Behavioral Dynamics of Cognitive and Metacognitive Conflict

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Abstract

Cognitive conflict has been widely used to investigate cognitive control mechanisms. Recent research extended this to the metacognitive level by defining metacognitive conflict as the inconsistency between external feedback and confidence. The current work investigates interaction between both types of conflict using a modified Simon task, tracking how and whether cognitive and metacognitive conflict jointly shape cognitive performance and confidence. The results revealed significant but independent effects of adaptation to cognitive conflict and adaptation to metacognitive conflict. Model-based analysis further revealed opposite effects of post-decision biased accumulation: biased towards high confidence after incongruent trials and biased towards low confidence after metacognitive conflict trials. Together, these results highlight independent yet parallel mechanisms through which different types of conflict shape decision making.

Keywords: Conflict; Confidence; Decision making; Metacognition

Introduction

Cognitive conflict, arising from incompatibility between task-relevant and task-irrelevant stimuli, has been widely used to investigate cognitive control mechanisms (Braem et al., 2019). Extending this framework, recent research has introduced metacognitive conflict — a higher-order mismatch between subjective confidence and objective feedback (Xing & Desender, in preparation). Specifically, metacognitive conflict occurs when participants have high confidence (i.e., they thought they made the correct choice), but external feedback indicates the decision was incorrect—or vice versa. Mirroring cognitive conflict effects, metacognitive conflict functions as a higher-order prediction error signal, leading to adaptive adjustment by adjusting latent decision-making parameters. The current work investigates how these two types of conflict interact by simultaneous tracking of cognitive conflict and metacognitive conflict in a modified Simon paradigm.

Method

Fifty-one participants completed a hybrid task combining a modified Simon paradigm with trial-level confidence reports and feedback (see Fig 1).

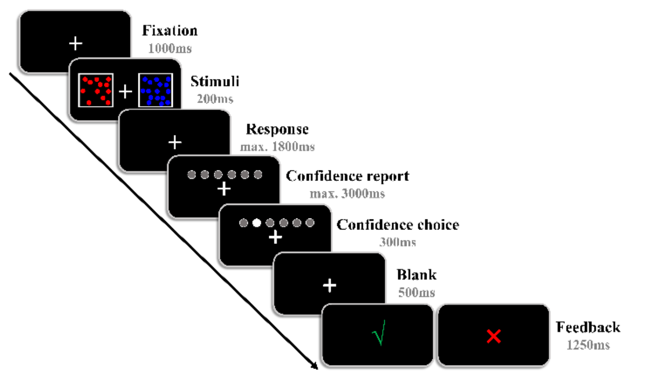

Fig 1. Experimental Design. On each trial participants were instructed to press the 'c' or 'n' key with the thumbs of their left and right hand to indicate whether they thought there were more red or blue dots respectively. Subsequently, they rated their confidence in the decision and then received feedback regarding the accuracy of their choice.

At the trial level, cognitive conflict arises from the incongruency between stimulus location and the required response—for example, when more dots appear in the left box, but the correct response is mapped to the right-hand key. The metacognitive conflict arises from the mismatch between confidence and external feedback. RT, accuracy and confidence data were analyzed using linear mixed models. Furthermore, we deployed a drift diffusion model with post-decision accumulation to quantify how both conflicts shape cognitive performance and confidence at the computational level (Desender et al., 2022; Herregods et al., 2023).

Results

The linear mixed model revealed significant effects of cognitive and metacognitive conflict but no significant interaction between both, indicating that both types of conflict independently trigger cognitive control mechanisms.

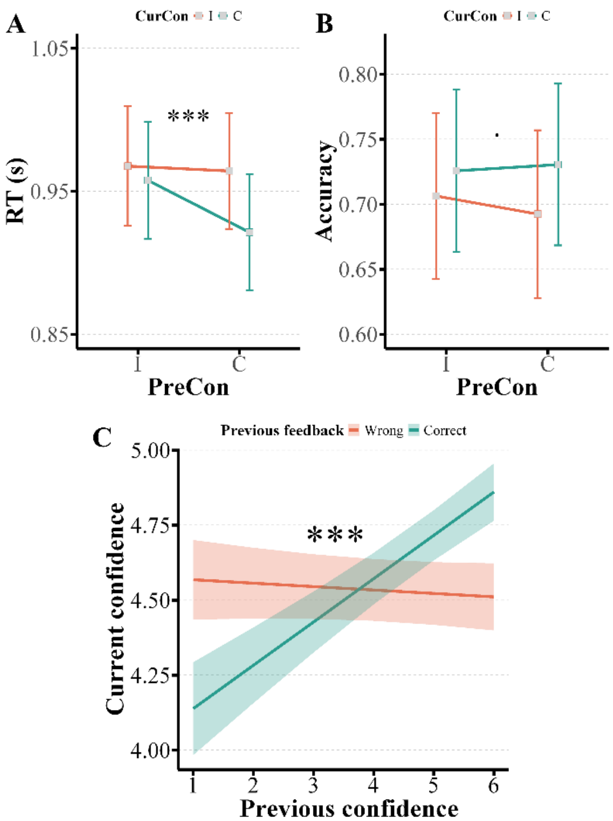

Fig 2. Behavioral results. A-B. Conflict adaptation was present for RT and Accuracy analysis. The congruency effect was smaller when the previous trial was incongruent compared to congruent. **C.** The two-way interaction effect between previous confidence level and previous feedback was significant when analyzing confidence. Participants consistently reported lower confidence when the previous trial contained a metacognitive conflict. ".": $p < 0.1$; "*": $p < 0.05$; "**": $p < 0.01$; "***": $p < 0.001$.

Furthermore, fits from a DDM with additional post-decision accumulation (Herregods et al., 2023) showed that the post-decision starting point was higher after incongruent trials and lower after metacognitive conflict trials (Fig 3A, 3B). Moreover, the decision boundary increased following incongruent versus congruent trials (Fig 3C).

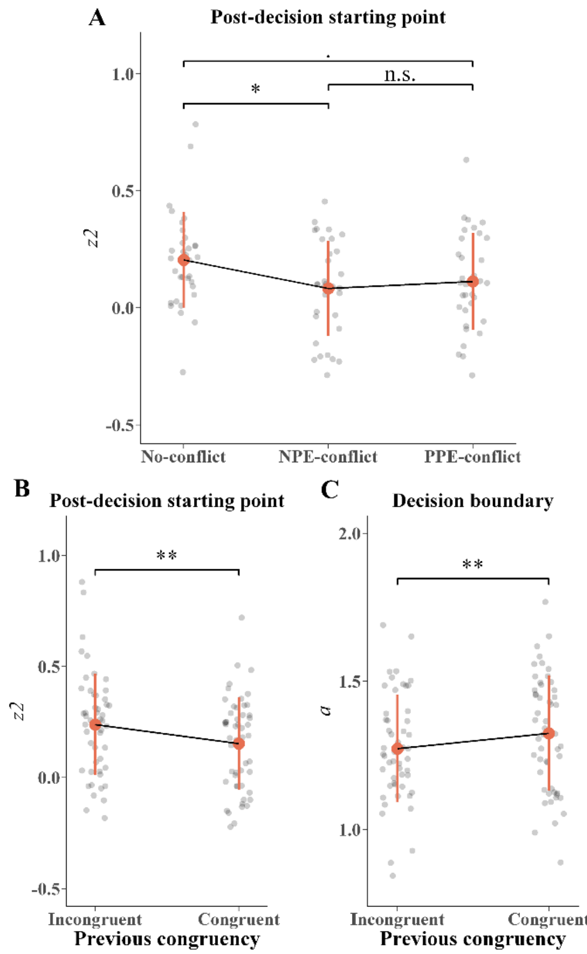

Fig 3. DDM result. A. The post-decision starting point decreased following metacognitive conflict trials (both when there was a negative prediction error (NPE) and when there was a positive prediction error (PPE)) compared to non-metacognitive conflict trials). **B-C.** The decision boundary decreased but the post-decision starting point increased following incongruent versus congruent trials. "n.s.": $p > 0.1$; ".": $p < 0.1$; "*": $p < 0.05$; "**": $p < 0.01$.

Discussion

We concluded that cognitive and metacognitive conflicts induce behavioral adaptations at distinct levels (cognition vs. metacognition). Interestingly, model-based analysis showed that both types of conflicts influence different (boundary) but also similar (post-decision starting point) latent parameters. Further investigation should employ neurophysiological methods (e.g., EEG) to test whether these conflict types share common oscillatory signatures.

Acknowledgements

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