Alterations of the Task-Set Reconfiguration Process in Closed Head Injury Adolescents

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The cost of shifting tasks across consecutive trials was examined as a function of the time interval between a task-cue and a subsequent target (cue-to-target interval, CTI). Task-shift costs are assumed to index a process by which subjects reconfigure their task-set when they must perform different tasks across consecutive trials. In neurologically intact teenagers, increased CTI causes reduced task-shift costs since subjects have more time to reconfigure their task-set prior to target onset. Some closed head injury adolescents however, show no reduction of task-shift costs with increased CTI. This indicates that subjects are incapable of reconfiguring their task-set from the cue alone, they also require the target before they are able to initiate this reconfiguration.

Introduction

Several of the behavioral problems observed in closed head injury (CHI) victims with frontal brain lesions (Levin et al., 1991; Van Zomeran & Brouwer, 1990) suggest an impairment of the Supervisory Attentional System (SAS; Norman & Shallice, 1986). The SAS is conceived as the general source of control for mental processes. Investigation of this system has often been said to be problematic because it is difficult to isolate its effects from the more elementary behaviors involved in task execution. Here, the SAS is investigated in neurologically intact and CHI adolescents in the context of a task-shift paradigm, where the cost of changing tasks across consecutive trials served as an index of its function.

On each trial, subjects were shown a task-cue indicating whether they should identify the shape of the subsequent target (circle or triangle) or provide its location (up or down). On half the trials, subjects performed the same task as in the previous trial, and a different task on the other half of trials. Variations in the cue-to-target temporal intervals (CTI) manipulated the time subjects had to appropriately configure their task-set prior to target onset.

Method

Subjects. Two CHI teenagers (P.O.B. and P.L.D.) participated in the experiment. Both CHI subjects were examined two month posttrauma. Respectively aged 12 and 14 years, each of these subjects was compared to its own age-matched neurological control group. Control group 1 comprised 10 subjects aged 11 or 12 years, whereas control group 2 was made of 11 subjects aged 13 or 14 years.

Stimuli. The fixation point was an asterisk (2 × 2 mm) appearing in the center of the screen. The target was either a circle or a triangle (2 × 2 cm), which was displayed either above or below (distance of 5 cm) the fixation point. The task-cues were: (1) a triangle drawn inside a circle (2 × 2 cm), indicating that the subject should report the shape of the target, or (2) a bidirectional vertical arrow, with one end pointing upward and the other downward, indicating that the subject should report the location of the target. All stimuli were shown in black over a white background. Subjects sat approximately 45 cm from the computer screen. The height of the screen was adjusted for each subject so that the fixation point was at eye level.

Procedure. Subjects were first administered two training blocks of 65 trials each. In each of these blocks, the task (identify the target shape—circle vs triangle—or localize the target—up vs down) to be performed on the target remained constant throughout. Then, five experimental blocks of 65 trials each were administered, with a 5-min pause between each block. In the experimental blocks, the task to be performed (shape or localization) varied randomly from trial to trial with the constraint that it remained the same as that on the previous trial on half the trials. Subjects were instructed to respond as rapidly and as accurately as possible. Responses were produced verbally (‘‘circle,’’ ‘‘triangle,’’ ‘‘up,’’ or ‘‘down’’) and were registered by means of a voice-key. In both the training and the experimental blocks, trials began by a 750-ms fixation point, followed then by the task-cue. Either 150, 450, 850, or 1550 ms later (cue-to-target interval, CTI), the target was displayed and remained visible until response production.

The factors examined were CTI (150, 450, 850, or 1550 ms) and whether the task to be performed on a particular trial was the same or different from that on the previous trial (task-shift factor: hold vs shift). Conditions were distributed randomly and in equal numbers of trials within each block. The first trial of each block was not included in the data analyses since the task-set factor was irrelevant for that particular trial. For the same reason, all trials on which an error occurred as well as all the trials that immediately followed were also rejected from the analysis.

Results

Correlations between RTs and error rates were nonsignificant and positive, thus showing no speed–accuracy trade-off. Correct response times (RTs) were analyzed with an ANOVA including the factors of task-shift (hold vs shift) and CTI (150, 450, 850, or 1550 ms).

In both control groups, the main effects of task-shift [group 1: $F(1, 9) = 17.9$; $p < .01$; group 2: $F(1, 10) = 59.3$; $p < .01$] and of CTI [group 1: $F(3, 27) = 75.4$; $p < .01$; group 2: $F(3, 30) = 89.3$; $p < .01$] were significant. These main effects indicate longer RTs in the shift than the hold condition and decreasing RTs with increased CTI. Both control groups also show a significant task-shift × CTI interaction [group 1: $F(3, 27) = 4.4$; $p < .05$; group 2: $F(3, 30) = 16.3$; $p < .01$]. This latter result indicates a progressive decrease of the task-shift cost with increasing CTI. In other words, both groups benefit from an increased CTI with respect to their task-shift costs.

Both patients showed significant main effects of task-shift [P.O.B.: $F(1, 283) = 9.8$; $p < .01$; P.L.D.: $F(1, 229) = 56.7$; $p < .01$] and of CTI [P.O.B.: $F(3, 283) = 21.8$; $p < .01$; P.L.D.: $F(3, 229) = 14.0$; $p < .01$] similar to those found in normal controls.

In striking contrast to normal controls however, P.O.B. and P.L.D. showed no task-shift × CTI interaction [P.O.B.: $F(3, 283) < 1$; P.L.D.: $F(3, 229) < 1$]. This result indicates that the CHI subjects do not benefit from an increased CTI to reconfigure their task-set when tasks change across consecutive trials.

Importantly, the absence of the task-shift × CTI interaction in P.O.B. and P.L.D. appears not to be a function of the magnitude of their task-shift costs. Indeed, P.O.B. showed task-shift costs that are within the range of those shown by his matched controls, none of them exceeding ± 1.2 standard deviations away from the normal mean. Notably however, P.L.D. exhibited abnormally large task-shift costs at all CTI's (z scores of 5.44, 6.05, 4.19, and 4.39 for CTI's of 150, 450, 850, and 1550 ms, respectively).

Discussion

The results of the control groups show reduced task-shift costs with an increased time interval between the onset of the task-cue and the subsequent target. This observation suggests that, when they must shift tasks across consecutive trials, neurologically intact subjects begin to reconfigure their task-set rapidly after the onset of the cue. This reconfiguration proceeds through time so that, with an increased interval between the task-cue and the target, the subject's task-set is brought closer to that required to appropriately process the target. These results and interpretations are in agreement with those previously reported by Meiran (1996).

On this basis, the lack of a task-shift × CTI interaction in P.O.B. and P.L.D. observed here should be considered a crucial anomaly. Indeed, it means that subjects are entirely incapable of reconfiguring their task-set based on the presentation of the task-cue alone. Rather, they appear to remain passive with respect to their task-set until the target is presented. Only at that time do they seem to deploy any of the task-set reconfiguration activity that is required to properly process the target in the shift condition. As indicated above, this deficit is not dependent upon the occurrence of abnormally large task-shift costs. This means that the apparent inertia shown by P.O.B. and P.L.D. with respect to task-set reconfiguration does not imply that the reconfiguration process is affected in itself. Rather, it appears that the spontaneous initiation of task-set reconfiguration and the act of reconfiguration should be conceived as separate. Whereas P.L.D. appears to have both processes impaired, only the former is affected in P.O.B.

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