Affective Influence on Context-Specific Proportion Congruent (CSPC) Effect: Neutral or Affective Facial Expressions as Context Stimuli

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This research was supported by grants within the Priority Program, SPP 1772 from the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG), Grant no. KI1388/8-1 and Grant no. DI 2126/1-1. Experimental materials, data and analyses scripts can be retrieved from the Open Science Framework: https://osf.io/2dzuc/?view_only=52a75b55897149be8a57f70e975dc2fe

The authors would like to thank Sari Alsalti, Julia Ditz and Patrik Seuling for help with the data collection and Gesine Dreisbach and Juan Lupiáñez for helpful comments on an earlier version of this manuscript.

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Abstract

Congruency effects diminish in contexts associated to mostly incongruent trials compared with contexts associated to mostly congruent trials. Here, we aimed to assess affective influences on this context-specific proportion congruent (CSPC) effect. We presented either neutral or affective faces as context stimuli in a Flanker task and associated mostly incongruent trials with male/female faces for a neutral-context group and with angry/happy faces for a affective-context group. To assess general influences of affective valence, we compared CSPC effects between the neutral-context group and the affective-context group. To assess valence-specific influences, we compared the size of CSPC effects—for the affective-context group only—between participants for whom mostly incongruent trials were associated with angry faces and participants for whom mostly incongruent trials were associated with happy faces. However, the modulating influence on the CSPC effect from affective vs. neutral contexts or from valence-proportion mappings was not statistically significant.

Keywords: cognitive control, affective valence, Flanker task, context-specific proportion congruent effect

Affective Influence on Context-Specific Proportion Congruent (CSPC) Effect:

Neutral or Affective Facial Expressions as Context Stimuli

Cognitive control is necessary when people face competing response tendencies. For example, when a person who plans to lose weight has to choose between high caloric, tasty food and fat-free, but less tasty food, cognitive control helps him or her to behave in a goal-oriented way. Typical protocols to investigate cognitive control in the laboratory include so-called interference tasks such as Stroop, Flanker or Simon tasks (see Egner, 2008, for a brief introduction of these tasks). For instance, in a color-word Stroop task, participants respond to the ink color of words while ignoring the semantic meaning of these color words. Typically, *congruent* combinations (e.g., *RED* in red ink), in which ink color and word meaning match, are responded to faster and with higher accuracy compared to *incongruent* combinations (e.g., *RED* in blue ink) in which ink color and word meaning do not match. The difference in reaction time (RT) and error rate between incongruent trials and congruent trials is termed congruence effect (CE), which provides an index of cognitive control: A smaller CE signals more cognitive control.

The Context-Specific Proportion Congruent (CSPC) Effect

Recent findings suggest that cognitive control can be highly context-sensitive. For instance, Crump, Gong, and Milliken (2006) used a version of the Stroop task, in which participants classified a color patch following an irrelevant prime color word. They manipulated the proportion of congruent to incongruent trials depending on locations (i.e., contextual cues). For example, while presentation of a color patch in the upper part of the screen comprised mostly congruent combinations (e.g., a blue patch followed *BLUE*), presentation of a color patch in the lower part of the screen comprised mostly incongruent combinations (e.g., a red patch followed *BLUE*). Results revealed that even though the overall proportion of congruent to incongruent trials across both locations was balanced, the biased proportions of congruent to incongruent trials at each location had a strong influence on the magnitude of CEs: The CE at the mostly-congruent location (i.e., the location associated with mostly congruent trials) was larger than the CE at the mostly-incongruent location (i.e., the location associated with mostly incongruent trials). This context-specific proportion congruent (CSPC) effect has been reproduced with other contextual cues such as shape (Crump, Vaquero, & Milliken, 2008), color (Lehle & Hübner, 2008), foreperiod (Wendt & Kiesel, 2011), and semantic categories (Cañadas, Lupiáñezet, Kawakami, Niedenthal, & Rodríguez-Bailón, 2016; Cañadas, Rodriguez-Bailon, Milliken, & Lupianez, 2013).

The CSPC effect suggests that different control settings are applied in different contexts. Because participants are not explicitly informed about the proportion manipulation, researchers assume that participants build up association between contextual cues and control settings (e.g. a control setting used on incongruent trials becomes bound to the mostly-incongruent context). Once this association has been learned, encountering a context stimulus acts as a retrieval cue that allows participants to recall the associated control setting (Crump, 2016). Therefore, the CSPC effect indicates not just learning of control settings and contextual cues, but also the implementation and retrieval of these control settings. Alternatively, it has been suggested that the CSPC effect might be driven by feature binding or contingency learning (e.g., Schmidt, Lemercier, & Houwer, 2014). However, the CSPC effect has been also reproduced with unbiased items, of which the proportion of congruent to incongruent trials was 1:1 (e.g., Crump & Milliken, 2009). Such a *transfer effect* (reflected by a CSPC effect in the unbiased items) suggests that contextual cues are associated to abstract control settings rather than simple stimulus-response mappings. In addition, generalization of control to inconsistent members or new members of a category provides further evidence that the CSPC effect cannot be attributed to specific context-stimulus-response bindings (Cañadas et al., 2013; 2016; see also Weidler & Bugg, 2015).

Affective General Influence on the CSPC Effect: Affective versus Neutral Context stimuli

In this research, we are particularly interested in affective influences on cognitive control. There is ample evidence that emotion affects cognitive control (e.g., Hart, Green, Casp, & Belger, 2010; Kanske & Kotz, 2011). While in most previous studies researchers focused on affective influences on the CE, our aim is to assess affective influences on the CSPC effect. We will specifically investigate *general* influences on the CSPC effect from affective context stimuli compared with neutral context stimuli.

Based on recent theories, two opposing hypotheses can be formulated. On the one hand, Pessoa (2009) proposed that task-irrelevant affective stimuli usually divert mental resources needed for cognitive control away from task-relevant stimuli and thus impair performance. Accordingly, we predict that affective context stimuli compared with neutral ones impair the implementation or retrieval of control states. Therefore, the size of the CSPC effect should become smaller for affective context relative to neutral context stimuli. We dub this prediction the *affective-impairment hypothesis*.

On the other hand, Verguts and Notebaert (2009) proposed that cognitive control effects are rooted in associative learning and that the conflict induced by an incongruent combination (e.g., *RED* in blue ink) triggers an arousal response which then facilitates associative learning. According to this view, arousal-inducing affective stimuli compared with neutral stimuli should facilitate the learning of context-control associations and therefore increase the CSPC effect. We term this prediction the *affective-facilitation hypothesis*.

Affective Valence-Specific Influence on the CSPC Effect: Positive versus Negative Affect

In addition to affective general influences, there are also reasons to assume more valence-specific influences on the CSPC effect. For instance, several theoretical accounts suggested that conflict is experienced as a negative affective state (Dreisbach & Fischer, 2012; Dignath & Eder, 2015), and that this negative signal is used to guide control adjustment (Botvinick, 2007; Dreisbach & Fischer, 2015; Inzlicht, Bartholow, & Hirsh, 2015). Based on this idea, it has been hypothesized that a negative signal triggered by conflict in incongruent trials might be counteracted by a positive signal induced by the affective context, which then decreases the degree of cognitive control on incongruent trials (van Steenbergen, Band, & Hommel, 2009). Consistent with this assumption, findings have shown that the induction of positive affect via task-irrelevant affective stimuli impairs cognitive control (e.g., van Steenbergen, Band, & Hommel, 2009, 2012; but see Dignath, Janczyk, & Eder, 2017). According to this *affective-signal neutralization hypothesis*, we predict that the CSPC effect should decrease when mostly incongruent trials are paired with positive context stimuli (compared with a situation when mostly incongruent trials are paired with negative context stimuli).

However, there is also evidence suggesting the other way around: Conflict stimuli in a negative context failed to trigger control adaptation whereas conflict stimuli in a neutral/positive context were effective (Dreisbach, Reindl, & Fischer, 2016; Fritz, Fischer, & Dreisbach, 2015). In the CSPC paradigm, task-irrelevant affect could serve as a background against which the actual conflict signal becomes relatively weaker (e.g., against a negative background) or relatively stronger (e.g., against a positive background). Indeed, research on 'hedonic contrast' effects has shown that affective evaluations of stimuli are not absolute but relative to evaluations of alternative stimuli or "background" affect (Eder & Dignath, 2014; Larsen & Norris, 2009). For this *affective contrast hypothesis*, we assume that the size of the CSPC effect becomes smaller when mostly incongruent trials are paired with negative context stimuli (compared with a situation when mostly incongruent trials are paired with positive context stimuli).

Previous Evidence for Affective Influences on the CSPC Effect

Currently, there is no empirical evidence of affective general influences on the CSPC effect. However, two published studies tested affective valence-specific influences on the CSPC effect (Cañadas et al., 2016; Dreisbach et al., 2016). Dreisbach et al. (2016) used locations (i.e., stimuli presented above or below the center of a screen) as contextual cues in a Simon task. Within a typical CSPC design, mostly incongruent trials were presented above (below) while mostly congruent trials were presented below (above). As a result, a significant CSPC effect was observed only when mostly incongruent trials were presented in the upper location. Based on the assumption that the lower location is associated with more negative affect relative to the upper location, the finding of Dreisbach and colleagues (2016) supports the affective contrast hypothesis. A study by Cañadas et al. (2016) manipulated valence more directly by using pictures of facial expressions (including angry faces and happy faces) as context stimuli in an arrow Flanker task. In a CSPC design, angry (happy) faces were paired with mostly incongruent trials while happy (angry) faces were paired with mostly congruent trials. However, Cañadas et al. (2016) observed no valence-specific influences on the size of CSPC effects.

Current Experiment

In the current experiment, we adopted the more direct way of affective manipulation used by Cañadas et al. (2016), to provide a further test of valence-specific influences on the CSPC effect. In addition, we also aimed to assess whether affect in general (positive and negative) influences the CSPC effect. Specifically, we used pictures of facial expressions as context stimuli in a letter Flanker task (for evidence of CSPC effects with facial expressions as context stimuli, see Cañadas et al., 2013; 2016). In the Flanker task, participants identified a central target letter accompanied by four lateralized distracting letters. The context stimuli were either pictures of neutral male faces and neutral female faces (the neutral-context group) or pictures of angry faces and happy faces (the affective-context group). The neutral-context group consisted of a male-high-conflict group, for which neutral male faces were paired with mostly-incongruent trials, and a female-high-conflict group for which neutral female faces were paired with mostly-incongruent trials. Similarly, the affective-context group consisted of a negative-high-conflict group, for which angry faces were paired with mostly-incongruent trials, and a positive-high-conflict group for which happy faces were paired with mostly-incongruent trials. To probe affect-general influences on the CSPC effect, we compared the CSPC effects between the neutral-context group and the affective-context group. To probe affective valence-specific influences on the CSPC effect, we compared the CSPC effects (for the affective-context group only) between the negative-high-conflict condition and the positive-high-conflict condition.

Regarding the affective general influence on the CSPC effect, we hypothesized that if CSPC effects were larger for the neutral-context group than for the affective-context group, this would speak in favour of the affective-impairment hypothesis and suggest that cognitive control is disrupted by affective context stimuli. Instead, if CSPC effects were larger for the affective-context group, this would be more consistent with the affective-facilitation hypothesis and suggest that the arousal induced by affective context stimuli facilitates cognitive control. Regarding the valence-specific influence on the CSPC effect, we hypothesized that if CSPC effects were decreased for the pairing of mostly-incongruent contexts with positive affect (i.e. happy faces), this would be consistent with the affective-signal neutralization hypothesis. Consequently, such pattern of results would support the idea that the negative signals triggered by conflict are crucial for control adjustment and that positive signals induced by affective contexts diminish control. Instead, if CSPC effects were reduced for the pairing of mostly-incongruent contexts with negative affect, this would be consistent with an affective contrast hypothesis, in support of the idea that aversive conflict signals become less effective in negative contexts relative to positive contexts.

Furthermore, as explained above in more detail, it has been claimed that different control mechanisms fed into the CSPC effect. Therefore, we used biased vs. unbiased items, since the CSPC effect for biased items has been attributed to stimulus-response learning (Schmidt et al., 2014), while the CSPC effect for unbiased items is assumed to reflect a more pure measure of attentional control processes (see Crump & Milliken, 2009). Although it was not our intention to disentangle these two (not mutual exclusive, see Egner, 2014) accounts, we included both items types for exploratory reasons.

Method

Participants

Using the CSPC effect size ($\eta_p^2 = .17$) observed by Cañadas et al. (2016, Experiment 1), we estimated that 42 participants are required for power of .8 to reproduce the CSPC effect for biased items in a similar design. Ninety-six volunteers (24 men, M_{age} = 24.4 years, age range: 19-45 years) participated for 7 euro or course credit. Each participant was quasi-randomly assigned to two groups including a neutral-context group (N = 48), for which pictures of neutral female and neutral male faces served as context stimuli, and an affective-context group (N = 48), for which pictures of angry faces and happy faces served as context stimuli. For half of the neutral-context group (n1 = 24), neutral female faces were used as context stimuli and paired to mostly-incongruent trials (female-high-conflict group). For the other half of the neutral-context group (n2 = 24), neutral male faces were used as context stimuli and paired with mostly-incongruent trials (male-high-conflict group). In addition, the affective-context group was further divided into two subgroups. For half of the participants in the affective-context group (n3 = 24), angry faces were used as context stimuli and paired with mostly-incongruent trials (negative-high-conflict group), while for the other half of participants of the affective-context group (n4 = 24) happy faces were used as context stimuli and paired with mostly-incongruent trials (positive-high-conflict group). One participant of the negative-high-conflict group did not finish the experiment due to technical problems. Furthermore, data of one participant in the negative-high-conflict group was excluded because of an exceptionally high error rate (M = 33%) deviating from the mean error rate of the overall sample (M = 9%) more than 3 SD. As a result, the female-, male-, positive-, and negative-high conflict groups included respectively data of 24, 24, 24, and 22 participants that were further analyzed. Participants were all right-handed, had normal or corrected-to-normal vision, and reported no color blindness.

Apparatus and Stimuli

The experiment was programmed with E-Prime 2.0 and presented on 1920 * 1080 LCD monitors. Pictures of two female and two male characters were selected from Karolinska Directed Emotional Faces (KDEF; Lundqvist, Flykt, & Öhman, 1998) and resized to 479 * 650 pixels. For the neutral-context group, context stimuli were pictures of neutral facial expressions (female face: *AF14NES* and *AF01NES*; male face: *AM09NES* and *AM11NES*). For the affective-context group, context stimuli were pictures of affective facial expressions of female characters (happy face: *AF01HAS* and *AF14HAS*; angry face: *AF01ANS* and *AF14ANS*). The average arousal of neutral expressions on a 9-point scale (1 = *calm*, and 9 = *aroused*) was 2.52, and the average arousal of affective expressions was 3.65 (for ratings of arousal, see Goeleven, De Raedt, Leyman, & Verschuere, 2008). Besides, pictures of happy faces (*AF01HAS*, *AF14HAS*, *AM09HAS*, and *AM11HAS*) were used as context stimuli in a practice block for the neutral-context group, and pictures of neutral expressions (*AF01NES* and *AF14NES*) were used as context stimuli in the practice block for the affective-context group.

For the Flanker task stimuli ([225, 0, 0]; Arial, 36), the letters *H* and *S* composed biased items (congruent combination: *HHHHH* and *SSSSS*; incongruent combination: *HHSHH* and *SSHSS*); *E* and *A* composed unbiased items (congruent combinations: *EEEEE* and *AAAAA*; incongruent combinations: *EEAEE* and *AAEAA*). Each Flanker task stimuli extended 1 cm in height and 4.5 cm in width. Responses were collected with a standard QWERTZ keyboard with the keys *Y* and *M*. Mappings of responses and stimuli were counterbalanced across participants whereby each response key was always mapped to one biased and one unbiased item. The background remained black during the entire experiment.

Procedure

Participants were instructed to respond always to the central letter as quickly and correctly as possible and were not informed about the proportion manipulation. Each trial began with a centered picture of a face. After 600 ms Flanker task stimuli were presented centrally, superimposed on the face with an SOA of 100 ms between the distractor letters and the central letter to maximize the flanker congruence effect (se e.g., Wendt, Kiesel, Geringswald, Purmann, & Fischer, 2014 for a similar procedure). Flanker stimuli disappeared after 200 ms, while the picture of the face remained on the screen until response (maximum: 1200 ms from the onset of the central target letter). If there was no response registered within the response window, participants received feedback ("Bitte schneller! [too slow]") for 500 ms; if participants responded incorrectly, they received feedback

(“Fehler![error]”) for 500 ms together with an acoustic error signal. The next trial started after a variable inter-trial-interval between 1000 and 1500 ms. The trial procedure was identical in all blocks.

There were 13 blocks of 80 trials each (as shown in Table 1). Block 1 was considered practice, in which participants learned the mappings between stimuli and response keys. Blocks 2 to 5 were a training phase to foster learning between control settings and context stimuli (Dreisbach et al., 2016; Lehle & Hübner, 2008), in which mostly-incongruent contexts and mostly-congruent contexts were respectively paired with 20% and 80% congruent trials. Each training block consisted of either mostly-incongruent contexts or mostly-congruent contexts only (blocked context presentation or list-wide proportion congruency effect, Logan & Zbrodoff, 1979). Blocks 6 – 13 were the test phase in which context stimuli were presented randomly and equally often.

During the training and the test phases, biased items were 4 times as often as un-biased items (see Table 1 for details). For biased items, the proportion of congruent to incongruent trials differed between contexts, with mostly-congruent contexts paired with 87.5% congruent trials and mostly-incongruent contexts paired with 12.5% congruent trials. For unbiased items, the proportion of congruent to incongruent trials was 1:1 in both contexts. This resulted in an overall proportion of 80% congruent trials for mostly-congruent contexts and 20% congruent trials for mostly incongruent contexts.

Analysis

To probe the valence-specific influence on the CSPC effect, correct RTs (and error rates) in the test blocks of the affective-context group were submitted into a 2 (proportion congruent: 20% vs. 80%) × 2 (congruence: incongruent vs. congruent) × 2 (valence of mostly-incongruent context: positive vs. negative) mixed factors analysis of variance (ANOVA), with valence of mostly-incongruent context as a between-subjects factor and proportion congruent and congruency as within-subjects factors. Biased items and unbiased items were analysed separately with identical ANOVAs. To probe the affective general influence on the CSPC effect, correct RTs (and error rates) in the test blocks of both the affective-context and the neutral-context groups were submitted into a 2 (proportion congruent: 20% vs. 80%) × 2 (congruence: incongruent vs. congruent) × 2 (context type: neutral vs. affective) mixed factors ANOVA, with context type as a between-subjects factor and proportion congruent (i.e., the proportion of congruent trials associated to contexts) and congruency as within-subjects factors. Data of the training blocks were analysed in the same method as in the test blocks.

Data were analysed with IBM SPSS Statistics 22 and R version 3.3.3. Significance criterion was 0.05 for the analysis of valence-specific effects and adjusted to 0.025 for the analysis of valence-general effects due to multiple testing on the same data set. Before analysis of RTs, the first trial in each block (1.25%), error trials

(8.35%), post-error trials (7.25%), and trials with RTs above or below 3 SDs from the cell mean for each condition (calculated separately for each participant; 1.25%) were discarded. Before analysis of error rates, the first trial in each block and post-error trials were excluded.

Additionally, Bayes factors for the null-hypothesis were computed (BF_{01}; Rouder, Speckman, Sun, Morey, & Iverson, 2009) for all theoretically relevant comparisons of CSPC effects (affective general influence: affective context vs. neutral context; affective valence-specific influence: negative mostly-incongruent context vs. positive mostly-incongruent context). A BF_{01} larger than 3 is considered to provide sufficient or positive evidence for the null hypothesis that the CSPC effect does not differ between groups (for more details, see Jarosz & Wiley, 2014). To calculate the BF_{01}, r was set to 1 (for more details, see Rouder et al., 2009).

Results

Training Block

Affective Valence-Specific Influence

Biased items. For RTs, the CE was significant, $F(1, 44) = 266.69$, $p < .001$, $\eta_p^2 = .858$. The mean RT for incongruent trials (487 ms) was longer than that for congruent trials (417 ms). The main effect of proportion congruent was significant, $F(1, 44) = 5.30$, $p = .026$, $\eta_p^2 = .108$, with a longer mean RT for mostly-incongruent contexts (456 ms) than for mostly-congruent contexts (448 ms). The main effect of valence of mostly-incongruent context was not significant, $F(1, 44) = 0.40$, $p = .533$. The CE was modulated by proportion congruent, $F(1, 44) = 100.65$, $p < .001$, $\eta_p^2 = .696$. The CE in mostly-incongruent contexts (36 ms) was smaller than that in mostly-congruent contexts (105 ms). The two-way interaction effect of Proportion Congruent × Valence of Mostly-incongruent Context or Congruence × Valence of Mostly-incongruent Context was not significant, $F(1, 44) = 0.36$, $p = .550$, and $F(1, 44) = 0.37$, $p = .544$, respectively. The three-way interaction of Congruence × Proportion Congruent × Valence of Mostly-incongruent Context was not significant, $F(1, 44) = 0.16$, $p = .687$, $BF_{01} = 4.25$.

For error rates, the main effects of proportion congruent and congruence were significant, $F(1, 44) = 16.82$, $p < .001$, $\eta_p^2 = .277$, and $F(1, 44) = 46.83$, $p < .001$, $\eta_p^2 = .516$, respectively. The mean error rate for mostly-incongruent contexts (7.0%) was smaller than for mostly-congruent contexts (10.7%). The mean error rate for incongruent trials (12.8%) was larger than for congruent trials (4.9%). The main effect of valence of mostly-incongruent context was not significant, $F(1, 44) = 0.90$, $p = .347$. The interaction effect of Congruence × Proportion Congruent was significant, $F(1, 44) = 39.46$, $p < .001$, $\eta_p^2 = .401$. The CE in mostly-incongruent contexts (2.4%) was smaller than in mostly-congruent contexts (13.4%). The two-way interaction effect of Proportion Congruent × Valence of Mostly-incongruent Context or Congruence × Valence of Mostly-incongruent

Context was not significant, $F(1, 44) = 3.74$, $p = .060$, and $F(1, 44) = 0.95$, $p = .336$, respectively. The three-way interaction effect of Congruence × Proportion Congruent × Valence of Mostly-incongruent Context was not significant, $F(1, 44) = 0.96$, $p = .333$. $BF_{01} = 2.99$.

Unbiased items. For RTs, the CE was significant, $F(1, 44) = 90.05$, $p < .001$, $\eta_p^2 = .672$. The mean RT for incongruent trials (536 ms) was longer than that for congruent trials (485 ms). The main effect of proportion congruent or of valence of mostly-incongruent context was not significant, $F(1, 44) = 3.47$, $p = .069$, and $F(1, 44) = 0.33$, $p = .571$, respectively. The CE was modulated by proportion congruent, $F(1, 44) = 4.89$, $p = .032$, $\eta_p^2 = .100$. The CE in mostly-incongruent contexts (38 ms) was smaller than the CE in mostly-congruent contexts (64 ms). The two-way interaction of Proportion Congruent × Valence of Mostly-incongruent Context or Congruence × Valence of Mostly-incongruent Context was not significant, $F(1, 44) = 0.10$, $p = .759$, and $F(1, 44) = 0.48$, $p = .491$, respectively. The three-way interaction of Congruence × Proportion Congruent × Valence of Mostly-incongruent Context was not significant, $F(1, 44) = 1.47$, $p = .232$, $BF_{01} = 2.39$.

For error rates, the main effects of proportion congruent and congruence were significant, $F(1, 44) = 15.51$, $p < .001$, $\eta_p^2 = .261$, and $F(1, 44) = 8.69$, $p = .005$, $\eta_p^2 = .165$, respectively. The mean error rate for mostly-incongruent contexts (12.0%) was smaller than for mostly-congruent contexts (17.6%); the mean error rate for incongruent trials (16.7%) was larger than for congruent trials (12.9%). The main effect of Valence of Mostly-incongruent Context was non-significant, $F(1, 44) = 0.26$, $p = .615$. The interaction effect of Congruence × Valence of Mostly-incongruent Context was significant, $F(1, 44) = 6.21$, $p = .017$, $\eta_p^2 = .124$. The CE was smaller when mostly-incongruent contexts were negative (0.6%) than when they were positive (7.1%). The two-way interaction effect of Proportion Congruent × Valence of Mostly-incongruent Context or Congruence × Proportion Congruent was not significant, $F(1, 44) = 0.01$, $p = .921$, and $F(1, 44) = 0.77$, $p = .385$, respectively. The three-way interaction effect of Congruence × Proportion Congruent × Valence of Mostly-incongruent Context was not significant, $F(1, 44) = 3.98$, $p = .052$, $BF_{01} = 0.83$.

Affective Valence-General Influence

Biased items. For RTs, the main effect of proportion congruent was significant, $F(1, 92) = 22.03$, $p < .001$, $\eta_p^2 = .193$, with a larger mean RT for mostly-incongruent contexts (467 ms) than for mostly-congruent contexts (453 ms). The CE was significant, $F(1, 92) = 520.88$, $p < .001$, $\eta_p^2 = .850$, with a longer mean RT for incongruent trials (492 ms) than for congruent trials (428 ms). The main effect of context type was not significant, $F(1, 92) = 2.01$, $p = .160$. The CE was modulated by context type, $F(1, 92) = 6.46$, $p = .013$, $\eta_p^2 = .066$, with a larger CE in affective contexts (70 ms) than in neutral contexts (56 ms). The CE was also modulated by proportion congruent, $F(1, 92) = 161.19$, $p < .001$, $\eta_p^2 = .637$, with a smaller CE in mostly-incongruent contexts (27 ms) than in mostly-congruent contexts (100 ms). The Proportion Congruent × Context Type interaction effect was not significant, $F(1, 92) = 4.30$, $p = .041$. The three-way interaction of Congruence × Proportion Congruent × Context Type was not significant, $F(1, 92) = 0.78$, $p = .378$, $BF_{01} = 4.38$.

The CE was also mirrored in error rates, with a higher error rate for incongruent trials (12.5%) than for congruent trials (5.4%), $F(1, 92) = 65.38$, $p < .001$, $\eta_p^2 = .415$. The main effect of proportion congruent was significant, $F(1, 92) = 13.72$, $p < .001$, $\eta_p^2 = .130$. The error rate in mostly-incongruent contexts (7.6%) was smaller than in mostly-congruent contexts (10.3%). The main effect of context type was not significant, $F(1, 92) < 1$, $p = .990$. The two-way interaction of Congruence × Proportion Congruent was significant, $F(1, 92) = 51.30$, $p < .001$, $\eta_p^2 = .358$. The CE in mostly-incongruent contexts (1.8%) was smaller than in mostly-congruent contexts (12.2%). The interaction of Proportion Congruent × Context Type was not significant, $F(1, 92) = 2.20$, $p = .142$, nor was Congruence × Context Type, $F(1, 92) = 1.19$, $p = .278$. The three-way interaction of Congruence × Proportion Congruent × Context Type was not significant, $F(1, 92) = 0.21$, $p = .650$, $BF_{01} = 6.18$.

Unbiased items. For RTs, the CE was significant, $F(1, 92) = 172.48$, $p < .001$, $\eta_p^2 = .652$, with a longer mean RT for incongruent trials (548 ms) than for congruent trials (497 ms). The main effect of proportion congruent was not significant, $F(1, 92) = 1.31$, $p = .256$, nor was the main effect of context type, $F(1, 92) = 2.45$, $p = .121$. The two-way interaction of Congruence × Proportion Congruent was significant, $F(1, 92) = 17.31$, $p < .001$, $\eta_p^2 = .158$, with a smaller CE in mostly-incongruent contexts (44 ms) than in mostly-congruent contexts (68 ms). The two-way interaction effect of Proportion Congruent × Context Type or Congruence × Context Type was not significant, $F(1, 92) = 1.85$, $p = .177$, and $F(1, 92) < 1$, $p = .988$, respectively. The three-way interaction of Congruence × Proportion Congruent × Context Type was not significant, $F(1, 92) = 1.20$, $p = .276$, $BF_{01} = 3.61$.

For error rates, the CE was significant, $F(1, 92) = 27.39$, $p < .001$, $\eta_p^2 = .229$, with a higher error rate for incongruent trials (17.6%) than that for congruent trials (12.7%). The main effect of proportion congruent was also significant, $F(1, 92) = 14.14$, $p < .001$, $\eta_p^2 = .133$, with a smaller error rate in mostly-incongruent contexts (13.4%) than in mostly-congruent contexts (16.9%). The main effect of context type was not significant, $F(1, 92) = 0.01$, $p = .924$. The two-way interaction of Congruence × Proportion Congruent was not significant, $F(1, 92) = 3.68$, $p = .058$, $\eta_p^2 = .058$, though the CE in mostly-incongruent contexts (3.3%) was smaller than in mostly-congruent contexts (6.6%). The interaction of Proportion Congruent × Context Type was not significant, $F(1, 92) = 3.25$, $p = .075$, nor was Congruence × Context Type, $F(1, 92) = 0.69$, $p = .409$. The three-way interaction of Congruence × Proportion Congruent × Context Type was not significant, $F(1, 92) = 0.56$, $p = .457$, $BF_{01} = 4.88$.

Test Block

Affective Valence-Specific Influence

Biased items. For RTs, the CE was significant, $F(1, 44) = 660.65$, $p < .001$, $\eta_p^2 = .938$, with a longer mean RT for incongruent trials (475 ms) than for congruent trials (403 ms). The main effect of proportion congruent or valence of mostly-incongruent context was not significant, $F(1, 44) = 2.21$, $p = .144$, and $F(1, 44) = 0.34$, $p = .561$, respectively. The two-way interaction of Congruence × Proportion Congruent was not significant, $F(1, 44) = 1.54$, $p = .221$, though the CE was smaller in mostly-incongruent contexts (69 ms) than in mostly-congruent contexts (75 ms; see Figure 1). The two-way interaction of Proportion Congruent × Valence of Mostly-incongruent Context or Congruence × Valence of Mostly-incongruent Context was not significant, $F(1, 44) = 1.48$, $p = .230$, and $F(1, 44) = 0.77$, $p = .386$, respectively. The three-way interaction of Congruence × Proportion Congruent × Valence of Mostly-incongruent Context was not significant, $F(1, 44) = 0.03$, $p = .863$, $BF_{01} = 4.51$.

For error rates, the CE was significant, $F(1, 44) = 37.42$, $p < .001$, $\eta_p^2 = .460$, with a higher error rate for incongruent trials (10.9%) than for congruent trials (4.2%). The main effect of proportion congruent or valence of mostly-incongruent context was not significant, $F(1, 44) = 0.36$, $p = .552$, and $F(1, 44) = 0.83$, $p = .366$, respectively. The interaction of Congruence × Proportion Congruent was not significant, $F(1, 44) = 0.05$, $p = .826$. The two-way interaction of Proportion Congruent × Valence of Mostly-incongruent Context or Congruence × Valence of Mostly-incongruent Context was not significant, $F(1, 44) = 0.72$, $p = .400$, and $F(1, 44) = 0.47$, $p = .497$, respectively. The three-way interaction of Congruence × Proportion Congruent × Valence of Mostly-incongruent Context was not significant, $F(1, 44) = 1.53$, $p = .222$, $BF_{01} = 2.32$.

Unbiased items. For RTs, the CE was significant, $F(1, 44) = 168.93$, $p < .001$, $\eta_p^2 = .793$, with a longer mean RT for incongruent trials (527 ms) than for congruent trials (462 ms). The main effect of proportion congruent was not significant, $F(1, 44) = 0.19$, $p = .664$, nor was the main effect of valence of mostly-incongruent context, $F(1, 44) = 0.21$, $p = .650$. The two-way interaction of Congruence × Proportion Congruent was not significant, $F(1, 44) = 0.04$, $p = .841$, nor was Proportion Congruent × Valence of Mostly-incongruent Context, $F(1, 44) = 0.25$, $p = .620$, or Congruence × Valence of Mostly-incongruent Context, $F(1, 44) = 0.27$, $p = .603$. The three-way interaction of Congruence × Proportion Congruent × Valence of Mostly-incongruent Context was not significant, $F(1, 44) = 2.53$, $p = .119$, $BF_{01} = 1.51$.

For error rates, the CE was significant, $F(1, 44) = 21.68$, $p < .001$, $\eta_p^2 = .330$, with a higher error rate for incongruent trials (16.5%) than for congruent trials (10.3%). The main effect of proportion congruent or valence of mostly-incongruent context was not significant, $F(1, 44) = 0.41$, $p = .525$, and $F(1, 44) = 0.75$, $p = .390$, respectively. The interaction of Congruence × Proportion Congruent was not significant, $F(1, 44) = 1.18$, $p = .282$. The two-way interaction of Proportion Congruent × Valence of Mostly-incongruent Context or Congruence × Valence of Mostly-incongruent Context was not significant, $F(1, 44) = 1.57$, $p = .217$, and $F(1, 44) = 0.35$, $p = .556$, respectively. The three-way interaction of Congruence × Proportion Congruent × Valence of Mostly-incongruent Context was not significant, $F(1, 44) = 0.23$, $p = .635$, $BF_{01} = 4.13$.

Affective Valence-General Influence

Biased items. For RTs, the main effect of congruence (i.e., CE) was significant, $F(1, 92) = 1186.87$, $p < .001$, $\eta_p^2 = .928$, with longer RTs for incongruent trials (477 ms) than for congruent trials (407 ms). The main effect of proportion congruent or context type was not significant, $F(1, 92) = 1.96$, $p = .165$, and $F(1, 92) = 0.37$, $p = .543$, respectively. The CE was modulated by proportion congruent, $F(1, 92) = 9.42$, $p = .003$, $\eta_p^2 = .093$. The CE was larger in mostly-congruent contexts (74 ms) than in mostly-incongruent contexts (66 ms), indicating a significant CSPC effect (see Figure 2).

The two-way interaction effect of Proportion Congruent × Context Type or Congruence × Context Type was not significant, $F(1, 92) = 0.85$, $p = .359$, and $F(1, 92) = 0.85$, $p = .360$, respectively. More important for the present research question, the three-way interaction of Congruence × Proportion Congruent × Context type was not significant, $F(1, 92) = 1.19$, $p = .278$, indicating that the CSPC effect was not further modulated by context type, $BF_{01} = 3.62$.

The CE was also mirrored in the analysis of error rates, $F(1, 92) = 69.62$, $p < .001$, $\eta_p^2 = .431$, with an higher error rate for incongruent trials (10.6%) than for congruent trials (3.9%; see Table 2). The main effect of proportion congruent or context type was not significant, $F(1, 92) = 2.13$, $p = .148$, and $F(1, 92) = 0.33$, $p = .570$, respectively. The interaction of Congruence × Proportion Congruent was not significant, $F(1, 92) = 0.45$, $p = .505$, nor was Proportion Congruent × Context Type, $F(1, 92) = 0.40$, $p = .529$, or Congruence × Context Type, $F(1, 92) < 0.01$, $p = .964$. The three-way interaction of Congruence × Proportion Congruent × Context Type was not significant, $F(1, 92) = 0.19$, $p = .662$, $BF_{01} = 5.77$.

Unbiased items. For RTs, the CE was significant, $F(1, 92) = 435.55$, $p < .001$, $\eta_p^2 = .826$, with longer RTs for incongruent trials (535 ms) than for congruent trials (470 ms). The main effect of proportion congruent was not significant, $F(1, 92) = 1.44$, $p = .233$, nor was the main effect of context type, $F(1, 92) = 1.72$, $p = .193$. The two-way interaction of Congruence × Proportion Congruent was not significant, $F(1, 92) = 0.41$, $p = .524$, nor was Proportion Congruent × Context Type, $F(1, 92) = 0.23$, $p = .631$, or Congruence × Context Type, F(1,

92) < 0.01, *p* = .961. The three-way interaction of Congruence × Proportion Congruent × Context Type was not significant, *F*(1, 92) = 0.08, *p* = .779, BF_{01} = 6.08.

For error rates, the CE was significant, *F*(1, 92) = 47.60, *p* < .001, η_p^2 = .341, with an higher error rate for incongruent trials (16.2%) than for congruent trials (10.1%). The main effect of proportion congruent or context type was not significant, *F*(1, 92) = 1.97, *p* = .164, and *F*(1, 92) = 0.08, *p* = .772, respectively. The two-way interaction of Congruence × Proportion Congruent was not significant, *F*(1, 92) = 1.86, *p* = .176, nor was Proportion Congruent × Context Type, *F* (1, 92) = 0.19, *p* = .664, or Congruence × Context Type, *F*(1, 92) = 0.01, *p* = .912. The three-way interaction of Congruence × Proportion Congruent × Context Type was not significant, *F*(1, 92) = 0.15, *p* = .697, BF_{01} = 5.88.

General Discussion

In the current experiment, we investigated how and whether affect influences the CSPC effect. In the typical CSPC design, we used pictures of facial expressions as context stimuli and manipulated the affective expressions of faces across participants. To probe affect-general influences on the CSPC effect, we compared the size of CSPC effects between a neutral-context group and an affective-context group. To probe valence-specific influences on the CSPC effect, we compared—for the affective-context group only—the size of CSPC effects between participants for whom negative faces were contextual cues of mostly incongruent trials and participants for whom positive faces were contextual cues of mostly incongruent trials.

While we observed a significant CSPC effect for biased items, results showed no affect-general influence on the CSPC effect. This interpretation was further supported by BFs (biased items: 3.62; 5.77; unbiased items: 5.88; 6.08) that provide sufficient or positive evidence (Jarosz & Wiley, 2014) for the null hypothesis that affect in general did not modulate the size of the CSPC effect. Therefore, the present results speak against the affective-impairment hypothesis and the affective-facilitation hypothesis. Instead, results suggest that affective cues (e.g., negative or positive facial expressions) are as efficient as non-affective cues (e.g. male or female faces) for the learning and retrieval of control settings. In the current experiment, we used affective expressions and gender categories, both of which are social categories. It is possible that there is little difference in efficacy between social categories (gender categories and affective expressions) as cues in the CSPC effect, which would also account for the absent valence-general influence on the CSPC effect. Therefore, it might be interesting to compare non-social, neutral cues with non-social, affective cues (for example, via conditioning). It might be also interesting for future studies to compare social cues (faces with features in their typical position) with non-social cues (feature-scrambled faces) (cf. Taubert, Aagten-Murphy, & Parr, 2015).

Regarding our second hypothesis, we did not observe evidence for a valence-specific influence on the CSPC effect. Regarding this question, BFs (biased items: 2.32; 4.51; unbiased items: 1.51; 4.13) provide only insufficient evidence to support the null hypothesis. Thus, the present results are not suitable to decide for or against the affective-signal neutralization and the affective contrast hypothesis. A power analysis (using G power 3.1.9.2) suggested that the required sample size for each group to detect a small effect size (d = 0.20) with power of .80 would N=394. Therefore, the present study cannot rule out that with sufficient power it might be possible to detect small effect. However, our results replicate a previous study by Cañadas et al.'s (2016) who observed a significant CSPC effect, but no valence-specific modulation on the CSPC effect.

Regarding the data of the training blocks, a proportion congruence effect (PCE) was observed both in biased and unbiased items, suggesting that the PCE resulted from a block-wise, top-down control rather than from contingency learning (cf., Bugg, 2012; see also Bugg & Chanani, 2011). Additionally, the CE in RTs of biased items was larger in the affective-context group than in the neutral-context group. This result is consistent with the idea of Pessoa (2009) that task-irrelevant emotional stimuli usually divert control resources away from and thus impair task performance. To further test valence-specific influences on the CE during training, we additionally submitted RTs of the biased items only in the mostly-incongruent context (and only in the mostly-congruent context) of the affective-context group into a 2 (Congruence) × 2 (Context-valence: negative vs. positive) ANOVA analysis, with congruence as a within-subjects factor and context-valence as a between-subjects factor. As a result, the two-way interaction effect of Context-valence × Congruence was not significant, $F(1, 44) = 0.46$, $p = .500$, $BF_{01} = 3.72$, and $F(1, 44) = 0.06$, $p = .804$, $BF_{01} = 4.44$, for the comparison in the mostly-incongruent context and in the mostly-congruent context, respectively, suggesting that affective contexts compared with neutral contexts impaired the CE irrespective of the affective valence of context stimuli.

Limitations of the Present Study

In the present research, we observed a significant CSPC effect only for biased items, but not for unbiased items (see also Hutcheon & Spieler, 2017). This is in line with recent research suggesting that a CSPC effect in unbiased items requires a considerable large sample size (Crump, Brosowsky, & Milliken, 2017). For biased items it remains unclear to which extend other processes such as contingency learning or feature-binding contribute to the CSPC effect (Schmidt et al., 2014).

Furthermore, the present study did not include a manipulation check to verify whether and how strong affective faces elicited affective responses. While we presented affective stimuli that have been used successfully in previous research to provoke affective responses even after many repetitions of the same stimulus material (e.g., Richards, Holmes, Pell, & Bethell, 2013), future studies would benefit from a more controlled manipulation checks (e.g. electromyography of the corrugator supercilii). Finally, although we did not assess directly whether participants paid attention to the affective faces (e.g. with catch trials), an overall significant CSPC effect combined with the absence of significant differences in the CSPC effect between the affective-context and the neutral-context groups provides evidence that participants of the affective-context group successfully encoded and used the affective expression of the faces as contextual cues.

Conclusion

In summary, the present study replicated previous findings that affective faces can act as context cues for the allocation of attention as indicated by the CSPC effect. While results were inconclusive regarding affective valence-specific influences on the CSPC, evidence suggests that the magnitude of CSPC effects did not differ between affective context cues and neutral cues.

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Table 1. The number of trials of each combination per block. In the leftmost column are the proportions congruent (i.e., proportions of congruent trials) associated to contexts. Context stimuli in Block 1 were equally associated with congruent and incongruent combinations, so the corresponding proportion congruent is 50%; Blocks 2 and 5 consisted of mostly-incongruent contexts, so the corresponding proportion congruent is 20%; Blocks 3 and 4 consisted of mostly-congruent contexts, so the proportion congruent stated is 80%; Blocks 6 to 13 consisted of both mostly-incongruent contexts and mostly-congruent contexts.

Proportion congruent	Biased item				Unbiased item			
	Congruent combination		Incongruent combination		Congruent combination		Incongruent combination	
	HHHHH	SSSSS	SSHSS	HHSHH	EEEEE	AAAAA	AAEAA	EEAEE
Block 1								
50%	10	10	10	10	10	10	10	10
Blocks 2 and 5								
20%	4	4	28	28	4	4	4	4
Blocks 3 and 4								
80%	28	28	4	4	4	4	4	4
Blocks 6 to 13								
20%	2	2	14	14	2	2	2	2
80%	14	14	2	2	2	2	2	2

Table 2. Mean error rate (M; %) and standard error (SE) as a function of item type (biased vs. unbiased), congruence (incongruent vs. congruent), proportion congruent (20% vs. 80%), and context type (neutral vs. emotional) or, for the emotional-context group only, valence of mostly-incongruent context (negative vs. positive).

		20%				80%			
		Incongruent		Congruent		Incongruent		Congruent	
	Item	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Context type									
Neutral	Biased	9.6	1.2	3.4	0.7	10.8	1.5	3.7	0.6
	Unbiased	15.0	1.7	9.6	1.3	16.8	1.8	10.2	1.3
Emotional	Biased	10.7	1.2	4.1	0.7	11.1	1.6	4.3	0.7
	Unbiased	15.7	1.7	10.5	1.3	17.4	1.8	10.1	1.4
Valence of mostly-incongruent context									
Negative	Biased	8.9	1.8	3.8	1.1	10.5	2.1	3.8	0.9
	Unbiased	14.9	2.5	10.1	2.1	14.9	2.8	9.0	1.9
Positive	Biased	12.4	1.7	4.4	1.1	11.7	2.0	4.8	0.9
	Unbiased	16.4	2.4	10.9	2.0	19.6	2.7	11.2	1.8

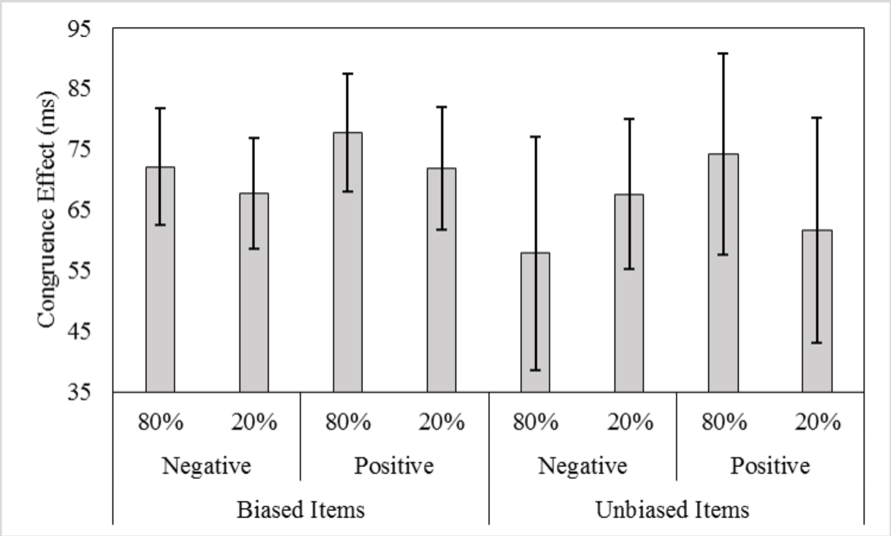

Figure 1. Congruence effect in millisecond as a function of proportion congruent (20% vs. 80%) associated with contexts, valence of mostly-incongruent contexts (negative vs. positive), and item type (biased vs. unbiased). Error bars attached to each column represent 95% CI.

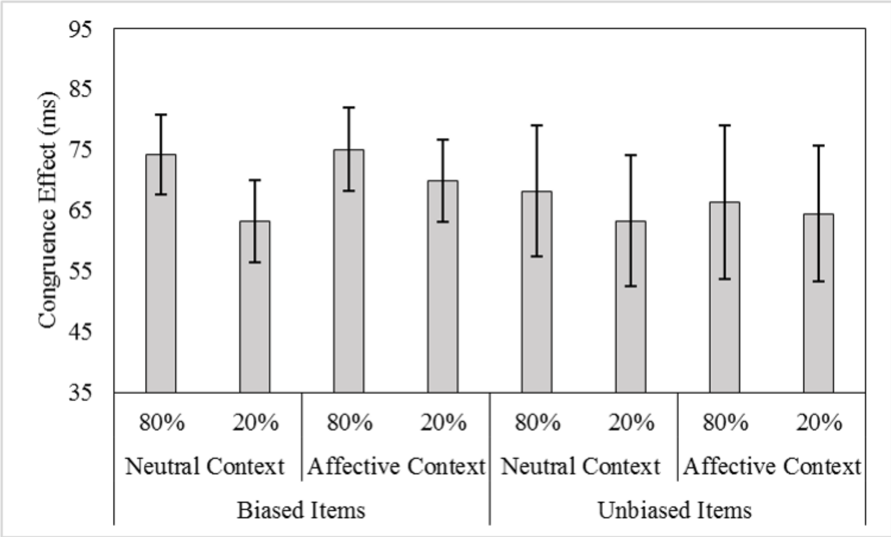

Figure 2. Congruence effect in millisecond as a function of proportion congruent (20% vs. 80%) associated with contexts, context type (neutral vs. affective), and item type (biased vs. unbiased). Error bars attached to each column represent 95% CI.