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Parkinson's disease is associated with goal setting deficits during task switching[☆]

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Abstract

Ten Parkinson's Disease (PD) patients and 10 control participants were tested using a task-switching paradigm in which there was a random task sequence, and the task was cued in every trial. Five PD patients showed a unique error profile. Their performance approximated guessing when accuracy was dependent on correct task identification, and was nearly perfect when accuracy did not depend on correct task identification or in conditions without task switching. Nonetheless, PD patients showed normal task-rule implementation, evidenced by their preparation-related reduction in the reaction-time task-switching cost. The results indicate that, without redundant task information, some PD patients have a specific goal setting deficit, reflected in a difficulty determining which task is currently relevant.

1. Introduction

Previous investigations (reviewed by Cools, Barker, Sahakian, & Robbins, 2001) indicated that Parkinson's Disease (PD) is associated with impaired performance in the task-switching paradigm. This paradigm is believed to tap mechanisms of cognitive flexibility independent of significant working memory demands or the need to identify a rule. The present work attempts to elucidate the specific cognitive deficit associated with PD's performance on this task.

Brown and Marsden (1988) presented participants with colored words and asked them to switch between word identification and ink color identification every 10 trials. In the cued condition, the word INK or COLOR was presented before the target stimulus. In the non-cued condition, the targets were preceded by the word READY. Interestingly, for PD patients only, the proportion of errors (PE) became considerably larger in the non-cued condition (∼.25, in trials immediately following a task switch) relative to the cued condition (∼.03).

Cools et al. (2001) asked participants to switch between digit and letter naming under cued conditions, every two trials. They compared two conditions: a crosstalk condition in which information related to the currently irrelevant task was presented (e.g., "G7") to a condition without crosstalk (e.g., "3#"). Note that Brown and Marsden's (1988) colored words also involved crosstalk. Moreover, without crosstalk, the target stimulus can serve as a supplementary task cue. Cools et al. found that PD patients exhibited increased switching cost (SC), but only in the crosstalk condition.

In both studies, the information regarding which task to execute was provided by the memory of the task sequence (switch every 2 or 10 trials, see Koch, 2001), and was redundantly cued in some conditions. In the present study, we reversed this assignment. While the tasks were always cued in advance by a task cue, the task sequence was random and, hence, participants could not rely on task sequence memory to determine task identity. In that respect, the conditions in the present study were similar to the non-cued condition in Brown and Marsden's (1988) study, in that only one source of task-identity information was provided. The participants in the current study were asked to determine the position of a target presented within a 2×2 grid according to one of two different task rules, UP–DOWN and RIGHT–LEFT. The relevant task rule was cued in every trial by

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arrows pointing to the sides or upward–downward, respectively (Fig. 1, Meiran, Chorev, & Sapir, 2000; for details).

We studied 10 non-demented (Mini Mental State Examination 27 and above) PD patients aged between 40–75, 9 men and 1 woman, with 9–18 years of education. All were diagnosed by a senior neurologist and all were on L-DOPA medication. None of them had a history of other neurological disease, brain damage or psychiatric disease. The 10 control participants were matched on sex, education, and age.

The study consisted of three sessions. All the sessions involved the paradigm presented in Fig. 1. Session 2 is of particular interest because we manipulated advance task preparation by varying the task-cue-to-target interval (CTI: 100, 700, 1500 ms, with a long intertrial interval of 3 s). The CTI was not varied in Session 1 and in the beginning of Session 3. Additionally, in the last part of Session 3, the participants were tested in a condition involving a single task without the need to switch tasks (CTI = 100 ms, intertrial interval = 1500 ms). For one half of the participants, Key 1 indicated LEFT and UP responses and Key 2 indicated DOWN and RIGHT responses. The other half was given the alternative pairing. Therefore, in half of the trials, a correct response could be made even when considering the wrong task rule (e.g., KEY 1 was the correct response to an upper-left target according to both rules), while in the remaining trials, the correct response depended on choosing the correct task rule (the correct response to an upper-right target was KEY 1 according to the RIGHT–LEFT rule, but KEY 2 according to the UP–DOWN rule). In order to minimize the influence of fatigue, the experiment consisted of short blocks of 48 trials, 4–6 blocks per session.

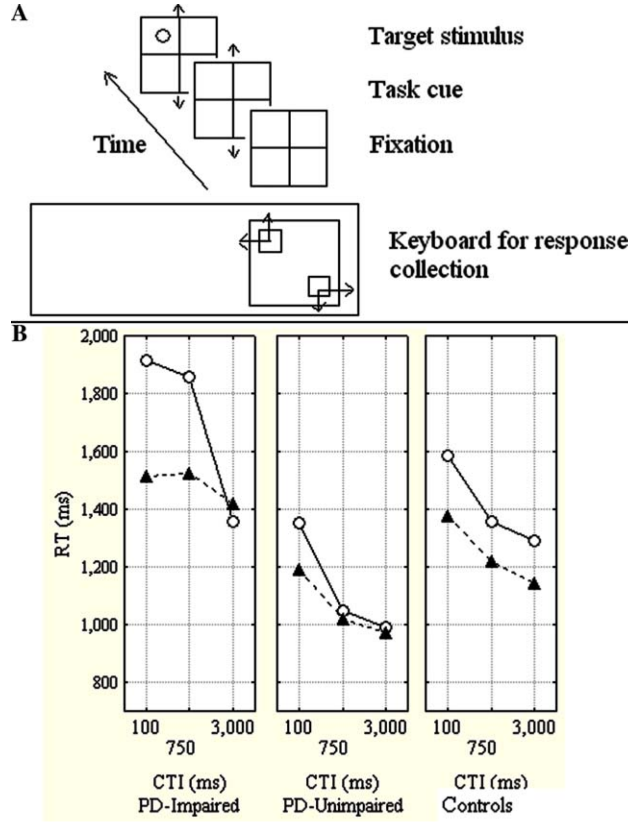

Fig. 1. (A) Schematic description of a trial involving the UP–DOWN Task. Key 1 and 2 are the upper-left and lower-right, respectively. The correct response is UP (Key 1) in this case. However, in this particular trial, correct key pressing would be achieved even when applying the wrong, RIGHT–LEFT rule. (B) Reaction time (RT, ms) according to Group, Switch (open circles = switch, filled triangles = non-switch) and cue-target interval (CTI). Impaired PD show increased task-switching cost but can abolish it by preparation. The triple interaction was non-significant, $p > .1$.

The most striking result concerns the proportion of errors (PE). When the correct response could be made even when the wrong rule was applied, PE was almost zero. However, when the correct response depended on correct task identification, the performance of 5 of the 10 PD patients approximated guessing (*Impaired PD*, PE = .54–.73, and .43–.58, mean = .62 and .50, in the sessions when CTI was varied and in the sessions when it was not varied, respectively) and five performed like the normal controls in both conditions (*Unimpaired PD*, PE = .02–.09 and .04–.07, mean = .04, .05), $t(8) = 16.26$, 14.93, $p < .0001$, for the group difference in the sessions when CTI was varied and in the sessions when it was not varied, respectively. This finding reflects difficulties primarily in mixed-tasks conditions. When only one task was required throughout the block of trials (Session 3) and even in trials where it was impossible to respond correctly based on the wrong task rule, PE among the impaired PD was only .11 as compared to .02 in all of the remaining groups, $p > .1$. Compared to the unimpaired patients, the impaired patients were older, had lower MMSE scores, more severe PD symptoms and less education (but $p > .1$). The PD groups showed the characteristic task-switching effects including the reaction time (RT) SC, its reduction by preparation (Fig. 1), and elevated RT in trials where correct responding depended on task identity.

Rubinstein, Meyer, and Evans (2001) argued that task switching involves two control operations: goal setting (deciding which task is currently relevant) and task rule implementation. The present results point to the locus of the PD-related deficit. They are consistent with the hypothesis that, in the absence of redundant task identity information, some PD patients exhibit a selective goal setting deficit without a deficit in task rule implementation. This deficit causes them to essentially guess the task identity in a given trial in mixed tasks conditions (but is not necessarily related to an inability to *maintain* the task set). Once a decision regarding task identity is made (even if it was a wrong decision), their rule implementation (seen in the elimination of SC by