The drive to control : how affect and motivation regulate cognitive control

Steenbergen, H. van

Citation

Steenbergen, H. van. (2012, January 17). *The drive to control : how affect and motivation regulate cognitive control*. Retrieved from https://hdl.handle.net/1887/18365

5

Mood and Conflict Adaptation

"A mood is a way, not merely a form or a mode, but rather a manner, like a melody, which does not float above the so-called actual being occurrent of a person, but rather sets the key of this being, that is, it attunes and determines the manner of his being."

Martin Heidegger

Abstract

Cognitive conflict plays an important role in tuning cognitive control to the situation at hand. On the basis of earlier findings demonstrating emotional modulations of conflict processing, we predicted that affective states may adaptively regulate goal-directed behavior that is driven by conflict. We tested this hypothesis by measuring conflict-driven control adaptations following experimental induction of four different mood states that could be differentiated along the dimensions of arousal and pleasure. After mood states were induced, 91 subjects performed a flanker task, which provided a measure of conflict adaptation. As predicted, pleasure level affected conflict adaptation: Less pleasure was associated with more conflict-driven control. Arousal level did not influence conflict adaptation. This study suggests that affect adaptively regulates cognitive control. Implications for future research and psychopathology are discussed.

Introduction

Emotions seem to have evolved to guide organisms and their conspecifics in their struggle for survival, and affective states are assumed to facilitate behavior that is adaptive to the current situational context (Morris, 1992). In particular, it has been suggested that negative mood stimulates the processing of stimuli that have a negative valence and, therefore, deserve priority. Indeed, low pleasure levels seem to induce negative-information biases in attention and memory. Although it has been suggested that these biases systematically change the way people cope with negative events (cf. Gendolla, 2000), it has yet to be demonstrated how affect may play this regulating role in cognitive-control adaptations.

The main function of cognitive control is to adapt the cognitive system to situational demands. It has been proposed that this adaptation is driven by the detection of cognitive conflict (Botvinick et al., 2001). Evidence supporting this view comes from conflict tasks, such as the flanker task. Subjects respond more slowly to target information if distracting flanker information suggests a different response. On trials following this conflict, however, flanker interference is reduced (Egner, 2007; Gratton et al., 1992), which indicates that facing conflict enhances control (Botvinick et al., 2001).

Numerous studies have shown that low-pleasure affect facilitates neural conflict monitoring (e.g., Luu et al., 2000). They illustrate that moods that are congruent with the negative valence inherent to conflict (Botvinick, 2007) facilitate conflict registration (cf. Rusting, 1998). Given that conflict registration is important for tuning goal-directed behavior (cf. Kerns et al., 2004), affective states that prioritize conflict processing should also strengthen behavioral adaptations to cognitive conflict. We therefore predicted that people in a low-pleasure mood would adapt more strongly to cognitive conflict, and thus would be more likely to recruit control, than people in a high-pleasure mood. Some authors have postulated that, independently of pleasure, changes in arousal level may also influence conflict adaptation by altering the signal-to-noise ratio of conflict information (Verguts & Notebaert, 2009). If so, conflict-driven cognitive control may be influenced by the arousal level of the current affective state.*

---

* Recent work has suggested a relationship between pleasure increases and shifts toward more flexible behavior at the cost of goal maintenance (Dreisbach & Goschke, 2004). The hypothesis that higher pleasure levels reduce conflict adaptation is in line with such a framework because

5

Given that pleasure and arousal are the two fundamental dimensions on which mood is assumed to vary (Yik et al., 1999), we investigated four groups of participants who underwent a standard mood-induction manipulation before performing a conflict-evoking flanker task. Each mood group occupied one of the four quadrants derived by crossing the dimensions of pleasure and arousal (see Fig. 1; cf. Jefferies, Smilek, Eich, & Enns, 2008). The four derived moods that were induced were anxiety (low pleasure, high arousal), sadness (low pleasure, low arousal), calmness (high pleasure, low arousal), and happiness (high pleasure, high arousal). We predicted stronger conflict-driven adaptation effects (i.e., reductions of flanker-induced interference after conflict trials) for participants with low pleasure levels (anxious and sad participants) than for participants with high pleasure levels (calm and happy participants).

Method

Participants and design
Ninety-eight students participated either for payment or for course credits (age range: 18–30 years; 24 males, 74 females; 11 left-handed). They were randomly assigned to one of the four mood-induction groups: anxious, sad, calm, and happy. Data from 7 subjects were excluded from analyses because of response omissions on more than 20% of the trials (n = 2), chance-level task performance (n = 3), or noncompliance with instructions (n = 2). All subjects completed a mood induction, the flanker task, and a manual color-word Stroop task.

Mood induction and assessment
We used a standard mood-induction procedure that combines music with imagination and is known to induce reliable mood changes (Eich, Ng, Macaulay, Percy, & Grebneva, 2007). Subjects used headphones to listen to specific classical music

---

conflict adaptation facilitates task maintenance at the cost of flexible switching (e.g., Notebaert & Verguts, 2008). Cumulating evidence suggests a role for neurotransmitter modulation in these effects. For example, pharmacological studies suggest that raised tonic dopamine levels reduce phasic dopamine responses to conflict (for a review, see Jocham & Ullsperger, 2009). However, other neurotransmitter systems involved in mood changes (e.g., serotonin and norepinephrine) may also play a role (Posner, Russell, & Peterson, 2005). The mutual interactions and causal role of these systems is complex and remains a hot topic for future investigation.

samples whose efficacy in inducing the intended moods was validated by previous research (Jefferies et al., 2008). They were instructed to develop a particular mood by imagining and writing about a mood-appropriate event in detail; they were free to either focus on a written vignette they were given or to recall a similar event from their past. Music continued to play throughout the remainder of the experiment. To check the induction manipulation, we asked subjects to rate their mood on a 9 × 9 Pleasure × Arousal grid (Russell, Weis, & Mendelsohn, 1989) with values ranging from –4 to 4. Subjects were instructed to rate their mood whenever the grid appeared on the computer monitor during the experiment.

Flanker task

We used a computerized version of the classic flanker task (Eriksen & Eriksen, 1974) in which, on each trial, a central target stimulus is vertically flanked by four response-compatible or four response-incompatible stimuli, two on either side. Dutch color words were used as targets and flankers, and were randomly drawn from one of two sets of words ("brown," "gray," "yellow," and "red" or "purple," "green," "orange," and "blue"); the other set of words was used for the Stroop task, with assignment of word set to task counterbalanced within mood groups. Subjects were instructed to respond using their index fingers, pressing a key with their left index finger when the central target was either of two specific words and pressing a different key with their right index finger when the target was either of the other two words (stimulus-response mapping was counterbalanced within mood groups). A reminder of the stimulus-response mapping was shown for 15 s before the start of each of the two blocks of 72 trials.

All trials started with a fixation cross (randomly varying duration of 800, 1,000, or 1,100 ms), followed by the stimulus, which was presented until response registration, or for a maximum of 1,500 ms. In half of the trials, the target and flanker stimuli called for different responses (response-incompatible condition: I), whereas in the other half, physically identical target and flanker stimuli called for the same response (response-compatible condition: C). All trials were presented in an unconstrained random sequence. Stimuli appeared in black, lowercase Arial bold font and were presented on a gray background. The stimulus array was 3.5 cm wide and 5.4 cm high. Participants viewed the stimuli on a 17-in. monitor from a distance of approximately 60 cm.

5

Procedure

After giving informed consent, subjects were instructed about the mood ratings and told how to perform the flanker and Stroop tasks.* Instructions for both tasks emphasized both speed and accuracy. Following 16 practice trials and a 10-min mood induction, subjects performed a block of 72 trials for each task. After a short, 3-min mood booster, another block of each task was presented. The order of tasks was counterbalanced within mood conditions. Following completion of a questionnaire in which subjects were asked to rate how genuinely they had experienced their mood (9-point scale), subjects were instructed to return to baseline mood levels. Negative-mood subjects received a candy to facilitate return to their baseline mood. During the experiment, nine mood ratings were obtained at the following time points: at the beginning of the experiment (baseline), following the practice trials, halfway through and at the end of the mood-induction procedure, after the first half of the tasks, following the mood booster, after the second half of the tasks, following the questionnaire, and at the end of the experiment.

Data analysis

Analyses of variance were used to test our hypotheses. Arousal and pleasure grid ratings served as a mood-manipulation check. We analyzed absolute reaction times (RTs) and error rates, as well as interference effects (I minus C), on correct trials as a function of mood condition. Standard conflict-adaptation effects, for both RTs and error rates, were calculated by subtracting the interference effect following a correct conflict, or incompatible, trial (i) from the interference effect following a correct no-conflict, or compatible, trial (c) (i.e., (cI – cC) – (iI – iC)). The first trial of each block (1.4%) and outlier trials (RT > 2 SD from the condition-specific mean, calculated for each subject separately; 4.7%) were excluded from all analyses.

---

* We could not use reaction time data from the Stroop task to test our hypothesis, given that no overall conflict-adaptation effect was observed in Stroop reaction times, $F_{(1, 87)} = 1.37$. As expected, mood effects on this measure were not observed, $F_{(1, 87)}s < 2.31$. In line with the flanker task, this task did produce a reliable interference effect, $F_{(1, 87)} = 70.60$, $p < .001$, which was not modulated by mood, $F_{(1, 87)}s < 1$.

Task-specific characteristics, such as task difficulty, may account for differences in the size of conflict-adaptation effects (e.g., Fischer et al., 2008). In a new series of experiments including Stroop and flanker tasks similar to those used in the current study, we indeed demonstrated that high task demands eliminate conflict-adaptation effects (see Chapter 8).

Results

Mood-induction manipulation check

Table 1 presents subjects' mean affect ratings at all nine assessment points. Participants began the experiment in a slightly positive (M = 0.59, SE = 0.14) and slightly aroused (M = 0.15, SE = 0.16) mood. Baseline ratings did not differ across the mood-induction groups, F(1, 87)s < 1.70. Participants reported the expected changes in arousal and pleasure following the mood induction. Average self-reported affect during task performance (ratings given at the beginning and end of the task blocks; i.e., at Times 3–6 in Table 1) indicated that the sad (M = –1.8, SE = 0.25) and anxious (M = –1.5, SE = 0.23) groups reported lower pleasure scores than the calm (M = 1.5, SE = 0.24) and happy (M = 1.7, SE = 0.25) groups, F(1, 87) = 181.14, p < .001, MSE = 1.33. Similarly, arousal scores were higher for the anxious (M = 1.7, SE = 0.31) and happy (M = 0.9, SE = 0.34) groups than for the sad (M = –0.5, SE = 0.34) and calm (M = –1.0, SE = 0.32) groups, F(1, 87) = 40.05, p < .001, MSE = 2.42, although the unpleasant-mood subjects reported slightly higher arousal than the pleasant-mood subjects, F(1, 87) = 4.30, p = .041. As in earlier studies (e.g., Eich et al., 2007), subjects judged their reported moods as genuine at the end of the task (M = 7.0, SE = 0.14), and this rating did not depend on mood condition, F(3, 87) = 2.69. Across mood conditions, comparisons between ratings given at baseline and at the end of the tasks suggest that the tasks themselves induced some reduction in pleasure, F(1, 90) = 7.78, p < .01, MSE = 2.30, but no change in arousal, F(1, 90) < 1.

Table 1. *Mean self-report mood scores per mood induction group*

Dimension	Induction group	Time point								
		Baseline	1	2	3	4	5	6	7	8
Pleasure	Anxious	0.42	0.54	-1.69	-1.69	-1.27	-1.96	-1.19	-0.04	0.77
	Sad	0.57	0.57	-2.05	-2.38	-1.57	-2.10	-1.14	0.14	0.71
	Calm	0.57	0.61	1.96	2.04	1.13	1.74	1.04	1.09	1.09
	Happy	0.81	0.33	2.62	2.33	1.62	1.62	1.29	1.24	1.14
Arousal	Anxious	0.12	0.92	1.58	1.46	1.85	2.00	1.65	0.73	0.65
	Sad	0.14	1.29	-0.52	-0.91	-0.14	-0.76	-0.19	-0.14	0.43
	Calm	-0.22	1.00	-0.61	-1.48	-0.57	-1.26	-0.74	-0.74	-0.22
	Happy	0.57	1.29	1.38	1.19	1.48	0.67	0.24	0.05	0.33

Table 2. *Behavioral data per mood induction group*

Trial type / Effect	Mood induction group							
	Anxious (N = 26)		Sad (N = 21)		Calm (N = 23)		Happy (N = 21)	
Overall	593	(9.3%)	619	(5.6%)	596	(2.9%)	604	(4.8%)
Compatible (C)	580	(8.6%)	600	(4.4%)	577	(1.9%)	587	(4.7%)
Incompatible (I)	607	(10.1%)	638	(6.8%)	616	(3.8%)	620	(5.0%)
Interference effect	27	(1.6%)	37	(2.3%)	39	(1.8%)	33	(.3%)
cC	572	(3.7%)	578	(3.0%)	568	(1.2%)	580	(2.8%)
cI	611	(8.8%)	631	(6.9%)	612	(4.0%)	613	(4.4%)
iC	587	(7.4%)	617	(3.5%)	582	(1.2%)	595	(3.1%)
iI	597	(8.1%)	637	(6.8%)	613	(2.3%)	619	(4.1%)
Conflict-adaptation effect	29	(4.5%)	33	(.5%)	13	(1.7%)	8	(.6%)

Note: Latency data in ms for all conditions with error rate between brackets.
Interference effect = I–C, Conflict-adaptation effect = (cI – cC) – (iI – iC)

Mood and conflict-adaptation effects

Reliable overall RT conflict-adaptation effects, $F(1, 87) = 16.83$, $p < .001$, MSE = 2,303.02, were observed for the flanker task, and, as Figure 1 shows, this effect was modulated by pleasure level, $F(1, 87) = 4.241$, $p < .05$, MSE = 2,303.02. This predicted effect of pleasure was not accompanied by an effect of arousal or by a Pleasure × Arousal interaction, $F(1, 87)s < 1$. Overall, interference effects were smaller if conflict was experienced on the previous trial (21 ms vs. 42 ms), and, as predicted, these conflict-driven interference reductions were larger for subjects in a low-pleasure mood (anxious and sad groups: $M = 29$, SE = 9.4, and $M = 33$, SE = 10.5) than for subjects in a high-pleasure mood (happy and calm groups: $M = 8$, SE = 10.5, and $M = 13$, SE = 10.0). This effect could not be accounted for by mood-induced differences in overall RT or interference effects, $F(1, 87)s < 2.23$ (see Table 2 for details on RTs, interference effects in RTs, and conflict-adaptation effects in RTs). Correlations between self-reported affect during task performance and individual conflict-adaptation effects across mood groups were not significant (pleasure: $r = -.161$, $p = .13$; arousal: $r = -.134$, $p = .21$).
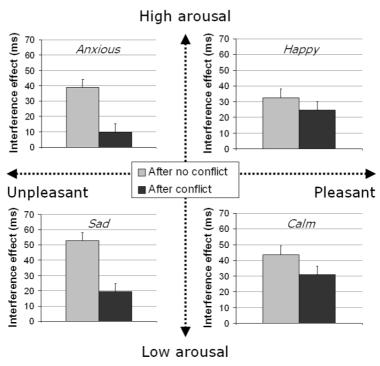
Figure 1. Conflict-adaptation effects as a function of mood induction group. Groups were defined by a crossing of the pleasure (horizontal) and arousal (vertical) dimension. Subjects in a low-pleasure mood show stronger conflict-adaptation effects (interference reduction after conflict) in comparison to subjects in a high-pleasure mood. Arousal does not modulate conflict-adaptation effects. Graph shows means and standard errors.

Overall, conflict-adaptation effects for error rates were not reliable, $F(1, 87) = 3.13$ (see Table 2 for details on error rates, interference effects in error rates, and conflict-adaptation effects in error rates). Overall interference effects in error rates, $F(1, 87) = 10.03$, $p < .01$, MSE = 0.002, were not modulated by mood condition, $F(1, 87)s < 1.57$, though subjects with low pleasure levels, $F(1, 87) = 6.741$, $p < .05$, MSE = 0.004, and subjects with high arousal levels, $F(1, 87) = 4.267$, $p < .05$, MSE = 0.004, made slightly more errors in general than their high-pleasure and low-arousal counterparts.

Discussion

This study provides substantial evidence for the hypothesis that conflict adaptation is sensitive to modulations in pleasure level. After a successful mood manipulation, both sad and anxious people showed stronger adaptation following conflict trials than did people in a happy or calm mood (see Fig. 1). This effect was not accompanied or modulated by effects of arousal level; subjects with high-activation moods (anxious and happy groups) did not show differences in conflict-adaptation effects in comparison with subjects in low-activation moods (sad and calm groups). These findings thus suggest that affect helps to regulate goal-directed behavior in response to cognitive conflict.

Our observations show an interesting parallel to the seminal work of Festinger (1957) on cognitive dissonance. Cognitive dissonance is thought to be triggered by conflicting cognitions and to be reduced by either avoiding the inducing perceptual events or changing one's attitude. Dissonance reduction and conflict adaptation may thus both reflect adaptive avoidance responses to situations of incompatibility and rely on the same neural mechanism (Harmon-Jones, Amodio, & Harmon-Jones, 2009; van Veen, Krug, Schooler, & Carter, 2009). In line with our findings, dissonance reduction through attitude change increases when people are in a negative mood (e.g., Rhodewalt & Comer, 1979). Low pleasure levels thus increase cognitive control after conflict situations only, rather than improving control in general (cf. van Steenbergen et al., 2009). Thus, we observed only context-sensitive, dynamic effects, probably because moods—unlike short-term affect manipulations used in other studies (e.g., Kuhl & Kazen, 1999)—are thought not to have stable, motivational consequences leading to improved sustained control (Gendolla, 2000; for a recent motivational account of emotions influencing cognitive control, see Gable & Harmon-Jones, 2010b).

We believe that our findings may also provide insight into the way cognitive-control processes are impaired in psychopathological individuals. Mood disorders such as depression and anxiety have been associated with increased negativity biases (Leppanen, 2006). Indeed, sensitized conflict-monitoring processes have been observed in people with internalizing mood disorders (Olvet & Hajcak, 2008). Whether conflict-driven adaptations are also changed in these people has yet to be investigated, because mood-disorder studies using cognitive-control measures usually overlook conflict-adaptation effects, reporting main interference effects only (but cf. Holmes & Pizzagalli, 2007).

Altogether, our findings suggest that conflict-driven control adaptations are highly dependent on one's emotional state, with pleasure level being more important than arousal level. Our results demonstrate that the influence of affect is not limited to conflict processing per se, but modulates subsequent behavioral adaptation as well. This suggests that affect is highly important not only in biasing perception and signaling environmental conflict, but also in adaptively regulating goal-directed behavior.

Acknowledgements

5