This is an Accepted Manuscript of an article published by Taylor & Francis in *Cognition and Emotion* on 04.03.2020, available online: https://doi.org/10.1080/02699931.2020.1736006

Situation Selection and Cognitive Conflict: Explicit Knowledge is Necessary for Conflict Avoidance

Constantin Schmidts, Anna Foerster, & Wilfried Kunde

University of Würzburg

Correspondence:

Constantin Schmidts

University of Würzburg

Department of Psychology III

Röntgenring 11

97070 Würzburg, Germany

Phone: +49 (0)931 / 3189637

Fax: +49 (0)931 / 3182815

Email: constantin.schmidts@uni-wuerzburg.de

Authors note

The preregistration, the experiment file, the data and the analysis script for Experiment 3 are openly available at https://osf.io/pmjh3/ (DOI 10.17605/OSF.IO/PMJH3).

Abstract

Humans transform their environment in order to regulate their own affect. One way to do so is to avoid situations that come with negative rather than positive affect. This selection might not solely bear on expectations of full-blown emotions, but may also be invoked by anticipating the aversiveness of cognitive conflict, when a situation suggests competing behavioral responses. If cognitive conflict is indeed aversive, it may trigger affect regulation goals, which in turn influence choices of situations depending on the magnitude of conflict they contain. People should prefer actions that produce conflict-free situations to actions that produce conflicting situations. In three experiments, participants had to solve a Stroop task by freely choosing between response keys that were either associated with low-conflict or high-conflict in the subsequent trial. We find that people do not automatically prefer actions associated with conflict-free situations to actions that are associated with conflicting situations. They only do so, when they are explicitly informed about the contingency between action and congruency of an upcoming situation. This suggests that cognitive conflict, at least at the level of a standard conflict task as used here, is insufficient to invoke affect regulation processes.

Keywords: cognitive control, affect regulation, demand avoidance

1.1 Introduction

Imagine you enter a train and you see to your left a train car filled with aggressive drunk people screaming at the top of their lungs and on the right a train car filled with people quietly staring into their devices. Most people will probably pick the right train car because they anticipate that spending time there will elicit less negative feelings. Choosing situations according to their likely emotional impact is an emotion regulation strategy called situation selection (Gross, 2015). When the goal of emotion regulation is a short-term hedonic one, situation selection predicts that people prefer to expose themselves to situations in which they feel pleasure instead of exposing themselves to aversive situations. For instance, when people are forced to select a picture to look at, they are more likely to select joyful pictures than neutral pictures or disgusting pictures (Markovitch, Netzer, & Tamir, 2017).

Recently, it has been suggested that cognitive conflicts, which occur when sensory input indicates competing behavioral responses, are registered as aversive signals (Dreisbach & Fischer, 2012; Fritz & Dreisbach, 2013). These cognitive conflicts play an important role in the regulation of behavior, by triggering cognitive control (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Egner, 2017). Affect involved in cognitive conflict may even lie at the heart of adapting cognitive control (Dignath, Eder, Steinhauser, & Kiesel, 2020; van Steenbergen, Band, & Hommel, 2009). Following the logic of a situation selection strategy, if a cognitive conflict has indeed an aversive component, people should also prefer situations they expect to be poor rather than rich in cognitive conflict. Consequently, if given the choice, they should be more likely to select a low-conflict situation than a high-conflict situation.

Imagine that once you have reached the station you had to pick a connection tube to your final destination leaving from one of two otherwise equivalent platforms. At one platform all tubes were running to your desired destination. At the other platform, tubes were running to your destination but also to other destinations. Which one would you choose? To avoid an unpleasant choice, you might tend to select the platform with an unequivocal destination. The

current study puts this assumption of situation selection as a means to regulate affect induced by cognitive conflict to test in the laboratory.

There is some tentative evidence that people avoid conflict, such as when they can freely choose between two univalent tasks, they are more likely to switch tasks after a conflicting trial, i.e., they select a different situation (Dignath, Kiesel, & Eder, 2015). Interestingly, switching tasks in these experiments did not actually reduce the chance of conflict in the upcoming trials. Conflict probability was 50/50 after repeating and after switching a task. Another piece of indirect evidence comes from the finding that people prefer to move a joystick away from conflict stimuli, rather than to move it towards these stimuli (Dignath & Eder, 2015; Schouppe, Houwer, Ridderinkhof, & Notebaert, 2012). This suggests that conflict has a motivational component that triggers avoidance as soon as the conflict is registered, supposedly because conflict is aversive.

In line with this, people are also more likely to choose a context that is associated with a low level of conflict, than to choose a context that is associated with a high level of conflict (e.g., Desender, Buc Calderon, van Opstal, & van den Bussche, 2017). The strongest evidence for avoiding conflict in anticipation comes from a study of Schouppe, Ridderinkhof, Verguts, and Notebaert (2014) who asked participants to do a vocal Stroop task. In a learning phase, there was a category cue, which signaled that the trial had a conflict probability of either 80% or 20%. In a choice phase, participants had to pick one of these conflict contexts by clicking on the category cues before the appearance of the Stroop trial. Participants showed a preference for the low-conflict category. Two explanations can account for the preference of the low-conflict context. First, experiencing the aversiveness of cognitive conflict could have served as a learning signal, biasing action choices implicitly. A similar mechanism has been proposed to account for attentional adjustments to conflict (van Steenbergen et al., 2009). The second possibility is that people avoid conflict deliberately based on their explicit knowledge of the relation of category cue and conflict signal.

In the current study, we wanted to figure out whether the experience of cognitive conflict is sufficient to bias choice behavior, or whether explicit knowledge about the contingencies between choices and the congruency of a situation is necessary. Therefore, participants selected situations with actions that had the main purpose of solving a Stroop task. We assigned two correct response keys to each color. One of these keys produced a high-conflict situation in the next trial, while the other key led to a low-conflict situation. In three experiments, we tested whether people implicitly learn to avoid response keys that lead to conflict. In Experiment 1, key-pairs were associated with an 80% and a 20% chance, respectively, of conflict in the upcoming trial. In Experiments 2 and 3, each key generated a certain level of congruency with 100% probability. Experiment 3 tested the impact of explicitly informing participants about the key-congruency assignment on choice behavior. We assumed that people prefer to use keys that produce a low-conflict environment and avoid those that produce high conflict.

1.2 Experiment 1

Methods

Participants solved a Stroop task by classifying whether a word was displayed in red, blue or yellow with button presses. Stroop stimuli were presented in the center of a 22' screen in the font Gill Sans MT in size 72. Each trial started with a fixation cross for 500 ms, followed by the stimulus, which was presented for 1500 ms or until a response was given. In case of an incorrect response, participants received an error message for 1000 ms. When they missed the response deadline an error message was displayed for 1500 ms. After an inter-trial interval of 500 ms, the next trial started.

We created congruent trials (e.g., BLUE in blue) and incongruent trials (e.g., BLUE in red) from the words RED, BLUE and YELLOW. For each color, participants were instructed to choose between two possible keys. Whenever a word was displayed in red, they could either press the *F* key with their left index finger or the *J* key with their right index finger. The yellow font color mapped to *D* and *K* (middle fingers), and the blue font color to *S* and *L* (ring fingers).

Participants were told to decide spontaneously which of the two possible keys to press, that they should not just press one of the two keys over the course of the experiment and that they should not press both in the same trial. Furthermore, we urged participants to respond with great speed, as soon as they saw the stimulus. Note, that we did not tell them to press each key equally often because such an instruction would have the potential to strongly bias response choices and obscure effects of the probability of the upcoming congruency.

The response keys differed in the probability of congruency in the following trial (see *Figure 1*). One key lead to a subsequent incongruent trial in 80% of the cases and to a congruent trial in 20% of the cases. The other key produced 80% congruent trials and 20% incongruent trials. As an illustration: If participants pressed the *F* key to the red font color, the following trial had a probability of 80% to be congruent, whereas if they pressed the *J* key the following trial had a 20% probability to be congruent. The mapping of keys to congruency probability was counterbalanced across participants. Participants could have none, one, two or all three keys of one hand associated with a high probability of congruency in the next trial.

Participants conducted a training phase in which they were told to get accustomed to all the response keys. The training ended adaptively when they pressed each key at least once and encountered at least 20 trials. If they did not press each key at least once, the training ended after 50 trials. Afterward, they went through 600 Stroop trials. At last, they were asked debriefing questions, i.e., whether they used strategies and whether they detected any differences between the keys and filled out an emotion regulation questionnaire (Gross & John, 2003). This exploratory interindividual measure did not lead to any correlation in any of the experiments, so we will not discuss it further.

As we were the first to address this research question, we planned our sample sizes of Experiments 1 and 2 based on an arbitrary, medium-sized effect of $d_z = 0.5$. We decided to strive for a power of .80 to detect this effect size in a within-subjects design with an alpha of 5%. According to the power analysis we did in R (version 3.5.1, package “pwr”), a sample size of 33 participants meets these criteria. Due to counterbalancing, we rounded up to 34

participants. We did not replace excluded participants. All of the following experiments were conducted in accordance with the local ethical guidelines and the Declaration of Helsinki. According to the ethical guidelines of the German Society for Psychology (DGPs) and the regulations of the local ethics committee of the Institute for psychology of the faculty for human sciences of the Julius-Maximilians-University of Würzburg, in-depth review by an ethics committee is not mandatory, providing that participants give signed informed consent; data are collected anonymously, and the study has no foreseeable negative impact on participants. These criteria have been screened by our ethics committee, and we received a statement that for a study with these characteristics no such approval is necessary. Informed consent was obtained from every participant prior to the start of the experiments. We excluded three participants due to their answers to the debriefing questions. One participant figured out the hypothesis, which is impractical for our goal to test the implicit influence of conflict. Another participant indicated that he or she ignored the instruction by sticking to one hand for a time and the third participant indicated that he or she just used the right hand. Including those participants does not change the results in a meaningful way. Of the remaining sample of 31 participants, 21 self-identified as female and 10 as male. Twenty-seven were right-handed (4 left-handed) and the mean age was 28 years (standard deviation, *SD* = 7 years).

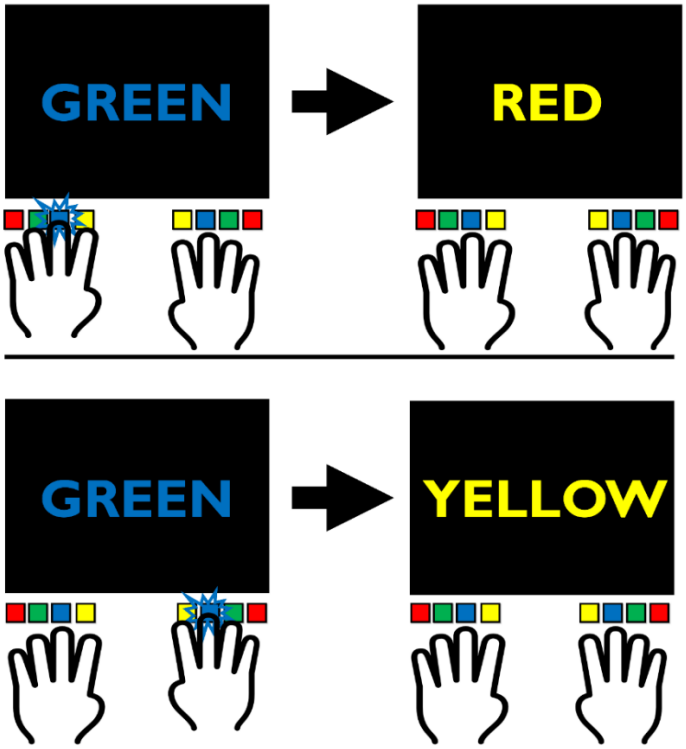

Figure 1. In this exemplary trial of Experiment 3, a correct keypress with the left hand produced an incongruent stimulus in the subsequent trial (upper panel). Pressing the correct key with the right hand produced a congruent Stroop stimulus in the next trial (lower panel). In Experiment 1 and 2, participants solved a three color-word Stroop task, whereas in Experiment 3 they solved a four color-word Stroop task. In all three experiments, every color was mapped to two keys, which determined the congruency of the following trial. Only in Experiment 3 was subsequent congruency always fully mapped to one particular hand. In Experiment 1, each key determined the subsequent congruency with an 80% probability, in Experiment 2 and 3 with a 100% probability.

Results

We included all Stroop trials in the error analysis. For the analysis of response times, we only included correct trials that did not deviate more than 2.5 *SD*s from their individual cell mean. Note that the number of trials in each cell is unequal, because participants determined by their choices how many congruent and incongruent trials they encountered. Participants committed more errors in incongruent Stroop trials (M = 8.70%, SD = 4.54%), than in congruent Stroop trials (M = 6.10%, SD = 4.25%), $t(30) = 4.47$, $p < .001$, $d_z = 0.80$. They also responded slower

in incongruent Stroop trials (M = 591 ms, SD = 65 ms), than in congruent Stroop trials (M = 536 ms, SD = 57 ms), $t(30) = 11.67$, $p < .001$, $d_z = 2.10$.

For the key choice analysis, we only included correct trials. Moreover, we decided also a priori to exclude the first 100 trials as learning trials for the contingency between keys and congruency probability. This number seemed reasonable to be able to learn contingencies but was otherwise arbitrary. We calculated the percentage of choosing the key that produces a congruent trial with an 80% probability (low-conflict key). This percentage should be higher the more people prefer creating congruent situations to creating incongruent situations. Participants chose the low-conflict key in 51.66% (SD = 5.19%) of the trials (see *Figure* 2), which did not differ significantly from chance level performance, $t(30) = 1.78$, $p = .086$, $d_z = 0.32$. To test whether these results support the null hypothesis we calculated a one-sample Bayesian *t*-test comparing the mean of the low conflict choices to the value of 50 using JASP 0.9.0.1 (JASP Team, 2018). Contrary to null hypothesis significance testing, this analysis tests whether the observed data is more likely under the null hypothesis than under the alternative hypothesis. If the resulting Bayes Factor is larger than 1 the observed data pattern is more likely under the null hypothesis of 'no difference from 50 and if it is smaller than 1, the probability of the data is greater under the alternative hypothesis. This resulted in a BF_{01} of 1.288. Given that Bayes Factors between than 1 and 3 are commonly assumed to provide only anecdotal evidence, the current data remain inconclusive (Rouder, Speckman, Sun, Morey, & Iverson, 2009; Schönbrodt & Wagenmakers, 2018).

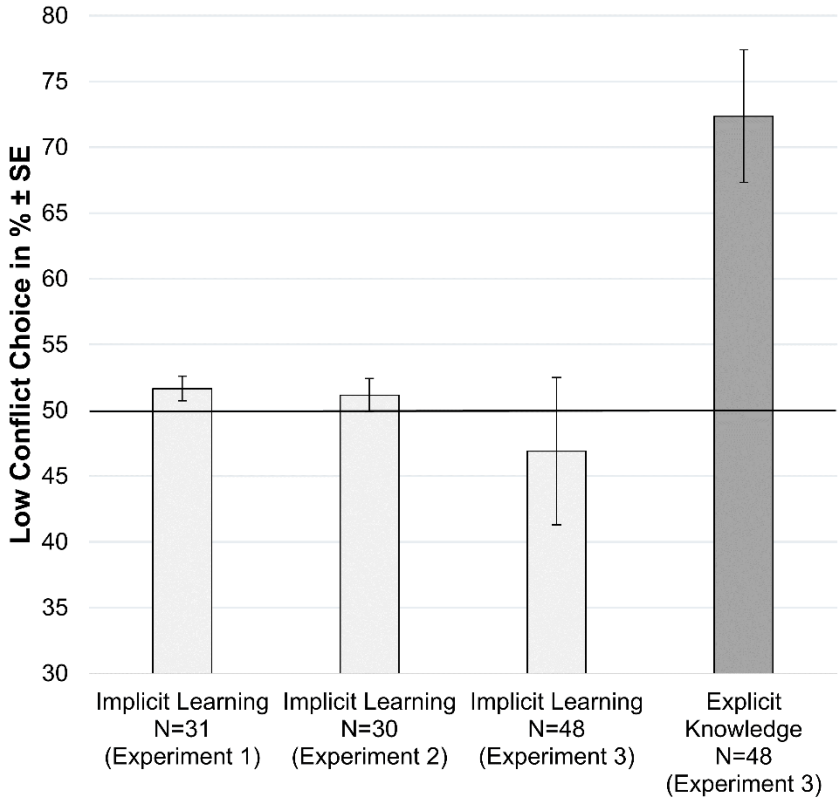

Figure 2. Mean percent of choices for the key associated with low or no conflict in the subsequent trial. The black line represents chance level performance. Error bars show the standard error (SE) of the mean.

Discussion

Participants showed a significant congruency effect in errors and response times, which means that they experienced conflict. However, contrary to our predictions, they did not choose the low-conflict key significantly more often than the one that is more likely to produce incongruent trials. This means, there was no evidence for a situation selection strategy to regulate affect originating from conflict. Participants either did not experience conflict as negative and thus saw no need to regulate any affect, or they did experience it as negative but did not choose situation selection as an emotion regulation strategy or failed to learn the contingency between their choice behavior and conflict implicitly. However, the Bayesian analysis revealed that there was also no evidence in support of the null hypothesis. A possible explanation is that the association between key choice and subsequent congruency was too weak, with 80% probability being too low to bias participants' choices. To test this, we conducted an additional

experiment in which each key was associated with a 100% probability of experiencing either congruent or incongruent trials.

1.3 Experiment 2

Methods

To keep it frugal, we only refer to aspects of Experiment 2 that deviated from Experiment 1. The contingency between the press of a certain key in the current trial and congruency in the upcoming trial was 100%. We excluded the possibility that subsequent congruency could sometimes be mapped exclusively to a single hand, instead, each hand was assigned keys that created conflict-free trials and keys that created conflicting trials.

The research assistant recruited one more participant than planned, thus a new sample of 35 participants took part, of which we had to exclude four participants who ignored the instruction to use both hands and did the entire main part of the experiment by using either the left or the right hand. We excluded one additional participant due to an excessive amount of errors (*SD* > 3.3 above the mean error rate of all participants). The 30 participants included for analysis had a mean age of 24 years (*SD* = 3 years). Twenty-six were right-handed, (four left-handed). Five of them self-identified as male and 25 as female.

Results

Our exclusion criteria for the analyses were the same as in Experiment 1. The error rate in the Stroop task was higher for incongruent Stroop trials (M = 8.89%, SD = 6.17%), than for congruent Stroop trials (M = 6.54%, SD = 3.37%), $t(29) = 2.74$, $p = .010$, $d_z = 0.50$. Participants were slower in incongruent Stroop trials (M = 564 ms, SD = 53 ms), than in congruent Stroop trials (M = 525 ms, SD = 47 ms), $t(29) = 8.34$, $p < .001$, $d_z = 1.52$. Participants chose the low-conflict key 50.33% (SD = 5.43%) of the time (see *Figure* 2), which did not differ from chance level performance, $t(29) = 0.33$, $p = .744$, $d_z = 0.06$. Furthermore, we calculated a Bayesian one-sample *t*-test against the test value of 50, which resulted in a BF_{01} of 4.891, which suggests moderate evidence for the null hypothesis (Schönbrodt & Wagenmakers, 2018). We test whether the observed data pattern provides support for the null hypothesis, so higher Bayes Factors represent stronger support for the null hypothesis of ‘no difference from 50’.

Discussion

Again, participants showed interference due to conflict, but this did not influence their choice behavior. Even with a 100% contingency between key choice and upcoming congruency, there was no preference for keys that created congruent trials over keys that created incongruent trials. Thus, we again could not find evidence for avoidance of conflict by a situation selection strategy. This could either indicate that people do not avoid conflict, or that they do avoid conflict, but are unable to learn associations between their choices and the congruency of subsequent situation implicitly. To examine whether conflict influences choices if people do have explicit knowledge of the relationship between choice behavior and conflict, we conducted an additional experiment.

1.4 Experiment 3

In Experiment 3, we tested whether people do prefer low-conflict environments, when they have explicit knowledge about the consequences of their actions, even if they do not use conflict signals implicitly to adjust situation choice behavior. To this end, we first replicated the previous experiments, but after completing 400 trials, we informed participants about the contingencies between key choice and subsequent congruency. Afterward, they completed an additional set of 140 Stroop trials. Moreover, to rule out a possible confound of stimulus set size, we employed a four color-word Stroop with four congruent and four incongruent stimuli. In the previous studies, there were only three individual congruent stimuli and six individual incongruent stimuli, which could have influenced choices. We also eliminated another influence on choice behavior, namely response repetitions, by splitting the four-color / four response task into two sets of two-color / two-response tasks that alternated (inspired by Schmidt & Weissman, 2014, who used this to control for contingency learning and feature integration confounds in congruency sequence effects).

Methods

To keep it frugal, we again only refer to aspects of Experiment 3 that deviated from the former experiments. To facilitate implicit learning, congruency production was mapped to hands, so that one hand produced a congruent trial, whereas the other produced conflict in the next trial

(see *Figure 1)*. Each key fully determined the congruency of the subsequent trial. As in the previous experiments, participants started with an implicit choice block, but crucially, after about two-thirds through the experiment, they were informed about the contingency between key presses and subsequent congruency. After we provided them with this explicit knowledge, they underwent an additional choice block. Further changes to the previous experiments concerned the instructions and appearance. We eased the restriction to free choice ("don't use one key exclusively for the whole experiment"), so the remaining instruction was that they should just use whichever key they spontaneously liked more at the moment, but should not press both at the same time. As they technically stuck to the instructions, we did not exclude participants who exclusively used one hand, contrary to the previous experiments and did not preregister their exclusion. Excluding them does not change the results of the following analysis in a meaningful way.

Additionally, we animated the stimuli after responding by showing it for 20ms at ¾ of the original size, 20ms at ½ the size, 20ms at ¼ the size and by starting the stimulus presentation after the fixation cross with a presentation of the stimulus at ½ the size for 20 ms. We wanted to introduce flow to the task and nudge people to see a connection between the trials (the E-prime files for the experiment are freely available at the *Open Science Framework*, https://osf.io/pmjh3/).

To control for stimulus and response repetitions, we added the color green. Participants had to choose between pressing the *A* key or the *L* key (pinky fingers) for stimuli displayed in red, the *S* key or the *K* key (ring fingers) for blue stimuli, the *D* key or the *J* key (middle fingers) for the color green and the *F* key or the *H* key (index fingers) for the color yellow. We grouped red and yellow together, while green and blue formed the second group. Incongruent trials were constructed by using the distractor word within a group: RED displayed in yellow / YELLOW displayed in red and BLUE displayed in green / GREEN displayed in blue. Trials alternated between stimuli from these two groups. In other words, a trial containing either a red or a yellow stimulus was always followed by a trial containing only blue or green as stimuli features. As a

consequence, there were no stimulus repetitions and no response repetitions. After 400 trials, participants were asked if they noticed any differences between the hands and whether they used any strategies. Afterward, they were informed which hand produces congruent trials and which hand produces incongruent trials. Then we asked them to do another 140 trials.

An additional change to the previous experiments is that we tested a higher number of participants to increase statistical power to detect an effect. Our power analysis aimed at the detection of differences between the implicit and the explicit condition, and we hypothesized that the preference for choosing low-conflict situations should be higher in the explicit than implicit condition, allowing for directed testing. Again, we had no indication of how big this effect might be if it exists, thus, relying on an arbitrary medium-sized effect of $d_z = 0.5$. We recruited 48 participants, which gives us a power of .96 to detect such an effect in a one-sided paired *t*-test, with an alpha level of .05, according to the package "pwr" (R 3.5.2). We had to exclude one participant due to an exceptionally high error rate (*SD* > 5.59). We replaced this participant, so our final sample consisted of 48 participants with a mean age of 25 years (*SD* = 4), of which ten self-identified as male and 38 as female. Nine of them indicated they were left-handed, the other 39 indicated they were right-handed. A preregistration of the main hypothesis, statistical analyses and data exclusions, as well as the raw data and the R scripts for all of the following statistical analyses, are freely available (Schmidts, 2019).

Results

For the Stroop analysis, we only included participants who provided at least five trials in each cell. For the response time analysis, we used correct Stroop trials that did not deviate more than 2.5 *SDs* from their individual cell means. These criteria lead to the exclusion of eight participants from the response time analysis. For the choice analysis, we did include all participants following our preregistration, because we did not deem these exclusions necessary for this analysis. However, excluding participants who failed the inclusion criteria for the response time analysis from the choice analysis does not change the results in a meaningful way.

Participants did not commit significantly more errors in incongruent trials (*M* = 14.06%, *SD* = 12.10%), than in congruent trials (*M* = 10.18%, *SD* = 5.71%), $t(39) = 2.00$, $p = .052$, $d_z = 0.32$. They responded slower to incongruent trials (*M* = 809 ms, *SD* = 230 ms), than to congruent trials (*M* = 651 ms, *SD* = 106 ms), $t(39) = 4.25$, $p < .001$, $d_z = 0.67$.

As in the previous experiments, we included only correct trials and excluded the first 100 trials for the implicit choice analysis. We tested choice frequencies within the implicit and explicit condition in two-sided *t*-tests as in the previous experiments and compared them between these conditions in a one-sided *t*-test in accordance with our preregistration. In the implicit choice condition, participants chose the low-conflict keys in 46.90% (*SD* = 38.75%) of the cases (see *Figure* 2), which did not differ from chance level performance, $t(47) = -0.55$, $p = .582$, $d_z = -0.08$. We also calculated a Bayesian one-sample *t*-test which tested whether the data are different from the test value of 50, which resulted in a BF_{01} of 5.515 which is in line with moderate support for the null hypothesis (Note that we did not test our directed hypothesis, but whether the data supports chance level performance). In the explicit choice condition, participants chose the low-conflict keys in 72.37% (*SD* = 34.89%) of the cases, which was significantly higher than chance level performance, $t(47) = 4.44$, $p < .001$, $d_z = 0.64$. The Bayesian one-sample *t*-test resulted in a BF_{01} of 0.002 which is in line with very strong support for the alternative hypothesis (Schönbrodt & Wagenmakers, 2018). The preference for low-conflict keys was significantly higher in the explicit choice condition than in the implicit choice condition, $t(47) = 5.13$, $p < .001$, $d_z = 0.74$.

Internal meta-analysis

To further explore whether there could be a preference for low-conflict key choices in the implicit conditions, we computed a meta-analysis over all three experiments ($k = 3$, $n = 109$), with the Cohen's *d* values, the standard errors of these *d* values according to formula 12.21 / 12.22 in Borenstein, Cooper, Hedges, and Valentine (2009), and an *r* of 0.5. We chose a random-effects-model and used the packages "meta" (Schwarzer, 2007) and "metafor" (Viechtbauer, 2010) in R (version 3.6.0). An I^2 of 32% suggests low heterogeneity between the studies. According to this meta-analysis, the estimated effect is $d = 0.08$, 95% CI [-0.43; 0.58].

Discussion

Even a relatively obvious contingency between a key choice and the congruency it produced in an upcoming trial, did not promote an adaptation of choice behavior in the current experiment. We expected participants to engage in an affect regulation strategy, based on the experienced aversiveness of the conflict signal, to avoid upcoming conflict. We did not observe such regulation strategies when participants were given the opportunity to implicitly learn the association between their choice behavior and the amount of conflict in the following situation[1]. However, when participants received explicit information that one hand produces a congruent trial, while the other produces an incongruent trial, people showed a preference for choices that created congruent situations over choices that created conflict situations.

1.5 General Discussion

Inspired by situation selection as an emotion regulation strategy (Gross, 2015), the current study examined whether situation selection also is a means to regulate cognitive conflict by avoiding it. In three experiments, however, participants did not spontaneously choose actions that produced conflict-free situations more often than actions that produced conflicting situations. They only preferred actions leading to conflict-free situations, when they were explicitly told about the association of their action and the subsequent congruency.

This clear distinction between implicit and explicit sources of situation selection in the context of cognitive conflict could help to reconcile diverging results in the relevant literature. People

[1] As mentioned in the methods sections, we did a manipulation check of awareness by asking participants several questions, either at the end of the Experiment (1 & 2) or at the end of the implicit block (Experiment 3). One of those questions inquired whether participants discovered any differences between the two keys they could use to respond to a specific color. If they answered yes, they were asked to provide the differences they discovered in an open question. In Experiment 3, 39 participants answered that they did not discover any differences between the keys. Of the 9 participants who did, we looked at the differences they indicated and there were 4 participants whose answers could be classified as having figured out the contingency (e.g., “for the right responses, the color fitted with the word”). An exploratory analysis shows that their mean low conflict choice in the implicit condition was 65%, which appears to deviate from chance performance (a *t*-test is not significant, but severely underpowered due to the small sample size). However, these participants are included in the reported main Bayes analysis, which provides evidence for the hypothesis that overall performance is about chance level. So if anything, the test for the implicit condition in Experiment 3 is very liberal and should have found an effect if there was one. We did not preregister any exclusion of these participants in Experiment 3, so we are hesitant to change our reported analysis in hindsight.

did not preferably choose the low-conflict keys unless explicitly informed about the consequences of doing so, whereas in the study by Schouppe et al. (2014), people did chose low-conflict contexts over high-conflict contexts. One probable explanation for this discrepancy might be that contrary to our design, all the participants might have become consciously aware of the relationship between context and conflict in their study. In Schouppe et al. (2014), the choice action (a mouse click), was more salient because it was separated from the action that was used to solve the Stroop task (vocalization), whereas in the current experiment these aspects were implemented in a single action (button press). Therefore, people might have only assigned the instrumental goal of classifying the color to this specific action but might not have used that specific action for other goals (feeling good). Furthermore, the temporal separation between situation selection and the cognitive control task might have freed cognitive resources. Solving the primary Stroop task might have taken so much attention, that there was no room to implement implicit secondary goals like affect regulation. However, the current results also stand in contrast with findings that show that people avoid cognitively demanding situations, even when they are not aware of the experimental manipulation (Kool, McGuire, Rosen, & Botvinick, 2010). On the other hand, there are studies using a block-wise instead of a trial-wise choice design that come to similar conclusions as our study (Desender et al., 2017). Furthermore, a recent study, using a task-switch design, showed that people need to be consciously aware of cues signaling cognitive effort to avoid it (Dunn, Gaspar, & Risko, 2019). It is not entirely clear why the methodological differences between the current studies and studies using a demand selection task yield such different patterns of results. These discrepancies present an interesting avenue for future research.

Participants showed a clear bias for low-conflict situations when they had explicit knowledge about the effects of their key choices, but they still only chose it in about 72% of the trials. If conflict is aversive, why did they not avoid it in 100% of the trials? For once, even though incongruent trials are more aversive than congruent trials and thus influence choices, their absolute aversiveness may still be relatively low (e.g., compared to IAPS pictures). Additionally, people may be reluctant to go exclusively for the easy and pleasant alternative

and might be willing to expose themselves to some amount of aversive stimulation in order to 'keep things interesting' (Wilson et al., 2014). However, to put it in context, this result is in line with other experiments that examine how effortful cognitive processes influence free choices. In experiments on voluntary task switching, participants switch tasks in about 30 to 40% of cases, rather than keep on repeating the task, even though switching tasks is much more effortful (Fröber & Dreisbach, 2016) and has been shown to be aversive (Vermeylen, Braem, & Notebaert, 2019). Furthermore, regarding experiments on situation selection, in Experiment 1 by Markovitch et al. (2017), participants voluntary made the choice to look at disgusting images rather than at a blank screen in 38% of the cases. This suggests, that even if given the choice, people do not fully avoid goal-irrelevant aversive stimuli.

One limitation of the current study is that we did not measure affect directly. We base the assumption that Stroop conflicts are implicitly viewed as negative on a variety of previous studies. Multiple studies have shown that incongruent Stroop trials can prime negative affect in affective priming paradigms (Dreisbach & Fischer, 2012; Pan et al., 2016) and affect misattribution procedures (Fritz & Dreisbach, 2013). Furthermore, when people are asked explicitly, stimuli associated with incongruent Stroop trials are liked less compared to the stimuli associated with congruent Stroop trials, no matter whether people were just primed or whether they actually responded (Damen, Strick, Taris, & Aarts, 2018). However, there is some opposing evidence, according to which the resolution of conflict can be perceived as positive (Ivanchei et al., 2019; Schouppe et al., 2015). Thus, it might be the case that even though participants initially experience negative affect when encountering conflict, the successful resolution of conflict leaves them with an overall more positive experience and thus there is no motivation to avoid conflict situations. Having said this, objective measures (electromyography of the facial corrugator muscles), suggest that participants experience negative affect after correctly solving conflict (Berger, Mitschke, Dignath, Eder, & Steenbergen, 2020). Additionally, recent studies find that Stroop conflict is associated with negative affect, no matter whether participants have to respond or not (Goller, Kroiss, & Ansorge, 2019). A forthcoming integrative review on the interplay between conflict and affect concludes that the hypothesis that conflict

triggers negative affect “is well supported by empirical evidence” (Dignath et al., 2020). Based on these previous works, we feel comfortable in our assumption that Stroop conflict was perceived as negative in our current study. Aside from that, if conflict were not explicitly aversive, why would participants avoid it in the explicit condition?

Another alternative explanation for the absence of implicit conflict avoidance in choices is that conflict is indeed perceived as aversive, but for some reason, participants do not strive to feel good and thus have no motivation to engage in regulating their emotions. There is some evidence that people sometimes expose themselves to unpleasant feelings in order to attain a goal. Tamir and Ford (2009) found that participants chose to face fear-inducing music and memories in order to help them play a threatening video game more successfully. However, this explanation seems unlikely in the current study, because there was no instrumental benefit to engage with conflict. On the contrary, choosing conflict trials lead to increased errors and response times and thus to worse task performance overall. This indicates that increased choices for conflict in pursuit of task benefits are an improbable explanation for the absence of a choice asymmetry. Besides, this does not explain that people do choose actions that produce conflict-free situations, as soon as they gain explicit knowledge of the consequences of their choices.

It is also conceivable that conflict triggers emotion strategies implicitly, but that situation selection does only operate explicitly. A free choice between two actions may be governed by higher-order decisions, which might not be under the influence of an implicit, aversive conflict signal. Affect regulation in response to a conflict may differ to emotion regulation in response to full-blown emotion, by predominantly depending on implicit affect regulation (Gyurak, Gross, & Etkin, 2011). Affect regulation strategies that rely on conscious deliberation, like situation selection and cognitive change, may only be susceptible to an influence of conflict when explicit knowledge exists about the relationship between an action and the amount of conflict it produces. Other, less explicit, affect regulation processes like situation modification and attentional deployment, on the other hand, may have a larger influence on conflict, even in the

absence of such explicit knowledge. Indeed there is evidence, that affect regulation processes similar to situation modification have an influence on conflict tasks: In a very similar Stroop task as the one used here, people are more inclined to change a conflict-laden situation to a conflict-free one, than they are to change a conflict-free situation to a conflict-laden one (Schmidts, Foerster, & Kunde, 2019).

In light of this, another explanatory approach is that people might have had the goal to regulate their affect in a way that makes them feel better, but tried to regulate affect in a different way, or not at all. Accordingly, instead of engaging in situation selection, they might have attempted other emotion regulation strategies such as cognitive change. Ghafur, Suri, and Gross (2018) argue that there are two puzzles related to emotion regulation, firstly, that people often do not regulate their emotions even when they have the opportunity to do so and secondly, that they frequently do not use the most adaptive emotion regulation strategy. In their view, orienting attention and action readiness might be responsible for that. They argue that when people do not apply enough attention to the value of the regulation of a situation, they will not take any action. This might be the case in the current study. Given that the primary task already occupies the attentional system, there might be no cognitive capacity left to evaluate the action choice on their anticipated affective consequences. People might just have failed to see the benefits of trying to engage in affect regulation. This might have changed when they were told about the association between keypress and subsequent congruency. After that, they might have focussed attention on affect regulation and started choosing actions that produced conflict-free and thus less aversive situations.

In conclusion, people do not necessarily avoid actions that produce cognitive conflict, unless they are consciously aware of the consequences of their action choices. Nevertheless, the explicit preference for actions that select conflict-free situations adds to the body of evidence showing that conflict has an aversive component.

2 References

Berger, A., Mitschke, V., Dignath, D., Eder, A., & Steenbergen, H. (2020). The face of control: Corrugator supercilii tracks aversive conflict signals in the service of adaptive cognitive control. *Psychophysiology*, *11*(5), 1202. https://doi.org/10.1111/psyp.13524

Borenstein, M., Cooper, H., Hedges, L., & Valentine, J. (2009). Effect sizes for continuous data. *The Handbook of Research Synthesis and Meta-Analysis*, *2*, 221–235.

Botvinick, M. M., Braver, T. S., Barch, D. M., Carter, C. S., & Cohen, J. D. (2001). Conflict monitoring and cognitive control. *Psychological Review*, *108*(3), 624–652. https://doi.org/10.1037/0033-295X.108.3.624

Damen, T. G. E., Strick, M., Taris, T. W., & Aarts, H. (2018). When conflict influences liking: The case of the Stroop task. *PloS One*, *13*(7), e0199700. https://doi.org/10.1371/journal.pone.0199700

Desender, K., Buc Calderon, C., van Opstal, F., & van den Bussche, E. (2017). Avoiding the conflict: Metacognitive awareness drives the selection of low-demand contexts. *Journal of Experimental Psychology. Human Perception and Performance*, *43*(7), 1397–1410. https://doi.org/10.1037/xhp0000391

Dignath, D., & Eder, A. B. (2015). Stimulus conflict triggers behavioral avoidance. *Cognitive, Affective & Behavioral Neuroscience*, *15*(4), 822–836. https://doi.org/10.3758/s13415-015-0355-6

Dignath, D., Eder, A. B., Steinhauser, M., & Kiesel, A. (2020). Conflict monitoring and the affective-signaling hypothesis-An integrative review. *Psychonomic Bulletin & Review.* Advance online publication. https://doi.org/10.3758/s13423-019-01668-9

Dignath, D., Kiesel, A., & Eder, A. B. (2015). Flexible conflict management: Conflict avoidance and conflict adjustment in reactive cognitive control. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, *41*(4), 975–988. https://doi.org/10.1037/xlm0000089

Dreisbach, G., & Fischer, R. (2012). Conflicts as aversive signals. *Brain and Cognition*, *78*(2), 94–98. https://doi.org/10.1016/j.bandc.2011.12.003

Dunn, T. L., Gaspar, C., & Risko, E. F. (2019). Cue awareness in avoiding effortful control. *Neuropsychologia*, *123*, 77–91. https://doi.org/10.1016/j.neuropsychologia.2018.05.011

Egner, T. (2017). Conflict Adaptation. In T. Egner (Ed.), *The Wiley handbook of cognitive control* (Vol. 14, pp. 64–78). Chichester, West Sussex, UK: John Wiley et Sons. https://doi.org/10.1002/9781118920497.ch4

Fritz, J., & Dreisbach, G. (2013). Conflicts as aversive signals: Conflict priming increases negative judgments for neutral stimuli. *Cognitive, Affective, & Behavioral Neuroscience*, *13*(2), 311–317. https://doi.org/10.3758/s13415-012-0147-1

Fröber, K., & Dreisbach, G. (2016). How sequential changes in reward magnitude modulate cognitive flexibility: Evidence from voluntary task switching. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *42*(2), 285–295.

Ghafur, R. D., Suri, G., & Gross, J. J. (2018). Emotion regulation choice: the role of orienting attention and action readiness. *Current Opinion in Behavioral Sciences*, *19*, 31–35. https://doi.org/10.1016/j.cobeha.2017.08.016

Goller, F., Kroiss, A., & Ansorge, U. (2019). Conflict-Elicited Negative Evaluations of Neutral Stimuli: Testing Overt Responses and Stimulus-Frequency Differences as Critical Side Conditions. *Frontiers in Psychology*, *10*, 2204. https://doi.org/10.3389/fpsyg.2019.02204

Gross, J. J. (2015). Emotion Regulation: Current Status and Future Prospects. *Psychological Inquiry*, *26*(1), 1–26. https://doi.org/10.1080/1047840X.2014.940781

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology*, *85*(2), 348–362.

Gyurak, A., Gross, J. J., & Etkin, A. (2011). Explicit and implicit emotion regulation: A dual-process framework. *Cognition & Emotion*, *25*(3), 400–412. https://doi.org/10.1080/02699931.2010.544160

Ivanchei, I., Begler, A., Iamschinina, P., Filippova, M., Kuvaldina, M., & Chetverikov, A. (2019). A different kind of pain: affective valence of errors and incongruence. *Cognition and Emotion*, *33*(5), 1051–1058.

JASP Team (2018). *JASP (version 0.9)[computer software].*

Kool, W., McGuire, J. T., Rosen, Z. B., & Botvinick, M. M. (2010). Decision making and the avoidance of cognitive demand. *Journal of Experimental Psychology. General*, *139*(4), 665–682. https://doi.org/10.1037/a0020198

Markovitch, N., Netzer, L., & Tamir, M. (2017). What you like is what you try to get: Attitudes toward emotions and situation selection. *Emotion*, *17*(4), 728–739. https://doi.org/10.1037/emo0000272

Pan, F., Shi, L., Lu, Q., Wu, X., Xue, S., & Li, Q. (2016). The negative priming effect in cognitive conflict processing. *Neuroscience Letters*, *628*, 35–39. https://doi.org/10.1016/j.neulet.2016.05.062

Rouder, J. N., Speckman, P. L., Sun, D., Morey, R. D., & Iverson, G. (2009). Bayesian t tests for accepting and rejecting the null hypothesis. *Psychonomic Bulletin & Review*, *16*(2), 225–237. https://doi.org/10.3758/PBR.16.2.225

Schmidt, J. R., & Weissman, D. H. (2014). Congruency sequence effects without feature integration or contingency learning confounds. *PloS One*, *9*(7), e102337. https://doi.org/10.1371/journal.pone.0102337

Schmidts, C. (2019). Does Conflict Influence Situation Selection? Retrieved from https://osf.io/pmjh3/

Schmidts, C., Foerster, A., & Kunde, W. (2019). Conflict modification: Predictable production of congruent situations facilitates responding in a stroop task. *Psychological Research*, *83*(8), 1722–1732. https://doi.org/10.1007/s00426-018-1021-8

Schönbrodt, F. D., & Wagenmakers, E.-J. (2018). Bayes factor design analysis: Planning for compelling evidence. *Psychonomic Bulletin & Review*, *25*(1), 128–142. https://doi.org/10.3758/s13423-017-1230-y

Schouppe, N., Braem, S., Houwer, J. de, Silvetti, M., Verguts, T., Ridderinkhof, K. R., & Notebaert, W. (2015). No pain, no gain: The affective valence of congruency conditions changes following a successful response. *Cognitive, Affective & Behavioral Neuroscience*, *15*(1), 251–261. https://doi.org/10.3758/s13415-014-0318-3

Schouppe, N., Houwer, J. de, Ridderinkhof, K. R., & Notebaert, W. (2012). Conflict: Run! Reduced Stroop interference with avoidance responses. *Quarterly Journal of Experimental Psychology*, *65*(6), 1052–1058. https://doi.org/10.1080/17470218.2012.685080

Schouppe, N., Ridderinkhof, K. R., Verguts, T., & Notebaert, W. (2014). Context-specific control and context selection in conflict tasks. *Acta Psychologica*, *146*, 63–66. https://doi.org/10.1016/j.actpsy.2013.11.010

Schwarzer, G. (2007). meta: An R package for meta-analysis. *R News*, *7*(3), 40–45.

Tamir, M., & Ford, B. Q. (2009). Choosing to be afraid: Preferences for fear as a function of goal pursuit. *Emotion*, *9*(4), 488–497. https://doi.org/10.1037/a0015882

Van Steenbergen, H., Band, G. P. H., & Hommel, B. (2009). Reward counteracts conflict adaptation. Evidence for a role of affect in executive control. *Psychological Science*, *20*(12), 1473–1477. https://doi.org/10.1111/j.1467-9280.2009.02470.x

Vermeylen, L., Braem, S., & Notebaert, W. (2019). The affective twitches of task switches: Task switch cues are evaluated as negative. *Cognition*, *183*, 124–130. https://doi.org/10.1016/j.cognition.2018.11.002

Viechtbauer, W. (2010). Conducting meta-analyses in R with the metafor package. *Journal of Statistical Software*, *36*(3), 1–48.

Wilson, T. D., Reinhard, D. A., Westgate, E. C., Gilbert, D. T., Ellerbeck, N., Hahn, C., . . . Shaked, A. (2014). Just think: The challenges of the disengaged mind. *Science (New York, N.Y.)*, *345*(6192), 75–77. https://doi.org/10.1126/science.1250830