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Brief report

Willed action in schizophrenia

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Abstract

This study examined stimulus-driven and willed action in schizophrenic patients and healthy controls using an easy finger-tap task and a more demanding peg-placement task under unimanual, bimanual and dual-task conditions. Peg-placement externally cued by a metronome was also examined, as were practice effects. Patients with marked negative symptoms placed fewer pegs unimanually with and without practice and benefited most from metronome-cueing. Under dual-task conditions, when the participants placed pegs while concurrently finger-tapping, finger-tapping slowed down relative to unimanual scores in patients more than controls. Number of pegs placed also dropped off in controls and the patients with fewer negative symptoms. However, patients with more severe negative symptoms placed just as many pegs, and sometimes more, in the dual-task, compared to the unimanual, condition. These patients appeared to be using their finger-tapping just like an 'external' pacing-stimulus for peg-placement, thus rendering their peg-placement more stimulus-driven than willed. In contrast, patients with fewer negative symptoms and controls tried to self-generate maximal performance on both finger-tapping and peg-placement, with deleterious effects on both tasks. That the patients with marked negative symptoms performed best when their actions were more stimulus-driven than willed strengthens the case that negative schizophrenic symptoms reflect a disorder of willed action.

Keywords: Self-generation; Apathy; Avolition; Motor control; Negative symptoms

1. Introduction

In recent years, schizophrenia has been characterised as a disorder of willed action. For example, Frith and colleagues (Frith, 1992; Jahanshahi and Frith, 1998; Frith et al., 2000) have proposed that an impaired ability to monitor, or to ascribe agency to, one's own actions causes the characteristic Schneiderian symptoms of schizophrenia (e.g., delusions of control, thought insertion). Less attention has been paid recently to the role of impaired initiation (as opposed to monitoring) of willed action in schizophrenia.

In his seminal book "The Cognitive Neuropsychology of Schizophrenia", Frith (1992) proposed a model of stimulus-driven versus willed action in which he distinguished between a breakdown in the monitoring of willed action and a breakdown in the initiation of willed action. While the breakdown in monitoring of willed action purportedly explains the classic Schneiderian symptoms, the breakdown in initiation of willed action

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may explain the negative symptoms of schizophrenia (e.g., apathy, anhedonia). As far back as 1920, Krapelin described the characteristic feature of schizophrenia as a loss of volition (see, e.g., Liddle, 1994, for discussion). Liddle (1994) has also proposed that disordered initiation of willed action plays a primary role in schizophrenia. He reported that patients with chronic schizophrenia performed better on tasks that are externally constrained, such as word repetition, compared to tasks that require self-initiation, such as generating category exemplars.

More recently, Fuller and Jahanshahi (1999a) have investigated willed action in schizophrenia using a series of reaction time tasks. They found that patients with schizophrenia generally slowed down as the demand for volitional control increased. These researchers went on to test finger-tapping (an easy manual task) and peg-placement (a more demanding manual task) under unimanual, bimanual and dual-task conditions in chronic patients with schizophrenia and healthy controls (Fuller and Jahanshahi, 1999b). They found that, while the patients' scores were significantly lower than the controls' scores in the unimanual conditions, the patients improved their peg-placement and slowed down their finger-tapping in the dual-task condition relative to their unimanual performance. Controls, in contrast, performed more poorly on both finger-tapping and peg-placement relative to unimanual performances. These authors suggested that the patients were using their finger-tapping just like an 'external' pacing-stimulus for concurrent peg-placement, while the controls were trying to self-generate maximal performance on both tasks. In other words, peg-placement became more stimulus-driven than volitional in patients in the dual-task condition.

The present study aims to investigate peg-placement cued by an external pacing-stimulus (a metronome), in addition to the unimanual, bimanual and dual-task conditions for finger-tapping and peg-placement in chronic patients with schizophrenia and healthy controls. That patients and controls might benefit differentially from practice is also examined. If chronic patients with schizophrenia use finger-tapping like an external pacing-stimulus for peg-placement in the dual-task condition, their level of improved peg-placement (relative to unimanual scores) should be similar to their level of improved peg-placement cued by a metronome.

2. Method

2.1. Participants

Twenty-seven clinical participants (15 males, 12 females) were recruited from outpatient clinics of the South Western Sydney Area Health Service. Twenty-two had a DSM-IV (American Psychiatric Association, 1994) diagnosis of schizophrenia and five were diagnosed with schizoaffective disorder. Mean age was 37.7 years (range 21–54). This was a chronic group with a mean illness-duration of 13.9 years (SD 7.3). Age of illness-onset ranged from 15–42 years (mean 23.7). All but one patient was receiving neuroleptic medication (five typical, 20 atypical, and one typical-plus-atypical combination). Twenty-two patients (82%) were right-handed. Fifteen healthy controls (7 females, 8 males), matched to the patient group on age, sex and IQ, were recruited from the general community and from amongst university students. Controls were screened using the affective, psychotic and substance abuse screening modules from the Structured Clinical Interview for DSM-IV Axis 1 Disorders (SCID-I: First et al., 1996). Their mean age was 36.9 years (range 18–55). Thirteen (87%) were right-handed. Exclusion criteria for both groups included history of central nervous system disease or head injury, current substance abuse and less than 8 years of formal education.

2.2. Materials and procedure

Following administration of the National Adult Reading Test (NART: Nelson, 1982) to assess pre-morbid IQ, participants completed the following tasks:

(1) Unimanual finger-tapping: Participants repeatedly tapped the right or left Shift-key on a standard computer keyboard using their right or left index finger as quickly as possible for 30 s. Order of hands was counterbalanced. The computer recorded the number of finger-taps per hand, which were then averaged.
(2) Unimanual peg-placement: Participants placed pegs (3 mm × 25 mm) one after the other in a vertical row of the Purdue Pegboard using their right or left hand as quickly as possible for 30 s. Order of hands was counterbalanced. The experimenter recorded the number of pegs placed per hand, which were then averaged.
(3) Bimanual finger-tapping: Participants finger-tapped with both hands simultaneously for 30 s. The number of finger-taps per hand was totalled and averaged across both hands.
(4) Bimanual peg-placement: Participants placed metal pegs in two adjacent vertical rows using both hands simultaneously for 30 s. The number of pegs placed per hand was totalled and averaged across both hands.

Table 1
Demographics and clinical data for healthy controls, Low-N patients and High-N patients

Group	Age	FSIQ	Depression	SAPS
Controls	36.9±13.0	104.2±12.9	3.0±2.2	
Low-N patients	38.3±8.2	99.0±13.0	6.7±5.7	1.5±0.9
High-N patients	36.3±10.1	94.0±13.2	11.3±9.0	2.0±0.9

Data expressed as mean±SD.

(5) Dual-task: Participants placed pegs with one hand while simultaneously tapping the computer Shift-key with their other hand for 30 s. The task was repeated with the alternate hand-task combination and the number of finger-taps and pegs placed averaged across both hands.
(6) Peg-placement cued by metronome: The computer was used to record a metronome beating at the same rate as a participant's dual-task finger-tap speed. The recorded beat was then played as participants placed pegs unimanually for 30 s. Number of pegs placed was averaged across both hands.

In accord with Fuller and Jahanshahi (1999b), scores for Tasks 3–6 were converted to a percentage of the participant's unimanual score for the relevant task in order to indicate whether their performance had dropped off relative to their unimanual performance (i.e. fell below 100%) or improved (i.e. exceeded 100%).

Order of Tasks 1–5 was counterbalanced. After completing Tasks 1–5, participants completed the Annett Handedness Scale (Annett, 1970) while the experimenter prepared the metronome recording for Task 6, which came next. Following that, participants were asked to repeat the unimanual peg-placement task in order to assess the effects of practice.

On completion of the experimental tasks, all participants were interviewed and their levels of depression assessed using the Hamilton (1967) Depression Scale.[1] The symptoms of clinical participants were also rated using the Scales for assessment of Positive and Negative Symptoms of Schizophrenia (SAPS and SANS: Andreasen, 1982, 1984).

3. Results

Initial group comparisons revealed that, while the patients performed more poorly than the controls in the unimanual conditions, P's<0.005, the patient group, as a whole, did not show the expected superiority for peg-placement in the dual-task condition, $P>0.05$. However, closer examination of the data revealed that these group comparisons were obscuring finer-grained distinctions within the patient group, in particular, between patients with marked negative symptoms and those without. In order to explore these differences further, patients were sub-grouped into a High-N group (average SANS global ratings of 2 or more: $N=8$) and a Low-N group (average SANS global ratings<2: $N=19$). Table 1 provides demographic and clinical data for the two patient subgroups. The High-N and Low-N patient groups did not differ significantly from each other, or from controls, in years of age, $F(2,39)=0.14$, $P=0.87$, or NART-estimated IQ, $F(2,39)=1.69$, $P=0.20$. Severity of positive symptoms was also similar in the two patient groups, $t(25)=2.00$, $P=0.06$. However, the High-N patients were significantly more depressed than the Low-N patients and the healthy controls, $F(2,37)=5.23$, $P=0.01$.

In order to evaluate the possible differential effects of practice, a (2×3) mixed ANOVA was used to compare peg-placement with and without practice across the three groups (Healthy controls, Low-N patients, High-N patients). Table 2 illustrates results. While the main effects of practice, $F(1,39)=28.46$, $P<0.005$, and group, $F(2,39)=12.66$, $P<0.005$, were significant, there was a non-significant interaction of group×practice, $F(2,39)=1.52$, $P=0.23$. The results of an ANCOVA controlling for depression were similar. All participants benefited from practice and practice effects were similar across groups with the High-N patients placing significantly fewer pegs unimanually than the controls and the Low-N patients with and without practice.

Fig. 1 illustrates scores for the bimanual, dual-task and metronome conditions, relative to unimanual performance. This set of data was analysed using a (3×5) mixed design with 3 levels on the between factor group (Healthy controls, Low-N patients, High-N patients) and 5 levels on the repeated factor task (Bimanual finger-tap, Bimanual peg-placement, Dual-task finger-tap, Dual-task peg-placement, Metronome peg-placement). Results

Table 2
Peg-placement scores with and without practice for the healthy controls, Low-N patients and High-N patients

Task	Controls	Low-N Pat's	High-N Pat's
Unimanual peg-placement	16.3±1.4	15.0±1.6	12.9±1.9
Unimanual peg-placement after practice	17.4±1.3	15.6±1.4	14.2±2.6

Data expressed as mean±SD.

[1] Two healthy controls did not complete the depression interview.

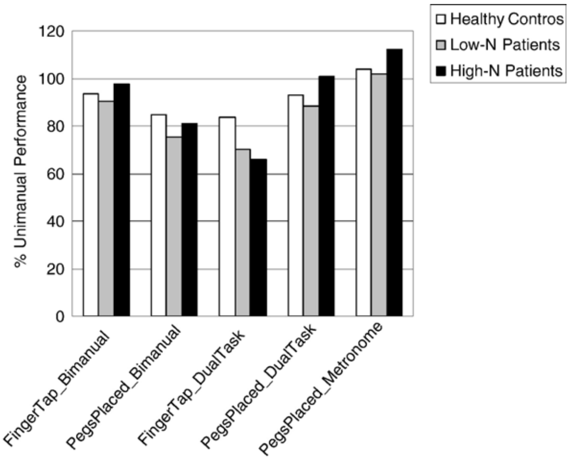

Fig. 1. Bimanual, dual-task and metronome-cued scores (expressed as a percentage of unimanual scores) for finger-tapping and peg-placement in healthy controls, Low-N patients and High-N patients.

revealed significant main effects of group, $F(2,39)=4.86$, $P=0.013$, and task, $F(2.55,99.28)=52.37$, $P<0.005$, as well as a significant interaction of group × task, $F(1.09, 99.28)=2.85$, $P=0.018$.[2] The results of an ANCOVA controlling for depression were similar.

The two-way interaction reflected different between-group profiles for the dual-task finger-tap condition compared to the dual-task peg-placement and peg-placement with metronome conditions. Dual-task finger-tapping slowed down relative to unimanual performance (i.e. relative scores fell below 100%) more so in patients, in particular High-N patients, than controls, $F(2,39)=3.78$, $P=0.03$. While the number of pegs placed in the dual-task condition also dropped off relative to unimanual scores in the healthy controls and the Low-N patients, the performance of the High-N patients was quite different, $F(2,39)=4.13$, $P=0.02$. These High-*N* patients did not show a similar drop in performance and showed a mean relative score that was slightly higher than 100%. In other words, the High-N patients were placing just as many pegs, and sometimes more, while concurrently finger-tapping as they had when placing pegs unimanually. Finally, metronome-cueing improved peg-placement across groups (i.e. relative scores exceeded 100% in all groups). However, it was the High-N patients who showed most benefit from the external pacing-stimulus when compared to the Low-N patients and the healthy controls, $F(2,39)=5.27$, $P=0.009$.

[2] Greenhouse–Geisser corrections are used since the assumption of sphericity was violated.

Since our criterion for sub-grouping patients into a High-N group and a Low-N group might be deemed arbitrary, and since the number of High-N patients was small, correlational analyses were also carried out. Correlations results for the full patient sample mirrored the ANOVA results reported above. There was a significant negative correlation between the ratings of negative symptoms and unimanual peg-placement, $r=-0.51$, $P=0.006$, and significant positive correlations between the ratings of negative symptoms and peg-placement scores (relative to unimanual performance) in the dual-task, $r=0.43$, $P=0.027$, and the metronome, $r=0.46$, $P=0.017$, conditions. Partial correlations, adjusting for depression, were similar. In other words, the patients with more severe negative symptoms placed fewer pegs unimanually (i.e. when required to self-initiate their actions), yet showed the greatest improvement in peg-placement when concurrently finger-tapping and when provided with an external pacing-stimulus.

4. Discussion

The aim of the present study was to investigate unimanual peg-placement cued by a metronome, in addition to the unimanual, bimanual and dual-task conditions used previously by Fuller and Jahanshahi (1999b) in chronic patients with schizophrenia and healthy controls. That patients and controls might benefit differentially from practice was also examined. It was hypothesized that if patients use finger-tapping like an external pacing-stimulus for peg-placement in the dual-task condition, while controls try to self-generate maximal performance on both tasks, the patients' relatively superior improvement in dual-task peg-placement should be mirrored by a similar enhancement of peg-placement cued by a metronome.

Predictions were supported by the data. First we note that practice effects were similar across controls and patient sub-groups. In the dual-task condition, finger-tapping dropped off relative to unimanual performance more so in patients, in particular those with marked negative symptoms, than controls. The number of pegs placed by controls and patients with fewer negative symptoms also dropped off relative to unimanual performance, while the patients with more severe negative symptoms placed just as many pegs, and sometimes more, while concurrently finger-tapping as they had when placing pegs unimanually. Furthermore, while metronome-cueing improved peg-placement in all participants, it was the patients with more severe negative symptoms who benefited most from the external pacing-stimulus, similar to their peg-placement improvement while concurrently finger-tapping.

Correlation results were entirely consistent with the ANOVA results. Patients with more severe negative symptoms placed fewer pegs unimanually when self-initiating actions without the aid of an external pacing stimulus, yet showed the greatest improvement in peg-placement while concurrently finger-tapping and when cued by a metronome.

Limitations of the present study need to be acknowledged before final conclusions. Our clinical sample was generally small and our sub-grouping procedure resulted in an even smaller number of High-N patients. These small numbers might prompt concerns about the robustness of our findings, despite consistencies between the ANOVA and the correlation results reported above. As such, our findings must be considered preliminary and warrant replication with a larger clinical sample.

In conclusion, schizophrenic patients with marked negative symptoms performed poorly when self-generating responses on a demanding manual task (i.e. peg-placement) and performed better when cued by an external-pacing stimulus (a metronome) and when, in the dual-task condition, they could use their finger-tapping just like an external pacing-stimulus. That the patients with marked negative symptoms performed better when their actions were more stimulus-driven than volitional supports the view that the negative symptoms of schizophrenia reflect a disorder of will (Frith, 1992; Liddle, 1994). Findings also hint at the type of disorder of will that is associated with negative symptoms in schizophrenia. To clarify, there are two ways in which a disorder of will might contribute towards negative symptoms. First, there might be a difficulty with summoning one's will to act. Second, there might be a difficulty with enacting one's will, once volition has been summoned. Frith (1992), for example, has proposed a distinction between: (1) disruption of the connections between goals and the 'will to act'; and (2) disruption of the connections between the will to act and the generation of action. That the patients with marked negative symptoms in the present study appeared more ready to abandon wilful control of their finger-tapping in the dual-task condition suggests that it is the first type of disorder of will that is associated with the negative symptoms of schizophrenia. Such an interpretation also accords with Frith who has proposed that negative schizophrenic symptoms reflect a disconnection between goals and the will to act, while the negative symptoms that are associated with Parkinson's disease reflect a disconnection between the will to act and the generation of action.

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