Journal of Experimental Psychology: General
2012, Vol. 141, No. 3, 411–416

0096-3445/11/$12.00 DOI: 10.1037/a0026322

BRIEF REPORT

Performance Costs When Emotion Tunes Inappropriate Cognitive Abilities: Implications for Mental Resources and Behavior

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Emotion tunes cognition, such that approach-motivated positive states promote verbal cognition, whereas withdrawal-motivated negative states promote spatial cognition (Gray, 2001). The current research examined whether self-control resources become depleted and influence subsequent behavior when emotion tunes an inappropriate cognitive tendency. In 2 experiments, either an approach-motivated positive state or a withdrawal-motivated negative state was induced, and then participants completed a verbal or a spatial working memory task creating conditions of emotion–cognition alignment (e.g., approach/verbal) or misalignment (e.g., approach/spatial). A control condition was also included. To examine behavioral costs due to depleted self-control resources, participants completed either a Stroop task (Stroop, 1935; Experiment 1) or a Black/White implicit association test (IAT; Greenwald, McGhee, & Schwartz, 1998; Experiment 2). Participants in the misalignment conditions performed worse on the Stroop task, and they were worse at controlling their implicit attitude biases on the IAT. Thus, when emotion tunes inappropriate cognitive tendencies for one's current environment, self-control resources become depleted, impairing behavioral control.

Keywords: emotion, cognition, regulation, self-control, ego depletion

Supplemental materials: http://dx.doi.org/10.1037/a0026322.supp

William James suggested that cognitive processes are in the service of action (James, 1890), and to serve action people's cognition needs to be responsive to their goals and the environment in which they pursue them (Schwarz, 2006). Emotion can serve as an environmental cue to prioritize cognitive processes (Lazarus, 1991; Simon, 1967). For instance, cognitive tuning models suggest that positive affect signals a benign situation promoting relational, heuristic, or intuitive processing styles, whereas negative affect signals a problematic situation inhibiting routine processing and instead promoting item-specific, systematic, or reflective processing styles (Bolte, Goschke, & Kuhl, 2003; Clore et al., 2001; Kuhl, 2000; Schwarz, 2002; Strack & Deutsch, 2004). In addition, emotion can also tune specific kinds of cognitive control processes, such as working memory (Dreisbach & Goschke, 2004; Gray, 2001).

Behavioral performance becomes impaired when emotion tunes an incompatible cognitive process for a task. Gray (2001) observed that an approach-motivated positive state enhanced verbal, but impaired spatial, working memory (WM) performance, whereas a withdrawal-motivated negative state enhanced spatial, but impaired verbal, WM performance. Similarly, Dreisbach and Goschke (2004) found that an approach-motivated positive state promoted cognitive flexibility and performance improved when task demands required flexible (vs. fixed) responding. Therefore, performance depended on the alignment of emotion, cognition, and task demands. When emotions tuned a cognitive process that matched task demands, representing a state of *alignment*, performance improved. But when emotions tuned a cognitive process that mismatched task demands, representing a state of *misalignment*, performance declined.

Emotion–cognition misalignment produces behavioral costs (e.g., Gray, 2001), and in the current studies I investigated whether those behavioral costs are related to a depletion of self-control resources. I postulated that if emotions do tune an inappropriate cognitive process for current task demands, self-control is required to inhibit the cognitive tendency promoted by the emotional state. Because people have a limited amount of self-control resources, the utilization of self-control to inhibit the cognitive tendency promoted by the emotional state can deplete this resource (Kahneman, 1973; Vergauwe, Barrouillet, & Camos, 2010). When the limited pool of self-control resources becomes depleted, performance is impaired for subsequent tasks that also require self-control (Hagger, Wood, Stiff, & Chatzisarantis, 2010; Inzlicht & Gutsell, 2007; Muraven & Baumeister, 2000). For instance, participants engaged in a task that required a high level of self-control (emotion flow task) or a low level of self-control (emotion suppression task), and then candies were made available to the participants after they completed the task. Those participants who actively monitored their diet, which requires self-control after, ate

This article was published Online First November 14, 2011.

Support for this research is acknowledged from National Institute of Mental Health Grant RO1 MH0 50074 to Gerald L. Clore.

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more candies following the high-demand (vs. low-demand) self-control task (Hofmann, Rauch, & Gawronski, 2007).

I adopted the self-control depletion paradigm, as just described, with the belief that when self-control resources are utilized on the first task, performance will be impaired on a second task. However, instead of manipulating the self-control demands on the first task, this research manipulated the alignment between the cognitive tendency promoted by the induced emotional state and the cognitive demands of the first task (i.e., verbal or spatial WM). Then all participants completed a second task that required self-control resources to perform well. I postulated that when an emotion (e.g., approach-motivated positive state) tunes an inappropriate cognitive tendency (e.g., verbal), self-control resources are used to inhibit that tendency (e.g., verbal) because it is incompatible with the cognitive demands (e.g., spatial) of the WM task. However, when an emotion tunes an appropriate cognitive tendency that is compatible with the cognitive demands of the WM task, little self-control is required. Therefore, I predicted that a demand for self-control will arise for the emotion–cognition misaligned conditions during the WM task, depleting self-control resources and impairing performance on the second task. However, a low demand for self-control is expected for the emotion–cognition aligned conditions during the WM task, leaving self-control resources available to perform well on the second task.

Design

Approach-motivated positive states or withdrawal-motivated negative states were induced to activate a verbal or spatial cognitive tendency, respectively. A no-emotion control condition was included for both experiments. Participants were then randomly assigned to complete either a verbal or a spatial 2-back WM task (Jansma, Ramsey, Slagter, & Kahn, 2001). The WM task served two purposes: (a) to activate distinct verbal and spatial processes (Fletcher & Henson, 2001) and (b) to ensure constant attention and updating in order to deplete mental resources (Muraven & Baumeister, 2000). Combinations of emotional states and WM task demands were used to create the conditions of emotion–cognition alignment (approach/verbal or withdrawal/spatial) and conditions of emotion–cognition misalignment (approach/spatial or withdrawal/verbal). Following the WM task, participants completed a Stroop task (Experiment 1; Stroop, 1935) or a Black/White Implicit Association Test (IAT; Experiment 2; Greenwald, McGhee, & Schwartz, 1998). Both tasks require self-control resources to perform well (i.e., reduce the Stroop effect and control implicit attitude biases on the IAT). Moreover, the tasks were selected because emotion has converse effects on these tasks. Positive (vs. negative) moods enhance Stroop performance (Kuhl & Kazen, 1999), but positive (vs. negative) moods decrease the control of implicit attitude biases (Huntsinger, Sinclair, & Clore, 2009). The use of these two tasks can reveal whether emotion–cognition interactions have similar costs on tasks that have different outcomes under the same emotional state.

Experiment 1

In Experiment 1, the Stroop task was used to measure the depletion of self-control resources. The goal of the Stroop task is to name the color of the font in which a color word is printed. Sometimes the font is congruent with the word (the word *RED* in red font), and sometimes the font is incongruent (the word *RED* in blue font). The Stroop score is computed by subtracting reaction times on congruent trials from times on incongruent trials. A larger Stroop score indicates higher interference from noninhibited reading processes (Besner & Stolz, 1999). Given that a depletion of self-control resources increases the Stroop effect and errors on incongruent trials (Benton, Owens, & Parker, 1994; Inzlicht & Gutsell, 2007), I predicted that the misalignment (vs. alignment and control) conditions would have a higher Stroop effect and more errors on incongruent trials.

Method

Participants. One-hundred twenty-two (63 female) undergraduate students from the University of Virginia participated to fulfill a course requirement. All participants gave written, informed consent.

Materials

Mood induction. In the positive mood condition, participants watched a 5-min clip from *Jerry Seinfeld: Stand Up in New York.* In the negative mood condition, participants watched a 5-min clip from *The Champ* (Storbeck & Clore, 2011).

Working memory task. For both WM tasks, a trial consisted of a single letter presented in one of six locations, which was displayed for 1 s and then followed by a blank screen for 2 s, for a total trial duration of 3 s. For the verbal task, the letter was compared with the letter presented two trials back, whereas for the spatial task, the location of the letter was compared with the location of the letter presented two trials back. Participants were required to respond before the start of the next trial. Eighty trials were completed.

Stroop task. The words *BLUE, RED, GREEN,* or *YELLOW* were randomly presented in blue, red, green, or yellow font, and each word remained on the screen until a response was recorded, with an interstimulus interval of 500 ms. The keys were *Z* (blue), *X* (red), > (yellow), and *?* (green), and each key was labeled with a corresponding colored sticker. Participants completed 10 practice trials and 100 experimental trials (75% of trials were incongruent).

Mood check. Participants rated their feelings of happiness while they viewed the movie (or when they started the experiment for the control conditions) using a 6-point scale (6 = *very happy,* 1 = *very unhappy*).

Procedure. Participants received 20 practice trials for each WM task. Mood states were then induced, followed by completing either the verbal or the spatial WM task. Participants then completed the mood check, followed by the Stroop task.

Results

Mood manipulation check. The mood check was not completed by three participants. A mood manipulation check was conducted with a 3 (emotion: approach, withdrawal, control) × 2 (task: verbal vs. spatial) factorial analysis of variance (ANOVA). The main effect of task and the interaction were both nonsignificant, $F\text{s} < 1$. A significant main effect of emotion, $F(2, 118) = 134.28$, $p < .01$, $\eta^2 = .70$, was observed. The positive conditions were the most happy, followed by the control conditions, and the negative conditions were the least happy. (See Table 1 for means and statistics.)

Table 1
The Mood Manipulation Check Means (SD) and Statistics

Condition	Descriptive statistics and results		
	Positive	Negative	Control
Experiment 1: Mean happiness ratings	5.22 (0.83)$_{a}$	1.46 (0.70)$_{a,b}$	3.83 (1.23)$_{a,b}$
Experiment 2: Mean happiness ratings	4.84 (1.01)$_{c}$	1.89 (0.77)$_{c,d}$	3.81 (1.21)$_{c,d}$

Note. Values with the same subscripts signify mean comparisons that are significant at $p < .05$.

Working memory performance. WM accuracy was examined with a 3 (emotion) × 2 (task) factorial ANOVA. The main effect of task, $F(1, 121) = 2.66$, $p = .11$, $\eta^2 = .02$, and emotion, and the Emotion × Task interaction were all nonsignificant, Fs < 1. (See Table 2 for descriptive statistics.)

Stroop performance. To test whether emotion–cognition interactions influenced Stroop performance, the Stroop score and errors on incongruent trials were subjected to separate 3 (emotion) × 2 (task) factorial ANOVAs. For the Stroop score, I observed a significant interaction, $F(2, 121) = 3.36$, $p < .05$, $\eta^2 = .06$, and the main effects for task, $F < 1$, and emotion, $F(2, 121) = 1.64$, $p = .20$, $\eta^2 = .03$, were nonsignificant. The alignment and control conditions had a lower Stroop score compared with the misalignment conditions (see Figure 1 for means, and see supplemental data for condition comparison results for both the Stroop effect and errors). As for the errors on incongruent trials, there was a significant interaction, $F(2, 121) = 7.98$, $p < .01$, $\eta^2 = .12$, and a significant main effect for emotion, $F(2, 121) = 5.49$, $p < .01$, $\eta^2 = .09$. The main effect for task was nonsignificant, $F < 1$. Participants in the alignment and control conditions made fewer errors compared with those in the misalignment conditions. For the emotion main effect, participants in the control condition had fewer errors compared with those in the positive, $p < .05$, and negative, $p < .05$, conditions (positive vs. negative, $p = .66$).

Discussion

Participants in the misalignment conditions had higher Stroop scores and more errors on incongruent trials compared with those in the alignment and the control conditions. Within the context of a self-control depletion paradigm, these results suggest that participants in the misalignment conditions experienced increased demands for self-control during the WM task, which led to impaired performance on the Stroop task.

Experiment 2

As mentioned above, positive and negative moods have converse effects on performance on the Stroop task and the IAT. Positive affect improves performance on the Stroop task (Kuhl & Kazen, 1999), whereas positive affect decreases performance on the IAT (Huntsinger et al., 2009). Therefore, the goal of Experiment 2 was to determine whether emotion–cognition interactions have the same influence for both tasks. Prior research has demonstrated increased implicit pro-White attitude biases following the depletion of self-control resources (Hofmann et al., 2007; Strack & Deutsch, 2004).

Method

Participants. One-hundred forty-seven (86 female) undergraduate students from Queens College–CUNY participated to fulfill a course requirement. All participants gave written, informed consent.

Materials. The mood induction and check and the WM task were the same as in Experiment 1.

Implicit Association Test. The race IAT measures implicit attitudes toward African Americans (AA) and European Americans (EA) by assessing associations between the concepts of race and pleasantness. Assessment involves comparing the speed of associations among the pairings of AA + pleasant versus EA + unpleasant and AA + unpleasant versus EA + pleasant.

The stimuli consisted of EA and AA faces that were used to represent the categories of EA and AA. Pleasant and unpleasant

Table 2
Mean and Standard Deviations for Working Memory Accuracy, by Condition

Condition	Descriptive statistics					
	PV	PS	NV	NS	CV	CS
Experiment 1						
Working memory accuracy	0.93	0.92	0.93	0.91	0.92	0.90
SD	0.04	0.06	0.05	0.03	0.08	0.06
Experiment 2						
Working memory accuracy	0.93	0.85	0.90	0.85	0.91	0.88
SD	0.03	0.07	0.07	0.07	0.07	0.09

Note. PV = positive verbal; PS = positive spatial; NV = negative verbal; NS = negative spatial; CV = control verbal; CS = control spatial.

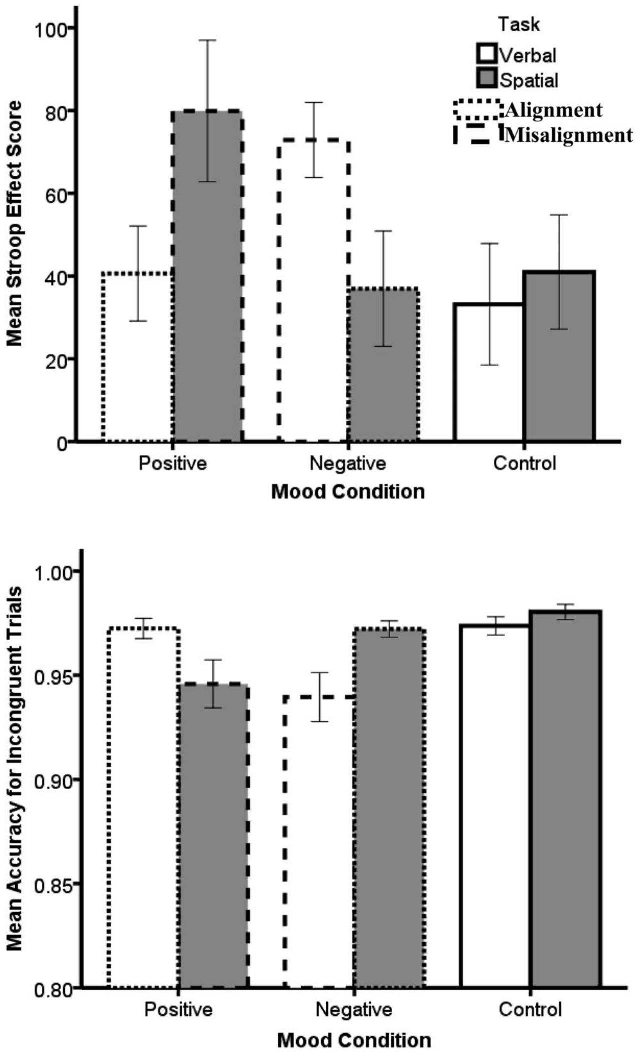

Figure 1. Mean Stroop effect score (top panel) and mean accuracy on incongruent trials (bottom panel) for mood by task in Experiment 1. Error bars represent one standard error of the mean.

words were used to represent the categories of pleasant and unpleasant (Nosek, Banaji, & Greenwald, 2002). The IAT consisted of a standard seven-block design (Nosek, Greenwald, & Banaji, 2007). The order of congruent (practice and test trials; 40 trials each block) and incongruent pairings was counterbalanced across participants (Blocks 3–4 and 6–7).

Explicit questionnaire. Explicit attitudes were assessed using a relative attitude measure toward AAs and EAs on a 7-point scale (1 = *strongly prefer EAs to AAs,* 7 = *strongly prefer AAs to EAs*).

Procedure. The procedure was identical to the Experiment 1 procedure, except the IAT replaced the Stroop task and the explicit attitude questionnaire was administered after the IAT.

Results

Mood manipulation check. A manipulation check was conducted with a 3 (emotion) × 2 (task) factorial ANOVA. A significant main effect of emotion, $F(2, 146) = 93.02$, $p < .01$, $\eta^2 = .57$, was observed, but the main effect of task and the interaction were both nonsignificant, Fs < 1. The positive conditions were the most happy, followed by the control conditions, and the negative conditions were the least happy. (See Table 1 for means and statistics.)

Working memory performance. Working memory accuracy was submitted to a 3 (emotion) × 2 (task) factorial ANOVA. A main effect for task was observed, $F(1, 146) = 21.49$, $p < .01$, $\eta^2 = .13$. The effects for emotion, $F < 1$, and the interaction, $F(1, 146) = 1.72$, $p = .18$, $\eta^2 = .02$, were both nonsignificant. The spatial task had a lower accuracy rate compared with the verbal task, $p < .01$. (See Table 2 for descriptive statistics.)

Explicit attitudes. A 3 (emotion) × 2 (task) factorial ANOVA was used to assess whether the conditions had a priori differences for explicit attitudes. Explicit attitudes did not differ across conditions as the main effects of task, $F(2, 146) = 1.65$, $p = .20$, $\eta^2 = .01$, and emotion and the interaction were all nonsignificant, Fs < 1.

Implicit Association Test. To test whether emotion–cognition interactions influenced performance on the IAT, a *d* score was computed (Greenwald, Nosek, & Banaji, 2003) and subjected to a 3 (emotion) × 2 (task) factorial ANOVA.[1] A significant Emotion × Task interaction was observed, $F(2, 146) = 5.80$, $p < .01$, $\eta^2 = .08$. The main effects of emotion, $F(2, 146) = 1.94$, $p = .15$, $\eta^2 = .03$, and task, $F < 1$, were both nonsignificant. Planned comparisons were run, and the misalignment condition had a higher *d* score compared with the alignment and control conditions. (See Figure 2 for the means and supplemental data for condition comparisons.)

Discussion

Participants in the misalignment condition demonstrated a stronger pro-White implicit attitude bias compared with those in the alignment and control conditions. These results are consistent with other research demonstrating impaired control of implicit attitude biases (Hofmann et al., 2007) after self-control resources had been depleted.

General Discussion

Behavioral costs were observed on a self-control task when emotion tuned an inappropriate cognitive tendency for the primary WM task. Specifically, emotion–cognition misalignment participants, relative to alignment and control participants, performed worse on the Stroop task (Experiment 1) and revealed a stronger pro-White attitude bias on a Black/White IAT (Experiment 2). Interpreting these results within a self-control resource-depletion framework, I suggest that emotion and cognition misalignment requires self-control resources in order to regulate competition between cognitive tendencies promoted by the emotional state and the cognitive processes necessary for the current task.

[1] When order was included as an independent variable, no interactions or main effects of order emerged, Fs < 1.

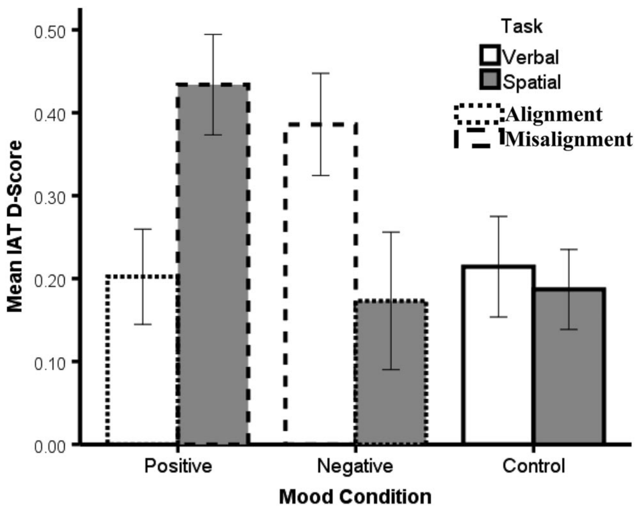

Figure 2. Mean Implicit Association Test *d* score for Mood × Task in Experiment 2. A higher *d* score signifies a stronger pro-White bias. Error bars represent one standard error of the mean.

Emotion–Cognition Interactions and Resource Management

Cognitive and emotional processes compete for a central pool of limited domain general resources (Kahneman, 1973;Vergauwe et al., 2010). Emotion–cognition interactions may manage the expenditure of resources more adaptively because of structural and functional adaptations in the brain (Gray, 2004; Pessoa, 2008). For example, approach-motivated positive emotion and verbal WM coactivate the left prefrontal cortex, and withdrawal-motivated negative emotion and spatial WM coactivate the right prefrontal cortex (Davidson, 1998; D'Esposito et al., 1998; Harmon-Jones & Sigelman, 2001; Petrides, 1995). This coactivation for emotion and cognition alignment may result in shared cognitive goals reducing competition for resources. However, when emotion and cognition are misaligned, different cognitive goals are promoted by the emotional state and by the demands of the task, producing competition over resources. This competition invokes self-control processes to regulate the priorities of the different cognitive goals, impairing subsequent behaviors that require self-control.

Limitations

WM performance was not influenced by emotion and cognition interactions. Although performance differences were not observed, it is possible that the misalignment condition was able to maintain WM performance through compensatory processes. In support of this conclusion, Gray, Braver, and Raichle (2002) also failed to find behavioral differences in a similar paradigm. However, brain activation differences appeared in the lateral prefrontal cortex consistent with the interpretation that emotion–cognition misalignment increased regulatory processes.

Conclusion

In everyday life, I propose that specific emotions promote specific kinds of cognitive tendencies, which is beneficial when appropriate for one's current environment or quite costly when inappropriate for one's current environment. For instance, a person in a withdrawal-motivated negative emotion, automatically activating spatial cognition, would effortlessly scan a dangerous forest and still have self-control resources available to inhibit inappropriate behaviors (e.g., running away from a bear). However, that same person at a social engagement has to invoke self-control to prevent spatial cognitions from interfering with language processes, which would deplete resources necessary to inhibit expression of inappropriate attitudes and behaviors (e.g., telling one's partner that his or her new outfit is ugly). Thus, the current results are consistent with the idea that a major function of emotion is to change the cognitive agenda (Schwarz, 2006; Simon, 1967), and being emotionally out of tune with one's environment can be quite costly and maladaptive for behavior.

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Received August 17, 2011
Revision received October 18, 2011
Accepted October 19, 2011 ■