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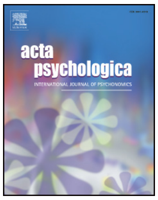

Phasic valence and arousal do not influence post-conflict adjustments in the Simon task

David Dignath [a,*], Markus Janczyk [b], Andreas B. Eder [c]

[a] *Albert Ludwigs University of Freiburg, Germany*
[b] *Eberhard Karls University of Tübingen, Germany*
[c] *Julius-Maximilians University of Würzburg, Germany*

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ABSTRACT

According to theoretical accounts of cognitive control, conflict between competing responses is monitored and triggers post conflict behavioural adjustments. Some models proposed that conflict is detected as an affective signal. While the conflict monitoring theory assumed that conflict is registered as a negative valence signal, the adaptation by binding model hypothesized that conflict provides a high arousal signal. The present research induced phasic affect in a Simon task with presentations of pleasant and unpleasant pictures that were high or low in arousal. If conflict is registered as an affective signal, the presentation of a corresponding affective signal should potentiate post conflict adjustments. Results did not support the hypothesis, and Bayesian analyses corroborated the conclusion that phasic affects do not influence post conflict behavioural adjustments in the Simon task.

1. Introduction

Goal directed actions require mechanisms that shield current goals against distractions. Central to these mechanisms is the idea of control processes that adjust attentional sets dynamically to the task at hand (Allport, 1989; Desimone & Duncan, 1995; Miller & Cohen, 2001). Typically, researchers use so-called conflict tasks to probe for control processes. For instance, in the Simon task (Simon, 1969), participants have to respond to the identity of a target (e.g., colour) presented at various locations. Critically, the selection of a correct response to the target can conflict with automatic response tendencies instigated by irrelevant task features, such as the spatial position of a target. Responses are faster and less error prone in trials in which the irrelevant feature affords the same response as the target (congruent trials) compared with trials in which the spatial feature affords a different response as the target (incongruent trials). The conflict between task-relevant and task-irrelevant response tendencies is quantified by the size of the congruency effect, that is, the performance difference between congruent and incongruent trials (Kornblum, Hasbroucq, & Osman, 1990).

The *conflict monitoring theory* (CMT) suggested that conflict between competing activation of different representations is automatically detected by a dedicated monitoring mechanism (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Botvinick, Cohen, & Carter, 2004). Brain imaging studies identified the anterior cingulate cortex (ACC) as a possible neurophysiological substrate of this monitoring (Botvinick, Nystrom, Fissell, Carter, & Cohen, 1999). After detection of a conflict, the conflict monitoring process triggers adaptations that aim at improving subsequent performance by, for example, enhanced processing of the relevant stimulus, which then shields the current task goal from a distracting influence (Kerns et al., 2004; MacDonald, Cohen, Stenger, & Carter, 2000). Another way to implement control is by weakening and/or inhibiting the automatic activation of a response by an irrelevant stimulus feature (Stürmer, Leuthold, Soetens, Schröter, & Sommer, 2002; Stürmer, Redlich, Irlbacher, & Brandt, 2007). Evidence for such mechanisms of post conflict adjustments comes from so-called sequential congruency effects (SCE). In a seminal study, Gratton, Coles, and Donchin (1992) demonstrated that when a previous trial was incongruent, the congruency effect was reduced in the current trial compared to when the previous trial was congruent (e.g. Janczyk, 2016; Notebaert & Verguts, 2008; Weissman, Hawks, & Egner, 2016; for a review see Egner, 2007).

Recent research argues that the conflict signal detected during performance monitoring is emotionally aversive (Botvinick, 2007; Dreisbach & Fischer, 2015; Inzlicht, Bartholow, & Hirsh, 2015). In support of this hypothesis, several studies showed that conflict is evaluated as negative (Dreisbach & Fischer, 2012; Morsella, Gray, Krieger, & Bargh, 2009; Schouppe et al., 2015) and triggers a motivational tendency to avoid stimuli and tasks associated with conflict (Dignath & Eder, 2015;

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[*] Corresponding author at: Department of Psychology, University of Freiburg, Engelbergerstrasse 41, 79085 Freiburg, Germany.
E-mail address: dignath.david@gmail.com (D. Dignath).

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Dignath, Kiesel, & Eder, 2015; Schouppe, De Houwer, Ridderinkhof, & Notebaert, 2012).

However, the interpretation of the SCE in terms of conflict monitoring was questioned by studies showing that SCEs are influenced by priming and episodic binding processes between stimulus and response features (Hommel, Proctor, & Vu, 2004; Mayr, Awh, & Laurey, 2003; Spapé & Hommel, 2014). On the basis of this research, the adaptation by binding (ABB) model proposed that the SCE is the result of an associative learning mechanism (Verguts & Notebaert, 2009). The ABB model explains sequential modulations with a transient feature binding between stimuli and responses that is triggered by a valence-unspecific arousal response after the detection of a conflict (Abrahamse, Braem, Notebaert, & Verguts, 2016; Braem, Verguts, & Notebaert, 2011; Verguts & Notebaert, 2009). Evidence for an arousing effect of conflict comes from studies that investigated skin conductance responses during the Stroop task (Kobayashi, Yoshino, Takahashi, & Nomura, 2007; Renaud & Blondin, 1997). To summarize, both the CMT and the ABB model proposed that conflict is detected as an affective signal. While the CMT assumed that conflict is registered as a negative valence signal, the ABB model hypothesized that conflict provides a high arousal signal.

2. Conflict and affect

The present research investigated the hypothesis that conflict is registered as an affective signal in more detail. As summarized above, several studies provided evidence that conflict elicits affect. Most evidence comes from experimental studies that manipulated *tonic* affective states (i.e., long-lasting mood states) in conflict tasks. Results provided experimental and correlative evidence that negative mood increases conflict monitoring (Clawson, Clayson, & Larson, 2013; Hengstler, Holland, van Steenbergen, & van Knippenberg, 2014; Larson, Clawson, Clayson, & Baldwin, 2013; Schuch & Koch, 2015; Van Steenbergen, Band, & Hommel, 2009; but see Plessow, Fischer, Kirschbaum, & Goschke, 2011). The present study, by contrast, focuses on *phasic* affect induction for two reasons. First, phasic affect is a brief and subtle change in the affective state on a trial-to-trial basis. Therefore, phasic affect addresses a similar timescale as the SCE. And second, long lasting mood states not only influence monitoring processes but also other cognitive processes that could influence control operations (see Ashby, Isen, & Turken, 1999). Therefore, studies with manipulations of tonic affect revealed important insights about how mood states influence monitoring, but they are not suited to draw clear conclusions about the affective quality of a monitoring signal.

Other studies investigated an affective influence on conflict monitoring with interspersed presentations of affective stimuli during and after conflict trials; however, this research provided only inconsistent and ambiguous results. For instance, Kanske and Kotz (2010) investigated conflict monitoring by measuring the N200 component, an EEG marker assumed to reflect the strength of the monitoring signal. The authors reported an increased N200 for negative compared to neutral irrelevant words in a colour Flanker task. This study suggests that conflict monitoring is increased for task irrelevant, negative affect. In line with this finding, van Steenbergen et al. (2009) observed a reduced SCE after presentation of a performance non-contingent reward feedback (assumed to induce positive affect) compared to loss feedback (Van Steenbergen et al., 2009; see also Braem et al., 2013 for similar results for a task switching paradigm). In contrast, Padmala, Bauer, and Pessoa (2011) reported that negative and high arousing pictures eliminate the SCE in a Stroop task. Thus, it is unclear how phasic affects influence adaptation to conflict, and more research is needed on this issue.

3. A Dimensional model of affect

To account for these seemingly discrepant results, it might be useful to consider a dimensional model of affect. These models typically describe affective states with two basic dimensions, valence and arousal (Barrett & Russell, 1999). Affective valence refers to the pleasantness or hedonic tone of an affective state, while arousal is related to its energy or potential for (physiological) mobilization, that is, the strength of the associated emotional state. These dimensions underlie affective experiences (e.g., Barrett & Russell, 1999) and emotional reactions (e.g., Lang, Bradley, & Cuthbert, 1997).

A distinction between valence and arousal is of particular relevance, because some theorists have argued that both dimensions are best understood as a combination of both factors (Citron, Gray, Critchley, Weekes, & Ferstl, 2014; Nielen et al., 2009; Watson, Wiese, Vaidya, & Tellegen, 1999). Indeed, recent empirical work suggested that valence and arousal can interact to produce affective experience and behaviour. In a study by Robinson, Storbeck, Meier, and Kirkeby (2004) participants responded in an evaluative judgement task faster to negative pictures high in arousal compared to negative pictures low in arousal, and faster to positive pictures low in arousal compared to positive pictures high in arousal (see also Eder & Rothermund, 2010).

However, most previous studies did not differentiate between valence and arousal or both factors were confounded (i.e. negative stimuli were consistently higher in arousal compared to positive stimuli, see Padmala et al., 2011; Braem et al., 2013). The only exception that we know of is a study of Zeng et al. (2016) who controlled for effects of emotional arousal. However, this study only included high-arousing unpleasant and pleasant stimuli (words), and neutral words in a baseline condition. Results revealed similar SCEs in the condition with unpleasant and pleasant stimuli that were of greater magnitude compared to the SCE obtained in the baseline condition. While this study suggests that arousal is probably more important than affective valence, it would be more convincing to vary the arousal level within each affective valence. Based on the research by Zeng and colleagues, one might expect stronger conflict adaptation with affective stimuli that are high in arousal relative to those that are low in arousal (arousal-hypothesis). An alternative hypothesis is that high arousal modulates the magnitude of SCE in an unpleasant context but not in a pleasant context (interaction-hypothesis; Eder & Rothermund, 2010). A third possibility is that valence influences conflict adaptation irrespective of the arousal value (valence-hypothesis; van Steenbergen et al., 2009). Thus, different hypotheses could be derived for effects of valence and arousal on conflict-adaptation.

4. Study overview

The present study investigated whether a phasic manipulation of emotional valence and arousal modulates post conflict adjustments (indexed by the size of the SCE). We used a spatial version of the Simon task to induce (sequential modulations of) conflict. Most importantly, we induced phasic affective states during conflict with affective pictures that varied orthogonally in their valence and arousal.

Based on the theoretical models of affective conflict monitoring, the following hypotheses were derived: (1) According to the CMT, conflict provides a negative signal. Thus, induction of phasic negative valence should potentiate the negative conflict signal, which means that SCE should be enlarged after presentations of unpleasant pictures relative to positive pictures, irrespective of emotional arousal (valence-hypothesis). (2) A different prediction is derived from the ABB. According to this model, conflict elicits high arousal. If feature binding is facilitated by high arousal states, then the SCE should be larger after high arousing pictures relative to low arousing pictures, irrespective of emotional valence (arousal-hypothesis). (3) Finally, research on emotions suggests that valence and arousal interact. More precisely, the influence of affective stimuli on task performance is enhanced when valence and arousal are affective-compatible (i.e., high-arousing negative and low-arousing positive pictures) compared to a situation when both dimensions are affective-incompatible (i.e., low-arousing negative and high-arousing positive pictures). Thus, according to this account the SCE should be larger after pictures affective-compatible pictures compared to affective-incompatible pictures (interaction -hypothesis)

5. Experiment 1

5.1. Method

5.1.1. Participants

We planned with 96 participants for each experiment. Due to no-shows of some participants and restricted lab space, data collection was finished with slightly less that the intended sample size in both experiments. 90 participants (62 women, 19–63 years; $M = 30.66$) were paid for participation. Data of three participants were excluded, because they misunderstood the task, resulting in extreme error rates ($M > 97\%$). Two additional participants were excluded due to exceptionally high error rates ($M > 36\%$, >3 SDs), leaving a final sample of 85 participants for analysis.

5.1.2. Apparatus and stimuli

Participants were tested on individual PCs in groups of three participants in a testing room with a divider between participants. Stimulus presentation was controlled by a professional software timer (E-Prime 2.0; Schneider, Eschman, & Zuccolotto, 2012). Digits (printed in "Courier New", bold, 18) appeared on the left (156 pixel [px]) or right (868 px) side of fixation on the computer screen (active screen resolution 1024 × 768 px). The approximate viewing distance was 60 cm. Fifty-six pictures were taken from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008) according to their valence and arousal norms (see the Appendix for the slide numbers). Half of the pictures were pleasant and the other half of the set was unpleasant. Within each valence category, half of the pictures were low arousing (pleasant: Mvalence = 7.6 [0.6] and Marousal = 4.6 [0.3]; unpleasant: Mvalence = 2.7 [0.7] and Marousal = 5.0 [0.4]) and half were high in arousal (pleasant: Mvalence = 7.2 [0.4] and Marousal = 6.3 [0.5]; unpleasant: Mvalence = 2.9 [0.8] and Marousal = 6.4 [0.4]). Thus, valence and arousal varied orthogonally, with other factors like visual complexity being controlled (for a more detailed analyses see Robinson et al., 2004). Pictures were presented in full size (1024 × 768 px) on the computer screen.

5.2. Procedure

Instructions were displayed on the computer screen. Participants first rated their current mood on a continuous rating scale ranging from 0 [very bad] to 100 [very good]. A spatial Simon task followed with categorisation of lateralized presented digits into smaller (digits 1–4) and larger (digits 6–9) than 5. Participants responded with presses of the 'a' and '#' keys using the index fingers of their left and right hand on a QWERTZ keyboard. The stimulus to key mapping was counterbalanced across participants.

Fig. 1 shows the sequence of events. A trial started with a fixation cross for 500 ms. Then the target stimulus (a digit) was presented for 200 ms, followed by a blank screen for 1800 ms or until registration of a response. An IAPS-picture was presented for a duration of 600 ms, and immediately afterwards the next trial started.

Previous research showed that affective responses to IAPS pictures peak 1000 ms after picture onset (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000), and that a short presentation without a masking stimulus is sufficient to elicit emotional responses (Codispoti, Bradley, & Lang, 2001). Affective responses elicited by the interspersed picture presentations should consequently have overlapped with conflict processing in time.

The experiment consisted of 4 blocks with 224 trials each. Valence and arousal of the interspersed pictures were varied in separate blocks (with counterbalanced order across participants). We decided to administer each valence/arousal combination block-wise to avoid carry-over effects from trials beyond N-1 (e.g., Aben, Verguts, & van den Bussche, 2017) and to avoid dynamic changes in emotional states due to contrast-effects (e.g., Eder & Dignath, 2014; Parducci, 1984). Participants received feedback about their mean response times (RTs) and accuracy after each block and they were encouraged to respond faster and with less errors than before. In case of an incorrect or without responses within the allowed time window of 2000 ms an error message appeared for 1000 ms.

5.3. Results

The first trial in a block, post-error trials (10.0%), and direct stimulus repetitions (12.1%) were removed before analyses. In addition, for the RT analysis, trials with erroneous responses (8.6%) and RTs that

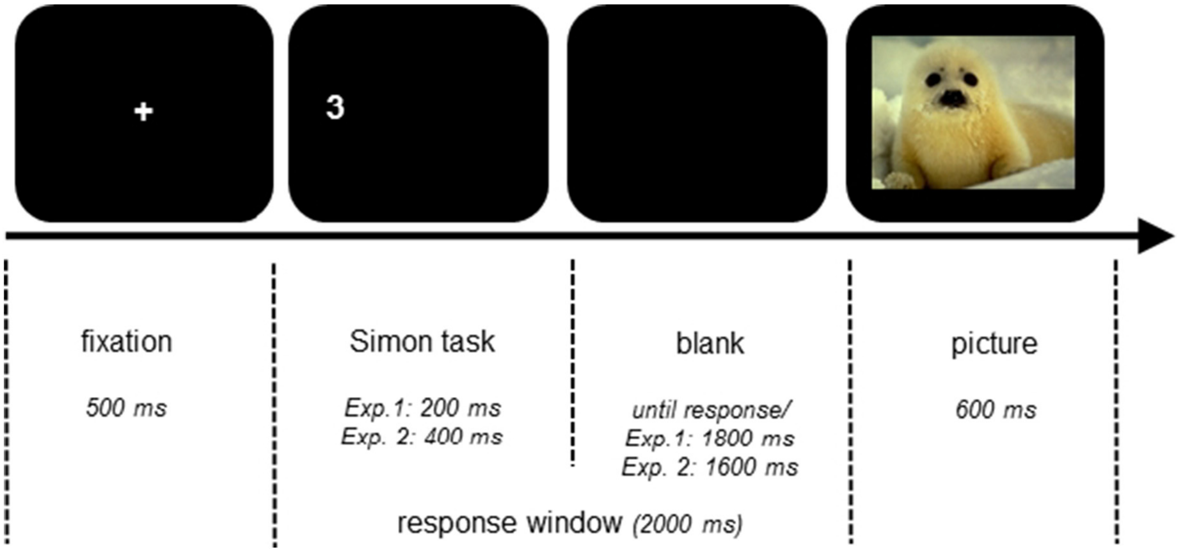

Fig. 1. Trial sequence in Experiments 1 and 2. Participants categorized digits shown at left and right locations with the left and right index fingers.

deviated >3 SDs from the cell mean for each condition (calculated separately for each participant) were discarded (0.8%). After exclusion of these trials, mean RTs and error rates were computed for each condition. The SCE was defined as the difference between the congruency effect after previously congruent trials (CI-CC) and the congruency effect after previously incongruent trials (II-IC) [i.e., SCE = (CI-CC)−(II-IC)].

5.3.1. Mood rating

Participants were in a good mood at the start of the experiment ($M = 68.5$; $SD = 18.5$). The mood rating was unrelated to the size of the overall SCE ($r = 0.04$, $p = 0.701$) or the size of the SCE in any specific valence/ arousal combinations (largest $r = 0.16$, largest $p = 0.148$).

5.3.2. Reaction Times

Data were submitted to a repeated-measures analysis of variance (ANOVA) with the factors *current congruency* (congruent, incongruent), *previous congruency* (congruent, incongruent), *picture valence* (positive, negative), and *picture arousal* (high, low) and are visualized in Fig. 2. The effect of *current congruency* was significant, $F(1, 84) = 107.69$, $p < 0.001$, $\eta_p^2 = 0.56$. Responses were faster in congruent trials ($M =$ 514 ms) compared to incongruent trials ($M = 531$ ms). Furthermore, the effect of *previous congruency* was significant, $F(1, 84) = 30.06$, $p < 0.001$, $\eta_p^2 = 0.26$. Responses were faster after congruent trials ($M = 519$ ms) relative to incongruent trials ($M = 525$ ms).

More relevant, the interaction between *previous congruency* and *current congruency* was significant, $F(1, 84) = 169.87$, $p < 0.001$, $\eta_p^2 = 0.67$, indexing a sequential modulation of the congruency effect: The congruency effect was reduced after a previous incongruent trial compared to a previous congruent trial (SCE = 37 ms). Most important to the present research, the SCE (i.e., the interaction between *previous congruency* and *current congruency*) did not interact with *valence* ($F < 1$) or *arousal* ($F < 1$). Furthermore, the SCE was also not modulated by a combination of valence and arousal, as indicated by a non-significant 4-way interaction ($F < 1$). No other effect reached significance (all $ps > 0.10$).

Given this surprising null-effect, we next performed a Bayesian rANOVA with default prior scales using JASP (version 0.7.5.6; Love et al., 2015; Rouder, Speckman, Sun, Morey, & Iverson, 2009). The Bayesian approach is a model selection procedure that indicates the likelihood ratio of two (or more) hypotheses given some data. Therefore, Bayesian statistics offers a way of evaluating evidence in favor of the (null-) hypothesis. The Bayes-factor (BF) provides an index of how strong the data is in favor of a hypothesis, with the convention that a BF between 1 and 3 indicates anecdotal evidence, a BF between 3 and 10 moderate evidence, and a BF above 10 strong evidence for a hypothesis (Lee & Wagenmakers, 2013). Our Bayesian analyses showed that

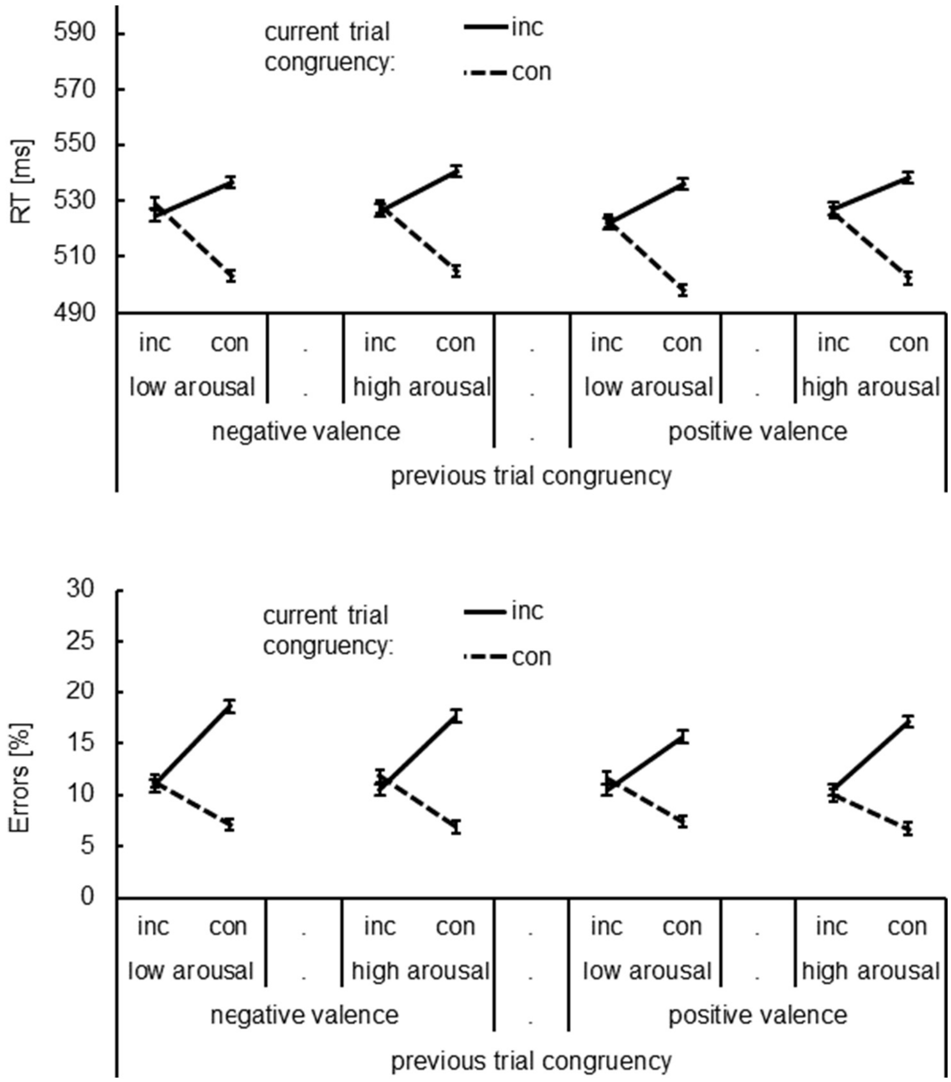

Fig. 2. Mean reaction times (RT) (upper panel) and error rates in percent (lower panel) in congruent (con) and incongruent (inc) trials of the Simon task as a function of task conditions in Experiment 1. Error bars indicate within-corrected standard errors of the mean (Loftus & Masson, 1994).

the null-hypothesis model for emotional valence (no modulation of SCE by valence) was >8 times as likely as the H1 (BF = 8.43). The null-hypothesis model for arousal (no modulation of SCE by arousal) was >6 times as likely as the H1 (BF = 6.73). All other models (additive main effects or the interaction) favoured the null-hypothesis with BFs > 10.

5.3.3. Error Rates

An analogous ANOVA was performed on the error rates. This analysis revealed a main effect of *current congruency*, $F(1, 84) = 85.25$, $p < 0.001$, $\eta_p^2 = 0.504$, showing that participants made fewer errors in congruent trials ($M = 9.1\%$) compared to incongruent trials ($M = 13.9\%$) and a main effect of *previous congruency*, $F(1, 84) = 21.77$, $p < 0.001$, $\eta_p^2 = 0.206$, indicating that participants made fewer errors in trials that followed incongruent trials ($M = 10.9\%$) compared to congruent trials ($M = 12.1\%$). The three-way interaction of *previous congruency*, *valence* and *arousal* was also significant, $F(1, 84) = 4.93$, $p = 0.029$, $\eta_p^2 = 0.055$. More importantly, the SCE was significant, $F(1, 84) = 110.62$, $p < 0.001$, $\eta_p^2 = 0.568$. The SCE was further modulated by *valence*, $F(1, 84) = 4.53$, $p = 0.036$, $\eta_p^2 = 0.051$, being enhanced after presentations of unpleasant pictures (SCE = 11.9%) compared to pleasant pictures (SCE = 9.6%). Neither arousal level nor the interaction of *arousal* and *valence* had an effect on the SCE (*F*s < 1).

Bayesian rANOVA indicated that the evidence in favor of a SCE modulation by valence was only anecdotal (BF = 1.31 for the H1 that valence modulates the SCE). Furthermore, the Bayesian analysis provided moderate evidence for the null-hypothesis model of arousal effects (arousal does not influence SCE; BF = 8.18). All other models favoured the null-hypothesis with BFs > 10, which provides substantial evidence against the valence-arousal interaction-hypothesis.

5.4. Discussion

Experiment 1 tested whether pleasant and unpleasant affect high and low in arousal influences post conflict behaviour adjustments. Results revealed a robust SCE in RTs and error rates. However, the induction of affects had no effect on the strength of conflict adaptation in the RT measure. Negative affect increased the SCE in analyses of error rates, but the effect was very small and anecdotal according to a Bayesian analysis. A possible explanation for the null-findings is that participants did not pay sufficient attention to the intermittent presentations of affective pictures, what may have reduced the effectiveness to elicit an affective response (Erthal et al., 2005; Pessoa, 2005). For a second experiment, we therefore directed the participants' attention to the affective pictures by using a secondary task.

6. Experiment 2

6.1. Method

6.1.1. Participants

Eighty-nine participants (65 women, 18–57 years; M = 26.5 years) were paid for participation. Data of two participants were excluded due to an exceptionally high error rate ($M > 20\%$, >3 SDs).

6.1.2. Stimuli and procedure

Experiment 2 was identical to Experiment 1 except for two changes. First, participants were informed that emotional pictures will be presented during the experiment and that they were asked to pay attention to the frame colour surrounding the picture. Pictures had a yellow (210 trial of a block) or a blue frame (14 trials per block). Participants had to indicate with the space bar whenever the picture had a blue frame, while no response was required when the picture had a yellow frame. This additional secondary task was included to ensure that participants paid attention to the pictures but performance in this task was not further analyzed. Second, the display duration of the digits was increased to 400 ms to give participants more time for target processing.

6.2. Results

The first trial in a block, post-error trials (5.7%), and trials with direct stimulus repetitions (11.9%) were not analyzed. For the RT analysis, trials with erroneous responses (5.5%) and RTs that deviated >3 SDs from the cell mean for each condition (calculated for each participant separately) were discarded (0.9%).

6.2.1. Mood rating

Participants were in good mood ($M = 74.0$; $SD = 19.2$). Similar to Experiment 1, subjective mood ratings were not correlated with the size of the overall SCE ($r = 0.05$, $p = 0.612$) or the size of the SCE in any specific valence/arousal combinations (largest $r = 0.09$, largest $p = 0.406$.

6.2.2. Reaction times

Data were analyzed as in Experiment 1 and are visualized in Fig. 3. The effect of *current congruency* was significant, $F(1, 86) = 146.24$, $p < 0.001$, $\eta_p^2 = 0.630$. Responses were faster in congruent trials ($M = 529$ ms) compared to incongruent trials ($M = 548$ ms). Furthermore, the effect of *previous congruency* was significant, $F(1, 86) = 35.09$, $p < 0.001$, $\eta_p^2 = 0.290$. Responses were faster after congruent trials ($M = 536$ ms) relative to incongruent trials ($M = 529$ ms). More important, there was a significant SCE (33 ms), as indicated by the interaction between *previous congruency* and *current congruency*, $F(1, 86) = 141.12$, $p < 0.001$, $\eta_p^2 = 0.621$. No other effect reached significance. Most important for the present research, neither the interaction of *SCE* and *valence*, $F(1, 86) = 1.21$, $p = 0.275$, $\eta_p^2 = 0.014$, the interaction of *SCE* and *arousal*, $F < 1$, nor the higher order interaction (*SCE*, *valence*, and *arousal*) reached significance, $F < 1$.

Bayesian rANOVA revealed that the valence null-hypothesis model (no influence of valence on the SCE) was >4 times as likely as the H1 (BF = 4.77), and the arousal null-hypothesis model (no influence of arousal on the SCE) was >6 times as likely as the H1 (BF = 6.32). All other models favoured the null-hypothesis with BFs > 10.

6.2.3. Error rates

An analogous ANOVA was performed on the error rates. This analysis revealed a main effect of *current congruency*, $F(1, 86) = 92.15$, $p < 0.001$, $\eta_p^2 = 0.517$, showing that participants made fewer errors in congruent trials ($M = 5.4\%$) compared to incongruent trials ($M = 8.3\%$). The effect of *previous congruency* was also significant, $F(1, 86) = 16.55$, $p < 0.001$, $\eta_p^2 = 0.161$. Participants made fewer errors in trials that followed incongruent trials ($M = 6.4\%$) compared to congruent trials ($M = 7.2\%$). The SCE was significant, $F(1, 86) = 93.34$, $p < 0.001$, $\eta_p^2 = 0.520$. No other effect on the magnitude of SCE reached significance, including the effects of valence, $F < 1$, and arousal, $F < 1$. Bayesian rANOVA corroborated that the valence null-hypothesis model was >6 times as likely as the H1 (BF = 6.95) and the arousal null-hypothesis model >8 times as likely as the H1 (BF = 8.22). All other models were with BF > 10 in favor for the null-hypothesis.

6.3. Discussion

Experiment 2 investigated whether affective states would modulate the SCE when participants' attention is directed towards affect-eliciting pictures. Replicating the results of Experiment 1, we observed a strong SCE, but the size of the SCE was neither affected by valence nor by arousal of the pictures.

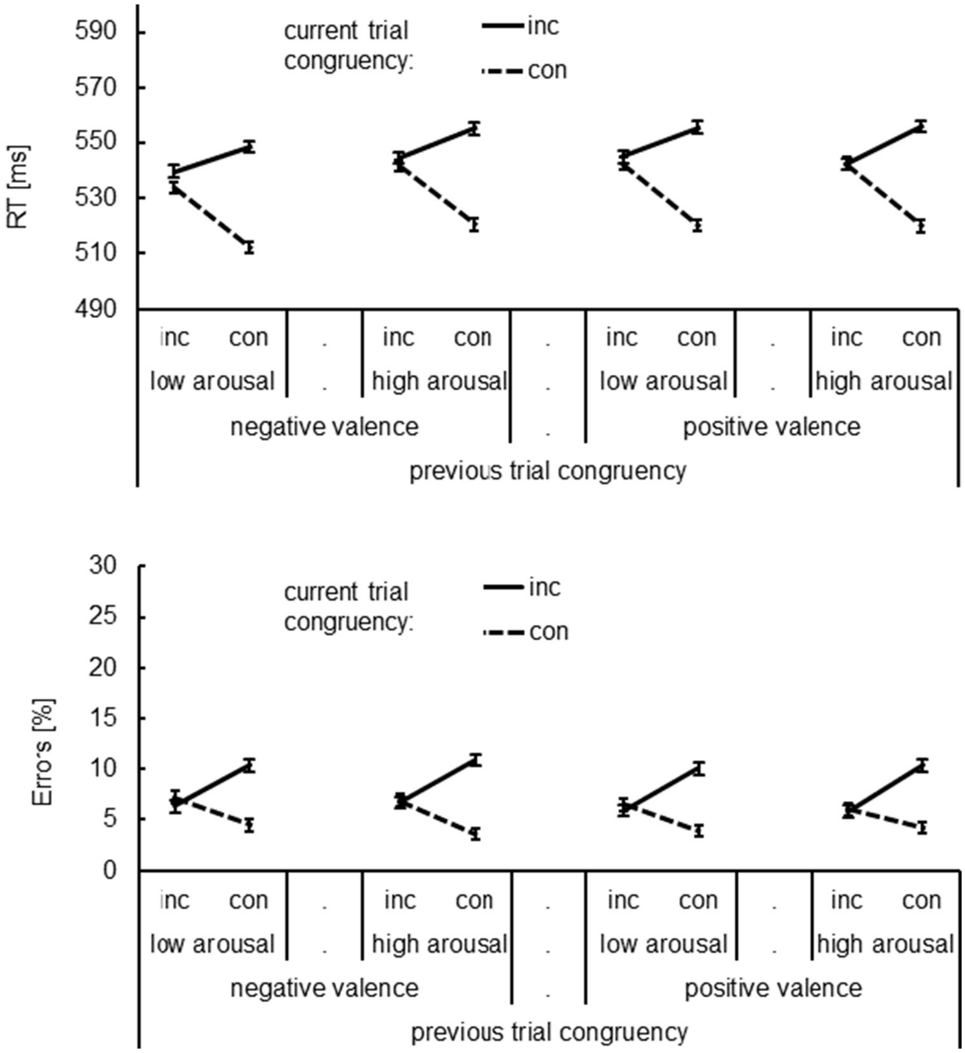

Fig. 3. Mean reaction times (RT) (upper panel) and error rates in percent (lower panel) in the Simon task for task conditions in Experiment 2. Error bars indicate within-corrected standard errors of the mean (Loftus & Masson, 1994).

7. General discussion

Do phasic affects influence cognitive control adjustments? According to the CMT, conflict provides an aversive signal that triggers cognitive adjustments. The induction of negative affect should hence augment monitoring and facilitate post conflict adjustments (Botvinick, 2007; cf. van Steenbergen et al., 2009). The ABB model alternatively proposed that conflict provides a high arousal signal (Notebaert & Verguts, 2008). Accordingly, states of high arousal should facilitate monitoring and associative processes underlying post conflict adjustments. The present research used briefly presented IAPS pictures to induce phasic affect while participants performed a Simon task. By crossing the valence and arousal of the pictures orthogonally, we aimed to pit the different theoretical accounts against one another. Furthermore, this manipulation allowed to test the hypothesis that valence and arousal interactively modulate post conflict adjustments.

Overall, results from two experiments with over 170 participants failed to provide evidence for an affective modulation of post conflict adjustments. Although we obtained robust evidence for post conflict adjustment in terms of an SCE, the size of the SCE did not differ for different classes of affective pictures. Furthermore, a Bayesian analysis provided substantial evidence *against* an affective modulation of post conflict adjustment processes in the Simon task. Therefore we conclude that (phasic) affect does not influence control adaptations in a spatial Simon task.

7.1. Limitations of the present study

Before we will discuss the theoretical implications of these results, we would like to first point out two limitations of the present study. First, we cannot provide a manipulation check (e.g. physiological measures on a trial-by-trial basis) whether and how strong picture presentation elicited affective responses. While it is well established that IAPS pictures reliably induce phasic affective responses (e.g. Bradley and Lang, 1994 for subjective rating; e.g. Cuthbert et al., 2000; Codispoti et al., 2001; Bradley, Codispoti, Cuthbert, & Lang, 2001 for physiological responses), it remains possible that participants affective responses changed over the course of the experiment. More precisely, because stimuli were repeated several times during a block of trials, it is possible that affective responses to the pictures habituated.

However, we are sceptical whether habituation provides a strong alternative explanation for the reported null-effect for three reasons. First, it is common practise in studies investigating the electrophysiological signature of affective responses to IAPS pictures to repeat stimuli several times during an experiment and to collapse data over multiple presentations (cf. Rozenkrants, Olofsson, & Polich, 2008). Second, a study by

Rozenkrants, Olofsson and Polich that directly addressed the influence of stimulus repetition on affective responses to IAPS pictures showed that affective responses and repetition effects are independent. As the authors conclude "the lack of interaction [of the factor stimulus repetition] with the arousal or valence factors indicates that the modulation of rapid brain responses to affective images is stable over repetitions" (p. 199). And third, we conducted an exploratory analysis of the present data set and tested a possible valence/arousal modulation of the SCE for the first and second half of a block of trials. This analysis revealed no differences for the first and second part of a block. However, future research could address this issue more directly by using larger stimulus set (to avoid stimulus repetitions) and/or smaller blocks of trials (to experimentally control for repetition effects).

A further limitation concerns the interpretation of the SCE in terms of cognitive control. As outlined in the introduction, an alternative interpretation assumes that the SCE is due to feature binding processes (Hommel et al., 2004; for an integrative model see also Egner, 2015). While it is possible to control for stimulus and response feature binding effects in tasks like the Erikson Flanker task, it is difficult to control for these effects in the Simon task. Although we used a version with a larger set of relevant stimulus categories and excluded trials with direct stimulus repetitions from the analysis, it remains unclear to which degree feature binding might have contributed to the results. This could be addressed in studies using confound minimized designs (e.g. in the Flanker task: Duthoo, Abrahamse, Braem, Boehler & Notebaert, 2014) for a more conclusive test of valence and arousal effects on the SCE in the absence of low-level feature binding processes.

Finally, some studies that included neutral trial conditions in addition to congruent and incongruent configurations reported evidence that SCEs were not due to incongruent trials, but rather due to (attentional) changes in congruent relative to neutral trials (e.g. Lamers & Roelofs, 2011). These findings are hard to reconcile with the CMT and the ABB model, because both theories assume that conflict during incongruent trials triggers negative affect. However, in our view this does not necessarily invalidate the more general idea that affect induced during a flanker or Simon task can modulate control adjustments. For instance, research on 'hedonic contrast' has shown that affective evaluations of stimuli are not absolute but relative to evaluations of alternative stimuli (Eder & Dignath, 2014; Larsen & Norris, 2009; Parducci, 1984). Therefore, it is possible that participants in the study by Lamers and Roelofs (2011) evaluated neutral Flanker configurations (e.g. OOSOO, with the letter O not mapped onto any response) as *relatively* more negative compared to congruent (e.g. SSSSS) configurations. Indeed, a recent study by Fischer and Dreisbach has shown that SCE-like effects can be obtained with stimuli - devoid of any response conflict - that differ in only in the ease of processing and thereby induce relative positive (fluent) or negative (disfluent) affective responses (Dreisbach and Fischer, 2011).

7.2. Affective conflict processing – is it real?

The outcome of this study is surprising, because previous studies obtained evidence for an affective modulation of SCEs, although with inconsistent results (Padmala et al., 2011; van Steenbergen et al., 2009; Zeng et al., 2016). A notable difference between these studies and the present research is the conflict task employed. While previous research investigated affective modulation of post conflict adjustments with a flanker task (Van Steenbergen et al., 2009; Zeng et al., 2016) or a Stroop task (Padmala et al., 2011), the present research used a spatial variant of a Simon task.

On a more general level, all three paradigms have in common that task-irrelevant information can conflict with processing of task-relevant information. However, on a structural level, the Simon task is different from Stroop and flanker in respect to the involved compatibility relations (Kornblum et al., 1990). While the latter tasks comprise stimulus-stimulus and stimulus-response compatibility relations (De Houwer, 2003; Fournier, Scheffers, Coles, Adamson, & Abad, 1997), the Simon task involves stimulus-response conflict only (Hommel, 2011; Ridderinkhof, van den Wildenberg, Wijnen, & Burle, 2004). Indeed, flanker and Stroop tasks on the one hand and the Simon task on the other hand produce markedly different behavioural effects in RT distributions (Ridderinkhof et al., 2004; Ulrich, Schröter, Leuthold, & Birngruber, 2015) and recruit distinct brain areas (Liu, Banich, Jacobson, & Tanabe, 2004). More important for the present discussion, evidence suggests that the mechanisms of post conflict adjustments for flanker and Stroop tasks are different from those in the Simon task. For instance, several studies suggest that post conflict adjustments are driven by stimulus conflict and not response conflict in the flanker and Stroop tasks (van Veen & Carter, 2005; Verbruggen, Notebaert, Liefooghe, & Vandierendonck, 2006), and post conflict adjustments affect *perceptual processes*: Post conflict adjustments amplify identification of the relevant task dimension in a Stroop task (Egner & Hirsch, 2005) and they facilitate perceptual filtering of distracting information in the flanker task (Wendt, Luna-Rodriguez, & Jacobsen, 2012). In the Simon task, by contrast, post conflict adjustments affect *response related processes*, which means the inhibition of the response instigated by the irrelevant location information (Stürmer et al., 2002, 2007).

Interestingly, not only the cognitive processes that resolve conflict differ between flanker and Stroop and the Simon task, but also the affective consequences of conflict. For instance, studies that demonstrated aversiveness of conflict (Dignath & Eder, 2015; Dreisbach & Fischer, 2012; Fritz & Dreisbach, 2013; Schouppe et al., 2015) used only Stroop and flanker tasks. Furthermore, studies showed a negative evaluation of stimulus-stimulus conflicts but not of stimulus-response conflicts (Dignath & Eder, 2015; Fritz & Dreisbach, 2013; Schouppe et al., 2012). These findings suggest a negligible role of negative affect in the Simon task. Indeed, a study that measured pupillometric responses (a physiological indicator of arousal) and corrugator muscle activity (a physiological indicator of negative affect) during a Simon task failed to observe evidence for conflict-induced affect (Schacht, Dimigen, & Sommer, 2010). In short, phasic affects may influence cognitive control processes only in tasks with stimulus conflict, while tasks with response conflict implement control adaptations by non-affective mechanisms. This would also explain why Stürmer and colleagues observed no effects of random reward (known to elicit positive affect) on post conflict adjustment in a Simon task (Stürmer, Nigbur, Schacht, & Sommer, 2011), while van Steenbergen and colleagues observed an effect of random rewards in a flanker task (Van Steenbergen et al., 2009).

This (speculative) line of reasoning would imply that one factor (among others) why control adjustments are different for response conflict and stimulus conflict tasks is due to the role of affect for control adaptations. According to the conflict-as-emotion hypothesis, conflict is registered as an aversive event, and this affective state is used as a signal for control adjustments. While an affective process is involved in stimulus conflict (Dignath & Eder, 2015), control adjustments for response conflict might be driven by cognitive processes only. Clearly, the idea that stimulus versus response conflicts involve different signals for control adjustments remains to be tested. For instance, future research can examine this hypothesis more directly by comparing affective modulations of post conflict adjustments in the Flanker and Simon tasks.

To summarize, the present research showed that phasic affective states induced by affective pictures have no effect on post conflict adjustments in a spatial Simon task. This finding constrains theorizing about affective influences on cognitive control and calls for a more detailed analysis of affect-based cognitive control.

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Data and analysis scripts can be retrieved from the Open Science Framework: https://osf.io/wgse6/?view_only=2b021fdb8eac472499ea77358e7d63d2

Appendix

Slide Numbers (see Lang, Bradley, & Cuthbert, 2008) for the negative/high arousal condition:1050, 1120, 1300, 1301, 1930, 3130, 3250, 6260, 6300, 6510, 6570, 7380, 9300, 9570; for the negative/low arousal condition 1111, 1220, 2053, 2520, 2800, 3230, 3350, 7361, 9008, 9290, 9320, 9415, 9421, 9561; for the positive/high arousal condition 4599, 4607, 4608, 4641, 4651, 4652, 4660, 5621, 8180, 8200, 8370, 8380, 8470, 8490; and for the positive/low arousal condition 1440, 1460, 1750, 1810, 2040, 2050, 2057, 2070, 2165, 2352, 2550, 2660, 4606, 8350.

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