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## Research Article

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**Competing and Interfering Conflict: Insights from Decision-Making Tasks**

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**Abstract**

Cognitive control, the most distinguishing characteristic of human behavior, is typically studied by conflict paradigms, in which conflicts are induced by goal-irrelevant stimuli (interfering conflict). We argue that competing conflict, where all stimuli need to be processed, is more basic and can also be measured using a decision-making task. In the current study, participants completed modified versions of the backward masking majority function task and the Flanker task to compare the two types of conflict in several dimensions, including reaction and resolving time, effects related to cognitive control (conflict adaption and error-related slowing), inter-stimuli distance, and uncertainty of the location. The results of these comparisons illustrate the unity and diversity of these two types of conflict. The potential application of the computational model in competing conflict is also discussed. The results will not only deepen our understanding of cognitive control and decision-making but also contribute to other areas like artificial intelligence.

*Keywords:* interfering conflict, competing conflict, cognitive control, Flanker task, the backward masking majority function task

### **Competing and Interfering Conflict: Insights from Decision-Making Tasks**

The ability to flexibly coordinate thoughts and actions in response to context-specific goals and intentions is the most distinguishing characteristic of human behavior (Miller, 2000; Koechlin, 2003; Badre, 2008; Kouneiher et al., 2009; Braver, 2012; Fan, 2014; Cohen, 2017; Grahek et al., 2019; Ott & Nieder, 2019). This ability depends on what is termed cognitive control—the set of processes responsible for the perceptual enhancement of task-relevant inputs and response, especially when our behavioral goals conflict with distractors or established response tendencies (Fernandez-Duque & Knight, 2008; Larson et al., 2016; Engström et al., 2017; Gratton et al., 2018; Schmidt, 2018). Cognitive control is also fractionated into different subcomponents, including error detection and correction mechanisms, conflict resolution, response inhibition, working memory, and task switching (van Gaal et al., 2012).

Conflict paradigms are the most common way to investigate cognitive control (Botvinick, 2001; Fröber et al., 2017; Widge et al., 2019; Hübner & Töbel, 2019). Conflicts in these paradigms might be triggered by different response patterns (response conflict), the trade-off between goals (goal conflict), unexpected events (prediction conflict), and competing stimuli from top-down (cognitive conflict) or bottom-up (perceptual conflict) processes (Egner, 2007; Nigg, 2017). The color-naming Stroop task (Stroop, 1935) provides a typical example of conflict, in which trials with color-word conflict (e.g., the word GREEN in red ink) are associated with worse task performance compared to trials without conflict (e.g., the word GREEN in green ink). Similarly, in the Flanker task, conflict occurs when the central target and flankers are incongruent (e.g., > > < > >) rather than congruent (e.g., > > > >) (Eriksen, 1974; Yeung, 2013; Jost et al., 2017). Conflicts in most of these paradigms were induced by goal-irrelevant stimuli or attributes.

However, conflicts can also occur when all stimuli or attributes, not just a subset, need to be processed. For example, Wu et al. (2016) proposed a perceptual decision-making task (the backward masking majority function task; MFT-M), in which several arrows (some pointed left and the others

pointed right) were presented simultaneously. Subjects were instructed to indicate the direction of the majority of arrows. All arrows were goal-relevant and required sufficient processing. Conflicts in this task stem from competition between different pieces of goal-relevant information rather than interference from goal-irrelevant information. Many studies have shown that manipulating the arrow ratios in the MFT-M produces parametric degradation in behavioral performance, with more conflicting information producing worse performance (Wu et al., 2016; Wu et al., 2019; He et al., 2019; Chen et al., 2019; Chen et al., 2020).

We propose that the conflicts in the MFT-M (competing conflict) might be a more basic type of conflict than the conflicts induced by goal-irrelevant stimuli (interfering conflict). Because lower-level cognitive processing cannot determine whether the information is related to the current goal, the redundant information cannot be fully excluded from multiple sensory channels before reaching higher-level cognitive processing. A certain degree of conflict is universal in the unrecognized information. For example, a previous study indicated that the sensory evidence for competing motion directions (e.g., up and down) was constantly compared until a decision was made (Heekeren et al., 2004).

Early decision-making models involving conflict assumed that decision was based on both automatic and controlled processes (Cohen et al., 1990; Ulrich et al., 2015; White et al., 2017). Automatic processes rely on lower-level cognitive functions to process all perceptual information without distinction, whereas controlled processes rely on higher-level cognitive functions (e.g. cognitive control) to process only goal-relevant information. Thus, only the automatic process would be subject to interference from goal-irrelevant stimuli (e.g., flankers) or attributes (e.g., words in color-naming), and the controlled process would be free from such interference. However, unlike the typical conflict tasks such as Stroop and Flanker tasks, conflicts in the MFT-M also exist in the controlled process because all stimuli are goal-relevant until the decision is made. Therefore, investigating the unity and diversity of these two types of conflict (competing conflict vs. interfering

conflict) might be crucial in understanding the influence of conflicts on cognitive control and decision-making. Several aspects of these conflicts were compared in the present study.

Firstly, both types of conflict should lead to increased reaction time (RT), but should differ in their effect on time required to get the correct answer. To make an optimal decision based on the balance of all evidence (e.g., both left and right arrows), subjects may sacrifice optimality in the face of limited processing time. This might explain why people sometimes pick the wrong escape route chosen by the panicked crowd, which violates the instruction of the rescuers, in an emergency (e.g., fires, earthquakes, and floods). Inadequate processing may impair task performance of the two conflicts in different degrees because distractors in the interfering conflict can be excluded from the controlled process. By contrast, all stimuli in competing conflict need to be processed in both automatic and controlled processes. Therefore, more time is required to resolve competing conflict than interfering conflict.

Secondly, the differences between the two types of conflict might lead to a discrepancy in effects related to cognitive control. Conflict adaption is one of the common markers of cognitive control engagement in tasks involving interfering conflict (e.g. Flanker task). Cognitive control resolves the interfering conflict induced by goal-irrelevant features and improves task performance by engaging more attention to the target than distractors in the next trial (Egner & Hirsch, 2005; Steenbergen et al., 2009). Since each stimulus provides useful information in tasks involving competing conflict (e.g. MFT-M), focusing solely on part of the stimuli would not facilitate decision-making or cause conflict adaption. Another common marker of cognitive control engagement is the error-related slowing effect (ERS), which refers to the observation that response times are slower after an error than after a correct trial (Gehring et al., 1993; Notebaert et al., 2009). Because the ERS is induced by the conflict between an unexpected error and the correct prediction, it would exist in both the MFT-M and the Flanker task.

Another discrepancy between the two types of conflict is related to the distance between arrows in the Flanker and MFT-M tasks. Studies have shown that the Flanker interference effect

decreases with increasing distance between flankers and target (Miller, 1991; Danielmeier et al., 2009; Forster et al., 2011; Larson et al., 2014). The flankers are located less centrally in the focus of attention, and thus a larger inter-stimuli interval leads to the weaker attentional weight of the flankers, resulting in better task performance. In contrast, when the inter-stimuli interval increases on the MFT-M, extra eye-movement might be needed to sufficiently process all the arrows, resulting in slower RTs and lower accuracy than in the Flanker task.

One intriguing aspect of cognitive control is that less engaged cognitive control may benefit performance on tasks ranging from learning and using environmental information to generating creative solutions to problems (Amer et al., 2016). On the Flanker task, although subjects knew the location of the upcoming target, they could not effectively recruit their cognitive control to eliminate effects from the flankers (White et al., 2011). We argue that such imperfection of cognitive control in human beings may be beneficial under the uncertainty of the changing world. Specifically, the uncertainty in MFT-M is represented by unpredictable locations of the arrows, and the inefficiency of cognitive control may override the cognitive load brought by the extra information.

In sum, the present study compared competing conflict (as in the MFT-M) with interfering conflict (as in Flanker and Stroop tasks) to investigate in detail the mechanisms of conflict processing. For these purposes, we modified the MFT-M (Tasks 1 - 3) and the Flanker task (Task 4) to study the two types of conflict in terms of reaction time, the effect of cognitive control (conflict adaption and ERS), inter-stimuli distance, and uncertainty of the location.

## Methods

### Participants

Thirty healthy adults (19 women; age range: 18-32 years; mean age: 21.53 years) volunteered to participate in this study. All participants had normal or corrected-to-normal vision.

### Measures

**The MFT-Ms.** Three modified versions of the MFT-M (Tasks 1-3) were used to assess the effects of competing control. Task 1 was designed to replicate the effects of the MFT-M. In each trial

of Task 1, a set of five arrows was displayed simultaneously at eight possible locations on the screen after a 500-ms fixation period, with each arrow pointing either left or right. The arrow set appeared with a variable exposure time (*ET*; 250, 500, or 1000 ms) and a different ratio between the majority and minority direction of arrows (5:0, 4:1, or 3:2). Participants were instructed to indicate the direction of the majority arrows. A 1500-ms response window was guaranteed by presenting square-shaped masks (500 ms) and a variable fixation period (0, 500, or 750 ms) following the stimuli. The feedback window was presented for 750 ms to inform the participants whether the current response was correct. The post-feedback fixation period was 1250 ms, which made the duration of each trial 4000 ms.

All parameters in Task 2 and Task 3 were identical to those in Task 1 except for the arrow locations. Task 2 controlled the randomness of the arrow locations by displaying them in five fixed locations selected from the eight possible locations in Task 1. Task 3 decreased the inter-stimuli distance by arranging five fixed locations horizontally, with the central arrow in the center of the screen. The stimuli in Task 3 were similar to those of the Flanker task, but with a different task goal. The timeline and the stimuli are shown in **Figure 1**. Each task comprised 180 trials (20 trials for each combination of *ET* and ratio) and required approximately 12 minutes to finish.

**The Modified Flanker Task.** Task 4 was modified from the Flanker task to assess the effect of interference conflict. The arrows were displayed in the same location as in Task 3. The parameters including *ET* and arrow ratios were identical to those in the MFT-Ms. The relative location of the arrows was arranged so that arrows with minority directions were always in the center. For example, when there were four left-pointing arrows and one right-pointing arrow (Ratio 4:1), the right-pointing arrow would be set in the center. When all arrows faced the same direction (Ratio 5:0), the stimuli were identical to Task 3. For the 3:2 Ratio, one of the minority arrows would be assigned to the center. Participants were instructed to indicate the direction of the center arrow.

## Procedure

Participants were asked to complete four tasks on two days, with order balanced across subjects. Participants received instructions about the task and completed 24 practice trials before the experiment each day. The study was approved by the Institutional Review Board of the university with which the first author is affiliated. Written informed consent was obtained from each participant. The study was conducted in accordance with the protocol approved by the review board. Participants received 40 RMB (about 6 US Dollars) after they completed all the tasks. The tasks were modified using PsychoPy v3.1.5 programming software (Peirce et al., 2019) and all analyses were performed using JASP software (Version 0.14.0.0; JASP Team, 2020).

### Results

Table 1 shows the mean and standard deviation (*SD*) of response accuracy and RT under each task. Table 2 shows the results of two 4 (Task: 1,2,3,4)  $\times$  3 (*ET*: 250ms, 500ms, 1000ms)  $\times$  3 (Ratio: 5:0,4:1,3:2) Repeated Measures ANOVAs, one for RT and one for accuracy. The main effects for Task, *ET*, and Ratio were significant for both accuracy and RT ( $ps < .001$ ). All interaction effects were significant ( $ps \leq .004$ ) except for the Task  $\times$  *ET* and the Task  $\times$  *ET*  $\times$  Ratio interactions on the accuracy.

#### Task Differences

There was a main effect for Task on both accuracy and RT, but different in pairwise comparisons. Post hoc comparisons revealed that accuracy was significantly different between each pair of the four tasks ( $ps < .001$ ,  $BF_{10s} > 30$ ) except between Task 1 and Task 2 ( $p > .05$ ,  $BF_{10} = 0.451$ ). However, RT was not significantly different between each pair of the three modified MFT-Ms ( $ps > .05$ ), while it was significantly different between any of the MFT-Ms and Task 4 ( $p < .001$ ). Bayesian post hoc analyses only showed evidence for the null hypothesis in the comparison between Task 1 and Task 2 ( $BF_{01} = 11.353$ ).

#### Task $\times$ Ratio

The interaction effect of Task  $\times$  Ratio on both accuracy and RT were significant. The simple main effects of Ratio on accuracy and RT in all four tasks were also significant ( $ps < .001$ ). Post hoc

comparisons revealed that RTs in congruent trials (Ratio 5:0) were significantly lower than incongruent trials (Ratio 4:1 and 3:2),  $ps < .001$  across conditions, However, RTs did not differ between the 5:0 vs. 3:2 ratio conditions in Task 4 ( $p = .032$ ). Accuracy and RT did not differ across tasks on the congruent trials, but did differ across tasks on the incongruent trials in comparisons between the Flanker task (Task 4) and each of the MFT-M tasks (Tasks 1 – 3) ( $ps < .001$ ; Figure 2).

### **Task × ET**

There was a significant interaction effect of Task × ET on RT, but not accuracy. Simple main effects of ET were significant or marginally significant on Tasks 1 - 3 (accuracy:  $p = .007, .062, \& .014$  for Tasks 1-3 respectively; RT:  $ps < .001$ ), but not on Task 4 (accuracy:  $p = .134$ ; RT:  $p = .158$ ). Post hoc comparisons revealed that RTs were significantly different between each pair of ETs within each task ( $ps < .001$ ) except for Task 4. Significant differences between accuracies were only observed in comparisons between the 250 ms and 1000 ms conditions in Task 1 and Task 3 (Task 1:  $p = 0.009$ , Task 3:  $p = 0.015$ ; Figure 3).

### **Conflict Adaption**

To compare the tasks on conflict adaption, the accuracy scores and RTs were averaged across all ETs. Paired samples *t*-tests showed that the accuracy on incongruent trials (Ratio 4:1 and Ratio 3:2) following incongruent trials was not significantly different from the accuracy that followed congruent trials (Ratio 5:0),  $ps > .05$ , and  $BF_{01} > 3$  (except in Task 4,  $BF_{01} = 1.157$ ). However, the RTs on incongruent trials following previous incongruent trials were slower than the RTs that followed congruent trials in Tasks 1-3 (Table 3).

### **Error-Related Slowing**

Paired samples *t*-tests showed that RT in trials following previous error trials was slower than RT in trials following correct trials, except in Task 4 (Table 4). However, the accuracy in trials following previous error trials was not different from the accuracy in trials following correct trials,  $p > .05$  and  $BF_{01} > 3$  (except in Task 3,  $p = .027$ ,  $BF_{01} = 0.515$ ).

### Discussion

The present study modified the MFT-M and the Flanker task to compare the behavioral effects of competing conflict and interfering conflict. The unity and diversity of these conflicts were investigated to reveal the underlying mechanisms of conflict processing. The MFT-M and the Flanker task were compared on reaction time, effects related to cognitive control (conflict adaption and ERS), inter-stimuli distance, and uncertainty of the location.

**Reaction time.** Compared to the scores on the incongruent trials of the Flanker task, the RTs were longer and the accuracies were lower on the incongruent trials in the MFT-M. This indicates that a longer time was needed to precisely resolve the competing conflict than the interfering conflict. Unlike the previous view that conflict resolution is only involved in the automatic process, we argue that conflict resolution is also involved in the controlled process used in tasks involving competing conflict (e.g. the MFT-M), which might account for the longer amount of time to respond. Competing conflict also happened frequently in real-world situations. For example, the soccer player must choose, within a limited time, which of many alternative movements they should execute, including the direction (left or right) and the type (a drop shot or lob) of play. The abilities to resolve competing conflict are needed regardless of the processing level (sensory or conscious process), and thus might be a core component of cognitive control.

**Effects related to cognitive control.** ERS was observed in the MFT-Ms, which might be attributed to the regulation of cognitive control. However, conflict adaption was not found in the MFT-Ms. Instead, RTs were longer after incongruent trials than after congruent trials. The results violate the conflict monitoring theory (Botvinick et al., 2001), which assumes that the top-down regulation of cognitive control following the detection of conflict leads to better performance in the next trial (van Gaal et al., 2010; Larson et al., 2012; Landman & van Steenbergen, 2020). The findings of the current study suggest that conflict in a prior trial may lead to the adjustment of cognitive control reflected by the increased RTs, but not necessarily result in better task performance. The evidence suggests that conflict adaption might only be observable in interfering conflict rather than

competing conflict. Furthermore, even in interfering conflict tasks like Simon, Flanker, and Stroop tasks, conflict adaption in these tasks has been found to be uncorrelated with each other (Whitehead et al., 2019).

***Inter-stimuli Distance.*** The findings suggested that the arrow distance can influence accuracy and RTs in the MFT-M. As expected, in incongruent trials of the MFT-Ms, accuracy increased when the inter-stimuli distance was smaller (Task 3), compared to a longer distance (Task 2). The result is inconsistent with earlier results using the Flanker task (Danielmeier et al., 2009). As stimuli get farther away from each other, the interfering effect from flankers fades and the target arrow can be effectively processed. By contrast, in the MFT-M, each arrow needs to be sufficiently processed, and the extra eye movement brought by the increased distance might account for worse task performance.

***Uncertainty of the location.*** As predicted, task performance was not affected by the uncertainty of the location. Similar to what had been found in the Flanker task (White et al., 2011), even though subjects knew the location of the upcoming stimuli in Task 2, they could not surpass their performance on Task 1. Acquiring information from as many sources as possible is crucial for human beings, who face various and vast uncertainties in the real world (Bach and Dolan, 2012). A certain degree of distraction is needed to accommodate uncertainty, and thus cognitive resources cannot be fully mobilized under cognitive control. The mechanism behind such distraction deserves further study, especially when we are in an era of information explosion, which means we need to constantly deal with information from multiple sources.

***General Discussion.*** Our results may provide several insights into the underlying processes involved in the resolution of competing conflict on the MFT-M. A number of models (e.g. the drift-diffusion model, DDM) have been developed to account for decision behavior in conflict tasks (e.g. Flanker task, Simon task, and Stroop task) in which people are asked to make fast decisions between two choices (Hübner & Töbel, 2012; Servant et al., 2014; Hanks & Summerfield, 2017; White et al., 2017). These various DDMs assume that decision evidence of the stimuli is accumulated with a

constant drift rate (average decision evidence per unit time) until reaching a threshold (also referred to as decision criteria), and the decision is made at that point (Ulrich et al., 2015; Ratcliff et al., 2016). Individual differences (e.g. speed-accuracy trade-off tendency, response caution) are reflected in the decision threshold, and drift rate reflects how automatic processing and controlled processing combine to drive the decision process. These models cannot simply be applied or generalize to the MFT-M because competing conflict violates the assumption that conflicts only exist in automatic processing, and a more elaborate computational model should take this into consideration.

The conflict monitoring model proposed by Botvinick et al. (2001) might be applicable to the present study. We proposed that the model could be modified by distinguishing the process of competing and interfering conflict after conflict monitoring (Figure 4). Interfering conflicts caused attention bias to the target in the next trial, which accounts for the reduction in RT. In contrast, a high-level of competing conflict leads to a speed/accuracy trade-off, resulting in slower but more accurate responses. A significant increase in RT, but not accuracy, was observed in the current study, which might be due to insufficient processing time limited by the response window.

In time-limited tasks, subjects have to keep adjusting their response strategies to achieve a balance between speed and accuracy when facing different levels of competing conflicts. Investigating the validity and practical usage of the computational model would make it possible to specify how the task performance varies over time as a function of the conflict intensity. Studying time-limited decision making in competing conflict would not only deepen our understanding of cognitive control but also contribute to research in other areas. For example, machines might be able to make correct decisions without having to process all available information.

### **Limitations and further questions**

There are several limitations in the present study. First, the length of the response window might limit the upper bound of task performance in the MFT-M, because it requires participants to

make the decisions without the evidence being fully processed. Given previous results (Chen et al., 2020), participants might be able to perform better with a longer ET. Future studies could manipulate the response window to verify the correlation of RT and the conflict intensity (which was quantified as information entropy in Wu et al.'s [2016] study).

Second, the disassociation between the MFT-M and Flank task in the two incongruent conditions (ratio 4:1 and 3:2) was not discussed in the present study, because it is hard to prove that task differences in these two ratios are caused solely by the type of conflict. Ratio 3:2 might provide different conflict intensity between the MFT-M and the Flanker task, and it did provide more conflicting information compared to ratio 4:1 within the MFT-M. However, the RT of the Flanker task in the ratio 3:2 condition was shorter than in ratio 4:1, suggesting that the inconsistency of the flankers would reduce the interfering conflict.

Third, task performance (RT and accuracy) did not differ between Task 1 and Task 2 (random location vs. fixed location) in our sample, indicating that processing the uncertainty of the arrow location might not affect the processing of competing conflict. To improve the efficiency of similar tasks addressing competing conflict (e.g., the MFT-M), fixed arrow locations might be acceptable. However, it remains to be seen whether placing the arrows in different shapes affects task performance.

## **Conclusion**

Compared to interfering conflict, competing conflict might be a more basic form involved in the cognitive control process. The two conflicts showed consistency and specificity in several respects, namely reaction time, effects related to cognitive control (conflict adaption and ERS), inter-stimuli distance, and uncertainty of the location. The results deepen our understanding of cognitive control and decision-making and have implications for research in other fields.

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**Table 1**

Means (and SD in parentheses) for response accuracy (%) and RT (ms) in tasks (N = 30).

		Task1(Random)			Task2(Far)		
		5:0	4:1	3:2	5:0	4:1	3:2
<b>ACC(%)</b>	Ratio ET(ms) \						
	<b>250</b>	98.0(3.6)	78.7(10.4)	56.8(11.9)	96.7(5.1)	81.3(10.8)	63.3(11.1)
	<b>500</b>	97.7(3.7)	84.8(8.6)	60.8(11.1)	98.3(3.3)	84.2(11.5)	62.2(9.3)
	<b>1000</b>	97.5(4.3)	87.0(8.9)	61.0(13.9)	98.5(3.0)	87.2(9.2)	63.5(13.5)
<b>RT(ms)</b>	<b>250</b>	493.0(36.2)	596.5(104.2)	633.3(119.3)	497.2(51.4)	581.1(108.2)	631.3(110.9)
	<b>500</b>	502.5(36.5)	630.4(85.6)	698.0(110.7)	503.4(33.0)	624.5(114.5)	702.2(93.5)
	<b>1000</b>	498.0(43.1)	647.7(88.7)	725.7(138.6)	502.1(29.8)	643.3(91.6)	707.3(134.6)
		Task3(Close)			Task4(Flanker)		
		5:0	4:1	3:2	5:0	4:1	3:2
<b>ACC(%)</b>	<b>250</b>	98.5(2.3)	86.3(9.4)	65.7(12.2)	99.5(2.0)	94.3(7.4)	96.7(3.8)
	<b>500</b>	99.7(1.3)	89.5(10.4)	68.3(13.4)	99.3(1.7)	95.5(5.1)	98.3(2.7)
	<b>1000</b>	99.2(1.9)	92.5(9.4)	70.3(13.1)	98.5(2.7)	95.3(6.0)	96.2(4.5)
<b>RT(ms)</b>	<b>250</b>	485.2(23.3)	617.3(93.7)	696.3(121.6)	441.5(20.1)	491.8(74.0)	480.9(37.9)
	<b>500</b>	498.4(12.7)	641.3(103.7)	767.6(134.1)	441.1(17.3)	493.6(51.4)	482.1(27.3)
	<b>1000</b>	512.6(19.0)	663.1(94.5)	782.6(131.3)	455.3(26.7)	497.4(60.1)	485.8(44.9)

Note. The Ratio refers to the ratio between the major and minor arrows, and *ET* is the exposure time of the stimuli.

**Table 2***Results of the Repeated Measures ANOVAs.*

	$(df_{\text{between}}, df_{\text{within}})$	Accuracy			RT		
		<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$
Task	(87,3)	160.901	< .001	.167	27.118	< .001	.225
<i>ET</i>	(58,2)	12.866	< .001	.005	28.895	< .001	.017
Ratio	(58,2)	645.874	< .001	.456	189.777	< .001	.287
Task × <i>ET</i>	(174,6)	1.75	.112	.002	5.287	< .001	.004
Task × Ratio	(174,6)	92.47	< .001	.142	54.496	< .001	.064
<i>ET</i> × Ratio	(116,4)	4.126	.004	.003	14.027	< .001	.006
Task × <i>ET</i> × Ratio	(348,12)	0.714	.738	.002	3.692	< .001	.003

Note. The Ratio refers to the ratio between the major and minor arrows, and *ET* is the exposure time of the stimuli.

**Table 3**

*Paired samples t-tests for average RT in incongruent trials following a congruent trial (CI), and average RT in incongruent trials following an incongruent trial (II).*

RT	<i>t</i>	<i>df</i>	<i>p</i>	Cohen's <i>d</i>	<i>BF</i> <sub>10</sub>
Task 1	-3.419	29	< .001	-0.624	>30
Task 2	-5.973	29	< .001	-1.091	>30
Task 3	-2.657	29	0.006	-0.485	7.316
Task 4	1.676	29	0.948	0.306	0.08

Note. The alternative hypothesis specifies that CI is less than II.

**Table 4**

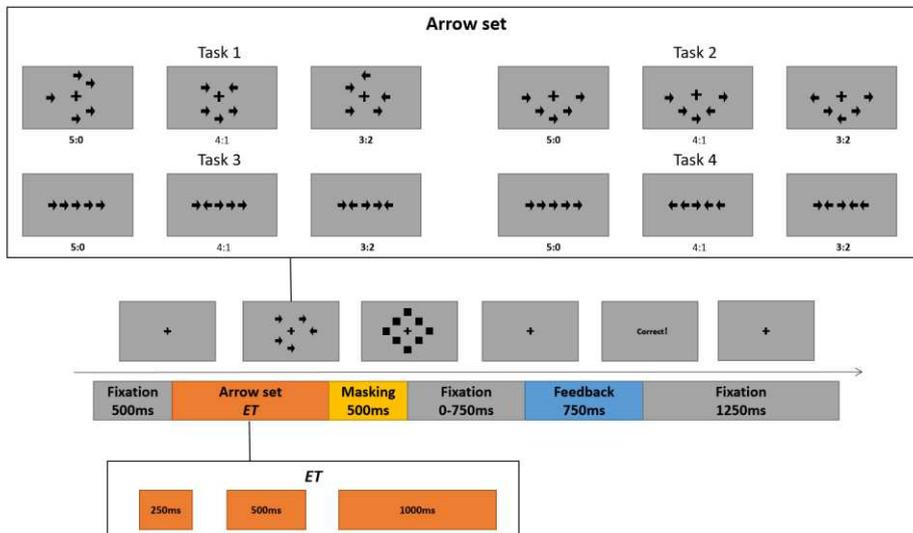
*Paired samples t-tests for average RT in trials following a previous error trial, and average RT in trials following a previous correct trial.*

RT	<i>t</i>	<i>df</i>	<i>p</i>	Cohen's <i>d</i>	<i>BF</i> <sub>10</sub>
Task 1	3.125	29	0.002	0.571	19.619
Task 2	3.807	29	< .001	0.695	>30
Task 3	3.215	29	0.002	0.587	23.899
Task 4	0.552	29	0.293	0.101	0.313

Note. The alternative hypothesis specifies that RT in trials following a previous error trial is greater than RT in trials following a previous correct trial.

**Figure 1**

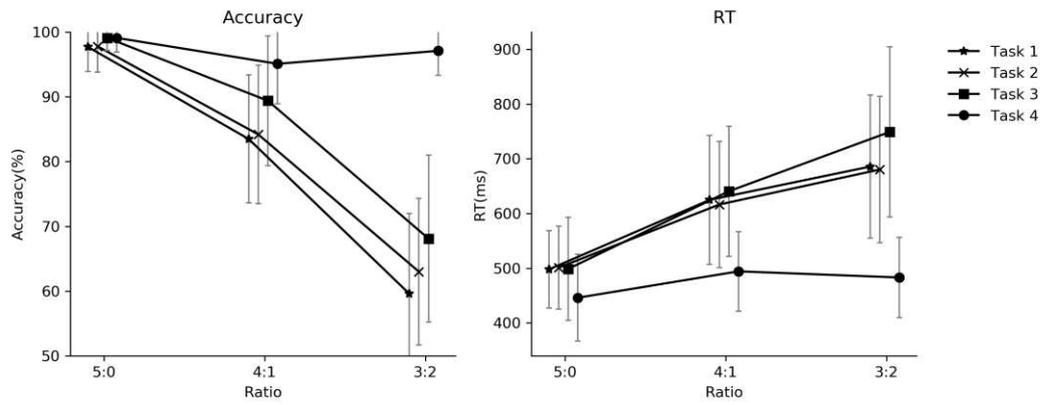
*The procedure of a single trial and stimuli in different tasks.*



*Note.* The sequence of a single trial in Task 1 (4:1 condition). Below the gray arrow is each period's name and time duration. Arrow ratios in all tasks and the time course are shown in the top and bottom square boxes respectively.

**Figure 2**

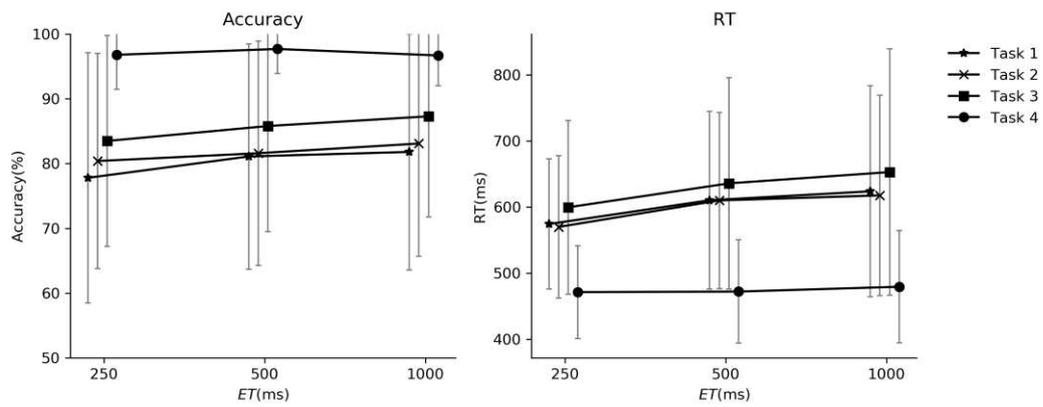
*Average accuracy and RT across all Ratios in four tasks.*



*Note.* Accuracy and RT were averaged across all ETs.

**Figure 3**

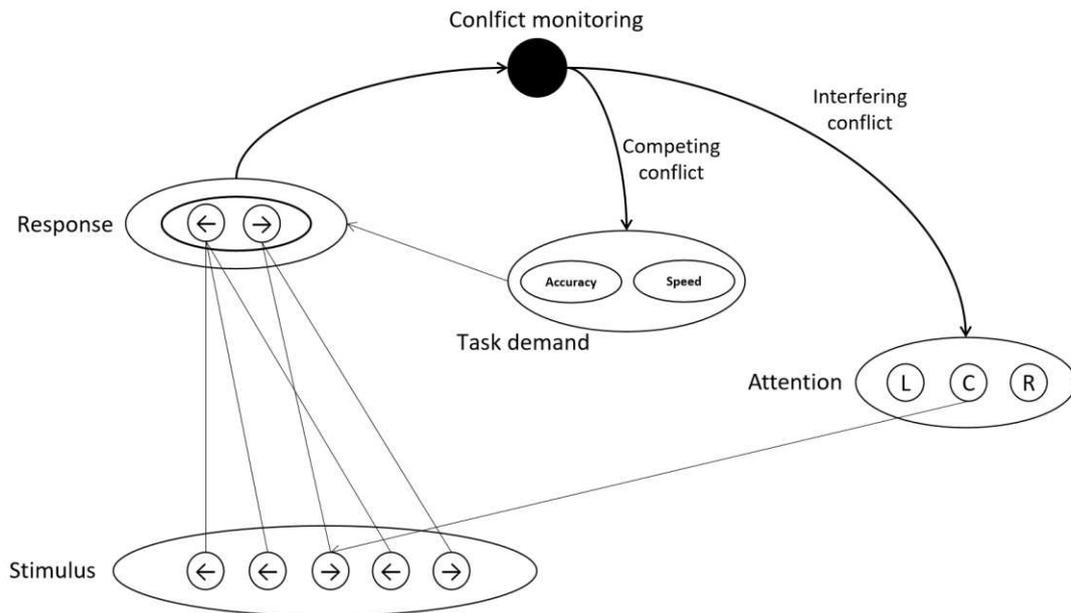
*Average accuracy and RT across all ETs in four tasks.*



*Note.* Accuracy and RT were averaged across all Ratios.

**Figure 4**

*The modified conflict monitoring model.*



*Note.* Left- (←) or right-pointing (→) arrows refer to the arrow stimulus in the tasks, L = left, C = center, R = right.

## Declarations

### Funding

This research was supported by National Natural Science Foundation of China (Grant number: 31671154).

### Conflicts of interest

The authors do not have any conflicts of interest to report.

### Availability of data and code

The source code of the program package and the data were uploaded to <https://gitlab.pavlovia.org/max730190/mixed-majority-function-task>.

### Author contribution

Xu He: Data collection, Formal analysis, Writing - original draft, Writing - review & editing.

Boyu Qiu: Methodology, Formal analysis, Writing - review & editing.

Yanrong Chen: Data collection, Writing - review & editing.

Ting Liu: Data collection, Writing - review & editing.

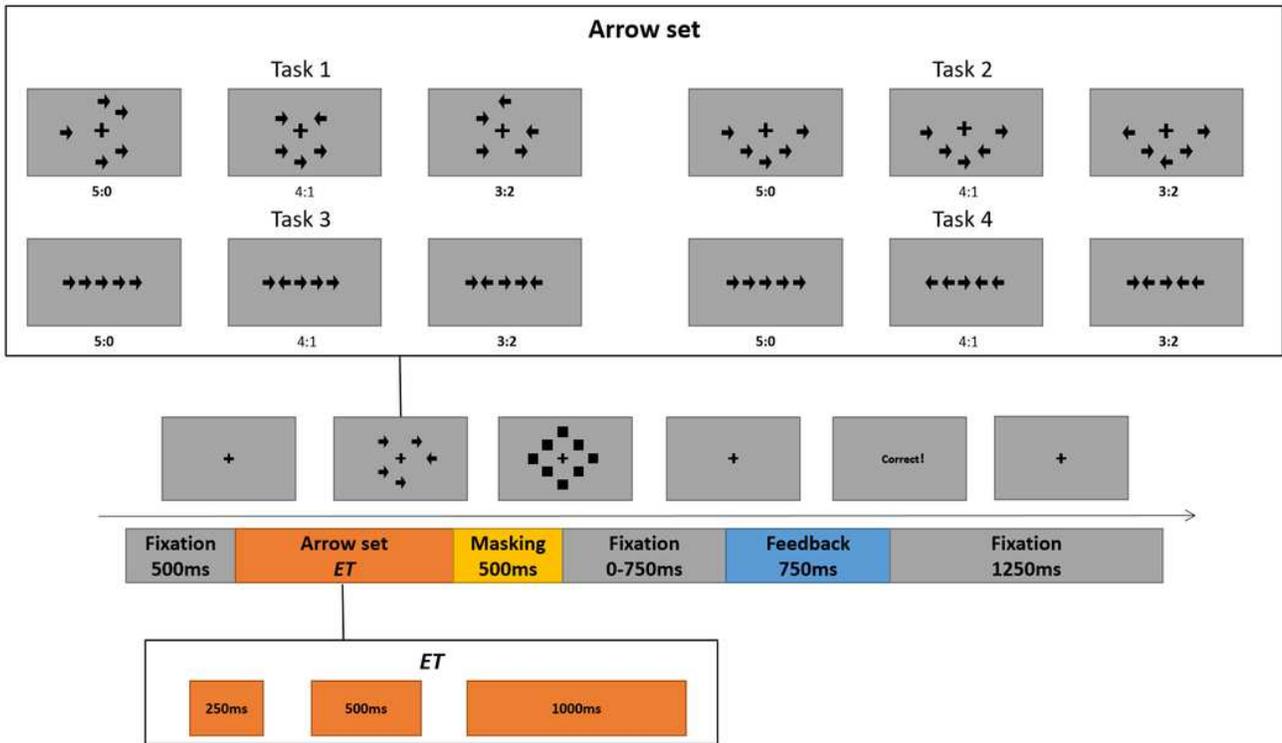
Sixian Wang: Data collection, Writing - review & editing.

Wei Zhang: Funding acquisition, Project administration, Supervision, Conceptualization,

### Ethics approval

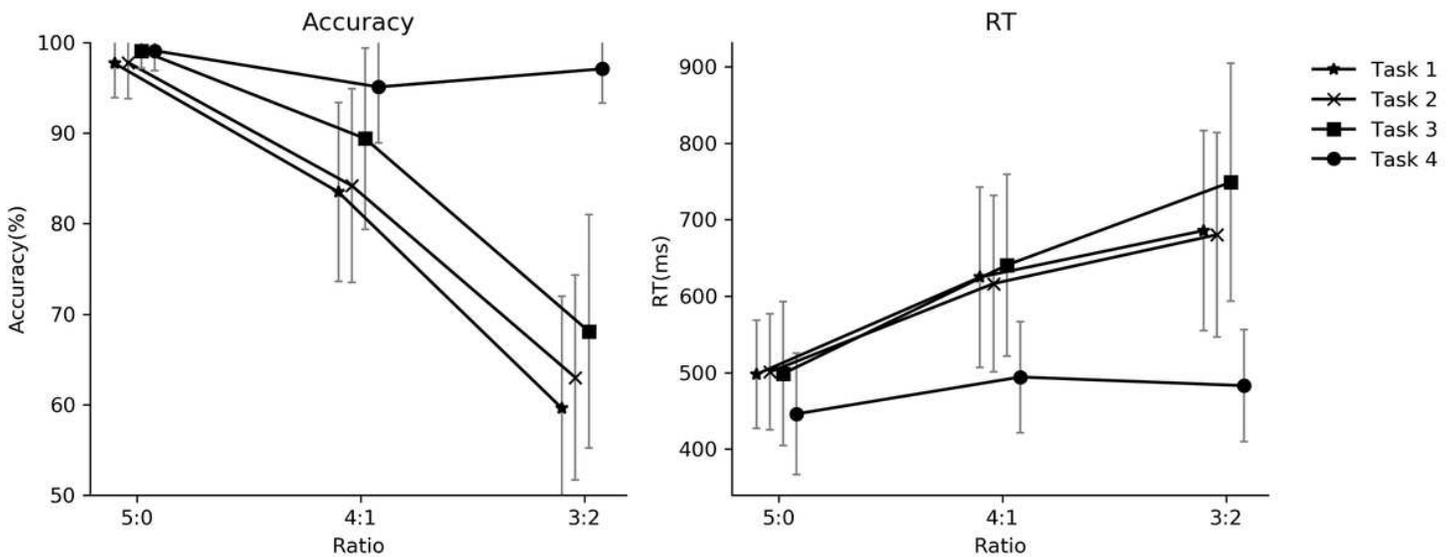
The materials and procedure of this study were approved by the Research Ethics Committee of South China Normal University. Written informed consent was obtained from each participant.

# Figures



**Figure 1**

The procedure of a single trial and stimuli in different tasks. Note. The sequence of a single trial in Task 1 (4:1 condition). Below the gray arrow is each period's name and time duration. Arrow ratios in all tasks and the time course are shown in the top and bottom square boxes respectively.



**Figure 2**

Average accuracy and RT across all Ratios in four tasks. Note. Accuracy and RT were averaged across all ETs.

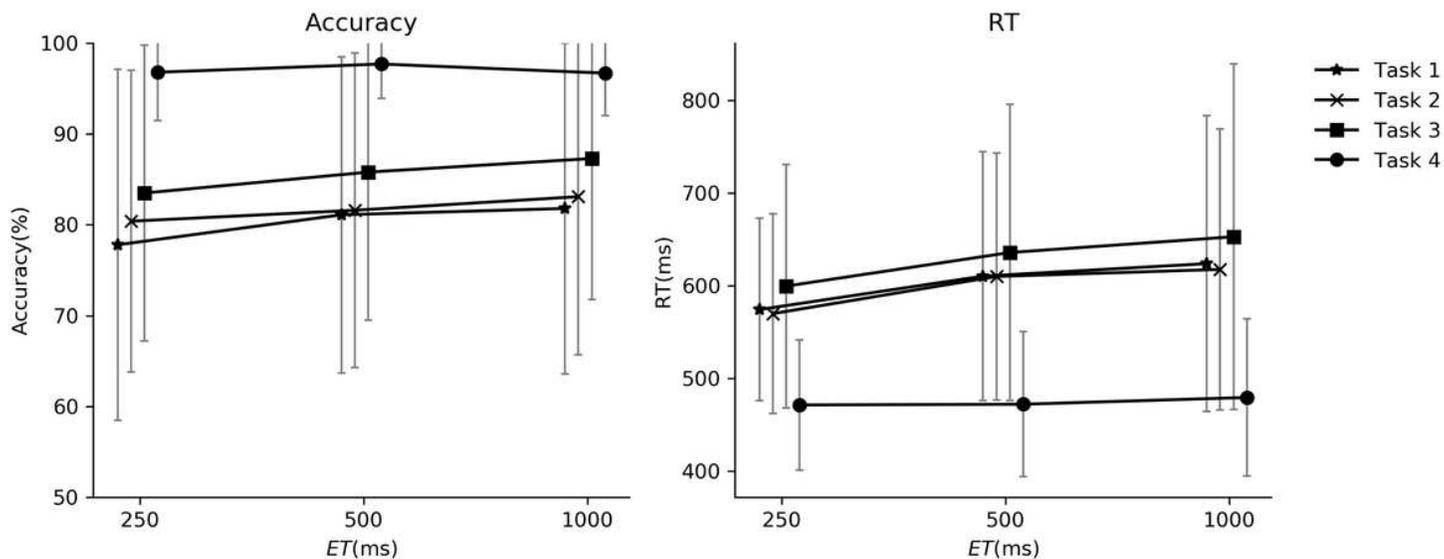


Figure 3

Average accuracy and RT across all ETs in four tasks. Note. Accuracy and RT were averaged across all Ratios.

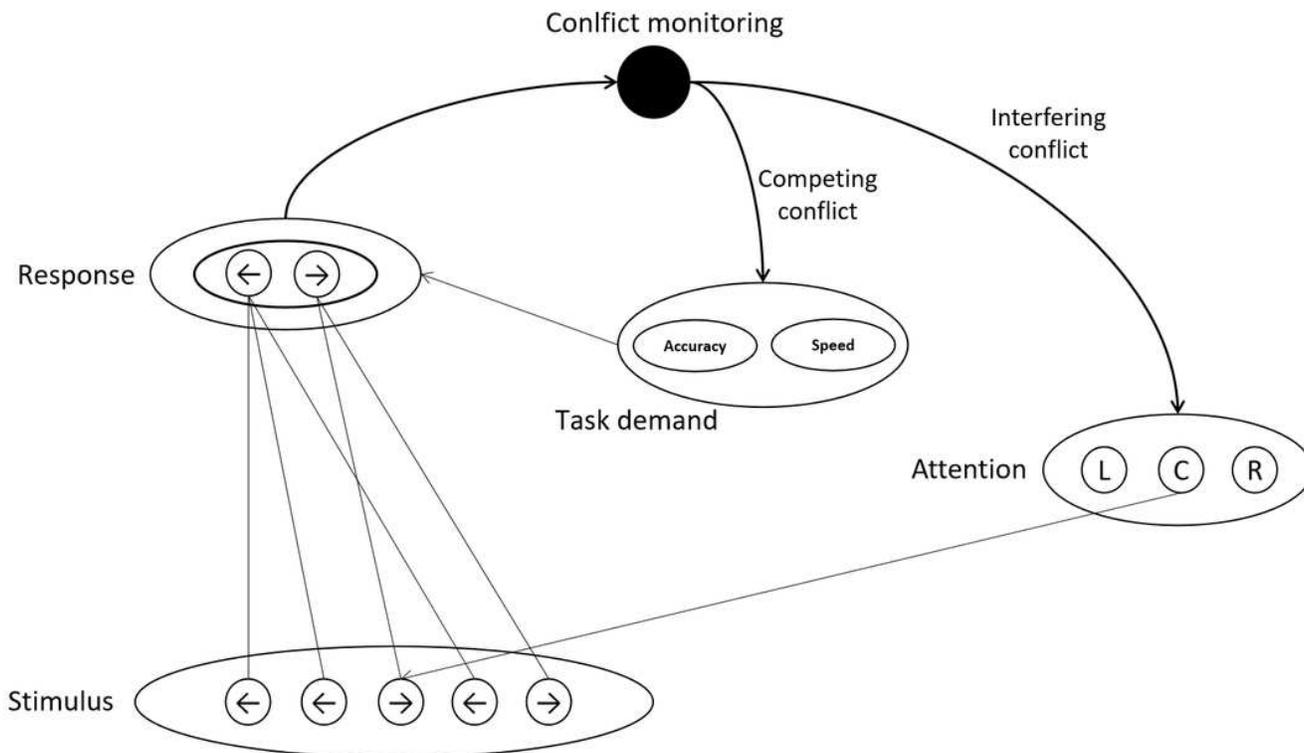


Figure 4

The modified conflict monitoring model. Note. Left- (↵) or right-pointing (↶) arrows refer to the arrow stimulus in the tasks, L = left, C = center, R = right.