Frequent change can be good for you: ERP evidence that task switch probability affects cognitive control

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Introduction

The cost of switching between two tasks is reduced by providing a cue warning of an impending switch. Cognitive control accounts of this effect claim that an informative cue allows for task-set reconfiguration prior to the actual switch (1). Nevertheless, the fact that switch costs remain even after a long preparatory interval suggests that different task sets can interfere with each other (2). However, such proactive interference might only be a problem when successive task sets must be reactivated. If switching is frequent, then keeping both task-sets active is a good strategy, assuming that little cost accrues from doing so. We examined how switch probability, switch predictability, and informative-cue availability interact to change the ease with which participants can maintain and access different task sets.

Methods

Participants: Fifteen young adults (19 to 30 years; M = 24.6; SD = 3.8).

Design: Digit (not 5) required response; more/less than 5? or odd/even? pure blocks: one task; mixed blocks: two tasks.

Factors:

(1) Ratio of switch (S) to stay or repeat (R) trials equiprobable; switch after 0, 1, or 2 trials: a-b-a-a; rare switch 1:3; switch after 2, 3, or 4 trials: aaa-b-bbb-bb-b-bbb-a-a-a
(2) Cue-status: informative, uninformative (Fig. 1b);
(3) Predictability Status: predictable, unpredictable

Mixing costs = pre-switch RTs in mixed blocks - RTs in pure blocks
Switch costs = switch RTs - pre-switch RTs mixed blocks

EEG recording:

d2 sintered Ag/AgCl electrodes; referred to averaged mastoids; continuous DC-100Hz; 500 Hz sampling rate; Fig. 1a: ERP epochs.

Baseline for cue-related ERPs

Target onset

Cue onset

More/less than 5?

Odd/even?

Informational cues preceding equiprobable, unpredictable switches elicited a parietal, P3-like effect relative to pre-switch trials. (a) This effect was absent for informative cues on equiprobable, predictable switch trials.

Fig. 4: (b) Informative cues preceding equiprobable, unpredictable rare switches elicited much larger amplitude P3s than those present in the equiprobable condition (cf. Fig 4).

Results

Participants seem to utilize predictive information to actively maintain both task sets when doing so aids performance. Decreased mixing and switch costs for predictable, equiprobable stimuli, the decrease of cue-related P3 amplitude from rare to equiprobable switches, and the absence of any P3 to informative cues for equiprobable, predictable switches all suggest that cue information is increasingly irrelevant to performing the task as switches become more probable and predictable. Although response conflict was highest after uninformative cues, smaller target P3s for predictable vs. unpredictable equiprobable switches were observed, suggesting that predictability allowed processing resources to be conserved. Participants may also have created a more global behavioral set encompassing both tasks (3). Switch costs in the equiprobable condition might be best described as relatively “pure” costs of switching between active task sets rather than as proactive interference.

Fig. 2: Informative cues reduced mixing costs. Mixing costs decreased dramatically after uninformative cues in the equiprobable condition, but only when task order was predictable.

Fig. 3: Informative cues reduced switch costs. In addition, when switches were equiprobable switch costs after uninformative cues were significantly reduced.

Fig. 4: (b) Informative cues preceding equiprobable, unpredictable switches elicited a parietal, P3-like effect relative to pre-switch trials. (a) This effect was absent for informative cues on equiprobable, predictable switch trials.

Discussion

Participants seem to utilize predictive information to actively maintain both task sets when doing so aids performance. Decreased mixing and switch costs for predictable, equiprobable stimuli, the decrease of cue-related P3 amplitude from rare to equiprobable switches, and the absence of any P3 to informative cues for equiprobable, predictable switches all suggest that cue information is increasingly irrelevant to performing the task as switches become more probable and predictable. Although response conflict was highest after uninformative cues, smaller target P3s for predictable vs. unpredictable equiprobable switches were observed, suggesting that predictability allowed processing resources to be conserved. Participants may also have created a more global behavioral set encompassing both tasks (3). Switch costs in the equiprobable condition might be best described as relatively “pure” costs of switching between active task sets rather than as proactive interference.