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Task Conflict Biases Decision Making

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The present research explores decision making in multitasking, investigating how people make optimal decisions between tasks. Empirical evidence suggests that difficulties in task performance (i.e., response conflict within a task) can bias decision making. Here we investigate whether also conflict between task representations can tune choices away from conflict-associated tasks. Using a combined forced/free-choice task-switching design, we tested whether task conflict that arises because of proactive interference of previously activated tasks biases task choice. We compared free-choice decisions between 3 tasks after forced-choice sequences that instigated either high task conflict (task sequences of type ABA, in which persisting inhibition needs to be overcome because one switches back to a just-abandoned task) or low task conflict (task sequences of type CBA). Results of 2 experiments (N = 16; N = 32, preregistered) showed that participants were more likely to switch away from the previously performed task after high than after low task conflict. Furthermore, participants preferably selected the task that suffered least from task conflict and/or proactive interference. In addition, a third experiment (N = 32) confirmed that this bias in task selection could not be explained in terms of randomness heuristics. These results suggest a close link between decision making and performance in multitasking.

Keywords: voluntary task switching, task conflict, task avoidance, N-2 task repetition costs, task inhibition

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For goal-directed behavior, people have to make the right decisions and they have to act accordingly. However, what makes both decisions and actions that follow from these decisions difficult are distractions and temptations that conflict with our actual goals. Not surprisingly, the notion of conflict as a fundamental constraint on human cognition has been central to many theories that assume that control mechanisms monitor for, and intervene in case of, conflict (Allport, 1989; Botvinick, Braver, Barch, Carter, & Cohen, 2001; Norman & Shallice, 1986; Shenhav, Botvinick, & Cohen, 2013; Verguts & Notebaert, 2008). For instance, stimuli that create conflict by activating more than one response alternative lead to slower and less accurate performance. Interestingly, the so-called conflict adaptation effect shows that recent experience of conflict in a previous trial reduces these conflict effects, suggesting that people learn from conflicts and adjust their actions accordingly (Gratton, Coles, & Donchin, 1992; for reviews, see Egner, 2007, 2017).

So far, this line of research focused on action control within a given task. But do people also learn from conflict for their decisions about which task to choose next? This question can be addressed with a version of the voluntary task switching (VTS) paradigm, in which participants are required to first choose a task and only then to perform the selected task (Arrington & Logan, 2005; for review, see Arrington, Reiman, & Weaver, 2014). Using the VTS paradigm, several studies provided evidence that response conflict during task performance biases subsequent task choices away from the conflict-associated task (e.g., Dignath, Kiesel, & Eder, 2015; Kool, McGuire, Rosen, & Botvinick, 2010; Schouppe, Ridderinkhof, Verguts, & Notebaert, 2014).

Hence, so far, there is evidence that conflict between different response options can lead to (a) control adaptation within a given task, and (b) task avoidance when participants are given the

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Raw individual data are available on the Open Science Framework: https://osf.io/r6u89/. Preregistration protocol: https://aspredicted.org/75kb9.pdf.

Part of these data was presented at the 21st Conference of the European Society for Cognitive Psychology, Tenerife, Spain.

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possibility to choose between tasks. In other words, in single tasking and externally organized multitasking, in which it is important to know how to perform a given task best, conflict leads to increased focus on the task (i.e., more persistence). In contrast, during self-organized multitasking, in which it is also important to know which task to choose best, conflict leads to disengagement from the conflict-associated task (i.e., more flexibility).

In the present study, we hypothesized that apart from conflict at the response level, also conflict at the task level can trigger avoidance of the conflict-associated task. This prediction is derived from a recent framework of monitoring and control in multitasking (Schuch, Dignath, Steinhauser, & Janczyk, 2019), in which we suggested that conflict-control loops may be a general principle of the cognitive system, and that conflict can occur on different levels in the cognitive system. Therefore, the question arises whether also conflict at a higher level, that is, at the level of task representation, can influence decision making in multitasking?

Here we manipulated task conflict by means of proactive interference in task-switching sequences. There is consensus that once participants switch away from a task, this task becomes inhibited (see Kiesel et al., 2010; Koch, Gade, Schuch, & Philipp, 2010 for reviews; Sexton & Cooper, 2017 for a computational model). Therefore, the sooner one switches back to a previously abandoned task, the more persisting inhibition needs to be overcome (Mayr & Keele, 2000). Empirical support for this kind of proactive interference on the task level comes from the finding of impaired performance when immediately switching back to a recently abandoned task, such as in sequences of type ABA, relative to sequences of type CBA (backward inhibition effect or N-2 task repetition costs). ABA means (from left to right) that Task A is performed, then a different Task B is performed, and then the participant switches back to the just-abandoned Task A. CBA means that Task C is performed, then a different Task B, and then a still different Task A.[1] The proactive interference in ABA sequences constitutes a conflict on the task level, in that there is increased competition between the still-inhibited but relevant task representation, and the less inhibited but irrelevant task representations.

Note that the way the present research instigated task conflict is different from the stimulus-driven task conflict in Stroop paradigms, in which slower responses to congruent trials (e.g., the word blue written in blue) than to neutral trials (e.g., the string XXXX written in blue) is taken as an indicator for conflict between the relevant color-naming task and the irrelevant but automatic word-reading task (e.g., Goldfarb & Henik, 2007; see Littman, Keha, & Kalanthroff, 2019 for review). Similarly, in task-switching paradigms, slower responses to bivalent stimuli (e.g., the word blue written in blue when switching between color-naming task and word-reading task) than to univalent stimuli (e.g., the string XXXX written in blue) have been taken as indicators of stimulus-driven task conflict (e.g., Elchlepp, Rumball, & Lavric, 2013; Rogers & Monsell, 1995; Steinhauser & Hübner, 2009). The proactive-interference–based task conflict manipulated here cannot be reduced to stimulus-driven task conflict because ABA and CBA task sequences include the same amount of stimulus-driven task conflict (i.e., both involve trivalent stimuli; see *Method* for details).

Evidence for aftereffects of proactive-interference–based task conflict comes from studies showing that performance after trials with high task conflict (i.e., after ABA sequences) is improved, in line with the idea of conflict triggering increased attentional focusing on the relevant task (Schuch & Grange, 2015, 2019). Whereas this shows that task conflict leads to control adaptation within a given task when the task is predetermined by the experimenter, it remains to be shown whether task conflict also biases subsequent decision making when participants are free to choose a task for themselves.

To provide direct evidence for biased task selection after task conflict, we used a combined forced-choice/free-choice task-switching paradigm. To manipulate task- conflict, we constructed three consecutive forced-choice task-switch trials that either elicited high task conflict (i.e., ABA sequence) or elicited low task conflict (i.e., CBA sequence). To assess behavioral consequences in decision making, each sequence of forced-choice trials was followed by one free-choice trial in which participants had to decide which task they wanted to perform (see Figure 1). To disentangle decisions and actions that follow from these decisions, we separated the effectors used for task choice and task performance (left vs. right hand). To disentangle task conflict and response conflict, we manipulated task conflict but kept response conflict constant across conditions.

We had two predictions for decision making in free-choice trials: (a) Participants should be less likely to repeat the previously performed task after high task conflict than after low task conflict and (b) within trials after high task conflict, participants should be most likely to choose the task that they did not perform in either trial N-1 or trial N-2. This is because they should be avoiding the conflict-associated task they performed in the previous trial N-1, and they should be avoiding the N-2 task because of persisting inhibition of this previously abandoned task (Lien & Ruthruff, 2008).

We used a paradigm in which participants could choose between three different tasks (A, B, C). With X denoting a free-choice trial, the predictions can be summarized as follows: Prediction 1: fewer task repetitions in ABAX than in CBAX sequences; Prediction 2: in ABAX sequences, Task C is more frequently selected than Task A and more frequently selected than B. Taken together, these findings would provide evidence that task conflict biases decision making away from conflict-associated tasks.

Experiments 1 and 2: Task Selection Under Task Conflict

Method

Raw individual data can be found on the Open Science Framework (https://osf.io/r6u89/; Schuch & Dignath, 2020).

Participants. Sixteen volunteers (13 women, $M = 20.3$ years; $SD = 1.5$) participated in Experiment 1. For Experiment 2, hypotheses, experimental methods, and analysis were preregistered (https://aspredicted.org/75kb9.pdf). Thirty-two (23 women, $M = 22.1$ years; $SD = 2.7$) participated, and sample size was based on the effect size observed in Experiment 1.

[1] Note that A, B, and C are only placeholders and can refer to any task.

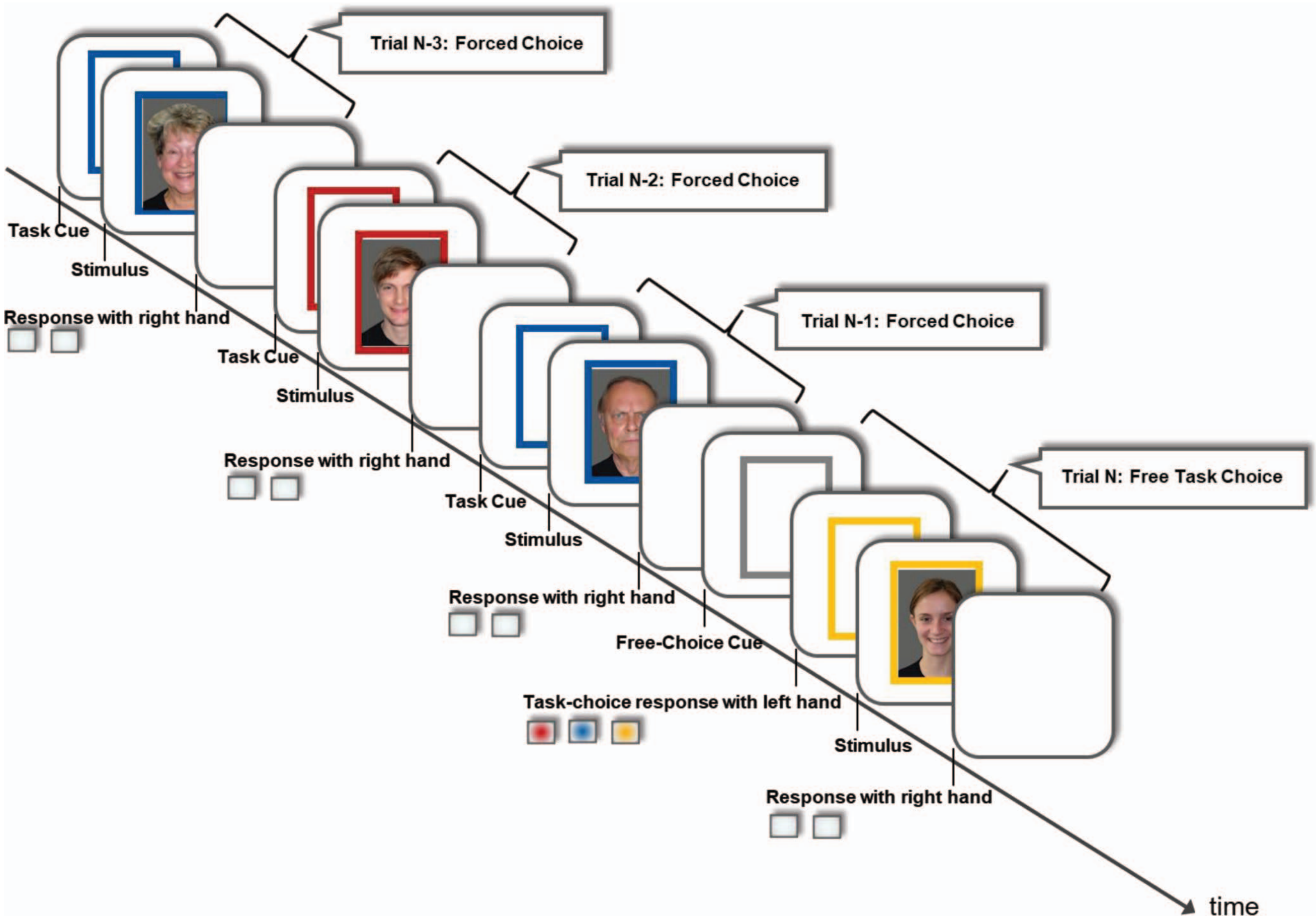

Figure 1. Schematic description of experimental procedure. Participants performed sequences of three forced-choice trials, followed by one free-choice trial. Task choice in trial *N* was analyzed as a function of the preceding task sequence, which was either a task sequence of type ABA (i.e., the task performed in trial N-1 was the same as the task performed in trial N-3, instigating high task conflict in trial N-1) or of type CBA (i.e., the task performed in trial N-1 was not the same as the task performed in trial N-3, instigating low task conflict in trial N-1). Written permission for publication in scientific journals has been obtained from each photographed individual. See the online article for the color version of this figure.

Tasks, stimuli, and responses. The tasks and stimuli were the same as in Schuch and Grange (2019; see Schuch, Werheid, & Koch, 2012 for further details on the stimulus material). Stimuli were 40 different pictures (10.6 cm × 14.1 cm) that were presented centrally on a 19-in. monitor (1280 × 1024 pixels, 60 Hz). Pictures showed faces that had to be categorized as young/old (age task), female/male (gender task), or happy/angry (emotion task). The relevant task was cued by a colored frame (red: age task, blue: gender task; yellow: emotion task). Free-choice trials were indicated by a gray frame.

For task performance, participants used their right hand (index and middle finger) to press the m key or comma key, respectively (response mappings were fully counterbalanced across participants) on a QWERTZ keyboard. The individual response mappings were depicted on a paper card, which was placed just below the computer screen and remained visible throughout the experiment. To indicate task choices, participants used their left hand (ring, middle, and index finger) and the y, x, and c keys, respectively. Task-choice keys were marked with colored stickers corresponding to the colors of the task cues.

Procedure. Participants gave informed written consent before the experiment and instructions emphasized both speed and accuracy. Regarding the free-choice trials, participants received the standard VTS instructions to choose tasks randomly according to mental dice throwing (see Arrington & Logan, 2004).

Participants performed sequences of three forced-choice trials followed by one free-choice trial. After two practice blocks with 12 trials (i.e., three cycles of three forced-choice plus one free-choice trial) each, the main experiment consisted of eight blocks with 120 trials (i.e., 30 cycles) each, with self-paced breaks between the blocks. Sequences of forced-choice trials consisted of 50% task sequences of type ABA and 50% of type CBA. Direct task repetitions were not possible by design. The tasks occurred in pseudorandom order; it was controlled that each task occurred about equally often across the entire experiment and about equally often in the third trial of ABA and CBA sequences. The facial stimuli also occurred in pseudorandom order, controlling that each task-stimulus combination occurred about equally often in forced-choice trials. In free-choice trials, each facial stimulus occurred at least three times and at most 11 times. Furthermore, stimulus repetitions were rare (in 2.5% of the trials, the stimulus from the preceding trial, or from two trials before, was repeated) and were excluded from analysis to minimize episodic retrieval effects.

In forced-choice trials, every trial started with the presentation of the task cue (i.e., the colored frame) for 500 ms, followed by the picture of the face. Frame and picture stayed on the screen until the response key was pressed. A correct trial ended with a blank screen for 500 ms. In case of an incorrect response, error feedback occurred for 1,000 ms. A free-choice trial started with the presentation of a gray frame. Upon task choice, the frame would take on the color corresponding to the chosen task, and the trial proceeded the same way as the forced-choice trials. In case of an incorrect task choice (i.e., right-hand response), a message would remind participants to "please choose a task first," presented for 1,000 ms.

Design. Task-choice behavior in free-choice trials was analyzed as a function of the preceding forced-choice sequence. The independent within-subjects variable was type of forced-choice sequence (ABA vs. CBA, instigating high vs. low task conflict, respectively). The dependent variable was relative choice frequency of task (A vs. B vs. C), in which task choice A means that the task was chosen that had been performed in the N-1 trial (i.e., task repetition); task choice B means that the task was chosen that had been performed in the N-2 trial; task choice C means that the task was chosen that had neither been performed in N-1 nor in N-2.

Analysis. We checked for extreme task-choice behavior as defined by an individual choosing a task in less than 5% or more than 95% of free-choice trials (none of the participants had to be excluded). We excluded practice trials, premature responses that occurred prior to cue onset (Experiment 1: 0.5%; Experiment 2: 0.6%), reaction time (RT) outliers (defined as trials with RT above or below 3 *SD* of the overall mean per participant), computed separately for choice RT (Experiment 1: mean = 1.7%, range = 0%-2.8%; Experiment 2: mean = 1.7%, range = 0.4–2.9%) and performance RT (Experiment 1: mean = 1.4%, range = 0.5–2.1%; Experiment 2: mean = 1.7%, range = 0.8–2.8%). We also excluded incorrect choice trials (Experiment 1: 0.4%; Experiment 2: 0.7%), and choice trials that followed after an incorrect forced-choice sequence (i.e., error in trial N-1, N-2, or N-3: Experiment 1: mean = 18.9%, range = 6.7–45.0%; Experiment 2: mean = 16.1%, range = 2.9–39.2%) or after a sequence containing a stimulus repetition (i.e., when the stimulus presented in trial N-1 was the same as the one presented in N-2 or N-3: 1.7%). Relative choice frequencies of Task A, B, and C in free-choice trials were computed per participant and condition (after ABA forced-choice sequence vs. after CBA forced-choice sequence) for both experiments.[2] In the online supplemental materials, we report the same analysis with arcsine-transformed frequency scores (Supplemental Analysis S1). Three preplanned comparisons were tested, using paired *t* tests, two sided, with Bonferroni-corrected significance criterion set to 0.0167. Standardized effect sizes (Cohen's d_z) are reported for significant differences. Relative choice frequencies in Experiment 1 were calculated based on M = 181 observations (SD = 30.8) and in Experiment 2 based on M = 194 observations (SD = 24.4). Figure 2 shows the condition means. Choice RT data and performance data of free-choice trials are reported in the Supplemental Analyses S2 and S3.

Results

Task-repetition rate was smaller after ABA forced-choice sequences than after CBA forced-choice sequences (Experiment 1: 28.9% vs. 34.8%, $t[15] = 3.43$, $p = .004$, $d_z = 0.86$; Experiment 2: 29.6% vs. 36.1%, $t[31] = 4.32$, $p < .001$, $d_z = 0.76$), confirming the predicted task-avoidance effect in trials after high task conflict (i.e., after ABA) relative to trials after low task conflict (i.e., after CBA). Within the trials preceded by ABA sequences, participants chose Task C more often than Task A (Experiment 1: 38.3% vs. 28.9%, $t[15] = 3.65$, $p = .0024$, $d_z = 0.91$; Experiment 2: 39.2% vs. 29.6%, $t[31] = 3.97$, $p < .001$, $d_z = 0.70$), again indicating task avoidance. Participants chose Task C more often that Task B (Experiment 1: 38.3% vs. 32.8%, $t[15] = 2.14$, $p = .049$, $d_z = 0.53$, not significant at the Bonferroni-corrected alpha level; Experiment 2: 39.2% vs. 31.3%, $t[31] = 3.63$, $p < .001$, $d_z = 0.64$, significant at the corrected alpha level), indicating the inhibitory task-choice effect reported by Lien et al. (2008). This data pattern was not found within the trials preceded by CBA sequences, in which participants did not choose Task C any more often than Task B or Task A (Experiment 1: Task C in 33.5%, Task B in 31.7%, Task A in 34.8%, *t*s < 1; Experiment 2: Task C in 31.7%, Task B in 32.2%, Task A in 36.1%). In Experiment 2, if anything, participants chose Task C less often than Task A, $t(31) = 2.18$, $p = .037$, not significant at the corrected alpha level; task choices between Tasks C and B did not differ, ($t(31) < 1$. The predicted data pattern was confirmed when analyzing arcsine-transformed frequency scores (see Supplemental Analysis S1).

Post hoc analysis I: controlling for response conflict. Response congruency in forced-choice trials preceding a free-choice trial was established the same way as in Schuch et al. (2019; see also Schneider, 2014; Longman, Lavric, Munteanu, & Monsell, 2014). That is, three levels of response congruency were defined, depending on whether both irrelevant tasks triggered the same response as the relevant task (congruent), both irrelevant tasks triggered the alternative response (incongruent), or one irrelevant task triggered the same response, the other irrelevant task the alternative response (intermediate). Task-choice behavior in free-choice trials was analyzed as a function of congruency of the previous trial. Task-switch rate did not differ between trials preceded by congruent, intermediate, and incongruent trials (Experiment 1: 68.5%, 67.7%, 67.1%, respectively; $F < 1$; Experiment 2: 67.6%, 66.0%, 66.6%, $F < 1$), suggesting that response conflict did not trigger task avoidance with the trivalent stimuli used in the present paradigm. Please see (Supplemental Analysis S4) for evidence that response-conflict occurred in forced-choice trials, as indicated by worse performance in incongruent than intermediate trials and in intermediate than congruent trials.

Post hoc analysis II: further evidence for effort avoidance. To determine whether task choice depends on relative task difficulty, it was assessed which of the three tasks (age task, gender task, emotion task) was the most difficult, which was intermediate,

[2] For two participants in Experiment 1, two of eight experimental blocks could not be analyzed because these blocks contained a programming error. The programming error was corrected prior to the start of Experiment 2.

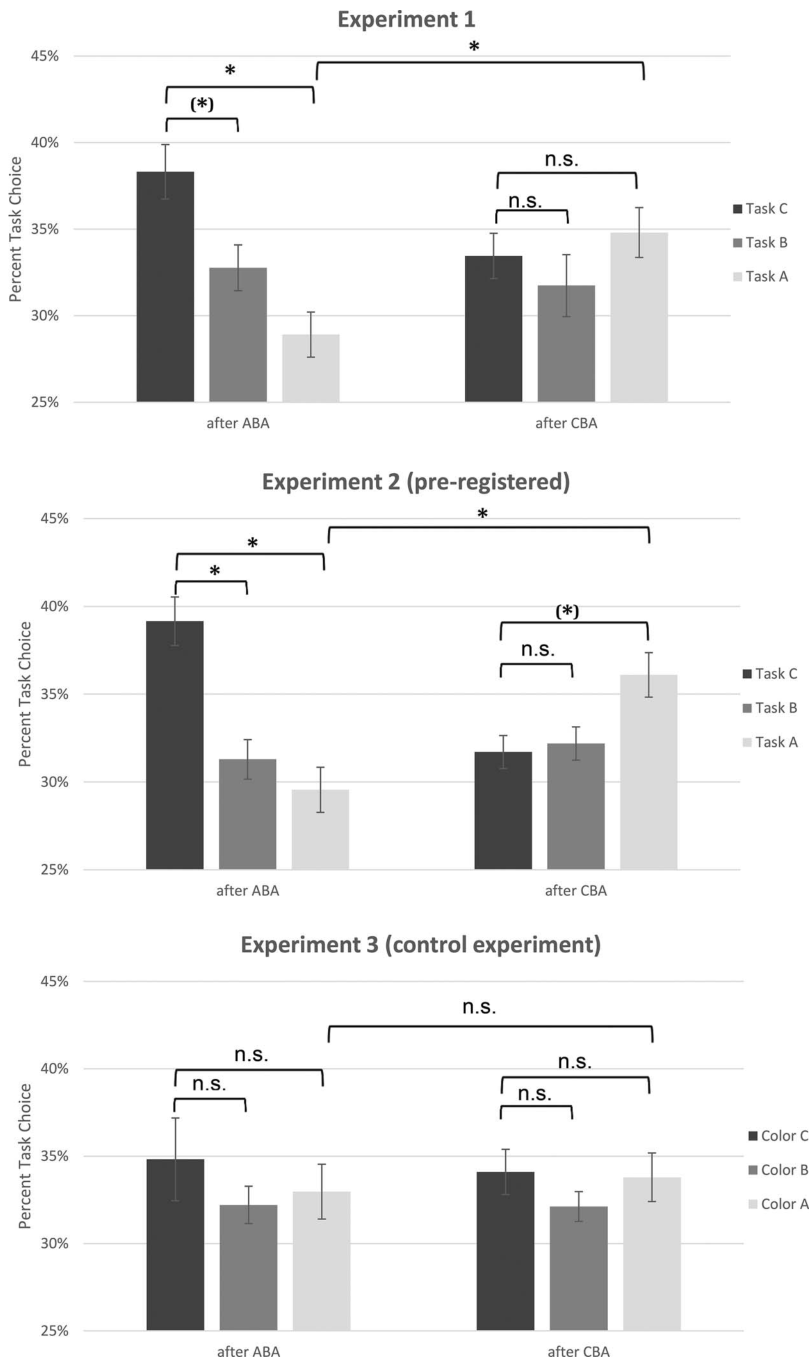

Figure 2. Upper and middle panel: Experiment 1 (N = 16) and Experiment 2 (N = 32, preregistered), investigating task selection under task conflict. Mean proportion of task choices in free-choice trials after forced-choice task sequences of type ABA (presumably instigating high task conflict) versus CBA (presumably instigating low task conflict). Lower panel: Experiment 3 (N = 32), investigating selection behavior without task conflict. Mean proportion of color choices in free-choice trials after color sequences of type ABA (i.e., the color in trial N-1 was the same as the color in trial N-3) versus CBA (i.e., the color in trial N-1 was not the same as in trial N-3). Task A/Color A means that the task/color was chosen that had been performed/presented in the N-1 trial (i.e., task/color repetition). Task B/Color B means that the task/color was chosen that had been performed/presented in the N-2 trial. Task C/Color C means that the task/color was chosen that had been performed/presented neither in N-1 nor in N-2. Error bars represent 1 standard error of mean. * $p < .0167$ for the two-tailed t test (Experiment 1: df = 15; Experiment 2: df = 31; Experiment 3: df = 30), corresponding to the Bonferroni-corrected significance level. $(^{*})$ $p < .05$ for the two-tailed t test corresponding to the noncorrected significance level. *ns* = not significant.

and which was the easiest task, separately for each individual of Experiments 1 and 2. To this end, mean RT per task in the trial preceding the free-choice trial was calculated, and these mean RT per task were rank ordered for each individual, determining the most difficult, intermediate, and easiest task per individual. Then we computed the average task-repetition rate in the free-choice trials after the most difficult task, intermediate, and easiest task (29.3%, 31.7%, and 36.5%, respectively; $F[2, 94] = 5.36$, $p < .01$, partial eta squared = 0.10, for the main effect of task difficulty; $t[47] = 3.22$, $p = .002$ for the difference between most difficult and easiest task; $t[47] = 1.91$, $p = .063$ for the difference between intermediate and easiest task; see Supplemental Analysis S5). That is, participants are more likely to voluntarily repeat the easiest task than they are to repeat the most difficult or intermediate task, in line with effects of effort avoidance previously observed in the literature (Kool et al., 2010; see also Desender, Buc Calderon, Van Opstal, & Van den Bussche, 2017; Dunn, Lutes, & Risko, 2016; Gold et al., 2015; Kool & Botvinick, 2014; Schouppe, Demanet, Boehler, Ridderinkhof, & Notebaert, 2014).

Experiment 3: Controlling for Randomness Heuristics

In an additional experiment with $N = 32$ new participants, we assessed choice behavior in the absence of task conflict to rule out the possibility that participants' task choices depended on the local frequencies of the preceding task sequence. One possible objection could be that participants are more likely to choose Task C after an ABA sequence than after a CBA sequence because of their notion of randomness: They might assume that Task C should occur more likely when it has not occurred in the last three trials (as is the case after an ABA sequence) than when it has occurred (as is the case after a CBA sequence). If the choice effect was due to such a randomness heuristic, it should be observed even when there was no task conflict at all.

Experiment 3 was identical to Experiment 2, except that participants never performed any categorization tasks and were never instructed about the different tasks. Rather, their instruction was to watch the colored frames and faces and, upon presentation of a gray frame in every fourth trial, to choose one of the three colors according to a mental dice throwing metaphor. That is, the instructions regarding free choice were identical to Experiment 2. The presentation times of each stimulus in each trial were determined on the basis of the individual participants' RTs in Experiment 2. That is, we used a yoked design, in which the trial-by-trial RTs of participant number 1 of Experiment 2 were the trial-by-trial presentation times of the stimuli for participant number 1 of Experiment 3, and so forth.

Method

Raw individual data can be found on the Open Science Framework (https://osf.io/r6u89/; Schuch et al., 2020).

Participants. Thirty-two volunteers (23 women, $M = 20.8$ years; $SD = 2.3$) participated; none of them had participated in Experiments 1 or 2.

Stimuli and responses. The colored frames and face stimuli from Experiment 2 were used. Other than in Experiment 2, there was no paper card showing the response mappings, and participants used their right hand only to start the next experimental block. The stimuli (i.e., gray frame) and responses in the choice trials were identical to Experiment 2: To indicate color choices, participants used their left hand (ring, middle, and index finger) and the y, x, and c keys, respectively. Choice keys were marked with colored stickers corresponding to the colors of the task cues.

Procedure. The experimental procedure was identical to Experiment 2, except that the categorization tasks and response mappings were never mentioned. Participants were told that they would see differently colored frames (red, blue, or yellow) and different faces presented in those frames. In every fourth trial, the frame would be gray. In those trials, they could decide for themselves what color the next frame should have by pressing one of three keys with the fingers of their left hand. As in Experiment 2, participants received standard VTS instructions, to choose the colors randomly according to mental dice throwing (cf. Arrington et al., 2004). Moreover, participants were encouraged to keep looking at the presented faces and frames throughout the experiment.

Three of four trials started with the presentation of a colored frame for 500 ms, followed by a face picture. Frame and picture stayed on the screen for the duration of the individual trial RT of the yoked participant and was followed by a blank screen for 500 ms. Every fourth trial started with the presentation of a gray frame. Upon left-hand key press, the frame would take on the chosen color, followed after 500 ms by the presentation of a face inside the colored frame. Frame and face stayed on the screen for the duration of the yoked RT, followed by a blank screen for 500 ms. In case of an incorrect task choice (i.e., right-hand key press), a message would remind participants to "please select a color," presented for 1,000 ms, after which the next trial started.

Results

The data from one participant were excluded because this participant did not adhere to the instructions and pressed color keys far too often throughout the experiment (1,736 color-key presses were registered, instead of the 240 required color choices). The data of the first block of one further participant were not included because the participant had pressed a color key in every trial in that block; the instructions were repeated and the data from Block 2 onward were included in the analysis.

Choice behavior was analyzed in the same way as in Experiment 2. We checked for extreme choice behavior as defined by an individual choosing a color in less than 5% or more than 95% of free-choice trials (none of the participants had to be excluded). We excluded practice trials, premature responses that occurred prior to cue onset (0.01%), RT outliers (defined as trials with RT above or below 3 SD of the overall mean choice RT per participant; mean = 1.7%, range = 0.4–3.8%), incorrect choice trials (0.04%), and choice trials after sequences containing a stimulus repetition (1.7%). Relative choice frequencies were calculated based on $M = 227$ observations ($SD = 4.8$). Figure 2 shows the condition means.

Relative choice frequencies of color A, B, and C were computed per participant and condition (after color sequences of type ABA vs. CBA). The same three preplanned comparisons were tested as in Experiment 2: Color-repetition rate did not differ after ABA color sequences versus CBA color sequences (33.0% vs. 33.8%, $t < 1$). Within the trials preceded by ABA color sequences, participants chose color C about equally often as color A (34.8% vs. 33.0%, $t < 1$) and about equally often as color B (34.8% vs. 32.2%, $t < 1$). Within the trials preceded by CBA color sequences, participants chose color C about equally often as color A (34.1% vs. 33.8%, $t < 1$), and color B (34.1% vs. 32.1%, $t[30] = 1.15$, $p = .26$). This data pattern was confirmed when analyzing arcsine-transformed frequency scores (see Supplemental Analysis S6 that also presents choice RT data for completeness).

Between-experiment comparison. Finally, choice frequencies in Experiment 2 and Experiment 3 were analyzed in a between-experiment ANOVA with the factors experiment (2 vs. 3), previous sequence (ABA vs. CBA), and task/color (A, B, C). The three-way interaction was significant, $F(2, 61) = 5.93$, $p < .01$, partial eta squared = 0.09 (when using arcsine-transformed frequency scores: $F[2, 61] = 5.85$, $p < .01$, partial eta squared = 0.09), confirming that choice behavior differed between Experiments 2 and 3. The only further significant effect in the ANOVA was the two-way interaction of previous sequence and color, $F(2, 61) = 8.98$, $p < .01$, partial eta squared = 0.13; all other Fs < 2.45.

Focusing on task-repetition rate, a follow-up two-way ANOVA with the factors experiment (2 vs. 3) and previous sequence (ABA vs. CBA) revealed a significant interaction, $F(1, 61) = 8.68$, $p < .01$, partial eta squared = 0.13 (when using arcsine-transformed frequency scores:, $F[1, 61] = 8.13$, $p = .01$, partial eta squared = 0.12), confirming that task-repetition rate differed after ABA sequences versus after CBA sequences in Experiment 2, but not in Experiment 3.

Focusing on the trials preceded by ABA sequences, we ran a follow-up ANOVA with the factors experiment (2 vs. 3) and color (A, B, C), with preplanned contrasts on the interaction comparing the choice frequencies for C versus A and for C versus B, between the experiments. There was a statistical trend suggesting that participants chose C more often than A in Experiment 2 but not in Experiment 3 ($F[1, 61] = 2.93$, $p = .09$, partial eta squared = 0.05; when using arcsine-transformed scores: $F[1, 61] = 2.88$, $p = .10$, partial eta squared = 0.05). Choice behavior for C versus B did not differ between the experiments ($F[1, 61] = 1.78$, $p = .19$, partial eta squared = 0.03; when using arcsine-transformed scores: $F[1, 61] = 1.92$, $p = .17$, partial eta squared = 0.03).

Discussion

Results of Experiment 3 showed that color choice behavior did not differ after color sequences of type ABA versus CBA: Color-repetition rate did not differ after ABA versus CBA, and within the trials preceded by ABA sequences, all tasks were chosen about equally often. Moreover, a combined analysis of Experiment 2 (in which task conflict occurred) and Experiment 3 (in which no task conflict occurre, because participants were not instructed about the tasks and did not perform any tasks) confirmed that choice behavior differed significantly between the experiments: Repetition rate was lower after ABA than after CBA in Experiment 2 but not in Experiment 3. On the basis of these results, we conclude that the data pattern of Experiment 2 cannot be explained in terms of a randomness heuristic. Rather, the data further strengthen our interpretation that task conflict triggered task avoidance.

General Discussion

The present study tested whether previous task-level conflict biases decision making in a multitasking situation. Results from two experiments (one preregistered) established that conflict at the level of task representations—independent from response conflict—biases task selection to avoid the conflict-associated task. Specifically, participants were more likely to switch tasks after task conflict. Furthermore, they also considered the relative difficulty of tasks and most often selected the option with minimal effort. The present findings provide further support for our recently suggested framework that conflict-triggered control adjustments (such as avoidance of the conflict-associated task as investigated here) may be a general principle of the cognitive system and that conflict can occur on different representational levels, such as response-level conflict or task-level conflict (Schuch et al., 2019).

More generally, the present research provides direct evidence for a close connection between control in decision making (what to do) and control in task performance (how to do it). This is in line with theoretical accounts like the expected value of control model (Shenhav et al., 2013) that explains adaptive decision making as an integration of expected payoffs that result from considerations regarding the control signal to be selected (i.e., the identity) and the vigor with which this control signal should be engaged (i.e., the intensity). Accordingly, this integration takes into account the intrinsic costs to control demands, which are directly related to the intensity of control demands. The present results are in line with this and other recent models proposing that cognitive and/or affective consequences of such control demands become associated with context information (Abrahamse, Braem, Notebaert, & Verguts, 2016; Dignath, Eder, Steinhauser, & Kiesel, 2020; Dignath, Johannsen, Hommel, & Kiesel, 2019; Egner, 2014; Lieder, Shenhav, Musslick, & Griffiths, 2018). Extending these accounts, they show that participants base their task decision both on the intensity of control demands as experienced in the previous trial (e.g., high task conflict) and the identity of control demands (e.g., avoiding the task associated with task conflict). Hence, conflict is not only a trigger to increase persistence within a task but also a cue to optimize decision making between tasks.

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