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Long-term memory and the control of attentional control

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ABSTRACT

Task-switch costs and in particular the switch-cost asymmetry (i.e., the larger costs of switching to a dominant than a non-dominant task) are usually explained in terms of trial-to-trial carry-over of task-specific control settings. Here we argue that task switches are just one example of situations that trigger a transition from working-memory maintenance to updating, thereby opening working memory to interference from long-term memory. We used a new paradigm that requires selecting a spatial location either on the basis of a central cue (i.e., endogenous control of attention) or a peripheral, sudden onset (i.e., exogenous control of attention). We found a strong cost asymmetry that occurred even after short interruptions of otherwise single-task blocks (Exp. 1–3), but that was much stronger when participants had experienced the competing task under conditions of conflict (Exp. 1–2). Experiment 3 showed that the asymmetric costs were due to interruptions per se, rather than to associative interference tied to specific interruption activities. Experiment 4 generalized the basic pattern across interruptions varying in length or control demands and Experiment 5 across primary tasks with response-selection conflict rather than attentional conflict. Combined, the results support a model in which costs of selecting control settings arise when (a) potentially interfering memory traces have been encoded in long-term memory and (b) working-memory is forced from a maintenance mode into an updating mode (e.g., through task interruptions), thereby allowing unwanted retrieval of the encoded memory traces.

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1. Introduction

The way we interact with the world is contingent on abstract control settings. These settings specify which external or internal information is currently relevant and how to act upon it in order to achieve one's goals. From research with the task-switching paradigm, in which people are prompted to switch between predefined task rules on a trial-by-trial basis, we know that it is difficult to flexibly change between task or control settings (for reviews see Kiesel et al., 2010; Monsell, 2003; Vandierendonck, Liefooghe, & Verbruggen, 2010). From this research we can also derive two fundamentally different accounts of how exactly these obstacles to flexible change arise. By the first, and intuitively most appealing account, costs of switching between tasks or control settings come from the direct clash between the residue of the most-recently used and the currently relevant task setting (e.g., Allport, Styles, & Hsieh, 1984; Gilbert & Shallice, 2002; Yeung & Monsell, 2003a, 2003b). In contrast, the second account holds that interference between competing task settings is not the result of carry-over from the most-recent past, but rather reflects the long-term memory (LTM) knowledge base about the space of tasks involved in a particular context (e.g., Bryck & Mayr, 2008; Mayr, 2009; Waszak, Hommel, & Allport, 2003).[1] In the work described here, we examine which of these two accounts is better suited to explain the costs of selecting and changing control settings. For this purpose, we focus mainly on the important, yet understudied problem of selecting between endogenous vs. exogenous control over spatial attention. Before we elaborate on our choice of control settings, we first develop our general theoretical and empirical approach.

1.1. Switch-cost asymmetry and carry-over of task sets

A benchmark result in the task-switching literature is the so-called switch-cost asymmetry. When people switch between a dominant task, such as Stroop word naming and a competing, non-dominant task, such as Stroop color naming, switch costs are larger when transitioning from the hard, non-dominant to the easy, dominant task than the other way round (e.g., Allport et al., 1984). This phenomenon is important here because carry-over models of task switching seem to be able to explain it in a straightforward manner: Non-dominant tasks require a particularly strong attentional setting to survive against the competition from the dominant task and this strong setting is carried forward into the next trial where it needs to be overcome when switching back to the dominant task. In contrast, the dominant task requires only weak support from a task setting and therefore relatively speaking, less change in control settings is required when switching from the dominant to the non-dominant task. Critically, for the carry-over account to work, trial-to-trial switching between the two competing tasks is a necessary condition for obtaining a switch cost asymmetry (Gilbert & Shallice, 2002; Yeung & Monsell, 2003a, 2003b).

Even though this model adequately accounts for the basic finding of the asymmetry in switch costs, there is also some initial evidence that directly contradicts the carry-over account. Obviously, the carry-over account can explain the task-selection cost asymmetry only for cases in which the alternative task was performed in the immediately preceding trial––otherwise there would be no opportunity for carry-over. However, Bryck and Mayr (2008) have shown that a cost asymmetry can be obtained even in the absence of a task-switch transition (see also Allport & Wylie, 2000). This finding, which will be elaborated below, is important because it indicates that opportunity for trial-to-trial carry-over is not a necessary condition for the cost asymmetry to arise.

[1] A separate discussion in the literature deals with the question to what degree task switching requires a special "reconfiguration process" (e.g., Allport & Wylie, 2000; Monsell, 2003). We ignore this issue here because it is largely orthogonal to the question where interference originates. An important purpose of such a configuration process could be to implement a task-specific attentional filter that could counteract any type of interference, no matter whether it originates from the previous trial or from LTM.