Reconfiguration or inertia? Identifying a possible origin of switch costs during visual short-term memory resource allocation

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Introduction

Overview

In previous work, we embedded a change detection paradigm within a task switching paradigm in an initial investigation into how visual short-term memory resources (see Bays et al., 2009; Zhang & Luck, 2008) are allocated to visual information. We found that when there was a requirement to switch between feature dimensions (colour and orientation), performance was detrimentally impacted, a phenomenon well replicated in the task switching literature referred to as a *switch cost*.

Here, we attempt to differentiate between two prominent accounts of switch costs, task set inertia and task set reconfiguration. On the task set inertia account, it is believed that switch costs arise as a result of interference from the previously relevant task set (Allport et al., 1994). In contrast, the task set reconfiguration account suggests that switch costs arise as a result of a failure to activate the currently relevant task set in time to perform the task (Rogers & Monsell, 1995).

The present study

In the present study, we employ the change detection switching paradigm used in our previous work across two experiments. In each experiment, we independently manipulate the response-cue interval (RCI) and cue-stimulus intervals (CSI), using either a long (900ms) or short (100ms) duration. Manipulation of the RCI and CSI is believed to manipulate the impact of task set inertia and task set reconfiguration respectively.

Interval manipulation

- By varying the duration between response on trial *N - 1* and cue presentation on trial *N*, we can manipulate the impact of task set inertia.
- By varying the duration between cue presentation and stimulus presentation on trial *N*, we can manipulate the impact of task set reconfiguration.

Method

Participants

60 participants completed each experiment. Participants were recruited via a combination of the SONA System at Keele University and Prolific (prolific.co). All participants were aged between 18-60 years of age (inclusive), and self-reported normal or corrected to normal visual acuity and normal colour vision. Participants were awarded a small honorarium for taking part. Ethical approval was obtained from the School of Psychology Ethics Committee at Keele University.

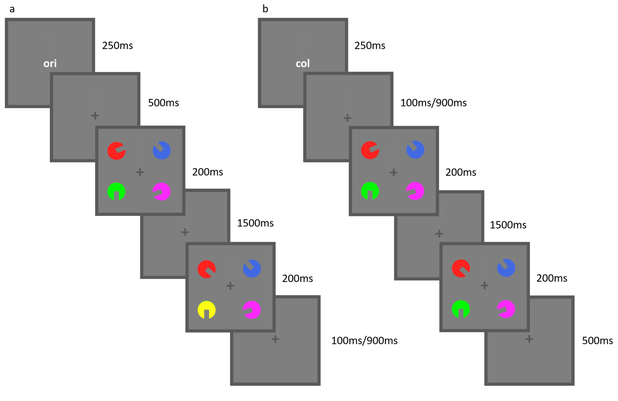

Figure 1:Figure showing trial procedures for a) a change trial in the RCI experiment (note the relevant orientation *and* irrelevant colour change and b) a no change trial in the CSI experiment (note only the irrelevant orientation change). Responses were provided after offset of test stimuli and were not time-limited. RCI began once a response was provided.

Task

Each experiment consisted of a change detection task embedded wherein participants made change/no change judgements to bivalent stimuli (coloured and oriented). Participants were cued at the beginning of each trial as to which feature dimension was relevant. Responses were provided through pressing either the "Z" key to indicate no change, or the "M" key to indicate a change. Accuracy and RTs were recorded on each trial. Both experiments were created and run using Gorilla Experiment Builder (gorilla.sc; Anwyl-Irvine et al., 2019).

Cues and changes

- If orientation was relevant on a trial, the word "ori" was presented.
- If colour was relevant on a trial, the word "col" was presented.
- A constant change in the irrelevant feature dimension was employed in both experiments.

Critically, each experiment manipulated trial timings, with either a short or long RCI or CSI. On short RCI and CSI trials, the duration was set to 100ms, while on long RCI and CSI trials, the duration was set to 900ms. In the RCI experiment, the CSI was held constant at 500ms on all trials, while in the CSI experiment, the RCI was held constant at 500ms on all trials. Each experiment consisted of eight blocks of 50 trials.

Stimuli

Stimuli on each trial within both experiments consisted of four coloured, oriented circular shapes. The orientations of each of the stimuli were at least 40° apart, with a changed orientation also being a minimum of 40° apart from the memory display stimuli.

Colours

- The RGB (red, green, blue) coordinates for the colours used in this experiment were black (0, 11, 16), blue (65, 105, 225), cyan (20, 253, 255), green (0, 250, 3), purple (255, 41, 255), red (255, 34, 31), and yellow (253, 254, 21).

Stopping rule

A Bayesian stopping rule was employed in each experiment, with a minimum sample size of 20, and a maximum of 60. Once the minimum sample size was reached, a Bayesian paired-samples t-test was conducted, comparing accuracy between mixed repetition and mixed switch trials (i.e., overall switch cost). The critical level of evidence was either a $BF_{10} \geqslant 10$ or a $BF_{10} \leqslant \frac{1}{10}$. As this level of evidence was not achieved, data collection continued, with the same test performed every five participants.

On one instance, a BF_{10} above 10 was achieved in the RCI experiment. This then required a second test to be performed, a further Bayesian paired-samples t-test, comparing the switch cost values (i.e., mixed switch minus mixed repetition) for accuracy between long and short trials. The critical level of evidence for this test was again a a $BF_{10} \geqslant 10$ or a $BF_{10} \leqslant \frac{1}{10}$. As this was not achieved, data collection continued as indicated above until the maximum sample size was obtained in each experiment.

Analysis

Bayesian statistical analysis was used in each experiment. As stated, accuracy and RTs were recorded on each trial, however the sensitivity measure *d'* and the response bias measure *criterion* were also calculated (however only accuracy is reported here). Analysis followed the same pattern as that of the stopping rule, with an initial Bayesian paired-samples t-test comparing accuracy performance between mixed repetition and mixed switch (i.e., the overall switch cost). Following this, a further Bayesian paired-samples t-test was conducted on the switch cost values for long and short trials in each experiment.

Data preparation

- The first trial in each block was removed as this is neither a repetition or switch trial.
- RTs < 150ms and 2.5 standard deviations above the mean were trimmed per participant, per sequencing condition.
- The rial immediately following an error was removed prior to accuracy analysis. As the nature of an error cannot be determined, this has the potential to disrupt sequencing.
- Error trials and trials immediately following an error were removed prior to RT analysis.

Results

Table 1:Table showing means, standard deviations, and Bayes Factors for Bayesian t-tests conducted between mixed repetition and mixed switch trials, and between switch costs for short and long trials.

RCI	Mean	SD	BF_{10}
Repetition x Switch	0.743 x 0.719	0.093 x 0.093	8.705
Short x Long	-0.028 x -0.014	0.066 x 0.080	0.241
CSI	**Mean**	**SD**	**BF_{10}**
Repetition x Switch	0.750 x 0.731	0.086 x 0.074	1.748
Short x Long	-0.018 x -0.017	0.067 x 0.080	0.167

Accuracy

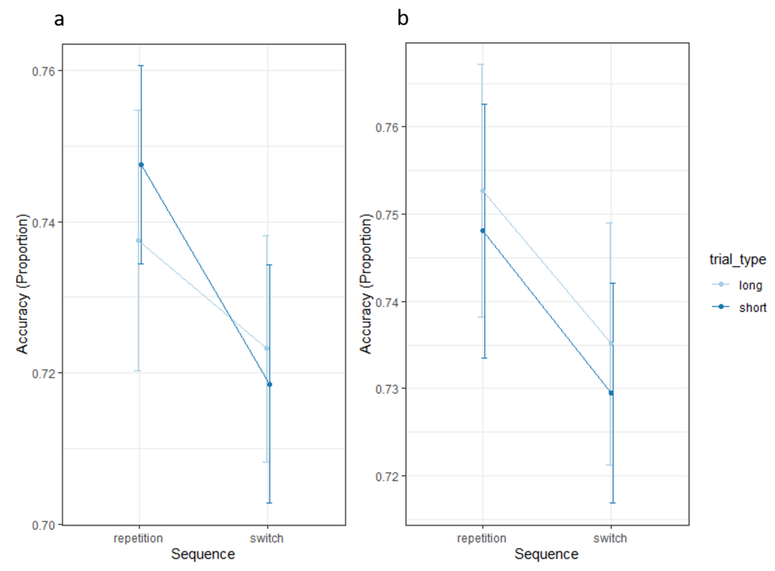

Figure 2:Plot displaying accuracy (proportion) for a) RCI and b) CSI manipulations across sequencing condition and manipulation duration. Note the differing y-axis values. Error bars represent the standard error of the mean.

Discussion

Our results show that manipulating either the RCI or CSI did not have any effect, suggesting that both task set inertia and task set reconfiguration are unable to account for the observed switch costs. It may be beneficial for further research attempting to identify the origin of these switch costs to consider the interplay of inertia and reconfiguration. Several models exist wherein a task switch consists of various stages (e.g., Mayr & Kliegl, 2003). These models suggest that stimulus-response mappings set at an earlier stage are susceptible to the effects of inertia, meaning responses provided at a later stage are based upon a less effective stimulus-response mapping, thus resulting in switch costs.

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