Time course of inhibition and facilitation in patients with schizophrenia

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Time course of inhibition and facilitation in patients with schizophrenia

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Introduction. Negative priming (NP) paradigms have been used extensively to understand the nature and time course of inhibitory deficits in patient populations. A majority of these studies have reported abnormal NP effects, with patients showing faster reaction times on NP sequences compared to the slowing displayed by controls.

Methods. A Stroop NP task was employed to measure immediate (within-trial) attentional processing as well as the sustainment (between-trial) of these processes in 12 medicated schizophrenia inpatients and 13 matched controls. Two response stimulus intervals (RSIs) were presented (500 ms and 2000 ms). Within-trial Stroop effects (interference and facilitation) and between-trial priming effects (negative and positive priming) were measured. Clinical symptomatology and duration of illness were also examined.

Results. At short RSIs of 500 ms, chronically ill state hospital schizophrenia patients failed to exhibit NP. In contrast, the control subjects exhibited normal NP at the short RSI but this priming faded at the long 2000 ms RSI and was no longer significant. The facilitatory priming effects remained stable across time in both groups.

Conclusions. These results suggest that schizophrenia patients are better able to inhibit irrelevant stimuli that are immediate, but the sustainment of inhibition across very short time intervals (500 ms) may fade compared to controls.

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Cognitive deficiencies have been described in schizophrenia patients since the end of the 19th century (Bleuler, 1911). Deficits in both memory and attention have been observed in schizophrenia patients across multiple processing domains and modalities (Cohen & Servan-Schreiber, 1993; Nestor et al., 1991; Neuchterlein & Dawson, 1984). Significant deficits on both spatial (Carter et al., 1996; Park & Holzman, 1992) and nonspatial working memory tests (Gold, Randolph, Carpenter, Goldberg, & Weinberger, 1992; Tamlyn et al., 1992) have been observed in patients with schizophrenia as well as first-degree relatives of schizophrenia patients (Park & Holzman, 1995). All of these tasks depend on the ability to hold on-line previously displayed information in order for a correct response to be executed (Goldman-Rakic, 1990). Furthermore, recent studies have shown increased performance deficits by schizophrenia patients at longer inter-stimulus intervals, with medication-withdrawn patients in particular performing at lower levels than medicated patients (Cohen & Servan-Schreiber, 1993).

Language patterns also reveal deficiencies in maintaining information over time (i.e., reduced syntactic complexity, Cohen & Servan Schreiber, 1993; Morice, 1986). Psycholinguistic analyses of schizophrenia speech have been employed by some researchers to better understand the abnormal patterns of language (Andreasen, Hoffman, & Grove, 1982). Results suggest that the abnormal patterns of schizophrenia speech reflect both deficiencies in working memory capacity and the inability to plan discourse. Similar language-processing deficits have been observed in patients with prefrontal lesions suggesting that the prefrontal cortex may be involved in maintaining cognitive processing across time (Coull, Frackowiak, & Frith, 1998; Koski & Petrides, 2001; Paus et al., 1997). As imaging studies have reported hypofrontality in subgroups of schizophrenia patients, decreased metabolism of the frontal lobe could be one contributing factor to deficits in maintaining information across time (Carter et al., 1998; Hazlett et al., 2000; Volz et al., 1999).

Although deficits in sustained processing have been widely reported in the schizophrenia literature (see Cornblatt & Erlenmeyer-Kimling, 1985), a number of studies have reported that the cognitive performance of the schizophrenia patients improves when the information to be processed is more immediate or “on-line” (Carter, Robertson, & Nordahl, 1992; Elkins & Cromwell, 1994; Kopp & Rist, 1999). Elkins and Cromwell (1994) found no performance differences between patients and controls on a standard flanker attention task using letter stimuli. Kopp, Mattler, and Rist (1994) reported a similar finding using a spatial variant of the same task. Several Stroop studies using the single trial-by-trial method have also failed to find abnormal interference effects in schizophrenia patients (Carter et al., 1992; Salo, Robertson, & Nordahl, 1996; Salo, Robertson, Nordahl, & Kraft, 1997; Taylor, Kornblum, & Tandon, 1996). The “immediacy” of the information in guiding behaviour seems to be a powerful determinant of attentional functioning in patients with schizophrenia.
(Cohen & Servan-Schreiber, 1993; Salzinger, Portnoy, Pisoni, & Feldman, 1970). Because the findings point to temporal distance as a critical factor in modulating attention in schizophrenia patients, tasks that measure cognitive operations across time may be well suited to assess attentional performance in patients with schizophrenia.

**PRIMING**

One method that has been widely used to study the time course of attentional processing is priming. Priming evaluates performance on a current trial as a function of a previous trial without resorting to memory instructions. It can be used to measure the cost and benefit of an attentional process across time. Priming tasks come in many forms, use a wide range of stimuli, and can measure both inhibitory (i.e., negative priming) and facilitatory processing (i.e., positive priming).

**Negative priming and clinical populations**

Negative priming paradigms have been used extensively to understand the nature and time course of inhibitory deficits in patient populations. Deficits in negative priming (NP) have been reported in patients with schizophrenia (Beech, Powell, McWilliam, & Claridge, 1989; LaPlante, Everett, & Thomas, 1992; Salo et al., 1996, 1997), schizotypal disorder (Beech & Claridge, 1987), and obsessive-compulsive disorder (Enright & Beech; 1990, 1993a, b; McDonald, Antony, MacLeod, & Swinson, 1999). A majority of these studies have reported abnormal NP effects in these patient groups, with many of the patients showing faster reaction times on NP sequences compared to the slowing displayed by healthy controls. Findings of abnormal NP in these patient groups suggest that either irrelevant information was not suppressed normally at the time of selection (Tipper, 1985), or that an inhibitory tag associated with ignored information at the time of selection was maintained over time in normals but faded between trials in the patient groups (Neill, Valdes, Terry, & Gorfein, 1992).

**Positive priming and clinical populations**

Abnormal sequential suppression effects and abnormal positive priming or hyperpriming effects have been reported in both psychiatric and neurological patient populations (Beech et al., 1989; LaPlante et al., 1992; Salo et al., 1996; Spitzer et al., 1993). Several groups have reported hyperpriming in schizophrenia patients (e.g., Henik, Nissimov, Priel, & Umansky, 1995; Kwapił, Hegley, Chapman, & Chapman, 1990; Manschreck et al., 1988; Spitzer et al., 1993), although other studies have failed to find increased positive priming in this population (e.g., Barch et al., 1996; Chapin et al., 1992; Henik, Priel, & Umansky, 1992; Ober et al., 1995; Vinogradov, Ober, & Shenaut, 1992).
Hyperpriming has also been reported in patients with Parkinson’s disease (McDonald, Brown, & Gorell, 1996; Spicer, Brown, & Gorell, 1994), and Alzheimer’s disease (Chenery, 1996; Chertkow et al., 1994).

Time course of sequential priming

A vast body of research has been dedicated to the study of the time course of information processing in normal populations (Posner, 1986). It appears that the quality of input builds up over time, with each input undergoing change as it is replaced by successive stages in processing. Hence, processes that operate early in selection can fade, strengthen, or change as a function of time. In addition, facilitation and inhibition can have different time courses (Muller & Rabbitt, 1989; Schendel, Robertson, & Treisman, 2001). For instance, Posner and Snyder (1975) discovered that facilitatory priming effects (i.e., benefits in reaction time when a letter stimulus was primed with a matching letter) occurred earlier and remained stable compared to inhibitory priming (i.e., costs in reaction time that occurred when a prime was incongruent with the target letter). Muller and Rabbitt (1989) found a similar time course pattern using a spatial cueing paradigm.

Numerous studies have also examined the persistence or time course of negative priming across response stimulus intervals to measure inhibitory persistence (Hasher, Stolzfus, Zacks, & Rypma, 1991; Neill & Westberry, 1987; Tipper et al., 1991). Those studies that randomised response stimulus intervals (RSIs) within blocks showed the greatest temporal decay in negative priming (Neill & Westberry, 1987; Neill & Valdes, 1987). In contrast, those studies that used either a blocked presentation of RSIs in a within-subjects design (Neill et al., 1992) or a between-subjects blocked design (Hasher et al., 1991; Tipper et al., 1991) found less decay at extended time intervals. These findings would suggest that methodological differences may contribute to the different pattern of results reported in the literature.

RATIONALE OF THE STUDY

The dissociation in the temporal properties of inhibition and facilitation (Posner & Snyder, 1975) motivated us to further examine the time course of negative and positive priming in patients with schizophrenia. In our previous priming research using Stroop stimuli (e.g., incongruent, RED printed in blue ink; congruent, RED printed in red ink; and neutral, XXX printed in red ink), we examined interference on-line (e.g., within a trial) and its influence on a subsequent trial (i.e., negative priming) in a group of schizophrenia patients (see Table 1). Reduced negative priming was observed in both medication-withdrawn outpatients (Salo et al., 1996) and more chronically ill state hospital patients (Salo, Henik, Nordahl, & Robertson, in press). Our previous research used relatively short RSIs (500 ms) and thus any change in priming
across longer RSIs was not examined (Salo et al., 1996, 1997, in press). In the current study, we directly compare negative and positive priming at a short (500 ms) and long (200 ms) (RSIs) using Stroop stimuli in order to better understand the time course of sequential processes in schizophrenia patients.

If inhibition takes time to develop (Posner & Snyder, 1975), then it is a reasonable hypothesis that the medicated state hospital patients who failed to exhibit negative priming (NP) at short RSIs, might develop normal inhibitory processing if enough time precedes the subsequent trial (Salo et al., in press). In contrast, if cognitive mechanisms underlying abnormal negative priming are able to sustain an inhibitory tag formed at the time of selection, then there should be no difference in NP at either RSI (Neill et al., 1992). In contrast, if facilitatory priming is a more automatic process, then increased time between trials may have no effect. Furthermore, if within- and between-trial effects are mediated by dissociable mechanisms then there is no reason to assume that the length of the RSI will affect either Stroop interference or Stroop facilitation.

Participants

Thirteen hospitalised psychiatric inpatients and 13 control subjects participated in the experiment. The data from one male patient was excluded due to excessive errors on the Stroop task. All patients had been administered the Structured Clinical Interview and Diagnostic Interview (SCID) and were given a verified diagnosis of schizophrenia or schizoaffective disorder according to DSM-IV criteria (Spitzer & Williams, 1986) by a psychiatrist author of this study (T.E.N). All patients reported normal colour vision and had normal or corrected-to-normal visual acuity. Patients were screened for negative and positive symptoms using the Scale for Assessment of Negative Symptoms (SANS) and the Scale for Assessment of Positive Symptoms (SAPS) rating scales (Andreasen 1982, Andreasen & Olsen, 1982), (see Table 1 for demographics). All patients were medicated and had continued use of the same neuroleptic medication for the previous two months and a fixed dosage for the two weeks prior to participation in the study (see Table 2). All subjects were right-handed. Exclusionary criteria included the following: (1) history of head trauma or neurological injury; (2) coexisting axis II disorder; (3) history of drug or alcohol abuse within the last year.

All 13 control participants reported normal colour vision and had normal or corrected-to-normal visual acuity. Exclusionary criteria for the controls were the

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1 Data from the patients in the short RSI condition were previously reported in a study that compared hospitalised schizophrenia patients to outpatients (Salo et al., in press). Data in the long RSI have never been published.
Control subjects were excluded if they reported a history of psychiatric illness or a family history of psychiatric illness. The two groups did not differ significantly in age ($F < 1$) or parental level of education, $F(1, 23) = 2.57; p > .05$. There was a significant difference in education levels, $F(1, 23) = 6.81; p < .05$, with the controls having more education than the patients (see Table 1). Both patients and controls were paid for their participation in the study and all gave informed consent.

**TABLE 1**
Demographic and clinical characteristics of subjects

<table>
<thead>
<tr>
<th></th>
<th>Patients ($n = 12$)</th>
<th>Controls ($n = 13$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean, SD)</td>
<td>40.4 (8.1)</td>
<td>38.0 (12.2)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Female</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Age at first psychiatric Hx (mean)</td>
<td>19.6 (6.5)</td>
<td>21.7 (9.8)</td>
</tr>
<tr>
<td>(mean chronicity)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean education (years)</td>
<td>12.3 (2.1)</td>
<td>14.6 (2.3)</td>
</tr>
<tr>
<td>Mean parental level of education (years)</td>
<td>12.7 (1.8)</td>
<td>14.5 (3.5)</td>
</tr>
<tr>
<td>SAPS ratings (mean)</td>
<td>29 (15.1)</td>
<td></td>
</tr>
<tr>
<td>SANS ratings (mean)</td>
<td>16 (13.1)</td>
<td></td>
</tr>
</tbody>
</table>

HX = history.

**TABLE 2**
Mean dosage of antipsychotic medication (in milligrams)

<table>
<thead>
<tr>
<th>Medication</th>
<th>Patients ($n = 12$)</th>
<th>Mean dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quietapine</td>
<td>5</td>
<td>210 mg</td>
</tr>
<tr>
<td>Clozapine</td>
<td>3</td>
<td>260 mg</td>
</tr>
<tr>
<td>Respirodone</td>
<td>1</td>
<td>8 mg</td>
</tr>
<tr>
<td>Haloperidol</td>
<td>2</td>
<td>10 mg</td>
</tr>
<tr>
<td>Valproic acid</td>
<td>1</td>
<td>1500 mg</td>
</tr>
</tbody>
</table>

Note: 1 of the schizophrenia patients was taking anticholinergic only; 2 were taking anticholinergics + depakote, and 1 was taking depakote only.
Apparatus

Stimuli were presented on a 14 inch VGA colour monitor. An IBM-compatible computer controlled stimuli presentation and data collection. Voice responses were recorded via a voice-operated relay interfaced to the microcomputer. Response timing was to 1 ms resolution and was controlled by the 8253 chip. Stimulus timing was tied to the vertical synchronous pulse.

Stimuli

Four colours were employed in this experiment: red, green, blue, and yellow. The incongruent stimuli were created by printing each of the four colour names in the three other ink colours. The congruent stimuli were created by printing each of the four colour names in its own colour. The neutral stimuli consisted of strings of XXXXs printed in one of the four colours of ink. Each letter within the stimulus words was upper case and subtended 1 degree vertically. The width of each word display varied as a function of the word presented (range 3–6 letters: approximate 2.4–5.4 visual degrees). There were three sequential conditions: In the colour-colour sequence, the colours of the stimuli on trials \( n-1 \) and \( n \) were the same, but the levels on the irrelevant dimensions were different—the word RED in blue ink followed by the word GREEN in blue ink; in the unrelated control sequence, the two stimuli were different on the levels of both relevant and irrelevant dimensions—the word RED in blue ink followed by the word GREEN in yellow ink; and in the word-colour sequence, the irrelevant word on trial \( n-1 \) was the same as the relevant colour on trial \( n \)—the word RED in blue ink followed by the word GREEN in red ink. For a given pair of stimuli, the leading stimulus (the one referred to as the stimulus on trial \( n-1 \) ) was always an incongruent stimulus.

<table>
<thead>
<tr>
<th>TABLE 3</th>
<th>Negative and positive priming sequences</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Negative priming conditions</strong></td>
<td><strong>Trial n-1</strong></td>
</tr>
<tr>
<td>SUP-SAY Trials</td>
<td>RED (printed in blue ink)</td>
</tr>
<tr>
<td><strong>Positive priming conditions</strong></td>
<td><strong>Trial n-1</strong></td>
</tr>
<tr>
<td>SAY-SAY Trials</td>
<td>RED (printed in blue ink)</td>
</tr>
<tr>
<td>SUP-SUP Trials</td>
<td>RED (printed in blue ink)</td>
</tr>
</tbody>
</table>
Procedure

Subjects were given instructions to discourage a speed/accuracy trade-off in that they were instructed to say aloud as rapidly and accurately as possible the ink colour that the words were printed in while ignoring the word itself. Each trial began with a blank screen followed by the stimulus at the centre of the screen. The onset of the subject’s voice triggered the voice-operated relay switch (recorded by the computer to the nearest msec) and terminated the stimulus display on the screen. The experimenter then typed in the first letter to record the subject’s response, which also initiated the subsequent trial.²

There were two blocks of trials, each one composed of 162 stimuli: 58 neutrals, 54 congruent, and 50 incongruent. Half of the trials in a block were related and half unrelated. The first trial (trial “n-1”) was not analysed for negative priming costs, thus served as a filler and was always an incongruent trial. In the critical pairs the leading stimulus was always incongruent and in the filler pairs it could be any one of the three congruency conditions. The trailing stimulus in each critical pair was further analysed and will be referred to here as a critical stimulus. Two response stimulus intervals (RSIs) were employed (500 ms and 2000 ms). RSIs were blocked and counterbalanced across subjects with half of the subjects performing the short RSI first and the other performing the long RSI first. A practice block was administered but was not included in the analysis.

Data analysis

Median RTs for correct responses for every condition were computed for each subject. Analysis of variance procedures for repeated measures were used to analyse the data in a $2 \times 2 \times 3 \times 3$ mixed ANOVA with group as a between-subjects factor (patients vs. controls) and RSI (short vs. long), word type (congruent vs. incongruent vs. neutral), and priming (colour-colour CC; word colour, WC; and unrelated NR) as within-subjects variables. Incorrect responses were not included within the analysis of variance for RT. Further analyses were planned to examine the effect of error responses on within- and between-trial effects. Although RT analyses were not carried out on difference scores, planned comparisons of facilitation (neutral minus congruent RT) and interference (incongruent minus neutral) as well as negative priming (WC-NR) and positive priming effects (NR-CC) were performed across all subjects.

² Any interval in the short RSI block that exceeded 500 ms and 2000 ms in the long RSI block were not included in the RT analysis. A very small number of trials (approx. 1%) were excluded.
RESULTS

Analyses revealed a main effect of group, $F(1, 23) = 17.38$, $MS_e = 244,457$, $p < .001$, with the schizophrenia group exhibiting significantly slower RTs (872 ms) than controls (678 ms). There were also main effects of RSI, $F(1, 23) = 4.88$; $MS_e = 45,725$; $p < .05$, word type, $F(2, 46) = 128.17$, $MS_e = 8,072$, $p < .001$, and priming, $F(2, 46) = 71.8$; $MS_e = 6,482$, $p < .001$. In addition, there was a significant interaction between group and RSI, $F(1, 23) = 5.76$, $MS_e = 45,725$, $p < .05$, and Stroop and priming, $F(4, 92) = 6.61$, $MS_e = 4,320$, $p < .001$, as well as a triple interaction between group, RSI and priming, $F(2, 46) = 4.12$, $MS_e = 3,304$, $p < .05$.

In order to determine the source of these interactions, planned comparisons were performed. Groups differed significantly on negative priming effects at short RSIs, $F(1, 23) = 4.11$, $MS_e = 6,938$, $p = .05$ (+35 ms and −20 ms for the patients and controls, respectively) but did not differ at the longer RSI ($F < 1$). This was because schizophrenia patients failed to exhibit significant negative priming at both response stimulus intervals. In contrast, the controls exhibited significant negative priming at the short RSI but the priming faded at the longer RSI (2000 ms) when negative priming was no longer significant for the controls ($F < 1$). The positive priming remained significant for both groups at the longer time intervals. Positive priming did not differ between schizophrenia (scz) patients (114 ms) and controls (90 ms) at the short intervals, $F(1, 23) = 1.08$, $MS_e = 5,378$, $p > .05$, or the long interval (scz = 94 ms; controls = 92 ms); $F < 1$. The groups did not differ significantly in within-trial Stroop effects (i.e., interference or facilitation) at either RSI, $F(2, 46) = 2.00$, $MS_e = 8,072$, $p > .05$. This is an important finding as it shows that the severely impaired schizophrenia patients are capable of ignoring irrelevant information within a trial.

Within-trial interference was significant for controls at both short RSIs $F(1, 12) = 141.48$, $MS_e = 1,892$; $p < .001$, and long RSIs $F(1, 12) = 45.58$, $MS_e = 6,678$, $p < .001$. Interference effects were also significant for the patients at short, $F(1, 11) = 50.49$, $MS_e = 5,059$, $p < .001$, and long intervals, $F(1, 11) = 41.2$, $MS_e = 11,877$, $p < .001$. Mean interference costs did increase in the schizophrenia group across RSIs but the group interaction did not reach significant levels, $F(1, 23) = 1.39$, $MS_e = 4,721$, $p = .25$.

Error analyses

Errors were analysed with the same design. Analyses revealed a main effect of word type, $F(2, 46) = 13.7$, $MS_e = 0.01$, $p < .001$, as well as significant interactions between group and RSI, $F(1, 23) = 6.7$, $MS_e = 0.01$, $p < .05$, and group, RSI, and Stroop word type, $F(2, 46) = 4.84$, $MS_e = .01$, $p < .05$. Planned comparisons revealed that both groups made significantly more errors in the incongruent condition (7%) than in either the neutral condition (2%) or the
congruent condition (2%). Errors on congruent trials are difficult to interpret as word reading errors would be coded as correct responses.

Controls showed a greater number of errors at the short RSI (4%) compared to the longer RSI (2.6%), $F(1,12) = 6.98; p < .05$. Patients with schizophrenia displayed an equal number of errors at both time intervals (4%). The increased error rates in the schizophrenia patients was consistent across RSIs for incongruent trials (7%) and actually doubled for neutral word types: short RSI = 2%; long RSI = 4%; $F(1,11) = 3.6; p = .08$, although this difference was only a statistical trend. In contrast, the error rate dropped significantly for the control subjects at the longer RSI for incongruent word types, $F(1,12) = 9.5; p < .01$. Although not statistically significant a trend also emerged for the neutral errors decreasing at the longer RSIs in the

Figure 1. Interference and facilitation across response stimulus intervals (RSIs).
control subjects $F(1, 12) = 3.19; p = .10$. Mean error rates for each group are reported in Tables 4 and 5.

**DISCUSSION**

The data from this current study suggest that chronically ill patients with schizophrenia fail to exhibit normal negative priming at both short RSIs (500 ms) and longer RSIs (2000 ms) despite normal on-line Stroop RT interference effects. These findings are consistent with other studies on negative priming and schizophrenia (Beech et al., 1989; LaPlante et al., 1992; Salo et al., 1996, in press). These results suggest that the memory trace for the inhibitory tag is very short (i.e. less than 500 ms), or perhaps not created at all for a subset of patients with schizophrenia, including those who are chronic and hospitalised. In contrast, healthy matched control subjects exhibit normal negative priming (NP) effects at the short RSI (500 ms) but the inhibitory tag decays in this Stroop NP task at RSIs of 2000 ms. The decay in healthy control subjects has been reported before (Neill & Westberry, 1987). Although significant NP has been found at longer RSIs in target localisation tasks (Neill et al., 1992), and in experiments using novel stimuli (DeSchepper & Treisman, 1996) it is quite possible that the duration of NP differs according to task demands. The duration of negative priming may be modulated by the both the difficulty of the task and the familiarity of the stimuli (i.e., how much processing capacity is needed). In the

**TABLE 4**  
500 ms RSI condition. Median reaction times for between-trial and within-trial conditions across groups (in ms)

<table>
<thead>
<tr>
<th></th>
<th>Word-colour</th>
<th>Unrelated</th>
<th>Colour-colour</th>
<th>Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congruent</td>
<td>652 (99)</td>
<td>657 (72)</td>
<td>578 (87)</td>
<td>.02</td>
</tr>
<tr>
<td>Incongruent</td>
<td>830 (131)</td>
<td>794 (114)</td>
<td>663 (94)</td>
<td>.08</td>
</tr>
<tr>
<td>Neutral</td>
<td>684 (96)</td>
<td>654 (80)</td>
<td>596 (86)</td>
<td>.03</td>
</tr>
<tr>
<td>Interference</td>
<td>146</td>
<td>140</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>Facilitation</td>
<td>32</td>
<td>3</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Error data</td>
<td>.05</td>
<td>.04</td>
<td>.04</td>
<td></td>
</tr>
<tr>
<td>Patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congruent</td>
<td>782 (108)</td>
<td>785 (127)</td>
<td>728 (125)</td>
<td>.03</td>
</tr>
<tr>
<td>Incongruent</td>
<td>919 (146)</td>
<td>1016 (214)</td>
<td>808 (105)</td>
<td>.07</td>
</tr>
<tr>
<td>Neutral</td>
<td>818 (136)</td>
<td>823 (178)</td>
<td>745 (141)</td>
<td>.02</td>
</tr>
<tr>
<td>Interference</td>
<td>101</td>
<td>193</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Facilitation</td>
<td>36</td>
<td>38</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Error data</td>
<td>.05</td>
<td>.03</td>
<td>.03</td>
<td></td>
</tr>
</tbody>
</table>
DeSchepper and Treisman study novel, previously unstudied stimuli were employed, while in the present study familiar words and colours were repeatedly presented throughout the task.

In addition to abnormal NP effects, the schizophrenia patients also failed to take advantage of the extra time between trials at the longer RSIs to reduce error rates compared to matched controls. Although there was no difference in error rates between the groups when RSIs were combined, a very different pattern emerged as a function of time. Control subjects reduced their error rates on both neutral and incongruent word types when they had more time between trials, while error rates remained constant or increased at the long RSI for the schizophrenia patients. This finding is an additional piece of evidence that temporal gaps or a slowed presentation pace may contribute to processing deficits in schizophrenia patients compared to matched controls. Thus, a slowed pace or temporal distance between trials may impair the ability of the schizophrenia patients to allocate attentional resources as evidenced by increased error rates at the longer RSI.

Although normal NP has been reported in some studies with medicated schizophrenia outpatients (Salo et al., 1997), but not all (David, 1995), it should be noted that the inpatients in the current study had been ill for almost double the length of time as the outpatients from our previous studies. In addition, the

<table>
<thead>
<tr>
<th></th>
<th>Word-colour</th>
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<th>Errors</th>
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<td>M (SD)</td>
<td>M (SD)</td>
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<td>656 (75)</td>
<td>579 (95)</td>
<td>.02</td>
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<td>807 (116)</td>
<td>688 (135)</td>
<td>.04</td>
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<td>103</td>
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<td></td>
<td></td>
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</tr>
<tr>
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<td>878 (207)</td>
<td>767 (156)</td>
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<td>1092 (247)</td>
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patients in this study exhibited a high level of positive symptoms as measured by the SAPS. As others and we have reported previously, there appears to be a relationship between symptomatology and abnormal priming effects (Park, Lenzenweger, Puschel, & Holzman, 1996; Peters et al., 2000; Salo et al., in press). Peters et al. reported that in a study of patients with diverse psychiatric disorders, it was the presence of strong positive symptomatology that predicted abnormal performance on a Stroop negative priming test, not diagnoses. Park et al. found abnormal NP effects in a group of acutely psychotic schizophrenia patients but not in a more chronic stable groups of schizophrenia patients.

General slowing

Many cognitive deficits reported in the schizophrenia literature may represent some type of generalised deficit, such as general slowing, associated with the schizophrenia syndrome (Chapman & Chapman, 1989). The finding of abnormally ‘‘fast’’ response times on NP sequences in the chronic schizophrenia patients in this study argues against such a generalised deficit. It is possible, however, that a subject might be adjusting his/her performance based on a speed-accuracy trade-off, but additional analyses does not support such a trend. A small but positive correlation was observed in the patients (r = .33), indicating that the slower the reaction time the greater the amount of errors. Because attentional deficits related to inhibitory priming are paradoxically linked to ‘‘faster’’ or ‘‘better’’ performance, NP paradigms are powerful tools to measure cognitive dysfunction and have been utilised in a number of clinical studies of: schizotypal personalities (Beech et al., 1989), obsessive-compulsive disorder (Enright & Beech, 1993a, b; Enright, Beech, & Claridge, 1995; MacDonald, Antony, MacLeod, & Swinson, 1999), neglect (Fuentes & Humphreys, 1996), and schizophrenia (La Plante et al., 1992; Salo et al., 1996, 1997).

SUMMARY

The present study adds additional evidence that attentional deficits reported in patients with schizophrenia may be both time and context dependent. This study systematically manipulated response stimulus intervals and evaluated both facilitatory and inhibitory processing in schizophrenia patients. Priming studies in the normal cognitive literature have demonstrated the importance of methodology in producing replicable priming effects (Neill & Valdes, 1992; Neill et al., 1992). This present study has carefully controlled for all those factors, thus increasing the potential for accurately measuring deficits resulting from attentional pathology rather than experimental design.

Behavioural deficits exhibited by patients with schizophrenia in a wide array of cognitive domains can be conceptualised as failures of cognitive control, due to ‘‘an impaired ability to internally represent, maintain, and update context
information’’ (Braver, Barch, & Cohen, 1999). Patients with schizophrenia appear to be deficient in utilising contextual information to guide their performance (Barch et al., 1996; Salzinger et al., 1970; Shakow, 1962; Stratta, Daneluzzo, Bustini, Prosperini, & Rossi, 2000). When information is immediate, patients appear to be able to utilise that information efficiently to guide attentional inhibition. In contrast, when a temporal gap exists between one item and another, patients with schizophrenia exhibit cognitive deficits in attentional processing. These deficits may result from a lack of sufficient resources necessary to build up sustained inhibition, or a loss of the inhibitory trace that appeared earlier in the stream either of the item itself or the trace of the process (inhibition) associated with that item. The data from the current study and from our previous findings support the latter hypothesis (Salo et al., 1996, 1997). If a longer RSI allowed for the build-up of inhibition over trials in the chronic schizophrenia patients, one would expect to see normalised or increased NP at the longer RSI and greater NP effects overall, but this did not occur. In addition, the error rates increased at the longer RSI in the patient group while they decreased in the control group.

This abnormal decay of the inhibitory tag at relatively short time intervals (500 ms) is consistent with other theories of episodic memory trace decay and deficits in short-term visual memory functions associated with schizophrenia (Rabinowitz, Opler, Owen & Knight, 1996). These findings are also similar to those reported in the latent inhibition (LI) literature (for a review, see Lubow & Gerwitz, 1995). In the LI paradigm previously exposed stimuli subsequently become the signal to which the subjects must respond, similar to NP tasks. Deficits in latent inhibition have been reported in high schizotypal individuals (Lubow & De La Casa, 2002) as well as acutely ill schizophrenia patients (Baruch et al., 1988; Gray et al., 1995). In addition, the failure to find group differences in positive priming at either RSI in the presence of abnormal negative priming suggests that the time course of inhibitory and facilitatory processing may differ for schizophrenia patients just as it does for healthy control subjects (Muller & Rabbitt, 1989; Posner & Snyder, 1975; Schendel et al., 2001). This dissociation in sequential processing warrants further exploration in patients with schizophrenia.

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REFERENCES


