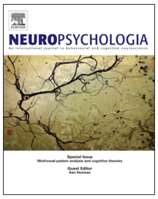
Neuropsychologia ∎ (∎∎∎∎) ∎∎∎–∎∎∎

Contents lists available at ScienceDirect

Neuropsychologia

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



Dissociating strategy-dependent and independent components in task preparation

Wouter De Baene*, Marcel Brass

Department of Experimental Psychology, Ghent University, Henri Dunantlaan 2, Ghent B-9000, Belgium

A R T I C L E I N F O

Keywords:
Task preparation
Strategy
Functional dissociation
Contextual effects

A B S T R A C T

A central aspect of cognitive control is the capacity to anticipatorily prepare for specific task requirements prior to carrying out a task. To study the changes caused by task preparation, the cued task-switching paradigm has generally been used. While research on anticipatory control has long focused on general processing differences between switch and repeat trials, more recent research suggests that contextual variations strongly modulate such differences. In the current paper, we argue that anticipatory task set preparation strongly depends on contextual variables leading to different strategies to prepare for an upcoming task. We provide behavioral as well as neuroscientific evidence for this claim. Furthermore, we show that some preparatory processes are sensitive to strategic modulations whereas other preparatory processes are not. Based on this, we propose a functional dissociation within the fronto-parietal network involved in task preparation.

1. Introduction

In daily life, we permanently need to adapt our behavior to new task situations, requiring cognitive control. Cognitive control processes refer to the ability to flexibly adapt one's thoughts and actions in the pursuit of internal goals. A central aspect of cognitive control is the capacity to anticipatorily prepare for specific task requirements prior to carrying out the task. A large body of behavioral research has used the cued task-switching paradigm (Meiran, 1996) to study the preparatory changes that enable fluent task implementation (for reviews, see Kiesel et al., 2010; Vandierendonck, Liefooghe, & Verbruggen, 2010). In the cuing procedure, a task cue indicates which task needs to be executed on each trial. By changing the time between the cue and the target, the degree of anticipatory preparation can be manipulated. Consequently, this procedure allows dissociating different preparation-related components from execution-related components in task switching. Independent of the specifics of the tasks that are used, a common observation in behavioral task-switching studies is that people are generally slower and less accurate at switching than at repeating tasks but these switch costs are reduced when participants are able to prepare the next task (Hoffmann, Kiesel, & Sebald, 2003; Kiesel & Hoffmann, 2004; Koch, 2001; Meiran, 1996; Meiran, Chorev, & Sapir, 2000; Monsell, Sumner, & Waters, 2003; Rogers & Monsell, 1995).

Traditionally, two opposing theoretical models on the source of the task switch cost and the preparatory reductions of these costs have been proposed (for a review, see Vandierendonck et al., 2010). According to the "reconfiguration" account, switch trials as compared to repetition trials require additional reconfiguration processes (e.g. Rogers & Monsell, 1995; Rubinstein, Meyer, & Evans, 2001). According to this view, the switch cost reflects the time needed to reconfigure a task set (Monsell & Mizon, 2006; Rogers & Monsell, 1995): In task switch trials, the appropriate task is not yet active, necessitating reconfiguration. By contrast, reconfiguration will normally not be needed in task repeat trials, since the task set from the previous trial is still active. According to the "interference" account, by contrast, the switch cost reflects the time needed to resolve the interference from the previous task set (e.g. Allport, Styles, & Hsieh, 1994; Allport & Wylie, 1999; Wylie & Allport, 2000). This account assumes that the activation of the previous relevant task set persists. In case of a switch trial, this persisting passively decaying activation of the previous task set interferes with the new task set, which is not the case in repeat trials.

Many models of task switching assume that task set preparation can be differentiated into a number of different processes operating on different task set components (e.g. Mayr & Kliegl, 2000, 2003; Monsell, 2005; Nicholson, Karayanidis, Poboka, Heathcote, & Michie, 2005; Rogers & Monsell, 1995; Rubinstein et al., 2001). A first critical process in task preparation is related to the retrieval of the task goal (e.g., Fagot, 1994; Mayr & Kliegl, 2000; Rogers & Monsell, 1995; Rubinstein et al., 2001). In this stage, the task set representations are maintained and updated by activating the relevant task set and inhibiting the irrelevant task set as

---

* Correspondence to: Department of Experimental Psychology, Ghent University, Henri Dunantlaan 2, Ghent, B-9000, Belgium. Tel.: +32 9 2646404; fax: +32 9 2646496.
E-mail address: Wouter.DeBaene@ugent.be (W. De Baene).

http://dx.doi.org/10.1016/j.neuropsychologia.2014.04.015
0028-3932/© 2014 Elsevier Ltd. All rights reserved.

Please cite this article as: De Baene, W., & Brass, M. Dissociating strategy-dependent and independent components in task preparation. *Neuropsychologia* (2014), http://dx.doi.org/10.1016/j.neuropsychologia.2014.04.015

needed (e.g. Karayanidis et al., 2009; Kiesel et al., 2010; Nicholson, Karayanidis, Davies, & Michie, 2006). This active maintenance of task set representations is assumed to bias responding according to the currently relevant task (e.g. Braver & Cohen, 2000; Gilbert & Shallice, 2002; Miller & Cohen, 2001). This is tightly linked to a second constituent process of task preparation, i.e. the activation of the relevant task rule (e.g., Jamadar, Hughes, Fulham, Michie, & Karayanidis, 2010a; Jamadar, Michie, & Karayanidis, 2010b; Rubinstein et al., 2001). Note that the task rule might refer to different things, depending on the paradigm used: in classical task-switching paradigms (e.g. Allport et al., 1994; Rogers & Monsell, 1995), different task rules (or categorization rules) involve two or more different stimulus-response (S-R) mappings that are defined, for instance, on different stimulus dimensions of a single item (such as magnitude vs. parity or color vs. motion). In these paradigms, activating a task rule involves setting the attentional focus on the relevant stimulus dimension (i.e. attentional control). In other (S-R reversal) paradigms, different task rules involve opposite S-R mappings. Consequently, activating a task rule solely involves activating the relevant S-R mapping (i.e. intentional control). We will come back to this distinction between attentional and intentional control below (for a discussion of this issue, see Ruge, Jamadar, Zimmermann, & Karayanidis, 2013).

In sum, task preparation requires the specification of two types of information: one needs to specify “what to do next” by setting the task goal and “how to do it” by activating the relevant task rule (e.g. De Baene, Albers, & Brass, 2012; Rubinstein et al., 2001).

1.1. ERP markers of task preparation

While task preparation has been investigated in the behavioral literature for almost two decades, only in the last 15 years it has also been investigated with neuroscientific methods such as EEG and fMRI. EEG research on task switching has been particularly successful in linking specific ERP components to task-set preparation, demonstrating larger amplitudes in switch compared to repeat trials (e.g. Jost, Mayr, & Rosler, 2008; Karayanidis, Provost, Brown, Paton, & Heathcote, 2011; Lavric, Mizon, & Monsell, 2008). These studies have identified various, temporally distinct, cue-locked EEG markers of task preparation that reflect the different preparatory processes (see Fig. 1; see Karayanidis et al., 2010 for a review): Task goal activation or task set updating is thought to be reflected by an early parietal positivity (e.g. Eppinger, Kray, Mecklinger, & John, 2007; Jamadar et al., 2010a; Jost et al., 2008; Kray, Eppinger, & Mecklinger, 2005; Manzi, Nessler, Czernochowski, & Friedman, 2011; West, 2004) that is present as early as 200 ms after cue onset. This early positivity has been associated with activity in the lateral prefrontal cortex (Jamadar et al., 2010a, see below). A second, but less consistently observed component linked to task set updating is an early frontal positivity emerging around 150–200 ms after cue onset (e.g. Astle, Jackson, & Swainson, 2008; Lavric et al., 2008; Rushworth, Hadland, Paus, & Sipila, 2002). This component has been particularly associated with inhibition of the alternative task set (Wylie, Murray, Javitt, & Foxe, 2009). Important to note is that this *cue*-dependent frontal positivity should not be confused with the *target*-dependent P2 that has been related to stimulus-dependent processes such as the retrieval of stimulus-response mappings (e.g. Allport et al., 1994; Kieffaber & Hetrick, 2005; Wylie & Allport, 2000).

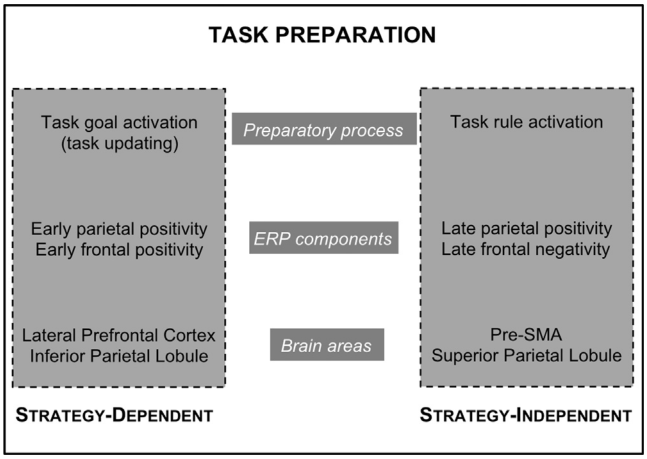


Fig. 1. Overview of the dissociation between a preparatory process that is affected by the adopted strategy (left) and a preparatory process that is not affected by the preparatory strategy (right). Task goal activation is assumed to be reflected by an early parietal and frontal positivity and is reflected by activation in the lateral prefrontal cortex and the inferior parietal lobule. This process is strategy-dependent and can be modulated by manipulation of the context. Task rule activation, by contrast, is strategy-independent and is assumed to be reflected by a late parietal positivity and a late frontal negativity and by activation in the pre-SMA and the superior parietal lobule.

The second preparatory process, namely task rule activation, by contrast, has been linked to a late parietal positivity (e.g. Barceló, Periáñez, & Nyhus, 2008; Jamadar et al., 2010a; Jost et al., 2008; Karayanidis et al., 2011; Lavric et al., 2008; Nicholson, Karayanidis, Bumak, Poboka, and Michie 2006) and has been observed between about 400 and 1000 ms after cue onset. This parietal positivity has been consistently found but inconsistently labeled: sometimes it is referred to as a cue-locked P3 (e.g. Gajewski & Falkenstein, 2011), sometimes as an increased P3b (e.g. Barceló, Muñoz-Céspedes, Pozo, & Rubia, 2000; Goffaux, Phillips, Sinai, & Pushkar, 2006; Kieffaber & Hetrick, 2005) and sometimes as a parietal switch positivity (e.g. Astle, Jackson, & Swainson, 2006; Karayanidis, Coltheart, Michie, & Murphy, 2003; Swainson, Jackson, & Jackson, 2006). This component, further denoted as the late parietal positivity, has been associated with activity in the posterior parietal cortex (Jamadar et al., 2010a, see below) and tends to reach its maximum over left-lateralized parietal scalp locations (Astle et al., 2006; Lavric et al., 2008).

Finally, some studies have also identified a late frontal negative component, especially when using a common average reference (e.g. Astle et al., 2008; Hsieh & Chen, 2006; Lavric et al., 2008; Mueller, Swainson, & Jackson, 2007). This frontal negativity occurs between about 500 and 1000 ms after cue onset and tends to be slightly right lateralized (Astle et al., 2006; Lavric et al., 2008). Lavric et al. (2008) observed a high interdependence between the late parietal positivity and the late frontal negativity, suggesting that they may reflect the two poles of the underlying dipolar generators and thus reflect the same underlying processes of anticipatory task preparation (though see Astle et al., 2008 and Mueller et al., 2007, for an alternative view). Indeed, the late frontal negativity has been interpreted, amongst others, as reflecting rule mapping or retrieval (e.g. Hsieh & Chen, 2006; Travers & West, 2008), as is the case for the late parietal positivity. Several studies have described this late frontal negativity as a contingent negative variation (CNV) or CNV-like component (e.g. Astle et al., 2008; Gajewski et al., 2010; Goffaux et al., 2006; Goffaux, Phillips, Sinai, & Pushkar, 2008; Lorist et al., 2000). The frontal CNV has been interpreted as reflecting a reassignment of resources, preparatory attention, motivation or response readiness (Falkenstein, Hohnsbein, Hoormann, & Kleinsorge, 2003; Grent & Woldorff, 2007; Tecce, 1972; van Boxtel & Brunia, 1994; Walter, Cooper, Aldridge, McCallum, & Winter, 1964). Lavric et al. (2008), however, showed that the late frontal negativity (with its frontal-polar topography) and the CNV (with its frontal-central or posterior-central distribution) are distinct components.

1.2. Task preparation and fMRI

Besides an extended amount of ERP research, also numerous fMRI studies have been performed using variants of the task-switching

Please cite this article as: De Baene, W., & Brass, M. Dissociating strategy-dependent and independent components in task preparation. *Neuropsychologia* (2014), http://dx.doi.org/10.1016/j.neuropsychologia.2014.04.015