Conscious of conflict, but not of the eliciting stimulus: Implications for the neuroscience of cognitive control

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1. Introduction

Can people be aware of conflicting urges without being aware of the stimulus that elicited the urges?

We examined participants' urges to err (an index of cognitive conflict) as they responded to subliminal stimuli that elicited conflicting action plans.

- Recent developments in neuroscience suggest that one can be aware of urges and other metacognitions while being unaware of the stimuli provoking these states[2].

- Participants can accurately introspect and provide systematic reports of their subjective experience during certain types of conflict, such as response interference[6].

- The standard metric of the Stroop effect, response time, is not affected by subliminal Stroop stimuli[8] (see Fig. 1, 3).

- For the first time we demonstrate that one can experience conscious conflict from subliminal stimuli.

- This was followed by two studies with supraliminal variations on the Stroop task to further probe aspects of cognitive control.

- In study 2, we investigated whether urges conflicting with the current goal are perceived as more foreign to the self and how this affects one's sense of agency.

- In study 3, we examined whether increasing the number of action plans associated with a stimulus lowers the strength of the urge evoked by that stimulus - a 'fan effect' of sorts.

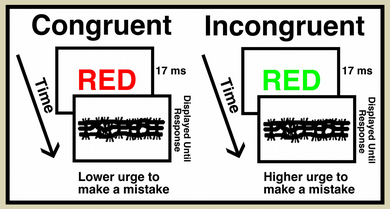


Figure 1: Sample sequence of events in congruent and incongruent subliminal Stroop trials

2. References

1 Baker, T. B., Japuntich, S. J., Hogle, J. M., McCarthy, D. E., & Curtin, J. J.(2006) Pharmacologic and behavioral withdrawal from addictive drugs. *Current Directions in Psychological Science.* 15, 5, 232-236.
2 Bargh, J. A., & Morsella, E. (2008). The unconscious mind. *Perspectives on Psychological Science,* 3, 73-79.
3 Botvinick, M. M. (2007). Conflict monitoring and decision making: Reconciling two perspectives on anterior cingulated function. *Cognitive, Affective, & Behavioural Neuroscience,* 7(4), 356-366.
4 Ilan, A., Polich, J. (1999). P300 and response time from a manual Stroop task. *Clinical Neurophysiology,* 110 (1999) 367-373.
5 MacLeod, C.M., & Dunbar, K. (1988). Training and Stroop-like interference: Evidencefor a continuum of automaticity. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 14, 126-135.
6 Morsella, E. (2005). The function of phenomenal states: Supramodular interaction theory. *Psychological Review,* 112, 1000-1021.
7 Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology,* 18, 643-662.
8 Tzelgov, J., Porat, Z., Henik, A., (1997). Automaticity and consciousness: Is perceiving the word necessary for reading it? *American Journal of Psychology,* 110(3), 429-448.

3. Method – Study 1

A subliminal Stroop task was adapted from Tzelgov et al. (1997) wherein the colored words were displayed on a computer screen for 17 ms, followed by a visual mask which persisted until the participant named the color of the word verbally into a microphone (see Fig. 1). Response time was collected by the computer. Following each trial, participants (n = 33) were asked "How strong was the urge to make a mistake at naming the color of the letter string?" which they rated on a scale from 1 - 8.

In the standard Stroop task[7], participants are instructed to name the color in which letter strings are presented. Response times and error rates increase when the color and the word are incongruent (e.g., RED presented in the color green), as compared to congruent (e.g., RED presented in the color red) (see Fig. 1).

4. Results – Study 1

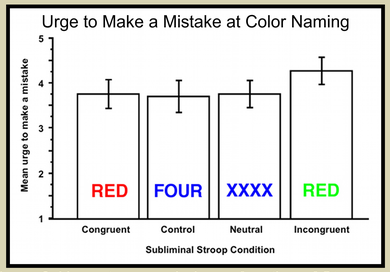


Figure 2: Urges to err varied as a function of Stroop condition, F (3, 96) = 3.538, p = .0176, with incongruent higher than all other conditions, ps < .05

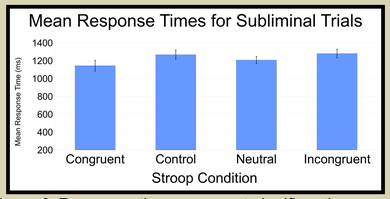


Figure 3: Response times were not significantly different in the four conditions, ps > .05

Awareness of Different Aspects of Stimuli

	Stroop Condition			
	Congruent	Control	Neutral	Incongruent
Aware of color and letter string	.37 (.05)	.25 (.04)	.09 (.02)	.39 (.04)
Aware only of color	.74 (.04)	.63 (.05)	.61 (.05)	.71 (.04)
Aware only of letter string	.39 (.04)	.30 (.04)	.12 (.03)	.43 (.04)
Unaware of color or letter string	.63 (.05)	.75 (.04)	.91 (.02)	.61 (.04)

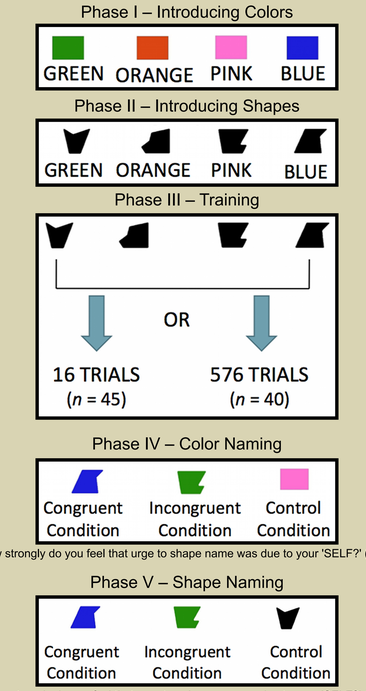
In a by-subject analysis, mean proportion of trials as a function of Stroop condition and awareness of different aspects of the stimuli. SEMs in parentheses

Figure 4: By-subject analysis of awareness of stimuli by Stroop condition

5. Method – Study 2

Do urges that conflict with current goals seem more foreign to the self than harmonious urges?

We used a non-orthographic variation of the Stroop Task[5] to test this hypothesis (n = 85)



6. Results – Study 2

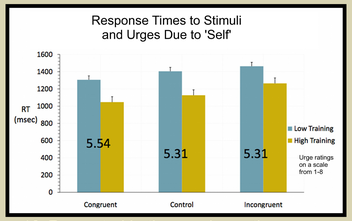


Figure 10: Presented in the graph are the mean response times for each Stroop-like condition. Figures within the bar graph represent mean responses to the question, "How strongly do you feel the urge to name the color was due to your 'self'?" for each Stroop-like condition.

Perception of urge to color-name was less due to self during incongruent than congruent condition, F (2, 166) = 3.843, p < .05

7. Method – Study 3

Our hypothesis is that merely increasing the number of automatized action plans associated with a stimulus will weaken the urge to perform any one of those actions.

SFSU undergraduate participants (n = 100) were randomly assigned to one of two conditions containing the same stimuli (uncolored words displayed on a computer screen) but different actions to perform:

1. Letter counting training - participants counted letters in the displayed words (See Fig. 11) and responded verbally. (800 trials)

RED = 'three'

Figure 11: Sample training stimulus

2. Word reading training - participants read the displayed words aloud. (800 trials)

Next all participants performed 32 trials of a Stroop task, using colored versions of the words previously practiced with. Verbal response time was collected by Psyscope X software. Following each trial participants were asked to rate their urge to make a mistake during their response on a scale from 1 - 8, typed on the keyboard.

The word reading condition served as a control because word reading is already an automatic response to Stroop stimuli. The letter counting condition introduced an additional potential response to the Stroop stimuli, for a total of three action plans: (1) color naming (the requested response) and two automatic interfering responses: (2) word reading and (3) letter counting. We examined how the additional stimulus-evoked response affected the urge to err at color naming.

8. Results – Study 3

Evidence was found that a short period of training (< 1 hour) was sufficient to automatize an alternative action plan (letter counting) which attenuated the existing automatic urge (reading).

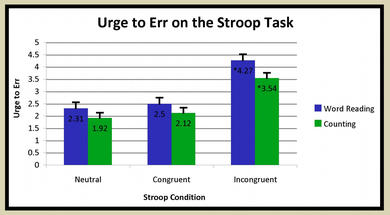


Figure 12: Urges to err were significantly, t(88) = 2.264, p = .026, less for the letter counting condition than the word reading condition for incongruent stimuli

9. General Discussion

We found evidence that participants can be aware of urges elicited by a stimulus without being aware of that stimulus. They also tend to experience internal "interfering" urges as less associated with the self than urges concordant with conscious goals. Furthermore urges can be attenuated by introducing an additional automatized response to a conflict inducing stimulus, in effect, fanning out that urge.

In study 1, the Stroop response-time effect fails to occur for masked stimuli (replicating Tzelgov et al., 1997); however, participants were still able to report conflict-related urges as a function of the Stroop condition, though the stimuli were subliminal. Stronger urges to err were reported for incongruent stimuli than for any other kind of stimuli (congruent, neutral, and control). This means that one can indeed be aware of cognitive conflict without being aware of the eliciting stimulus. These findings are also consistent with the *Supramodular interaction theory*[6], which proposes that the activation of incompatible action plans must trigger strong changes in consciousness, even if the eliciting stimuli are unconscious.

In study 2, the conflicting urge to color-name was perceived as less due to the self during the incongruent than the congruent condition during shape naming. This finding contributes to our understanding of self control and agency in behavior.

Study 3 demonstrates that conflicting urges were lower for participants that were trained to perform an alternative response to the eliciting incongruent stimuli. This finding informs us of potential interventions for helping modify unwanted behaviors triggered by unconscious urges such as in addiction.

10. Implications

Response interference is a part of every day human experience and can arise from any number of factors—internal or external. For example, when a smoker who is in the process of quitting has a craving triggered by something in their environment (e.g., an ashtray), they can then experience cognitive conflict[1] based on competing inclinations: “I want to smoke” versus “I don’t want to smoke–I’m trying to quit."

Often, they may remain unaware of the eliciting stimulus (e.g., the ash tray). These feelings of subjective conflict can interfere with achieving the intended goal, but might be weakened by increasing the number of action plans associated with the given stimulus (such as drinking a glass of water and playing with a ring in response to a smoking-related stimulus).

Also, in these conflictive states the unintended goal may be seen as more foreign to the self, reducing one's perceived control over modifying it. While addiction is an extreme example of cognitive conflict, there are other situations that can elicit the same kind of conflict, such as dieting and during the innocuous Stroop color naming task.