Motiv Emot (2016) 40:489–497
DOI 10.1007/s11031-016-9547-9

ORIGINAL PAPER

Is happiness a cure-all for mental fatigue?: mood interacts with situational requirements in predicting performance

Justin Storbeck[1,2]

Published online: 24 February 2016

Abstract There is a set of competing theories for how emotion influences behavior after being psychologically challenged. One group of theories emphasize that positive affect enhances performance after a psychological challenge. Conversely, the emotion and goal compatibility theory argues that positive and negative emotions can enhance or reduce performance and motivation to control behavior depending on the task requirements. To test these contrasting predictions, participants were psychologically challenged by completing a Stroop task and then induced into a positive, negative, or neutral mood. A verbal or spatial working memory task was then completed to assess performance and motivation to control behavior. As predicted, positive mood benefited performance and behavioral control on the verbal working memory task, whereas, a negative mood benefited performance and behavioral control on the spatial working memory task. Thus, following a psychological challenge motivation to control behavior depended on interactions between mood and task requirements consistent with the emotion and goal compatibility theory. (155).

Keywords Emotion · Behavioral control · Regulation · Motivation

✉ Justin Storbeck
justin.storbeck@qc.cuny.edu

[1] Department of Psychology, Queens College, CUNY, 65-30 Kissena Blvd., Flushing, NY 11367, USA

[2] The Graduate Center at CUNY, New York, NY, USA

Introduction

Behavioral control (or self-control) involves overriding a dominant response in favor of a sub-dominant response (Inzlicht and Schmeichel 2012). Persistent behavioral control (i.e., psychological challenge) decreases motivation and attention to override such dominant responses resulting in negative outcomes and worse performance (Inzlicht and Schmeichel 2012; Muraven and Baumeister 2000). Emotions or moods are one of many factors that can influence the motivation to control behavior. In particular, positive moods can increase behavioral control through the use of heuristics (Clore et al. 2001; Forgas 2013; Schwarz 2006), increasing motivation (Ashby et al. 1999) and resiliency and coping (Cohn et al. 2009; Fredrickson 2001), or replenishing depleted mental resources (Tice et al. 2007). Conversely, negative moods have been associated with increasing psychological effort (or cognitive load) by competing for psychological resources (Pessoa 2009; Shackman et al. 2006; Vytal et al. 2013), increasing task-irrelevant thoughts (Ellis and Ashbrook 1988; Park and Banaji 2000), or promoting systematic processing (Schwarz and Clore 2007). However, both happy and sad moods can be beneficial on cognition (Clore and Huntsinger 2007; Dreisbach and Goschke 2004; Forgas 2013; Storbeck and Clore 2005), which suggests that the burden negative affect and the benefit positive affect has on psychological effort may be more nuanced.

The emotion[1] and goal compatibility theory tries to reconcile these nuances by taking into account situational requirements (i.e., task demands; Storbeck 2012; Storbeck et al. 2015). The theory was developed with the assumption that emotions promote goal-driven behavior (Lang 1995; Simon 1967), which prioritizes specific cognitive/executive functions over other functions to achieve the intended behavior (Bargh et al. 2001; Kruglanski et al. 2002; Simon 1967). The theory hypothesizes that positive emotions (e.g., happiness) promote goals related to social relations and exploration (e.g., Ashby et al. 1999; Beckes and Coan 2011; Clore and Huntsinger 2007; Fredrickson 2001) prioritizing cognitive/executive processes related to language (semantic memory, verbal working memory, etc.), executive control, and cognitive flexibility. On the other hand, negative emotions promote goals related to detecting threats and error analysis (e.g., Clore and Huntsinger 2007; Corr and McNaughton 2012; Vuilleumier 2005) prioritizing cognitive/executive processes related to perceptual/spatial analysis (e.g., spatial perception, spatial working memory), monitoring, and inhibitory control (Storbeck 2012). Moreover, situations (i.e., party) that are appraised similarly should elicit similar feelings (positive), cognitions (verbal working memory), and behaviors (socializing) and overtime integration of those entities results (Crick and Dodge 1994; Rolls 1999; Simon 1967). When integration occurs, the theory stipulates that emotions become embodied anticipations of cognitive requirements of situations with which they are integrated. Therefore, when one aspect of the relationship becomes active (positive) the other aspect (verbal working memory) also becomes prioritized automatically to anticipate and facilitate goal-driven behavior (socializing). Such integration can also work in reverse with cognitive processes (verbal working memory) activating associated feelings (positive affect; see Bar 2009; Storbeck and Watson 2014).

The emotion and goal compatibility theory also argues that the automaticity of cognition and behavior has a functional feature. Friston (2010) suggested that when cognitive and behavioral requirements can be anticipated for upcoming situations psychological effort is minimized. Therefore, emotions can be functional by reducing psychological effort when they correctly anticipate task or situational demands (Storbeck 2012; Storbeck et al. 2015). This reduction in psychological effort would preserve motivation to continue engaging in behavioral control (Inzlicht and Schmeichel 2012; Vergauwe et al. 2010). Conversely, when emotion (e.g., happy → verbal working memory) fails to correctly anticipate task demands (spatial working memory), goal competition arises due to emotion prioritizing cognitive processes (i.e., dominant response) that compete for resources with the cognitive processes associated with the task demands. Such competition often invokes psychologically effortful compensatory or regulatory processes (Hockey 1997), which would decrease the motivation to control behavior.

Prior research has found support for the emotion and goal compatibility theory. Specifically, positive (negative) mood increased task performance on a verbal (spatial) working memory task and maintained behavioral control on a second task (e.g., Stroop); however, positive (negative) mood decreased task performance on a spatial (verbal) working memory task and reduced motivation to control behavior on the second task (Storbeck 2012; Storbeck et al. 2015, see also Gray et al. 2002, for results that are conceptually similar). The findings then suggest that simply knowing a person's emotional state is not an accurate predictor for both performance and expenditure of psychological effort. Rather, interactions between emotion and task requirements better predicted both variables.

Design and predictions

The current study sought to test tenets of the emotion and goal compatibility theory. Namely, following a psychological challenge can positive affect improve performance and the motivation to control behavior on a task that is often enhanced when in a negative affective state, but not a positive affective state? To examine this question, we designed an experiment for which every participant began the study by completing a Stroop task. The Stroop task requires behavioral control and therefore should reduce motivation to control behavior on a subsequent demanding task (i.e., the working memory task; Inzlicht and Gutsell 2007; Muraven and Baumeister 2000). After the Stroop task, participants were randomly assigned to receive a positive, negative, or neutral mood induction. Then participants completed either a verbal or spatial working memory 2-back task, which served as the measure of behavioral control. The working memory task was selected because it requires behavioral control to be successful (i.e., updating trial-relevant and preventing interference from trial-irrelevant items; Vergauwe et al. 2010) and the two domains (verbal, spatial) are independent and interact with positive and negative moods (Braver et al. 1997; D'Esposito et al. 1998; Gray 2001; Storbeck 2012). The positive

[1] When discussing the emotion and goal compatibility theory, I used emotion because the theory specifies that specific emotions prioritize specific behavioral tendencies. When referring to the induced mood states used within this study, I used positive and negative mood because the manipulation check only assessed how negative-positive a person felt and how aroused a person felt. The tenets of the emotion and goal compatibility theory should hold true because the mood induction material was selected to induce a state of happiness and amusement (the positive movie clip) and sadness (the negative mood clip) based on standardized ratings (see Rottenberg et al. 2007).

affect resource theories (Ashby et al. 1999; Fredrickson 2001; Tice et al. 2007) would predict that the positive mood would overcome the psychological challenge to increase performance and maintain motivation to control behavior for both the verbal and spatial working memory tasks. The emotion and goal compatibility theory would predict that performance and motivation to control behavior would remain higher in the emotion and task compatible conditions (positive/verbal and negative/spatial) compared to the emotion and task incompatible conditions (positive/spatial and negative/verbal).

A secondary aim of this experiment was to test the claim that emotions automatically prioritize executive/cognitive processes (Storbeck 2012). To test this claim, I assessed performance at the start of the working memory task. If cognitions were prioritized automatically no effort would be required; therefore, the compatible conditions would be cognitively prepared for the working memory task resulting in high-level performance initially. Conversely, the incompatible conditions would demonstrate poor performance initially due to goal competition caused by the prioritization of an inappropriate cognitive process.

In an exploratory analysis, I sought to examine how emotion-task compatibility interacts with motivation to control behavior over the entire task. Although there were no formal predictions, the performance throughout the task (i.e., the slope of the performance) can provide insight into how emotion-task compatibility interacts with motivation to control behavior. These findings may help to rule out alternative interpretations.

Method

Participants

One-hundred fifty-one participants (98 female) from the Queens College psychology subject pool, with a mean age of 21.01 ($SD = 6.18$), consented and participated for course credit. Based on prior research (Storbeck et al. 2015), the goal was to obtain about 20–25 participants per cell. We purposely oversampled due to known demographics of the population (e.g., English proficiency), which often results in poor performance on reaction time or complex tasks.

Materials

Stroop task

A classic Stroop task (Stroop 1935) was used. 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. Once a response was recorded, there was a 500 ms delay before the start of the next trial. Each color was assigned to a key on the keyboard signaled with a matching color sticker, the keys were "Z" (blue), "X" (red), ">" (yellow), and "?" (green). Half of the trials were congruent (e.g., the word BLUE in blue font), and half were incongruent (e.g., the word RED in blue font). The primary measure of interest was reaction time (due to the ratio of congruent/incongruent trials; Logan and Zbrodoff 1979) with accuracy on the incongruent trials serving as a secondary measure.

Mood induction

All film clips were approximately 4 min long, and the positive group viewed a clip from *Jerry Seinfield: Stand up in New York*, the negative group viewed a clip from *The Champ*, and the neutral group viewed a clip from the documentary *If Dolphins Could Talk* narrated by Michael Douglas. These videos have been shown to induce emotional states, while having similar effects on arousal (Rottenberg et al. 2007; Storbeck 2012; Storbeck and Clore 2011). It was important to control for arousal, because arousal has been associated with increased energy (Blake et al. 2001; Thayer 1989), which may influence motivation and performance (Muraven and Baumeister 2000).

Working memory task

A verbal and a spatial 2-back working memory task were used. The stimuli consisted of the letters of the alphabet. On each trial, a single letter was presented in one of six spatial locations. The spatial locations were fixed on an *unseen* perimeter of a circle, with the top of the circle positioned 20 % from the top of the monitor. The letters were presented at locations along the perimeter of the circle at 30°, 90°, 120°, 170°, 230° and 290°. Each trial began with a single letter shown for 1 s, followed by a blank screen. Participants were able to make a response once the letter was removed, and the next trial was presented immediately after a response was recorded. Participants were instructed to determine whether the letter (or location of the letter) was the same as ('A' key) or different ('L' key) from the letter (or location of the letter) presented two trials back. There were 160 trials in total, and they were broken up into eight blocks with 20 trials each. Accuracy was the primary dependent variable, and reaction time was a secondary dependent variable.

Mood manipulation check

The check consisted of two items assessing valence and two items assessing arousal. Each item asked participants to indicate how they felt while viewing the film clip on a 6-point scale. Valence was assessed with the anchors: "very unhappy" (1) to "very happy" (6) and "very negative" to "very positive". Arousal was assessed with the anchors: "very calm" to "very alert", and "not aroused" to "very aroused". The mean for the two valence items and the two arousal items served as the valence and arousal mood check scores, respectively.

Procedure

A complete between-subjects design was implemented, and participants were randomly assigned to one of the mood inductions and one of the working memory tasks. All participants began the study by completing ten practice trials of the Stroop task and 15 practice trials of the working memory task for which they were assigned. The working memory practice trials occurred at the start of the study to minimize the delay and interruption between the mood induction and the experimental trials of the working memory task. After finishing the working memory practice trials, participants completed 120 experimental trials of the Stroop task ($\sim$7 min). Then participants were instructed to attend to the movie and to focus on their feelings while watching the movie. The movie was watched ($\sim$4 min), and then participants completed the experimental trials for the working memory task they were assigned ($\sim$12 min). Finally, the mood check was completed, demographic information was collected, several personality measures were completed (Emotion Regulation Questionnaire, BIS/BAS, and the Trait Meta-Mood Scale), and participants were debriefed.

Results

The data analysis included only one-hundred thirty-nine participants (90 female). Six participants were removed due to accuracy scores on the Stroop task that were below 30 % (chance performance was 25 %), and six other participants were removed due to accuracy on the working memory task that was below 55 % (chance performance was 50 %). 10 of the 12 participants removed self-identified as being "very less proficient" (1) or "moderately less proficient" (2) on a 7-point scale when asked how proficient they are in English relative to their peers.[2]

Manipulation check

Valence

A 3 × 2 (Mood [positive, negative, neutral] × Task [verbal, spatial]) factorial ANOVA was conducted for the valence score. A significant main effect of mood was observed, $F(2, 133) = 90.60$, $MSE = .59$, $p < .001$, $\eta^2 = .57$, and the positive condition reported the highest level of happiness followed by the neutral condition and then the negative condition, all *p*s < .01 (Tukey post hoc). The task, $F(1, 133) = .28$, $p = .49$, $\eta^2 = .001$, and interaction, $F(2, 133) = 2.33$, $p = .11$, $\eta^2 = .015$, effects were both non-significant. See Table 1 for mood manipulation check descriptive statistics.

Arousal

A 3 (Mood) × 2 (Task) factorial ANOVA was conducted for the arousal check score. All conditions reported similar levels of arousal; mood, $F(2, 133) = 1.43$, $MSE = 1.34$, $p = .24$, $\eta^2 = .02$, task, $F(1, 133) = 1.00$, $p = .32$, $\eta^2 = .007$, and interaction, $F(2, 133) = .07$, $p = .93$, $\eta^2 = .001$.

Stroop task

A Stroop score was created by subtracting reaction times for congruent trials from reaction times for incongruent trials. Greater interference (an inability to over-ride dominate responses) is reflected with a higher Stroop score. Errors were only assessed on the incongruent trials, as these trials capture failure to control dominant responses. Because the Stroop task was completed prior to the manipulations (3 (Mood) × 2 (Task) factorial ANOVA), we neither expected nor found any significant main or interaction effects for the Stroop score [mood, $F(2, 133) = .83$, $MSE = .003$, $p = .44$, $\eta^2 = .012$; task, $F(1, 133) = .21$, $p = .65$, $\eta^2 = .002$; interaction, $F(2, 133) = .08$, $p = .92$, $\eta^2 = .001$], or errors on incongruent trials [$F(2, 133) = .22$, $p = .81$, $\eta^2 = .004$; $F(1, 133) = .44$, $p = .51$, $\eta^2 = .004$; interaction, $F(2, 133) = 1.49$, $p = .23$, $\eta^2 = .022$]. See Table 1 for descriptive statistics.

[2] To examine whether the removal of participants had an effect on the statistical effects, we ran an analysis that included all participants who completed the study. The mood by task interaction effect for the four variables of interest, Stroop RT [$F(2, 145) = .017$, $p = .983$, $\eta^2 < .001$], Errors on Incompatible trials [$F(2, 145) = .765$, $p = .467$, $\eta^2 = .010$], working memory accuracy [$F(2, 145) = 4.225$, $p = .016$, $\eta^2 = .055$], and working memory reaction

Footnote 2 continued
time [$F(2, 145) = 2.641$, $p = .075$, $\eta^2 = .035$], produced similar results conceptually when all participants were included in the analysis. Moreover, the main effect for task when considering working memory accuracy also remained significant, $F(1, 145) = 6.398$, $p = .012$, $\eta^2 = .042$. All other effects were non-significant.

Table 1 The mood manipulation check and descriptive statistics

	Descriptive statistics					
	Pos verb	Pos spat	Neg verb	Neg spat	Con verb	Con spat
Val	4.79 (1.06)	4.96 (1.08)	1.76 (.72)	1.70 (.70)	4.22 (.92)	4.60 (1.05)
Arl	3.36 (1.22)	3.38 (1.86)	3.04 (1.24)	3.39 (1.34)	3.05 (1.29)	3.30 (1.66)
SIA	.94 (.10)	.93 (.20)	.96 (.04)	.96 (.04)	.97 (.03)	.92 (.22)
SRT	83.67 (81.4)	92.28 (99.2)	50.22 (149)	68.12 (168)	62.16 (55.4)	60.31 (101)
Wacc	.924 (.056)	.833 (.120)	.864 (.114)	.902 (.053)	.918 (.066)	.863 (.070)
WRT	602 (264)	771 (466)	703 (320)	585 (259)	616 (249)	761 (365)
B1	.931 (.082)	.812 (.189)	.856 (.146)	.932 (.084)	.890 (.081)	.862 (.127)
B2	.944 (.048)	.819 (.116)	.876 (.116)	.896 (.080)	.946 (.071)	.805 (.137)
B3	.918 (.084)	.898 (.097)	.842 (.120)	.959 (.049)	.909 (.092)	.923 (.077)
B4	.930 (.069)	.865 (.144)	.888 (.128)	.878 (.100)	.925 (.097)	.870 (.094)
B5	.922 (.071)	.838 (.148)	.862 (.144)	.867 (.098)	.934 (.076)	.855 (.109)
B6	.932 (.071)	.825 (.137)	.890 (.132)	.904 (.104)	.918 (.088)	.848 (.118)
B7	.908 (.090)	.806 (.148)	.880 (.119)	.898 (.086)	.916 (.082)	.903 (.091)
B8	.904 (.097)	.798 (.138)	.818 (.151)	.878 (.084)	.902 (.109)	.843 (.103)

Standard deviations are in parentheses

Val valence rating, *Arl* arousal rating, *SIA* stroop incompatible accuracy, *SRT* stroop reaction time (i.e., the Stroop effect), *Wacc* overall working memory accuracy, *WRT* overall working memory reaction times (ms), *BX* working memory accuracy on block X

Working memory task

Accuracy

To assess whether mood and task influenced overall performance, we ran a factorial ANOVA. The main effect of mood was not significant, $F(2, 133) = .24$, MSE = .007, $p = .79$, $\eta^2 = .003$; however, the effect for task was significant, $F(1, 133) = 6.13$, $p = .015$, $\eta^2 = .04$. Individuals were more accurate on the verbal task compared to the spatial task. As predicted, there was a significant mood by task interaction, $F(2, 133) = 7.29$, $p = .001$, $\eta^2 = .096$. See Fig. 1 for a graphic display of working memory performance.

Because the working memory tasks were not psychometrically matched (verbal was more accurate than spatial), we only compared the mood conditions assigned to the same working memory task. Within the verbal working memory task, the positive condition outperformed the negative condition, $p = .036$ (Tukey post hoc), but not the neutral condition, $p = .965$; and the negative condition performed worse than the neutral condition at a trend level, $p = .079$. Within the spatial condition, the negative condition outperformed the positive condition, $p = .023$, but not the control group, $p = .326$. The positive and control condition had similar performance, $p = .477$.

Reaction time

Another factorial ANOVA was ran with reaction times as the dependent variable. The main effects for mood, $F(2, 133) = .274$, $MSE = 108{,}696.60$, $p = .761$, $\eta^2 = .004$, and task, $F(1, 133) = 1.358$, $p = .246$, $\eta^2 = .010$, were both non-significant. However, the interaction was

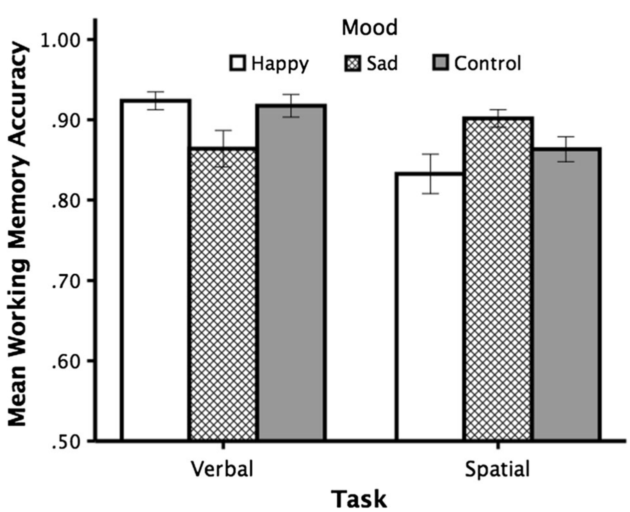

Fig. 1 Overall working memory performance as a function of working memory task and mood conditions. *Bars* represent one standard error of the mean

marginally significant, $F(2, 133) = 2.751$, $p = .067$, $\eta^2 = .040$. Because the verbal and spatial conditions were not psychometrically matched, we ran the same post hoc analyses for reaction time as I did for accuracy. For both the verbal, *p*s > .420, and spatial, *p*s > .214, working memory task, all mood conditions had similar reaction times.

Automaticity/control assessment: working memory

The second aim was to examine performance on the first block to determine if the compatibility between emotion and task demands had an immediate impact on performance. If the emotion induces an inappropriate cognitive mind-set for the working memory task, an immediate decrease in performance would be observed compared to an emotional state that prioritized an appropriate mind-set for the working memory task. To test this prediction, Tukey post hoc analyses were conducted within each working memory task to compare performance on the mood conditions (see Table 1 for block means). Within the verbal working memory task, the happy condition performed more accurately than the sad condition for the first, $p = .040$, block, but performed similarly compared to the control condition, $p = .396$. The sad condition performed similar to the control condition, $p = .533$. Within the spatial condition, the sad condition performed more accurately on the first block than the happy condition, $p = .014$; but performed similarly to the control condition, $p = .239$. The positive and control condition had similar first block performance, $p = .485$.

An exploratory analysis was conducted using a repeated measures analysis to assess performance throughout the entire task for the compatible and incompatible conditions and the control conditions. The test of interest was the within-subjects contrast for performance across the eight blocks focusing on the linear and quadratic effects. The combination of slope analysis and first/last block performance can provide insight into how emotion-task compatibility interacts with motivation to control behavior throughout the task. The compatible conditions, $F(1, 47) = 9.771$, $p = .003$, $\eta_p^2 = .172$, demonstrated a significant decreasing linear effect with no quadratic effect, $F(1, 47) = .011$, $p = .916$, $\eta_p^2 = .018$. Thus, the performance for the compatible conditions started high and then slowly decreased throughout the task. The incompatible condition demonstrated a significant quadratic effect, $F(1, 48) = 21.427$, $p < .001$, $\eta_p^2 = .309$, such that accuracy was initially poor then improved during the middle blocks only to decrease again at the end of the task. The linear effect the incompatible conditions was not significant, $F(1, 48) = 2.231$, $p = .142$, $\eta_p^2 = .044$. The control condition demonstrated a marginally significant quadratic effect, $F(1, 41) = 3.651$, $p = .063$, $\eta_p^2 = .082$, demonstrating a similar performance curve as the incompatible conditions, and the

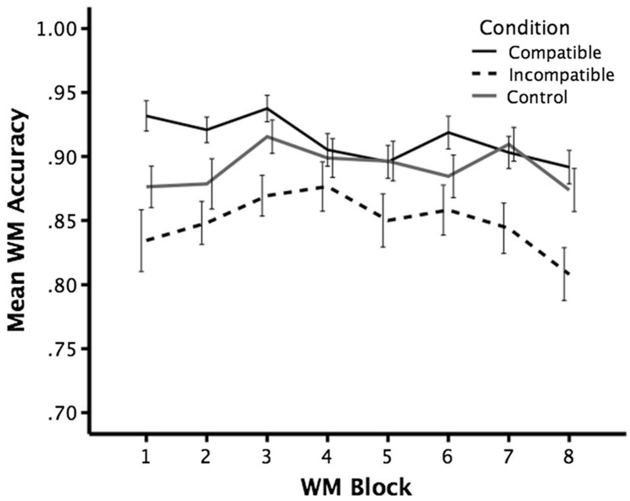

Fig. 2 Working memory performance across the eight blocks collapsed across the compatible, incompatible, and control conditions. *Bars* represent one standard error of the mean

linear effect for the control condition was not significant, $F(1,\ 41) = .040$, $p = .842$, $\eta_p^2 = .001$. See Fig. 2 for performance across the eight blocks.

Correlations

We ran simple correlations between valence check score and working memory performance to serve as a secondary confirmation of our predictions that mood interacts with working memory demands. Correlations were ran separately for the working memory tasks, and we expected that higher positive mood ratings would better predict performance on the verbal working memory task, whereas higher negative mood ratings would better predict performance on the spatial working memory task. As predicted, within the verbal working memory conditions, the more positive the mood rating the better people performed on the verbal working memory task, $r(72) = .36$, $p = .002$. Within the spatial working memory conditions, the more negative the mood rating the better people performed on the spatial working memory task, $r(67) = -.24$, $p = .050$. We also ran partial correlations controlling for Stroop performance (RT), and the effects were maintained, $r(69) = .35$, $p = .003$ (verbal) and $r(64) = -.24$, $p = .052$ (spatial). Arousal scores did not predict verbal, $r(69) = -.02$, $p = .902$, or spatial, $r(64) = .02$, $p = .869$, working memory performance.

General discussion

As predicted, following a psychological challenge, interactions between mood and task demands best predicted performance during the working memory task. Specifically, people induced into positive moods were more accurate initially and overall on the verbal working memory task, and they were worse initially and overall on the spatial working memory task. Conversely, people induced into negative moods were more accurate initially and overall on the spatial working memory task, and they were worse initially and overall on the verbal working memory task. Moreover, the emotion and task incompatible conditions and to a lesser extent the control conditions revealed initially poor performance at the start of the task followed by a modest recovery and then ultimately a decline in performance. The combination of findings imply that: (1) emotions prioritize domain-specific working memory processes evidenced by initial performance, and (2) the incompatible conditions were less likely to maintain their motivation to control behavior as evidenced by their performance throughout the task.

Full support was not observed for the positive affect resource theories. In particular, positive affect did not unilaterally overcome psychological challenge through resiliency, motivation, coping, cognitive flexibility, or by replenishing depleted resources (Ashby et al. 1999; Fredrickson 2001; Tice et al. 2007). Rather, the findings were best supported by the emotion and goal compatibility theory. Specifically, performance was best predicted by the task demands even after people were psychological challenged. The present findings also advanced the theory to suggest that emotions may automatically prioritize specific cognitive/executive processes, which suggests that cognitions are prioritized using minimal psychological effort. However, this automaticity may come with a cost when emotion and task priorities are incompatible. Unfortunately, given the mixed results when the compatible and incompatible conditions were compared to control conditions, it remains unclear whether emotions promote greater benefits or costs when they are functional or dysfunctional, respectively.

Given that positive affect is linked to increases in both motivation and cognitive flexibility, then how come positive affect did not improve performance in a domain-general manner? First, dopamine is linked with a specific set of cognitive abilities, including cognitive flexibility and verbal working memory. In other words, positive affect, via dopamine, may prioritize those cognitions making them a dominant response. But, when cognitive flexibility needs to be inhibited (as a dominant response) to do well on a task, such as on a perseveration task, people in positive moods often reveal worse performance (Dreisbach and Goschke 2004). Second, simply increasing motivation, which is often associated with positive affect, does not always result in superior performance. For instance, motivation is more likely to increase response time, but not necessary accuracy, and therefore, depending on the task demands motivation can be more harmful than helpful (Chiew and Braver 2013; Locke and Braver 2008). Moreover, positive affect and motivation may interact to influence the amount of effort expended on a task, and happiness has been found to reduce task effort even when the task involves helping others (Fishbach and Labroo 2007). Thus, although positive affect is quite advantageous for creativity, problem solving, recovering from stress, and increasing well-being (Ashby et al. 1999; Fredrickson 2001), there are situations where positive affect can impair performance and reduce motivation to control behavior.

Future directions

Future research should replicate the current findings with neuroimaging data and extend those findings to other emotions and executive functions. Behavioral data can be difficult to interpret when assessing psychological effort and motivation to control behavior, whereas neuroimaging can provide a clearer answer (e.g., Gray et al. 2002; Hockey 1997; Kok 1997). The current study induced an affective state that is often low in intensity and motivation. Future studies could manipulate emotions that vary in motivation to further explore how a positive or negative, intense motivational state (e.g., desire or fear) has similar or dissimilar effects as a positive or negative, low motivational state (e.g., happy or sad). Such studies could further clarify whether affect and motivation interact to influence task performance and motivation to control behavior. Moreover, the current study only focused on working memory, but future studies could investigate other executive functions (e.g., inhibition, cognitive flexibility) to determine whether emotion has similar effects on other executive functions beyond working memory.

Conclusion

These findings support the view that mood and task interactions better predict performance and the motivation to control behavior following a psychological challenge. Consistent with the emotion and goal compatibility theory, emotions may prioritize specific cognitions to support goal-driven behavior, which has the advantage of minimizing psychological effort when emotion correctly anticipates the behavioral requirements of the situation. Emotions are often more functional than dysfunctional (Gray 2004), and as a result, having emotions anticipate situational requirements would be an ecologically advantageous mechanism to promote long-term behavioral control across a variety of good, bad, or frightening situations.

References

Ashby, G., Isen, A., & Turken, A. (1999). A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review, 106*, 529–550.

Bar, M. (2009). A cognitive neuroscience hypothesis of mood and depression. *Trends in Cognitive Sciences, 13*, 456–463.

Bargh, J., Gollwitzer, P., Lee-Chai, A., Barndollar, K., & Trotschel, R. (2001). The automated will: Nonconscious activation and pursuit of behavioral goals. *Journal of Personality and Social Psychology, 81*, 1014–1027.

Beckes, L., & Coan, J. A. (2011). Social baseline theory: The role of social proximity in emotion and economy of action. *Social and Personality Psychology Compass, 5*, 976–988.

Blake, T., Varnhagen, C., & Parent, M. (2001). Emotionally arousing pictures increase blood glucose levels and enhance recall. *Neurobiology of Learning and Memory, 75*, 262–273.

Braver, T., Cohan, J., Nystrom, L., Jonides, J., Smith, E., & Noll, D. (1997). A parametric study of prefrontal cortex involvement in human working memory. *Neuroimage, 5*, 49–62.

Chiew, K. S., & Braver, T. S. (2013). Temporal dynamics of motivation-cognitive control interactions revealed by high-resolution pupillometry. *Frontiers in Psychology, 4*, 15.

Clore, G. L., & Huntsinger, J. (2007). Feelings as information for judgment and cognitive processing. *Trends in Cognitive Science, 11*, 393–399.

Clore, G. L., Wyer, R. S., Dienes, B., Gasper, K., Gohm, C., & Isbell, L. (2001). Affective feelings as feedback: Some cognitive consequences. In L. L. Martin & G. L. Clore (Eds.), *Theories of mood and cognition: A user's guidebook* (pp. 27–62). Mahwah, NJ: Lawrence Erlbaum Associates Inc.

Cohn, M., Fredrickson, B., Brown, S., Mikels, J., & Conway, A. (2009). Happiness unpacked: Positive emotions increase life satisfaction by building resilience. *Emotion, 9*, 361–368.

Corr, P. J., & McNaughton, N. (2012). Neuroscience and approach/avoidance personality traits: A two stage (valuation-motivation) approach. *Neuroscience and Biobehavioral Reviews, 36*, 2339–2354.

Crick, N., & Dodge, K. (1994). A review and reformulation of social information-processing mechanisms in children's social adjustment. *Psychological Bulletin, 115*, 74–101.

D'Esposito, M., Aguirre, G., Zarahn, E., Ballard, D., Shin, R., & Lease, J. (1998). Functional fMRI studies of spatial and nonspatial working memory. *Brain Research. Cognitive Brain Research, 7*, 1–13.

Dreisbach, G., & Goschke, T. (2004). How positive affect modulates cognitive control: Reduced perseveration at the cost of increased distractibility. *Journal of Experimental Psychology. Learning, Memory, and Cognition, 30*, 343–353.

Ellis, H., & Ashbrook, P. (1988). Resource allocation model of the effects of depressed mood states on memory. In K. Fiedler & J. Forgas (Eds.), *Affect, cognition, and social behavior: New evidence and integrative attempts* (pp. 25–43). Toronto: Hogrefe.

Fishbach, A., & Labroo, A. (2007). Be better or be merry: How mood affects self-control. *Journal of Personality and Social Psychology, 93*, 158–173.

Forgas, J. (2013). Don't worry, be sad! On the cognitive, motivational, and interpersonal benefits of negative mood. *Current Directions in Psychological Science, 22*, 225–232.

Fredrickson, B. (2001). The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions. *American Psychologist, 56*, 218–226.

Friston, K. (2010). The free-energy principle: A unified brain theory? *Nature Reviews Neuroscience, 11*, 127–138.

Gray, J. (2001). Emotional modulation of cognitive control: Approach-withdrawal states double-dissociate spatial from verbal two-back task performance. *Journal of Experimental Psychology: General, 130*, 436–452.

Gray, J. (2004). Integration of emotion and cognitive control. *Current Directions in Psychological Science, 13*, 46–48.

Gray, J., Braver, T., & Raichle, M. (2002). Integration of emotion and cognition in the lateral prefrontal cortex. *Proceedings of the National Academy of Sciences, 99*, 4115–4120.

Hockey, R. (1997). Compensatory control in the regulation of human performance under stress and high workload: A cognitive-energetical framework. *Biological Psychology, 45*, 73–93.

Inzlicht, M., & Gutsell, J. (2007). Running on empty: Neural signals for self-control failure. *Psychological Science, 18*, 933–937.

Inzlicht, M., & Schmeichel, B. (2012). What is ego depletion? Toward a mechanistic revision of the resource model of self-control. *Perspectives in Psychological Science, 7*, 450–463.

Kok, A. (1997). Event-related-potential (ERP) reflections of mental resources: A review and synthesis. *Biological Psychology, 4*, 19–56.

Kruglanski, A., Shah, J., Fishbach, A., Friedman, R., Chun, W., & Sleeth-Keppler, D. (2002). A theory of goal systems. *Advances in Experimental Social Psychology, 34*, 331–378.

Lang, P. (1995). The emotion probe. *American Psychologist, 50*, 372–385.

Locke, H. S., & Braver, T. S. (2008). Motivational influences on cognitive control: Behavior, brain activation, and individual differences. *Cognitive, Affective, & Behavioral Neuroscience, 8*, 99–112.

Muraven, M., & Baumeister, R. (2000). Self-regulation and depletion of limited resources: Does self-control resemble a muscle? *Psychological Bulletin, 126*, 247–259.

Park, J., & Banaji, M. (2000). Mood and heuristics: The influence of happy and sad states on sensitivity and bias in stereotyping. *Journal of Personality and Social Psychology, 78*, 1005–1023.

Pessoa, L. (2009). How do emotion and motivation direct executive control? *Trends in Cognitive Sciences, 13*, 160–166.

Rolls, E. T. (1999). *The Brain and Emotion*. Oxford: Oxford University Press.

Rottenberg, J., Ray, R., & Gross, J. (2007). Emotion elicitation using films. In J. A. Coan & J. J. B. Allen (Eds.), *The handbook of emotion elicitation and assessment* (pp. 9–28). New York: Oxford University Press.

Schwarz, N. (2006). Feelings, fit, and funny effects: A situated cognition perspective. *Journal of Marketing Research, 43*, 20–23.

Schwarz, N., & Clore, G. L. (2007). Feelings and phenomenal experiences. In A. Kruglanski & E. Higgins (Eds.), *Social psychology: Handbook of basic principles* (2nd ed., pp. 385–407). New York: Guilford.

Shackman, A., Sarinopoulos, I., Maxwell, J., Pizzagalli, D., Lavric, A., & Davidson, R. (2006). Anxeity selectively disrupts visuospatial working memory. *Emotion, 6*, 40–61.

Simon, H. (1967). Motivational and emotional controls of cognition. *Psychological Review, 74*, 29–39.

Storbeck, J. (2012). Performance costs when emotion tunes inappropriate cognitive abilities: Implications for mental resources and behavior. *Journal of Experimental Psychology: General, 141*, 411–416.

Storbeck, J., & Clore, G. L. (2005). With sadness comes accuracy, with happiness, false memory: Mood and the false memory effect. *Psychological Science, 16*, 785–791.

Storbeck, J., & Clore, G. L. (2011). Affect influences false memories at encoding: Evidence from recognition data. *Emotion, 11*, 981–989.

Storbeck, J., Davidson, N. A., Dahl, C., Blass, S., & Yung, E. (2015). Emotion, working memory task demands, and individual differences predict behavior, cognitive effort, and negative affect. *Cognition and Emotion, 29*, 95–117.

Storbeck, J., & Watson, P. (2014). Verbal makes it positive, spatial makes it negative: Working memory biases judgments, attention, and moods. *Emotion, 14*, 1072–1086.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*, 643–662.

Thayer, R. (1989). *The biopsychology of mood and arousal*. New York: Oxford University Press.

Tice, D., Baumeister, R., Shmueli, D., & Muraven, M. (2007). Restoring the self: Positive affect helps improve self-regulation following ego-depletion. *Journal of Experimental Social Psychology, 43*, 379–384.

Vergauwe, E., Barrouillet, P., & Camos, V. (2010). Do mental processes share a domain-general resource? *Psychological Science, 21*, 384–390.

Vuilleumier, P. (2005). How brains beware: Neural mechanisms of emotional attention. *Trends in Cognitive Sciences, 9*, 585–594.

Vytal, K., Cornwell, B., Letkiewicz, A., Arkin, N., & Grillion, C. (2013). The complex interaction between anxiety and cognition: Insight from spatial and verbal working memory. *Frontiers in Human Neuroscience, 7*, 93.