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Does mood help or hinder executive functions? Reactivity may be the key

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ABSTRACT

Our ability to utilize executive functioning (EF) in day-to-day life is influenced by our mood, which consists of two fundamental dimensions reflecting positive and negative affect. It remains unclear, however, what impact these affective experiences have on our executive skills and whether this association may be influenced by individual differences in emotional reactivity. Our study investigated the interplay of emotional reactivity, naturally occurring variations in affective dimensions underlying mood, and latent constructs of response inhibition and working memory in an undergraduate sample. Reactivity moderated an association between negative affect and EF, such that high-reactive individuals performed better on EF tasks when experiencing high levels of negative affect whereas low-reactive individuals showed the converse pattern. These results are discussed through the lens of mood-related effects on information processing styles and the availability of cognitive resources to cope with current situational demands. An implication of this work is that emotional reactivity is an important factor in understanding how affective experiences influence executive skills and, by extension, everyday function.

1. Introduction

Think before you act. This simple instruction is the basis for keeping oneself from getting into trouble at work and at school, in social situations and with the law. Keeping track of important information (i.e., working memory; Baddeley, 1992) and withholding responses that are pre-potent yet inappropriate (i.e., response inhibition; Nigg, 2000) are foundational executive skills that play an integral role in our ability to navigate the ever-changing milieu of day-to-day life (Friedman & Miyake, 2017). These skills, commonly referred to as executive functions (EF), have a protracted course of development and are not fully mature until the second decade of life (for review see Luna, Marek, Larsen, Tervo-Clemmens, & Chahal, 2015). Even in adulthood, however, there exists a great deal of variability in how successful individuals are at using their executive skills – particularly in situations that are affective in nature (Pessoa & McMenamin, 2017).

In one of the most basic yet well-validated of taxonomies, mood is represented by two distinguishable feeling states that broadly reflect enthusiasm (i.e. positive affect) and distress (i.e. negative affect) along a continuum of low to high emotional arousal (Watson, Clark, & Tellegen, 1988; Watson & Tellegen, 1985). In this framework, positive and negative affect are orthogonal dimensions such that an individual may simultaneously experience high, low, or mixed levels of both. Compared with emotions, moods tend to be less intense, longer lasting, and typically lack a well-defined object of reference (Larsen, 2000). Because moods may thus be less amenable to regulatory efforts and more prone to dysfunction, they have the potential to exert particularly salient and widespread influences on EF.

In their review of the extant literature on this topic, Mitchell and Phillips (2007) identified three theoretical accounts for the impact of mood states on select executive skills. Cognitive load theory posits that moods place demands on cognitive resources that interfere with the application of EF, leading any mood state to interfere with EF-task performance. In contrast, mood-as-information theory suggests that the impact of mood on EF-task performance varies as a function of mood state. According to this perspective, positive moods signify the absence of threat and promote a heuristic processing style that hinders EF-task performance, whereas negative moods signify the presence of threat and promote an analytic processing style that has the converse effect. A final theory proposes that positive moods activate a network of positive cognitions that facilitate problem-solving on interesting and/or novel EF tasks. Based on the balance of available evidence, Mitchell and Phillips (2007) concluded that positive moods likely bolster cognitive flexibility/creativity, hinder working memory, and have inconsistent effects on response inhibition. They further noted, however, that little research had explored the interplay of negative mood and EF, nor had studies explored potential moderators of mood-EF associations – an important consideration given the heterogeneity of research findings.

Building on this body of work, our study explored whether mood states are differentially associated with the core executive skills of

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working memory and response inhibition, and the extent that these associations are moderated by the onset, intensity, and duration of one's affective experience (i.e., emotional reactivity). We evaluated emotional reactivity as a potential moderator of mood-EF associations because individual differences in this construct are evident early in life, persist into the adult years, and are linked to factors that increase risk for psychopathology (Davidson, 1998; Larsen & Diener, 1987; Sturm, Haase, & Levenson, 2016). In a departure from many studies in this field, we opted to assess naturally occurring variations in mood because it is believed to be more representative of the kinds of mood fluctuations that characterize our daily, lived experience (Parrott & Hertel, 1999). Rather than focus solely on positive affect or negative affect in our analyses, however, we examined both in tandem because doing so is likely to provide a more accurate assessment of an individual's mood compared with either dimension examined in isolation (Watson et al., 1988; Watson, Wiese, Vaidya, & Tellegen, 1999).

Our predictions were derived from the integration of two theories described by Mitchell and Phillips (2007). Consistent with mood-as-information theory, we expected negative affect to promote an analytic thinking style that would bolster performance on our EF tasks, and positive affect to promote a heuristic thinking style that would have the opposite effect. We further anticipated, however, that the influence of mood-induced processing styles on EF would vary under conditions of cognitive load, with load being inversely related to emotional reactivity. Consequently, we hypothesized that better levels of EF task performance would be observed in highly reactive individuals experiencing high levels of negative affect compared with individuals experiencing other combinations of reactivity and affect. These predictions are presented in Table 1.

2. Method

2.1. Participants and procedure

Participants were recruited through a departmental pool of students enrolled in psychology courses at the University of [blinded]. Ninety-six undergraduates completed a 90-minute session for course credit (mean age = 19.8 years, age range = 17 to 30, 66% female, 31% Asian, 30% Caucasian, 16% South Asian, 23% Other). Because this was an individual differences design, measures were presented in the following fixed order across all participants: Letter-Number Sequencing, Flanker, Positive and Negative Affect Schedule, Automated Reading Span, Emotion Regulation Questionnaire, Stop Signal, Emotion Reactivity Scale, Automated Operation Span, Brief Symptom Inventory, Spatial Compatibility, and a Demographic Questionnaire. The Emotion Regulation Questionnaire and Brief Symptom Inventory are the focus of another study and are not described here further.

2.2. Measures

2.2.1. Working memory tasks

2.2.1.1. Letter-Number Sequencing (Wechsler, Coalson, & Raiford, 2008). Participants were required to re-sequence an auditory string of jumbled numbers and letters in alpha-numeric order. Strings increased in length from two to nine items, with each length presented in a block of three trials, until participants failed to correctly repeat all three strings within a block. A total score was derived by summing the number of correctly recalled strings (mean = 20.87, standard deviation = 2.27, skew = 0.02, kurtosis = −0.67). Internal consistency could not be ascertained in our sample as only total scores were available for analysis; however, test-retest reliability of this task is 0.88 per the WAIS-IV manual.

2.2.1.2. Automated Reading Span and Operation Span (Unsworth, Heitz, Schrock, & Engle, 2005). Participants were instructed to hold letters in mind whist evaluating either reading problems or math problems that were interleaved between each letter. Both tasks presented strings ranging from three to seven letters in length in three blocks consisting of five strings each. An absolute score was derived by summing the number of trials on which the participant recalled all letters correctly (reading span: mean = 35.37, standard deviation = 17.18, skew = 0.46, kurtosis = −0.40; operation span: mean = 43.39, standard deviation = 19.89, skew = −0.88, kurtosis = 1.98). Internal consistency was 0.89 for operation span and 0.78 for reading span using participants' scores from the three blocks of each task.

2.2.2. Inhibition tasks

2.2.2.1. Spatial Compatibility (Simon & Rudell, 1967). Participants were required to rapidly respond to the direction of a peripherally presented left- or right-pointing arrow using either a left or right keypress. Following a central fixation of 500 milliseconds (ms), an arrow appeared on either the right or left side of the screen. On compatible trials, the arrow pointed in the same direction as the side on which it appeared (e.g., right pointing arrow on the right side), whereas the converse occurred on incompatible trials (e.g., right pointing arrow on the left side). Following a keypress, or up to 2000 ms, a blank interval of 1000 ms was presented. The task included 24 trials in each condition, with trial type randomly inter-mixed. Inhibitory ability was assessed by correct RT (ms) on incompatible trials (mean = 517.06, standard deviation = 91.85, skew = 0.39, kurtosis = 0.82). Internal consistency of trials in the incompatible condition was 0.80.

2.2.2.2. Flanker (Eriksen & Eriksen, 1974). Parameters of the task were identical to those of the spatial compatibility task, except that the stimulus consisted of a central arrow flanked on either side by two arrows that pointed in the same direction on compatible trials (e.g., right-pointing central arrow surrounded by right-pointing flankers) and in the opposite direction on incompatible trials (e.g., right-pointing central arrow surrounded by left-pointing flankers). Inhibitory ability was assessed by correct RT (ms) on incompatible trials (mean = 456.61 standard deviation = 65.82, skew = 1.71, kurtosis = 1.47). Internal consistency of trials in the incompatible condition was 0.89.

2.2.2.3. Stop Signal (Logan, Cowan, & Davis, 1984). Task parameters were similar to those of the spatial compatibility task, except that participants were instructed to respond to a centrally presented pink or green star and to stop their response when the star was followed by a tone. Timing of the tone was determined using a dynamic tracking algorithm such that participants were able to stop their response on approximately 50% of trials. The task was presented in four blocks, with each block including 8 (25%) stop trials and 24 (75%) go trials. Inhibition was indexed using the stop signal reaction time (SSRT), calculated as the mean delay of the stop signal subtracted from the average time taken to correctly respond to the stimulus on go trials in ms (mean = 304.85, standard deviation = 52.36, skew = 1.00, kurtosis, 1.47). Internal consistency of stop trials was 0.96.

2.2.3. Self-report questionnaires

2.2.3.1. Positive and Negative Affect Schedule (PANAS; Watson et al., 1988). This 20-item scale was conceived of as a mood measure by its

Table 1
The anticipated interplay of affective dimensions underlying mood with reactivity on executive functioning performance based on cognitive load theory (rows) and mood-as-information theory (columns), with asterisks denoting the strength of the prediction.

	High Negative Affect (more analytic)	High Positive Affect (more heuristic)
High Emotional Reactivity (lower cognitive demands)	Better**	Worse*
Low Emotional Reactivity (higher cognitive demands)	Worse*	Worse**