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

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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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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