Effects of reward on cognitive control when conflict is temporally unpredictable

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Introduction

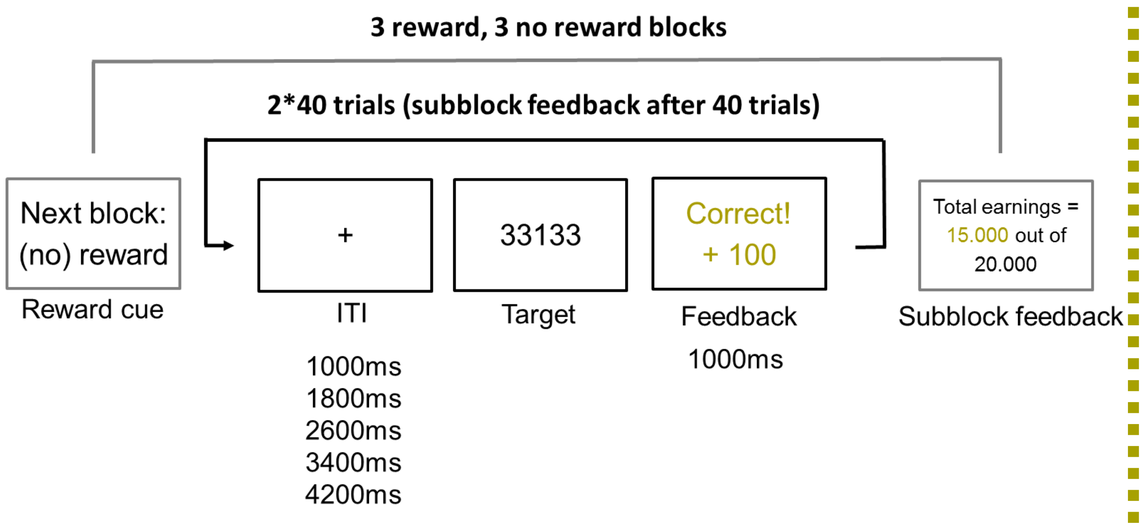
Cognitive control - the ability to flexibly adjust behavior to situational demands, for example when faced with conflict - is thought to be a combination of **transient**, on-the-fly control, and **sustained**, anticipatory control (Braver, 2012). When a potentially conflicting target **is temporally predictable** (i.e., intertrial intervals [ITIs] are fixed), there is no necessity to sustain control throughout the ITI. In this case, an alternative strategy could be to routinely activate transient control only when the target is expected. When the temporal predictability of the target is low, this strategy is no longer effective and control should be sustained throughout the ITI. However, it has been argued that this kind of cognitive control is **effortful** (Braver, 2012; Shenhav, Botvinick, & Cohen, 2013). It has also been shown that control can be boosted by **reward** (Botvinick & Braver, 2015). We therefore hypothesized that when intertrial intervals vary and no reward is offered, control is largest at the average ITI, reflecting a transient activation of control when the target is expected on average. However, increasing motivation by offering performance contingent rewards should lead to steady control on all ITIs, reflecting a sustained control mode.

Method

Task: number flanker task (*N* = 15)
Stimulus:
- Congruent (C; e.g., 22222)
- Incongruent (I; e.g. 22422)

Reward:
- Reward
- No reward

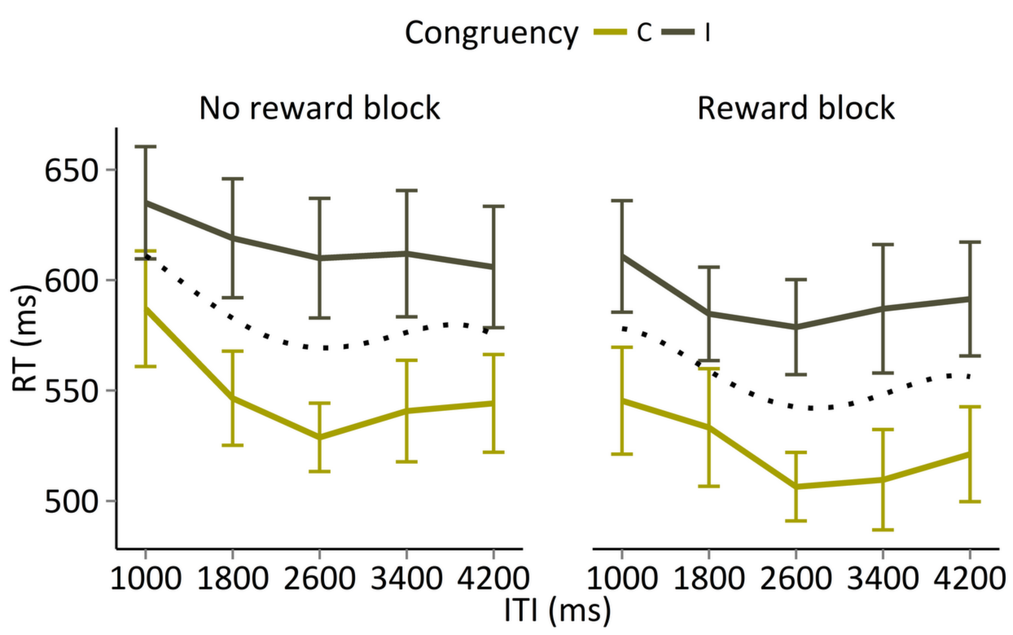
ITI: 1000/1800/2600/3400/4200 ms



The **reward threshold** was set - separately for C and I trials - at the RT corresponding to the 80th percentile of the RTs of the previously performed reward subblock of 40 trials. Only correct trials were rewarded.

A maximum of 24.000 points could be earned, which could be exchanged for € 10,80 after the experiment. In reality, all subjects scored less than 20.000 points (€ 9,00) and received € 10,00.

Results



Repeated measures ANOVA

Congruency:	***F*(1.0, 14.0) = 92,78, *p* <.001 *****
ITI:	***F*(3.0, 41,8) = 10,35, *p* <.001 *****
Reward:	***F*(1.0, 14.0) = 13.79, *p* = .002 ****
Congruency x ITI	*F*(2.6, 35.7) = 1.34, *p* = .28
Congruency x Reward	*F*(1.0, 14.0) = 0.00, *p* = .95
ITI x Reward	*F*(2.4, 34.0) = 0.70, *p* = .53
Congruency x ITI x Reward	*F*(2.8, 39.7) = 1.14, *p* = .34

The effect of ITI was characterized by a quartic trend (▪ ▪ ▪), *t*(56) = -5,14, *p* < .001***.

On error rates, only a main effect of Congruency was observed, *F*(1, 14) = 16,67, *p* = .001.

Discussion

These preliminary results show that, although reward improved subjects' general performance, it did not interact with ITI or congruency. Performance was also affected by ITI: the observed quartic trend showed that performance was best at the average ITI, i.e., when the average predictability of the target is largest. **These results suggest that sustained control was applied steadily over all ITIs, both in rewarded and unrewarded blocks.** However, since reward had no effect on control, this conclusion remains speculative. In fact, the reward schedule with **separate dynamical thresholds** for congruent and incongruent trials in combination with the **equal proportion of both trial types** may have left no room for specific adjustments in control (i.e., increased effort on incongruent trials) in the reward blocks. Instead, this may have "forced" subjects to become increasingly faster on both trial types.

Botvinick, M. M., & Braver, T. S. (2015). *Annual Review of Psychology*, *66*, 83–113.
Braver, T. S. (2012). *Trends in Cognitive Sciences*, *16*(2), 106–13.
Shenhav, A., Botvinick, M. M., & Cohen, J. D. (2013). *Neuron*, *79*(2), 217–240.

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