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# Advance preparation of set-switches in Parkinson's disease

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**Abstract**

Eighteen patients with Parkinson's disease (PD) and 18 healthy control subjects were presented with a switching task where stimuli elicited either one (no-conflict condition) or two (conflict condition) task-relevant stimulus-response mappings. The response stimulus interval (RSI) between trials was varied to allow investigation of the extent to which participants engaged in advanced preparation of task set. In line with previous findings, set-switching deficits of PD patients were only observed in the conflict condition. Prolonging the RSI led to a reduction of switch costs for control subjects in both the conflict and the no-conflict task, whereas this effect was attenuated for PD patients in the conflict condition. This deficit was explained in terms of a reduced ability to maintain cue-action representations active in working memory in high interference conditions, and was related to the possible role of the frontostriatal circuit in maintaining focussed attention.


*Keywords:* Set-switching; Advance preparation; Parkinson's disease; Set-maintenance; Working memory

## 1. Introduction

The ability to flexibly switch from one task to another has been shown to be affected by damage to the frontal lobe and the frontostriatal circuit (Brown & Marsden, 1990; Downes, Roberts, Sahakian, Evenden, Morris, & Robbins, 1989; Gauntlett-Gilbert, Roberts, & Brown, 1999; Lees & Smith, 1983; Owen, Hodges, Summers, Polkey, & Robbins, 1993; Patriot, Verin, Pillon, Teixiera-Ferreira, Agid, & Dubois, 1996). Patients with frontal lobe damage and patients suffering from Parkinson's disease (PD) show deficits on a variety of set-switching tasks, such as the Wisconsin Card Sorting Task (WCST) (Lees & Smith, 1983), the Odd-Mann-Out (OMO) task (Flowers & Robertson, 1985), the Visual Learning Discrimination Task (Downes et al., 1989; Gauntlett-Gilbert et al., 1999; Owen et al., 1993), and the Delayed Response Switching task (Patriot et al., 1996). In PD, these deficits have been attributed to nigrostriatal dopamine depletion, which has also been associated with the motor deficits characterizing the disease, such as tremors, rigidity and akinesia (Bannister, 1992; Hoehn & Yahr, 1967; Knight, 1992). Recently, the multi-componential nature of set-switching tasks like the WCST has been recognized as a problem for identifying the component processes underlying set-switching that are affected in clinical populations (Rogers, Sahakian, Hodges, Kennard, & Robbins, 1998). As outlined by Rogers et al. (1998), performance on the WCST does not only rely on the ability to switch from one task-set to another, it also relies on concept formation, rule learning, the ability to make effective use of error feedback, and on the ability to maintain task-relevant rules in working memory whilst performing the task. To overcome this problem, Rogers et al. (1998) used a set-switching task where performance relied less on rule-learning and concept formation (Rogers & Monsell, 1995; see also Jersild, 1927; Spector & Biederman, 1976). This task required a switch between letter and digit naming on every second trial, allowing comparison between switch and repeat trials (switch costs). The relevant task stimulus was either accompanied by a stimulus relevant for the second task, causing 'crosstalk' (e.g., 'G2'), or by a neutral stimulus (no crosstalk: e.g. 'G#'). In contrast to previous studies, PD patients showed only minor set-switching deficits on this task. Error switch costs were increased for PD patients but only towards the end of blocks. Using the same task, comparable findings were obtained in a study by Cools et al. (Cools, Barker, Sahakian, & Robbins, 2001) who explained the observed deficit in terms of a differential load on the selection mechanism in the crosstalk and the no-crosstalk conditions. They argued that set-switching in PD patients is more likely to be affected when the load on this selection mechanism is high.

In the studies by Rogers et al. (1998) and Cools et al. (2001), the response stimulus interval (RSI) between trials was 1000 ms, providing an opportunity to prepare reconfiguration of the next task set in advance (Rogers & Monsell,

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1995). Deficits of PD patients observed in these studies may therefore have been associated with processes occurring either before or after the first stimulus for the new task. The present study aims to investigate the extent to which set-switching deficits of PD patients are associated with advance preparatory processes, and with processes occurring after stimulus presentation (e.g., conflict resolution when stimuli elicit two competing, task-relevant responses). This will be investigated by varying the RSI between trials in a set-switching task with predictable switches. Prolongation of the RSI has been found to reduce switch costs when switches are predictable or cued (Allport, Styles, & Hsieh, 1994; Meiran, 1996; Rogers & Monsell, 1995). It has also been shown that task set preparation is a resource demanding and time consuming process (Goschke, 2001). Goschke (2001) compared switch costs at short RSI with two long RSI conditions where participants were instructed to either verbalize the upcoming task (facilitating advance task set retrieval) or to verbalize task unrelated words (blocking advance task set retrieval). His results showed a strong reduction of switch costs when task set retrieval was facilitated, but switch costs were similar to the short RSI condition when task retrieval was blocked by verbalization of task unrelated words. Based on the findings that advance preparation can reduce switch costs and that this process is resource demanding (Brown & Marsden, 1990; Woodward, Bub & Hunter, 2002), it could be argued that the increased switch costs for PD patients observed in the studies of Rogers et al. (1998) and Cools et al. (2001) may have been partly due to less effective preparation of task set.

Although prolongation of the RSI reduces switch costs, increasing the RSI does not abolish all costs associated with task transitions (Allport et al., 1994; Meiran, 1996; De Jong, 2001; Goschke, 2001). This residual switch cost has been associated with the idea that full preparation of a task switch is not always successful, even on long RSI trials (e.g., 1200 ms) (De Jong, 2001). Assuming a fully prepared state on long RSI non-switch trials and an unprepared state on short RSI switch trials, De Jong's analysis (2001) showed that the RT for switch trials varied with increased RSI as predicted by his proposed mixture—probability model. The finding that small costs were observed on long RSI trials was explained as resulting from a mixture of switch trials where task transitions were fully prepared in advance (without time cost) and switch trials where task switches were not prepared (with time costs). De Jong suggests that effective preparation is dependent upon the formation of an intention to engage in advance preparation in response to a cue, and on the ability to maintain this cue-action representation in an active state whilst performing the task (De Jong, 2001). Evidence for this idea can be inferred from a study by Nieuwenhuis and Monsell (2002), who showed that performance related reward can increase the intention to engage in advance preparation, reflected by a reduction of switch costs. De Jong (2001) further showed that switch costs tend to be greater when a task consists of long blocks of trials, where the cue-action representation needs to be maintained active for a longer period of time.

To investigate if (and under which conditions) advance preparation of task-set reconfiguration is affected in PD, switch and non-switch trials are presented in either short (100 ms) or long (2000 ms) RSI blocks. The task used in the present study is an adaptation of the procedure described by Goschke (2001). In this adapted version switches of task set are cued by location and are fully predictable. Stimuli in the 'no-conflict' condition are black letters or color patches. As only one stimulus dimension is presented in this condition, interference from the irrelevant task set should be minimal. Letter and color responses are also required in the 'conflict' condition, but here the stimuli are colored letters and require inhibition of the task irrelevant stimulus-response mapping. Based on previous findings (Cools et al., 2001; Rogers et al., 1998), the prediction for short RSI blocks is that switch costs for PD patients are more likely to be enhanced in the conflict condition, where interference from competing stimulus-response mappings increases load on the selection mechanism.

Prolongation of the RSI to 2000 ms should allow more time to engage in advance preparation of task-set reconfiguration. This preparation includes recollection of task-relevant stimulus-response mappings, whereas selection of the correct response can only be finalized after presentation of the stimulus. Assuming that advance preparation is dependent upon the ability to maintain the cue-action representation active, it is predicted that advance preparation will be less often successful in PD patients, resulting in increased overall switch costs. Evidence for the idea that the ability to maintain relevant task-sets active is impaired in PD patients can be inferred from previous studies using the Odd-Man-Out switching task (Flowers & Robertson, 1985) and the Delayed-Response switching task (Patriot et al., 1996). Both studies found supportive evidence for a 'loss of set' in PD patients after correct selection of the new task set. If load on the selection mechanism (Cools et al., 2001) also affects maintenance of cue-action representations, then less successful advance preparation may be restricted to the conflict condition.

## 2. Method

### 2.1. Participants

Eighteen patients suffering from Idiopathic Parkinson's Disease (nine men and nine women) and 18 control subjects participated in this study. Demographic and clinical characteristics of the PD patients are shown in Table 1. Patients were recruited from the neurological outpatients clinic of Hull Royal Infirmary. Control subjects were recruited from the local community and from family members of the PD patients participating in this study. Patients and controls were matched for age. The mean age of PD patients was 60 and for controls 58 years.