Acta Psychologica 159 (2015) 52–60

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

Incorrect predictions reduce switch costs

Thomas Kleinsorge *, Juliane Scheil

Leibniz Research Centre for Working Environment and Human Factors, Germany

ARTICLE INFO

Article history:
Received 12 December 2014
Received in revised form 26 March 2015
Accepted 20 May 2015
Available online xxxx

Keywords:
Task switching
Cognitive control
Conflict adaptation

ABSTRACT

In three experiments, we combined two sources of conflict within a modified task-switching procedure. The first source of conflict was the one inherent in any task switching situation, namely the conflict between a task set activated by the recent performance of another task and the task set needed to perform the actually relevant task. The second source of conflict was induced by requiring participants to guess aspects of the upcoming task (Exps. 1 & 2: task identity; Exp. 3: position of task precue). In case of an incorrect guess, a conflict accrues between the representation of the guessed task and the actually relevant task. In Experiments 1 and 2, incorrect guesses led to an overall increase of reaction times and error rates, but they reduced task switch costs compared to conditions in which participants predicted the correct task. In Experiment 3, incorrect guesses resulted in faster performance overall and to a selective decrease of reaction times in task switch trials when the cue-target interval was long. We interpret these findings in terms of an enhanced level of controlled processing induced by a combination of two sources of conflict converging upon the same target of cognitive control.

1. Introduction

The ability to act flexibly in accordance with a permanently changing environment is one of the core requirements of human behavior needed every day. To cope with changing demands, cognitive control is needed. Cognitive control comes in many guises, and the last couple of years have seen a surge in interest in how different manifestations of cognitive control relate to each other.

One important distinction with respect to the study of cognitive control is between conditions affording the engagement of cognitive control like stimulus incongruence, changes in processing requirements, or errors, and manifestations of an engagement of cognitive control like sequential modulations of congruency effects, reductions of switch costs, or post-error adaptations. Unfortunately, this distinction often becomes blurred when studying sequential adaptations in order to elucidate dynamic adjustments of cognitive control. One example is the study of congruency sequence effects (CSEs) that has garnered a lot of empirical effort in recent years (for reviews, cf. Duthoo, Abrahamse, Braem, Boehler, & Notebaert, 2014; Egner, 2014). The signature of CSEs is a modulation of a congruency effect that depends on the congruency of the preceding trial, with the congruency effect being reduced after incongruent as compared to congruent trials. One dominant account of such effects in terms of the conflict-monitoring theory (cf. Botvinick, Braver, Barch, Carter, & Cohen, 2001) posits that incongruency in a preceding trial triggers the engagement of cognitive control, resulting in a reduced congruency effect in the following trial. Accordingly, incongruent trials are both triggers for engaging cognitive control as well as targets for controlled processing.

Using basically the same task as the trigger as well as the target for the engagement of cognitive control has resulted in extended controversies regarding the (relative) contribution of bottom-up versus top-down factors in the dynamic regulation of cognitive control (cf. Egner, 2014). Trying to tease these factors apart by using different tasks as triggers and targets for control has resulted in an amazingly heterogeneous picture, with sometimes subtle differences between conditions determining whether adjustments of control occur or not. For example, Kim and Cho (2014) investigated the CSE across two different flanker-compatibility tasks that were presented alternately in a trial-by-trial manner. When participants responded in both tasks with four fingers of the same hand, a significant CSE accrued. However, when the two tasks engaged fingers of different hands, no CSE could be observed. Although the exact reasons for these divergent observations are not entirely clear up to now, it is likely that a crucial factor consists of the degree to which both tasks are represented in an overlapping manner within the same task-control structure (Kim & Cho, 2014).

In the present study, we attempted to vary the degree to which the engagement of control was triggered by manipulating two sources of conflict related to the same target of control, namely the identity of the task to be performed on the next trial. This was done by complementing a task-switching procedure with the requirement to explicitly guess aspects of the forthcoming task.

With respect to task switching, most theories assume that the main challenge of the cognitive system consists of the overcoming of cognitive settings and action tendencies (‘task sets’) that were induced by

---

* Corresponding author at: Leibniz Research Centre for Working Environment and Human Factors, Ardeystraße 67, D-44139 Dortmund, Germany.
E-mail address: kleinsorge@ifado.de (T. Kleinsorge).

http://dx.doi.org/10.1016/j.actpsy.2015.05.006
0001-6918/© 2015 Elsevier B.V. All rights reserved.

the recent performance of another task (for a review, cf. Vandierendonck, Liefooghe, & Verbruggen, 2010). Thus, when there is a requirement to perform another task a conflict arises between the action tendencies carried over from the preceding trial and the requirements stemming from the actual task. On the other hand, we assumed that explicitly guessing the next task is associated with enhancing the activation of the corresponding task set. If the task to be performed is different from the one that was explicitly indicated, this mismatch should induce another kind of conflict. We do not assume that the 'repetition bias' induced by the recent performance of a task and the biased expectancy induced by explicit guessing converge upon exactly the same level of task conflict in terms of the source of conflict; however, we hypothesize that both types of conflict are resolved by strengthening the actually relevant task representation, resulting in some kind of convergence in terms of the target of cognitive control. This, in turn, led us to predict that incorrect guesses would result in a reduction of switch costs because the conflict induced by an incorrect guess should increase the amount of cognitive control needed to resolve the conflict induced by the requirement to switch the task.

Preliminary evidence for the viability of this reasoning comes from a recent study by Duthoo, De Baene, Wühr, and Notebaert (2012). In this experiment, participants switched among two tasks and were required to predict the next task during the inter-trial interval. A main observation as reported by the authors consisted of a disappearance of switch costs when participants predicted a task alternation. However, because these authors analyzed their data in terms of the factor 'repetition predicted' versus 'switch predicted' (instead of correct versus incorrect prediction, as we did in the experiments reported below), the interaction in the focus of the present study went unnoticed by these authors. If the data reported by Duthoo et al. are analyzed in the way we analyzed our data, an interaction of task prediction and task transition emerges (W. Duthoo, personal communication, November 13, 2013): In terms of RTs, mean switch costs for correctly predicted trials amounted to 95 ms, whereas mean switch costs for incorrectly predicted trials amounted to only 61 ms. Even more pronounced was the effect on ERs. Mean error switch costs amounted to 2.3% for correctly predicted trials, whereas a switch benefit of 1.1% accrued for incorrectly predicted trials. Thus, these observations are in line with our assumption of a switch-cost reducing effect of incorrect task predictions.

In the experiments reported below, participants switched among four tasks. In the main phase of the first two experiments, participants were asked to make explicit predictions about the forthcoming task during the interval separating the performance of two trials. Given that the sequence of tasks was completely random and participants were informed about this, these task predictions were based on guessing. Predicting the wrong task was assumed to result in a performance decrement in the first place. However, based on the considerations outlined before, we assumed that this performance decrement would be offset to some degree by a transient boost of cognitive control which should facilitate the performance of task switches more than the performance of task repetitions, resulting in a reduction of task switch costs.

We also varied the duration of the cue-target interval (CTI) in order to capture the dynamics of the effect of incorrect guesses. With a short CTI, there is a relatively long interval during which participants can prepare for a guessed task, whereas preparation for the correct task as indicated by the precue is rather restricted. Conversely, with a long CTI, there is relatively much time to counteract effects of an incorrect guess. If, for example, participants inhibit the previous task in case of an incorrectly guessed task switch, the expected slowdown of task repetitions that were guessed to be task switches should be more pronounced with a short compared to a long CTI.

The first two experiments differed with respect to their motor requirements. In Experiment 1, participants indicated their guess by pressing the central key of one of four rows of keys that were assigned to one of the four tasks each. As a consequence, in case of an incorrect guess participants were required to respond to the imperative stimulus by pressing one of two keys that were associated with another task (for details, see below). This factor was removed in Experiment 2 in which task indications and task responses were performed with non-overlapping sets of keys that were operated with different hands.

2. Experiment 1

2.1. Method

2.1.1. Participants

19 right-handed subjects (7 male, 12 female) with normal or corrected-to-normal vision participated. Their mean age was 24.7 years (range: 19–30).

2.1.2. Stimuli, tasks, and apparatus

Imperative stimuli consisted of digits from the range 1–9 (excluding 5) and the letters A, B, G, E, N, O, S, and U. Each digit was about 7 mm high ×4 mm wide. Digits and letters were presented side by side, their position was chosen randomly on every trial. Task precues consisted of a dark blue square, diamond, circle or triangle surrounding the position of the imperative stimulus with a size of about 15 cm × 15 cm. There were four tasks, two of them regarding the digit and two regarding the letter. The numerical judgment tasks either concerned the magnitude (smaller vs. larger than five) or the parity of the digits. The magnitude task was indicated by the diamond, the parity task was indicated by the circle. The letters had to be judged regarding their position in the alphabet (first or second half, indicated by the triangle) or regarding whether it is a consonant or a vowel (indicated by the square). Stimuli were presented centrally on a 17″ monitor in black on light-gray background. Viewing distance was not controlled, but equally given with approximately 60 cm.

The response device consisted of a custom-built keyboard (cf. Fig. 1) connected to a Fujitsu Esprimo P700 that was equipped with an external data acquisition module (National Instruments NI USB-6431). The response device registered not only the pressing but also the release of each individual key with a precision of about 1 ms.

Each row of three keys was assigned to one of the tasks during the whole course of the experiment. The central key of each row was used to indicate the guessing response and was attached with a sticker that depicted the task cue associated with the respective task (see Fig. 1). The two outer keys of each row were used to respond to the imperative stimulus. Participants were instructed to use only the index finger of their right (dominant) hand for responding.

2.1.3. Design and procedure

The experiment consisted of three phases. The first and third phases were designed as the usual cuing-variant of the task switching paradigm. During the second phase, participants additionally had to guess at the beginning of each trial on which of the tasks they would have to perform in this trial. Switching probability was .5 during the whole experiment.

At the beginning of the experiment, participants were provided with on-screen instructions in which the tasks and the meaning of the task cues were explained. The first phase, in which no guessing was required, consisted of three blocks of 120 trials each. The response–stimulus interval (RSI), separating the response in trial n-1 from the onset of the imperative stimulus in trial n, was set to 1100 ms in the first and third phases of the experiment and to 3600 ms during the second (guessing) phase. In case of an error, error feedback was presented for additional 1000 ms; in case of reaction times (RTs) slower than the RT deadline of 2500 ms, RT feedback was presented for additional 1000 ms. Two CTIs of 200 and 1000 ms were employed during the whole experiment, with the duration of the CTI being evenly and pseudo-randomly distributed across all tasks. At the start of the second phase, participants were instructed to guess on every trial which task