A deficit in the adjustment of grip force responses in schizophrenia

Yvonne Delevoye-Turrell,\textsuperscript{CA} Anne Giersch and Jean-Marie Danion

INSERM Unité 405, Département de Psychiatrie, I place de l'Hôpital, 67091 Strasbourg, France

\textsuperscript{CA}Corresponding Author

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Delusions of control in schizophrenia may be due to a deficit in the generation of an efference copy, used to distinguish between self generated and externally imposed changes in the environment. This hypothesis was tested using a framework that differentiated automatic and controlled levels of motor behavior. Subjects resisted collisions that were either self or externally imposed. The grip to load force correlation (response accuracy) and the overall grip force level used (response efficiency) were measured. Controls improved both accuracy and efficiency of their grip force responses in self compared to externally imposed collisions. Patients improved accuracy but not efficiency of motor response. There was no difference between patients with and without delusions of control. These results refute the hypothesis of a perturbed efference copy in patients with delusions of control. We rather propose that schizophrenia globally preserves the automatic level but affects the controlled, more voluntary level of motor behavior.


Key words: Central monitoring; Efficiency; Grip force; Predictive control; Schizophrenia

INTRODUCTION

During object transport, forward models modulate grip force to the predicted load force fluctuations, on the basis of the efference copy of the issued motor commands [1]. This modulation process is thought to take place at a sub-cortical level and may be totally automatic as it is not penetrable by voluntary control [2]. By multiplying the grip force response by a safety factor, the overall level of grip force necessary to avoid object slippage is determined [3]. This component is influenced by verbal instruction [2]. Hence, grip force adjustments may be determined on the basis of the combined effects of an automatic process for the accuracy of response modulation and a controlled process for the efficiency of the motor responses.

Perturbation in the generation of the efference copy has been a potential explanation for the first rank symptoms described in patients with schizophrenia [4,5]. The goal of the present study was to investigate how this hypothesis fitted with the classical view of preserved automatic processes in schizophrenia. Subjects maintained a stable grip on an object while experiencing collisions that were either externally or self imposed (an efference copy was thus available in the latter condition only). Following the efference copy model for schizophrenia [5], grip force modulation should be impaired specifically for patients with delusions of control, and this should be observed only in self imposed collisions. However, if schizophrenia affects globally controlled processes, grip force modulation for all patients should be preserved whereas the efficiency of the adjustments should be impaired.

MATERIALS AND METHODS

Sixteen patients with schizophrenia (mean (± s.d.) age 37.6 ± 15.5 years; mean educational level 12.1 ± 7.0 years) and 16 controls (mean age 39.0 ± 16.5 years; mean educational level 12.8 ± 6.2 years) participated in the study. The protocol was approved by the local ethics committee. Subjects were paid for their participation and provided written informed consent.

Patients fulfilled the DSM-IV criteria for schizophrenia and were clinically stable. Fourteen patients were receiving neuroleptic treatment; two were not receiving any treatment. All patients underwent clinical assessment (Scale for the Assessment of Positive Symptoms (SAPS), mean score 15.9, range 0–58; Scale for the Assessment of Negative Symptoms, mean score 41.8, range 9–77; Brief Psychiatric Rating Scale, mean score 26.1, range 6–46). In addition, a Schneiderian sub-scale for first rank symptoms was calculated by adding 7 items from the SAPS (items 2, 3, 15–19).

With the criterion set to 3, patients were classified as having (SZ+; \( n = 6 \)) or not having (SZ−; \( n = 10 \)) delusions of control [7].

Subjects grasped a 6-axis load cell (Novatech Gamma SI-130-10) with parallel cotton-covered surfaces (width 4.5 cm; weight 450 g). This manipulandum measured forces and torques normal and tangential to the loading axes. Subjects faced a pendulum (length 75 cm; weight 750 g) that was made of an aluminum rod and of a hard-rubber head. The subjects’ task was to maintain the manipulandum immobile while experiencing collisions that were either externally imposed, i.e. the experimenter released the pendulum, or
self imposed, i.e. subjects used their free hand to release the pendulum. For both conditions, subjects experienced 12 collisions of three distinct force levels (3.4 ± 0.7 N, 8.4 ± 0.6 N and 25.1 ± 0.6 N). Baseline levels were recorded during the first 500 ms of each trial.

Grip force baseline, grip force and load force at impact were automatically scored. The accuracy of grip force modulation was evaluated by calculating the grip to load force correlation parameter for each subject and task. Second, after subtracting grip force baseline from the overall grip force level, the efficiency of the grip force adjustments was estimated by calculating the relative safety margin, i.e. the excess grip force employed at impact (as a percentage) [8]. A two-way ANOVA with repeated measures on group (3) and task (2) was run on the grip force baseline, the grip to load force correlation and the safety margin.

RESULTS
Grip force baseline was significantly smaller for the SZ+ patients (8.6 N) than for the controls (10.4 N) and the SZ− patients (10.6 N) (F(2,431) = 8.06, p < 0.01), which indicated that patients were not more affected than controls by the novelty of the tasks.

Figure 1a shows the grip to load force correlation. Main effect of task was significant (F(1,29) = 14.58, p < 0.01): grip force was more correlated with load force in the self imposed (0.66) than in the externally imposed tasks (0.45). Neither the group effect (F(1,29) = 0.15, ns) nor the group × task interaction (F(1,29) = 1.19, ns) was significant, indicating that the automatic level of grip force adjustment was preserved in all groups.

For safety margin, main effect of group (F(2,401) = 7.40, p < 0.01) and the interaction group × task were significant (F(2,401) = 3.51, p < .05; Fig. 1b). For the controls, the safety margin was significantly smaller in the self imposed (37.5%) than in the externally imposed tasks (47.7%). For both patient groups, the safety margin was similar in the self imposed (47.6%) and the externally imposed tasks (47.7%), indicating that the patients did not limit differentially the amount of excess grip force whether they self-released the pendulum or not.

DISCUSSION
Results revealed that patients with schizophrenia scaled grip force to load force increases at a similar degree of accuracy than healthy controls. As there was furthermore no difference between patients with and without delusions of control, the attractive idea that delusions of control is a specific problem with the generation of a forward model [5] does not seem to explain our findings. Other reports have also been in favor of a preserved efference copy in hallucinated patients with schizophrenia [7,9,10].

Patients used abnormally high force levels for self-imposed collisions only: the grip force adjustments were indeed normal both during baseline and for externally imposed collisions. Hence, our results are not due to an overall impairment in force control but reflects a specific deficit in the controlled process of grip to load force scaling.

Several explanations are possible. First, schizophrenia may affect specifically the integrative mechanisms for controlled processes, as it has been proposed in cognitive tasks [6]. Following a problem of attribution [11], a second hypothesis is that our patients were not aware of who was generating the collisions. At a purely conscious level, this was not the case as patients were clearly aware of who was releasing the pendulum. A third possibility is that patients were not aware of the use of too high a grip force level. A certain awareness of the adequacy of ones actions may be required in order to improve the efficiency of the control. Future work is needed to partial out which of these hypotheses may best explain the present findings.
CONCLUSIONS
Our results suggest that patients with schizophrenia are impaired in the efficient control of movement. This is not due to an overall deficit in the predictive mechanisms, as the accuracy of motor performance is similar in patients and in healthy controls. We here propose that schizophrenia globally preserves the automatic level but affects the controlled, more voluntary level of motor behavior.

REFERENCES

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