processes, we reasoned that they may also contribute to emotion regulation. Emotion regulation refers to efforts to change the duration or intensity of an emotional response. For example, a graduate student who feigns enthusiasm for a tedious task, a footrace winner who suppresses her pride to spare the feelings of her competitors, and a first-time dater who reappraises his nervousness as excitement are all engaging in emotion regulation (see Gross, 2013; Koole, 2009). The cognitive processes that underlie emotion regulation have not been specified, but the executive functions are likely contributors. Inhibition, for example, may enable expressive suppression, which involves reducing outward expressions of emotion, and updating is likely to aid reappraisal, which involves generating and maintaining nonemotional appraisals for emotionally charged events.

Inhibitory Control and Emotion Regulation

One of the first studies to consider the relationship between executive functioning and emotion regulation in adults looked for links between inhibitory control and the suppression of socially inappropriate expressions of emotion (von Hippel & Gonsalkorale, 2005). Participants completed a Stroop task as a measure of inhibitory ability. Then, in the crucial condition of the study, non-Asian participants were asked by a Chinese experimenter to taste what was purported to be the national dish of China: a chicken foot. Participants' facial expressions and verbal utterances were recorded by a hidden camera as they received the chicken-foot dish. Participants who performed better (more quickly) on the Stroop task exhibited less negative responses, providing initial evidence that

individual differences in executive functioning may contribute to successful emotion regulation. Specifically, inhibitory control appeared to contribute to the successful suppression of socially inappropriate emotional expressions.

Despite this promising beginning, only a handful of subsequent studies have examined individual differences in inhibitory control and emotion regulation. One fMRI study tested the hypothesis that the same brain regions contribute to both inhibitory control and emotion regulation (Tabibnia et al., 2011). Participants in this study completed a popular measure of inhibitory control (i.e., the stop-signal task) and an emotion-reappraisal task. Better performance on the stop-signal task predicted more successful emotion regulation (i.e., less negative affect after viewing aversive images under instructions to reappraise), and activity in the right inferior frontal gyrus appeared to underlie performance on both tasks. This study suggested that inhibitory control contributes to successful reappraisal, presumably by inhibiting emotional appraisals and paving the way for nonemotional ones.

Participants in another study completed the stop-signal task and then retrieved an angry, anxious, or emotionally neutral autobiographical memory (Tang & Schmeichel, 2014). Better performance on the stop-signal task predicted less anger and anxiety after recalling emotionally charged memories. Further, objective text analysis and ratings by naïve judges revealed that the emotional content of participants' memories did not vary as a function of inhibitory ability. Thus, participants recalled equally emotional memories, but those higher in inhibitory control felt less negative emotion after recalling them. These patterns suggested that inhibitory control regulates subjective responding to a common method of emotion induction: recalling emotional events. Thus, in addition to aiding expressive suppression and reappraisal, good inhibitory control may also contribute to the inhibition of subjective emotional responses.

Memory Updating and Emotion Regulation

The capacity to monitor and update the contents of working memory may also be relevant for emotion regulation. For example, updating may help to sustain the intention to suppress emotions in the presence of stimuli that otherwise trigger emotional responses and may also help to generate and maintain nonemotional appraisals of emotional events. Several studies have found support for these notions by examining the relationship between working memory capacity and emotion regulation.

In a first study (Schmeichel, Volokhov, & Demaree, 2008), participants completed a well-validated measure of working memory capacity known as the operation-span

task (OSPAN; Turner & Engle, 1989), which required them to encode and recall word lists while solving simple math problems. Then they viewed a highly aversive film clip under instructions to suppress all expressions of emotion. Participants with higher working memory capacity expressed less emotion on their faces. A second study found the same pattern using an amusing film clip. Together, these studies support the idea that working memory capacity contributes to successful suppression of facial expressions of emotion.

Schmeichel and colleagues (2008) also observed a relationship between working memory and success at making nonemotional appraisals of emotional stimuli. Participants in one study completed the OSPAN and then viewed a disgust-inducing film clip under instructions either to view the film clip naturally (express condition) or to adopt an unemotional attitude and think about the film objectively (reappraisal condition). Working memory moderated the effectiveness of cognitive reappraisal, such that only participants with higher capacity reported less disgust after reappraisal. A final study in this series replicated this pattern using a different measure of working memory (the *n*-back task) and different emotion-laden film clips.

Altogether, the studies by Schmeichel et al. (2008) revealed that working memory capacity is important for success at two different forms of emotion regulation—expressive suppression and cognitive reappraisal. However, a more mundane explanation for their findings is possible: Because participants were instructed to regulate their emotional responses, the results may show simply that individuals with higher cognitive ability are better at following instructions (e.g., Engle, Carullo, & Collins, 1991). The question arises, then, whether the link between executive functioning and successful emotion regulation is a simply a matter of following orders.

To answer this question, Schmeichel and Demaree (2010) examined spontaneous or uninstructed emotion regulation. After completing the OSPAN, participants took a bogus personality test and received either negative feedback or no feedback about their personalities. Based on previous evidence that people respond defensively when their self-image is threatened (e.g., Greenberg & Pyszczynski, 1985), the authors predicted that receiving negative feedback would increase the motivation to self-enhance. Participants then completed a test purported to measure crystallized intelligence. This test was in fact the Over-Claiming Questionnaire (OCQ), a disguised measure of self-enhancement tendencies developed by Paulhus, Harms, Bruce, and Lysy (2003). The OCQ asks respondents to rate their familiarity with different components of cultural knowledge. Embedded in the OCQ are several fake items, and self-enhancement was quantified as the proportion of fake items participants deemed familiar.

Negative feedback caused an increase in self-enhancement, but only among participants higher in working memory capacity. Participants higher in capacity also reported less negative emotion at the end of the experiment, suggesting successful emotion regulation. These results are consistent with the view that participants spontaneously recruited cognitive resources to cope with threats to self-regard and minimize negative emotion. Further, because participants had not been instructed to regulate their emotions, the observed link between higher working memory capacity and less negative emotion cannot reflect differences in following directions.

Another study by a different team of investigators replicated and extended the evidence that working memory contributes to successful emotion regulation. McRae, Jacobs, Ray, John, and Gross (2012) measured several different cognitive abilities, including working memory capacity, set-shifting ability, verbal ability, abstract reasoning, and inhibitory control, and then examined how each of these abilities relates to cognitive reappraisal. They found that successful reappraisal correlated with working memory capacity and with set-shifting ability but not with verbal ability, reasoning ability, or inhibitory control.

Batteries of Executive-Functioning Tasks and Emotion Regulation

The study by McRae et al. (2012) is one of several studies that has examined several cognitive abilities and associated them with emotion-regulation outcomes. For example, Gyurak and colleagues (Gyurak, Goodkind, Kramer, Miller, & Levenson, 2012; Gyurak et al., 2009) conducted two studies involving a battery of cognitive tests, including verbal and spatial measures of updating, the Stroop task to measure inhibition, the Trail Making Test to measure shifting, and a measure of verbal fluency. In the first study, the key emotional responses were facial expressiveness and body movement during the 5 seconds following an aversive but expected noise burst. In the second study, the key responses were changes in heart rate and facial expressions as participants attempted to regulate responses to disgust-inducing film clips. In both studies, only verbal fluency predicted successful emotion regulation, such that those higher in verbal fluency were less startled by the aversive noise and regulated their facial and cardiovascular responding more effectively during disgust-inducing film clips.

The predictive power of cognitive ability also appears to hold up outside the laboratory. A daily diary study including over 1,000 adult participants found that executive functioning predicts successful emotion regulation in response to daily life events (Stawski, Almeida, Lachman, Tun, & Rosnick, 2010). Participants completed

a phone-based battery of executive-functioning measures, including tests of working memory and verbal fluency. Participants also completed brief interviews about their experiences and emotions on 8 consecutive days. Better executive functioning predicted smaller stressor-related increases in negative mood but more stressors. That is, adults with higher (vs. lower) cognitive ability experienced more daily hassles, but they experienced smaller changes in mood in response to those hassles. These results provide novel support for the hypothesis that executive functioning helps to regulate emotional responding to stressors, and they provide compelling evidence that this relationship exists outside the laboratory.

Summary

Individual differences in executive functioning predict differences in success at emotion regulation. This relationship has been observed across diverse measures of both executive functioning and emotion regulation. It holds across a range of cognitive-ability levels and has been detected both inside and outside of the laboratory. The most reliable predictor has been working memory capacity—an index of the executive function of updating. Higher capacity has been associated with success at expressive suppression, cognitive reappraisal, self-enhancement following negative feedback, and coping with daily stressors. However, two studies found no relationship between working memory and emotion regulation as assessed by responses to a startling noise and to disgusting film clips, respectively.

The evidence pertaining to shifting and inhibition is still relatively scarce. One study found that shifting (as well as updating) predicted success at reappraisal, though other studies found null effects or did not include a measure of shifting. Regarding inhibition, performance on the Stroop task has been found to moderate the expression of socially inappropriate emotions, and performance on the stop-signal task has been observed to predict both successful reappraisal of negative emotional images and less negative emotional experience after recalling angry or anxious memories. However, a handful of other studies found null effects of inhibition or failed to include a standard behavioral measure of inhibition. This is surprising, insofar as inhibition seems like an obvious candidate contributor to emotion regulation. It may be that inhibitory processes are routine or ubiquitous enough in emotion regulation that individual differences in inhibitory control become relevant only when the emotional response is particularly strong.

Conclusions

Altogether, the most appropriate conclusion is that the relationship between executive functioning and emotion

regulation may depend on the specific forms of executive functioning and emotion regulation under investigation. The tendency has been for different investigators to use different measures. One upshot of this tendency is increased confidence in the existence of a link between the two constructs when different methods yield converging evidence, and there are obvious signs of this in the extant research. But different patterns of results across studies using different measures limit the conclusions that can be drawn. A great deal of theoretical and empirical work remains to be done to draw more specific conclusions about when and why individual differences in executive functioning predict successful emotion regulation.

Going forward, a deeper understanding of the cognitive requirements for different forms of emotion regulation is needed to derive more precise predictions. Precisely what cognitive capacities are needed to suppress an emotional expression? At minimum, expressive suppression would seem to require the capacity to attend to an emotional event and simultaneously monitor one's emotional response to the event, in addition to the capacity to stifle any expressions of emotion that arise. In this analysis, both inhibition and updating are relevant, and the evidence reviewed above supports the notion that these two executive functions contribute to suppression. Shifting may also be relevant (e.g., switching between attending to the emotional event and attending to one's response), though the role of shifting in expressive suppression has received little attention in research.

A similar analysis of the cognitive requirements for successful reappraisal, distraction, situation selection, self-enhancement, and other forms of emotion regulation would help to advance research in this domain. We presume that emotion-regulation attempts rely on multiple executive functions. Much as performance on complex cognitive tasks (e.g., the Stroop task) is not process pure, emotion-regulation attempts are likely not process pure. The process-impurity problem further underscores the need for a taxonomy of cognitive requirements for different forms of emotion regulation. The research reviewed in this article provides an initial step in this direction by identifying links between specific executive functions and success at emotion regulation. Future research may also benefit from moving beyond bivariate relationships between different forms of executive functioning and emotion regulation to quantifying the latent factors that may link the two constructs.

Recommended Reading

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