Direct and indirect semantic priming with neutral and emotional words in schizophrenia: Relationship to delusions

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Introduction. Evidence is accumulating that suggests that semantic networks are abnormal in schizophrenia. Methods. To investigate this further, we examined priming in 42 schizophrenics and 28 normal controls on a lexical decision task involving three different prime-target conditions all at 700 ms stimulus onset asynchrony (SOA): directly semantically related, indirectly semantically related, and unrelated; and three types of emotional pairings: positive, negative, and neutral. Two schizophrenic groups were compared: nondeluded (no current delusions) and deluded. Results. Schizophrenic patients did not demonstrate significant direct priming overall, whereas controls did. However, when material was examined according to emotional pairing, the controls and deluded subjects demonstrated significant priming to neutral word pairs. Neither schizophrenic group showed direct priming with positive and negative word pairings, the deluded subjects showing inhibition of priming with negative stimuli. Controls failed to show direct priming with negative stimuli. Indirect priming was obtained in all groups. The absence of direct priming and indirect priming with negative material in deluded subjects was particularly striking. The results point to quantitative and qualitative abnormalities in semantic networks in schizophrenia. Conclusions. We propose that delusions may be the result of intact, unusual (indirect) associations in contrast to poorer normal (semantic) associations; a particular bias being shown toward material of a negative valence.

Disordered associative processes or semantic memory are increasingly being recognised as central to cognitive deficits in patients with schizophrenia (Chen, Wilkins, & McKenna, 1994; McKay et al., 1996; Paulsen et al., 1996; Tamlyn et al., 1992), with schizophrenic thinking typically characterised by loose, mediated, indirect, and oblique associations (Neuchterlein & Dawson, 1984). In recent years modern cognitive theories have been used to address the
association disturbances in schizophrenia. The current model of semantic
associations or memory is based on a spreading activation network, which
postulates a series of connected nodes that store semantic/world knowledge
information (Collins & Loftus, 1975), activation of which spreads to related
nodes. One of the most popular paradigms used in semantic memory research is
semantic priming (for a review see Neely, 1977), which examines common word
associations. The subject is presented with two words in quick succession and
has to respond overtly to the second (either by word pronunciation or lexical
decision). Priming is the decrease in reaction time (RT) to pronounce/respond to
a word when the previous word was directly related as opposed to unrelated, i.e.
a prime-target of arm-leg vs. arm-duck. It is believed that the decrease in RT is
the result of activation spreading through the association network from prime to
target. Priming is believed to involve both automatic spreading of activation
through the semantic network, and two further controlled processes. Controlled
processes are defined as those that involve conscious attentional capacities and
strategic factors. These processes are influenced by the stimulus onset
asynchrony (SOA); the time that has elapsed from prime presentation to the
the onset of the target and the number of prime-target relationships within a
study list.

There has been much interest in direct semantic priming in patients with
schizophrenia. However, results to date are rather contradictory, some studies
report increased direct semantic priming (greater reduction in RT to directly
related pairs) [Henik, Nissimov, Priet, & Umansky, 1995; Kwapisl, Hegley,
Chapman, & Chapman, 1990; Manschreck et al., 1988; Spitzer, Braun, Hermle,
& Maier, 1993a; Spitzer, Braun, Maier, Hulme, & Maher, 1993b; Spitzer et al.
1994; Weisbrod, Maier, Horig, Himmelsbach, & Spitzer, 1998], others have
recorded decreased priming (increase in RT to related word pairs) [Barch et al.,
1996 (>950 ms SOA); Besche et al., 1997; Henik, Priet, & Umansky, 1992
(240 ms SOA); Ober, Vinogradov, & Shenaut, 1995 (exp. 4); Passerieux, HardyBayle, & Widlocher, 1995 (paranoid patients); Vinogradov, Ober, & Stenaut,
1992 (exp. 2)], and lastly, in some studies there was no difference between
control participants and schizophrenic subjects [Barch et al., 1996 (<950 ms
SOA); Chapin, Vann, Lycaki, Josef, & Meyendorff, 1989; Chapin, McGown,
Vann, Kenny, & Yousseff, 1992; Henik et al., 1992 (1840 ms); Ober et al., 1995
(exp. 1, 2, and 3); Passerieux et al. 1995 (64 ms SOA and hebephrenic patients at
240 ms SOA); Vinogradov et al., 1992 (exp. 1)].

Additionally, Spitzer et al. (1993a,b) has examined indirect semantic priming
in schizophrenia: where the prime and target are connected with a mediating
associated word, e.g., black (white) chalk. Spitzer and colleagues reported that
only schizophrenics demonstrate significant indirect priming at both short and
long SOAs (200 and 700 ms), whereas controls only show indirect priming at
700 ms SOA. These findings have been recently replicated at the short SOA (a
long SOA was not studied) (Weisbrod et al., 1998), in thought disordered (TD)
schizophrenics and nonthought disordered (NTD) patients and controls. However, in normal subjects word pronunciation paradigms have recorded significant priming with indirect word pairs at various SOA’s (Balota & Lorch, 1986; Sayette, Hufford, & Thorson, 1996), whereas studies using lexical decision paradigms, have produced mixed findings (McKoon & Ratcliff, 1992; Shelton & Martin, 1992).

Methodological and clinical variables

Throughout the priming research literature as applied to schizophrenia, five variables are identified as influential; stimulus onset asynchrony (SOA), percentage of prime-target pairs utilised, type of task used (WP, LD), medication, and the symptomatology of the patient. First, some authors have argued that the length of the SOA (the time from prime to target presentation including any interval of a blank screen) has important effects on whether there is increased or decreased priming in schizophrenic subjects. Generally, it is has been assumed that increased direct semantic priming in schizophrenia occurs at a short SOA (i.e. <400 ms) (Henik et al., 1995; Manschreck et al., 1988; Spitzer et al., 1993a,b, 1994; Weisbrod et al., 1998). Thus, researchers have argued that automatic processes are intact or even disinhibited in schizophrenia. However, an examination of the literature does not reveal such a clear pattern. Chapin et al. (1989, 1992) presented both prime and target together (i.e., zero SOA) and reported priming in the schizophrenics, no different from that of controls, whereas, Passerieux et al. (1995) used a 64 ms SOA and reported that schizophrenics showed less direct semantic priming than control subjects. The studies using a 200 ms SOA from one research group have all shown increased priming in schizophrenics, especially those with thought disorder (Spitzer et al., 1993a,b, 1994; Weisbrod et al., 1998), whereas Barch et al. (1996) did not find any difference between controls and schizophrenics on a semantic priming task at 200 ms SOA.

There are many studies which have used a 240/250 ms SOA; three demonstrated no difference in the direct priming of schizophrenics and controls [Ober et al., 1995 (exp. 1, 2, and 3); Passerieux et al., 1995 (hebephrenic patients); Vinogradov et al., 1992 (exp. 1)]. Four studies have reported a decrease (no facilitation) in priming in schizophrenic patients [Henik et al., 1992; Ober et al., 1995 (exp. 4); Passerieux et al., 1995 (paranoid patients); Vinogradov et al., 1992 (exp. 2)]. The other studies showed an increase in priming in the patients (Henik et al., 1995; Manschreck et al., 1998; Weisbrod et al., 1998). The pattern of results for mid range and long SOAs is equally opaque.

Vinogradov et al. (1992) argued that the discrepancy between the slowed RT to the primed targets (decreased priming) found in some studies and those that have found increased priming is due to differences in the percentage of prime-
target pairs utilised and not slight differences in the timing of the SOA. When a low percentage is used (<25%) there is equivalent or decreased priming in schizophrenia compared with controls (Besche et al., 1997; Chapin et al., 1989, 1992; Henik et al., 1992; Passerieux et al., 1995; Ober et al., 1995; Vinogradov et al., 1992); whereas higher percentages (>25%) have showed increased priming (Henik et al., 1995; Kwapil et al., 1990; Manschreck et al., 1998; Spitzer et al., 1993a,b, 1994; Weisbrod et al., 1998). Barch et al. (1996) is the only study that does not conform to this pattern. Using a 50% prime-target pairs, they reported decreased or no difference in priming. Ober et al. (1995) also stated that decreased priming was only found in certain circumstances, specifically, tasks involving LD, and prime-target pairs that are horizontally related, that is, co-members of the same category (cat-dog), and not vertically related pairs (subordinate-superordinate: fruit-pear).

Two studies have concentrated on the effects of medication and priming performance in schizophrenia. Spitzer et al. (1994) provided pilot study data on 11 medication-free patients during the acute phase of illness and later when medicated, with the illness in remission. The results were unclear as to whether the noted reduction in direct priming was due to clinical differences or medication. Barch et al. (1996) examined the role of medication more thoroughly, matching medicated and non-medicated patients on the degree of positive symptoms experienced. They suggested that medication dosage was significantly associated with increased direct priming scores with SOA under 950 ms.

One problem within schizophrenia research is the heterogeneity of its major syndromes, leading some cognitive researchers to study single symptoms. A number of studies have demonstrated that patients with thought disorder show a greater increase in direct semantic priming compared to nonthought disorder schizophrenics and psychiatric controls (Manschreck et al., 1988; Spitzer et al., 1993b; 1994; Weisbrod et al., 1998), and the results used as evidence that activation within the semantic network is either broader and/or of greater magnitude in TD. However, Besche et al. (1997) recently demonstrated decreased direct priming in thought disorder patients compared with nonthought disorder patients and controls; as previously discussed they have pointed to procedural differences as a possible explanation for the atypical results. Also within this realm are several studies which have examined subtypings in schizophrenia, for example, Passerieux et al. (1995) compared paranoid and hebephrenic schizophrenic subtypes: hebephrenic patients demonstrated the same pattern of significant direct priming as controls, whereas, the paranoid patients did not show direct semantic priming (i.e., a deficit) at 240 ms SOA. Last, Chapin et al. (1992) reported no difference in priming in three schizophrenic subtypes: chronic undifferentiated, schizo-affective, and paranoid. Therefore, at present there appears to be no clear-cut evidence for particular subtypes of schizophrenics showing increased or decreased semantic priming.
Delusions

Delusions are commonly defined as abnormal beliefs but could also be construed as statements and inferences based on a faulty knowledge-base or semantic system. To date, the effect of delusions on the direct semantic priming paradigm has not been fully examined (Spitzer et al., 1994). Rossell, Shapleske, and David (1998) recently used a sentence verification task to investigate semantic memory in patients with delusions. They established that cognitive bias towards certain emotional themes may underlie illogical semantic connections and delusions, in agreement with previous studies on attentional bias towards delusion-sensitive material (Bentall, Kaney, & Bowen-Jones, 1995; Leafhead et al., 1996). However, the study also indicated that higher order semantic processes may be disturbed in patients with delusions. Also shown by Rossell, Rabe-Hesketh, Shapleske, and David (1999), this study established that deluded schizophrenics were differentially impaired on a test of semantic fluency in comparison to phonological fluency, and that further analysis of word associations during semantic fluency showed deluded subjects were more idiosyncratic than those patients who were not currently deluded or normal controls.

Attentional bias has also been reported in other psychiatric disorders using direct semantic priming paradigms: Richards and French (1992) demonstrated increased priming to threat-related stimuli in high versus low anxiety subjects. The anxious subjects again seemed to lock on to stimuli which were preoccupying their thoughts. Whereas, Matthews and Southall (1991) examined depressed patients and controls on a priming task with neutral, negative, and positive word pairs. Depressed subjects showed increased priming of neutral words at a 240 ms SOA but no differences at 1500 ms or with the emotional word pairs. The findings suggest that there may be impaired automatic associations of emotional concepts in depression.

There is extensive evidence to suggest that emotions bias our perceptions, beliefs, and actions in characteristics ways (for a review see Power & Dalgleish, 1997). For example, several studies have investigated the effects of mood induction on semantic priming in normal subjects. Originally, Clark, Teasdale, Broadbent, and Martin (1983) reported that lexical decision times for positive, negative, and neutral words were not influenced by mood induction: mood-congruent words were not faster than mood-incongruent words (see also Weaver & McNeill, 1992). Challis and Krane (1988) subsequently showed that subjects with induced elated mood did demonstrate facilitated lexical decisions of positive words, whereas depressed induced subjects did not show the reverse for negative words (also see Hanze & Hesse, 1993; Hesse & Spies, 1996). The results of these studies have suggested that both positive and negative moods heighten subjects’ awareness to the semantic relationship between primes and targets and facilitate the spread of activation. Such studies raise questions
about the effect of the emotionality of the stimuli on cognitive processes, especially stimuli that are related to a patient’s thought processes or preoccupations.

From the foregoing review we propose that the inconclusive nature of priming experiments can be explained by: (1) differences in methodology; (2) heterogeneity among patients with schizophrenia; and (3) failure to control the emotional or personal relatedness of the material used. In an attempt to overcome these confounding factors we designed a priming experiment which contained a number of novel variations. First, we specifically selected patients on the basis of the unequivocal presence or absence of a single symptom, namely delusions (not thought disorder that has previously been extensively investigated by Spitzer et al., 1993a,b). Second, we have tried to integrate work from social and cognitive psychology by employing stimuli with differing emotional content: negative, positive, and neutrally toned words, for use in a LD priming paradigm. Third, we sought to investigate indirect as well as direct semantic priming as the former according to Spitzer and colleagues may be a more specific probe for disordered semantic networks in schizophrenia. Last, we chose to use a single medium-to-long SOA (see Spitzer et al., 1993a,b) to investigate these effects due to the aforementioned equivocal differences between long and short SOAs and a need to limit the number of independent variables; the primary interest being the effects of emotionality.

We predicted that: (1) patients with schizophrenia would demonstrate a greater decrease in RT (i.e., increased priming of emotional stimuli, especially negative stimuli, due to heightened awareness of such stimuli); (2) this would be especially marked in patients with prominent delusions; and (3) indirect semantic priming would be most influenced by the content of the material used; (4) since delusions can be conceived of as erroneous connections between items in semantic memory at the expense of more conventional/logical connections, we conjectured that deluded subjects would show relatively increased indirect semantic priming alongside reduced direct semantic priming.

**METHOD**

**Subjects**

A sample of 42 right-handed (Edinburgh Inventory, Oldfield, 1971) (laterality coefficient cut off of >50) male schizophrenics was recruited from the inpatient and outpatient departments of the Maudsley Hospital, London. All patients were diagnosed as suffering from schizophrenia according to DSM-IV criteria (American Psychiatric Association, 1990) on the basis of interview and chart review. Patients with a history of traumatic brain injury, epilepsy, alcohol or substance abuse, or other neurological or psychiatric conditions were excluded. All subjects were between the ages of 18 and 55 years and had an estimated
premorbid IQ as scored by the National Adult Reading Test (NART; Nelson, 1981) of > 90 (see Table 1). They had a mean age of onset of 23.1 years (SD 5.7) and a mean of 10.9 years illness (SD 8.3). A review of all patients’ medical records revealed that they had all had delusions at some point in their illness. Current psychopathology was rated (by JS) using the Schedule of Negative Symptoms (SANS) and the Schedule of Positive Symptoms (SAPS) (Andreasen & Olsen, 1982) prior to testing. Patients were divided into two groups, those with no current delusions \((n = 16)\) (SAPS delusion rating of 0–1), those with delusions \((n = 26)\) (SAPS rating 2–5). The currently deluded patients had a range of different delusions, 93% of them scored highly on persecutory delusions and many also had grandiose delusions. All the deluded patients were so on the day of testing and those not currently deluded had been so for at least 6 weeks. There was no significant difference between the two patient groups on total number of positive or negative symptoms as scored by the SANS and SAPS. The mean dosage of medication in chlorpromazine equivalent units for the patients was 861.1mg (SD 649.8), again with no significant difference between the two patient groups, although, currently deluded patients tended to be on a higher dosage.

A total of 28 normal right-handed (Oldfield, 1971) male controls were also recruited for the study by advertisement in two local London job centres. There was no significant difference in age, number of years in education or IQ as scored by the NART between the schizophrenics and controls, nor was there any significant difference between the two subgroups of patients (Table 1). Informed consent was obtained from both subject groups.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Demographic and clinical characteristics of the subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Controls ((n = 28))</td>
</tr>
<tr>
<td>Age</td>
<td>33.3 (9.7)</td>
</tr>
<tr>
<td>Years of education</td>
<td>14.6 (3.3)</td>
</tr>
<tr>
<td>IQ (NART)</td>
<td>116.0 (8.9)</td>
</tr>
<tr>
<td>Medication CPZ equivalents</td>
<td>–</td>
</tr>
<tr>
<td>Mean positive symptoms (SAPS)</td>
<td>–</td>
</tr>
<tr>
<td>Mean negative symptoms (SANS)</td>
<td>–</td>
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</tbody>
</table>

CPZ = Chlorpromazine.
Apparatus and stimuli

The stimuli for this study were selected from a list of 260 words. This list was constructed first, from a selection of negative word associations from French and Richards (1992), second, from a list of semantically related words from Shelton and Martin (1992) and last, from a list of indirectly related words from Richards and Chiarello (1995). The final list was rated by 33 normal control subjects selected from members of the Institute of Psychiatry staff as to how positive/pleasant or negative/unpleasant the word was on a 7-point scale; −3 being the most unpleasant, 0 neutral (no particular emotional content), and 3 the most positive. According to these ratings the words were then characterised as either being negative (a mean score of $< -0.05$), neutral (a mean score between $-0.05$ and 0.05), or positive ($> 0.05$). A list of 64 legally spelled nonwords was constructed by the experimenters. The nonwords were formed by changing one or two letters of real words to make them look as real as possible, thus increasing the difficulty of the lexical decision task. The nonwords were between 3 and 9 letters long (average = 5.27 letters).

A total of 192 words (16 were shown twice) was selected, between three and ten letters long (average = 5.12 letters). Most of these words were nouns although a few were adjectives and verbs. Next, the stimuli were organised into 128 pairs, a prime and a target; the 128 primes only appeared once throughout the experiment. There were four types of prime type, directly semantically related words, indirectly semantically related words, unrelated words, and nonword pairs (see Table 2 for examples).

Directly related prime types were chosen from published category norms from either Shelton and Martin (1992), Battig and Montague (1969) or Shapiro and Palermo (1968). Indirectly related prime types were constructed utilising Richards and Chiarello (1995) or Spitzer et al. (1993b). The unrelated prime types (or baseline condition) were constructed by pairing 16 primes with ten “old” targets from the directly related word pair set and six from the indirectly related word pair set. Nonwords pairs included a word prime and nonword target.

Additionally, words were only paired together if they belonged to the same category of emotion (i.e., negative with negative); and only neutral words were used for the unrelated prime type pairs. This was to increase the unrelatedness of the pairs (i.e., not related by emotionality). Within each of the other prime types (directly related, etc.), one-third was neutral, a third positive, and a third negative (Table 2). Last, to control for any other possible confounds known to effect lexical decision tasks all the four prime types and the three emotional types of word pairs (neutral, negative, positive) were matched for overall word length, mean word frequency (words were only selected between 10 and 200 words per million from Kutíra & Francis, 1967), imaginability and concreteness (words were only selected with high concreteness and imaginability from Toglia & Battig, 1978), and last, associative value (from Postman & Keppe, 1970; Richards & French, 1992).
The prime-target pairs were divided into two stimulus sets, in each set there were a total of 64 word pairs: 32 nonword pairs, 16 directly related pairs, 8 indirectly related pairs and 8 unrelated pairs. The order of word pairs in both stimulus sets was initially randomised within a set but then remained constant for all presentations. An additional practice set was constructed in the same way. No results were recorded for these items.

**Procedure**

Stimuli were presented on an IBM-compatible PC. All words were written in 60-point Helvetica font, in lower case, and displayed at a viewing distance of 60 cm. Data were collected automatically by the computer, namely, accuracy and reaction time.

Initially, the computer screen was blank whilst the instructions were given to the subject. The instructions were given by SLR who was blind to diagnosis. The experiment began when the subject indicated that he fully understood by pressing the space bar. A fixation point was displayed in the centre of the screen for 700 ms followed by the presentation of the first word to be read for 200 ms. The screen went blank for 500 ms (an ISI of 500 ms) and then the target word was presented until the subject made a response, or 2000 ms had elapsed. All words were presented in the centre of the screen over where the fixation point had been. Following the subjects’ response, the screen went blank again for 500 ms before the next word was presented.

All subjects were tested individually. They were told that they would be presented with pairs of words or strings of letters which would follow each other quickly in time. The task of the subject was to silently read the first word then when the second word or letter string appeared, they were required to decide quickly and accurately whether or not it was a word that could be found in the English dictionary, by pressing the right or left mouse button respectively with their right hand. Subjects began with the practice trials, and when it was clear that they understood the test, the first stimulus set was presented. After a rest period they completed the second stimulus set. The order of stimulus sets was randomised across subjects.

<table>
<thead>
<tr>
<th>Neutral</th>
<th>Negative</th>
<th>Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directly related pairs (32)</td>
<td>ceiling-floor (12)</td>
<td>mug-attack (10)</td>
</tr>
<tr>
<td>Indirectly related pairs (16)</td>
<td>tea (coffee) bean (6)</td>
<td>fork (knife) cut (5)</td>
</tr>
<tr>
<td>Unrelated pairs (16)</td>
<td>tea-maze (16)</td>
<td>–</td>
</tr>
<tr>
<td>Non-word pairs (64)</td>
<td>pine-jair (22)</td>
<td>grave-krife (21)</td>
</tr>
</tbody>
</table>

*Note: Numbers in parentheses indicate the number of words in the condition.*
Design

The between-subject comparison was group (controls vs. nondeluded vs. deluded). The within-subject variables were, prime type (direct, indirect, unrelated) and emotionality (negative, neutral, positive).

Data analysis

Reaction time data frequently produces outlier responses (Ratcliff, 1993). Such outliers are usually the result of medication effects and illness in general and are probably not the result of delusions. Several statistical methods have been used to overcome this problem including data trimming, using medians rather than means, and logarithmic transfer. In this study we decided to transform the data using an inverse transformation (1/RT) as this method reduces the effects of long reaction times (more common in the patient group) and does not reduce statistical power as with median responses (see also Barch et al., 1996). The results on transformed data are therefore reported throughout our ANOVA analysis, however, for ease of presentation Table 3 shows both untransformed and transformed reaction times (the untransformed data is clearly more meaningful to most readers).

RESULTS

Reaction times were calculated from correct responses only. The mean reaction time and percentage errors were treated as the raw data. The data were not trimmed. Schizophrenics generally have slower reaction times than controls; this finding holds true for all data in this study. The mean overall reaction time for controls was 843 ms (SD 245) and for schizophrenics 1036 ms (SD 195), which differs significantly, \( F(1, 68) = 13.38, p < .000 \). Controls made 6.64% errors overall, whereas schizophrenics made 10.19%, a nonsignificant difference, \( F(1, 68) = 3.27, \text{n.s.} \). There was a significant difference in errors between deluded (12.9%) and nondeluded (5.76%) schizophrenics, \( F(1, 40) = 6.48, p < .02 \). Further analysis of the error data did not show any further significant findings either across the prime types (directly, indirectly or unrelated) or across emotionality types (neutral, positive, and negative), therefore these data will not be reported. Correlations between overall RT and percentage of errors were not negative in controls (\( r = .19, p < .33 \)) or schizophrenics (\( r = .13, p < .41 \)), indicating there was no speed accuracy trade off in either group.

The mean 1/RT to direct, indirect and unrelated word pairs was used as the dependent variable throughout the analysis (see Table 3).

Delusions

First, a subject-wise 3 x 3 ANOVA was performed involving three groups (controls, nondeluded, and deluded) and the 1/RT of the three prime types (direct, indirect, and unrelated). The results of this ANOVA showed main effects
of group, $F(2, 67) = 9.75, p < .0001$, and prime type, $F(2, 134) = 16.65, p < .0001$, and a significant interaction of subject group $\times$ prime type, $F(4, 134) = 2.85, p < .026$. Further, planned post-hoc analysis of the group main effects using Student Newman–Keuls comparisons for unequal sample sizes, demonstrated that both deluded and nondeluded subjects were significantly slower overall than the normal controls ($p < .05$). However, there was no difference in RT between the two patient groups (nondeluded 1035 ms and deluded 1036 ms). The main effect of prime type suggests that there were significant differences in overall RT to each of the different prime types (RTs: direct 869 ms, indirect 841 ms and

<table>
<thead>
<tr>
<th>TABLE 3</th>
<th>Untransformed raw RT and transformed data (means and standard deviations across deluded and nondeluded schizophrenia patients, and normal controls on priming tasks)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Controls $(n = 28)$</td>
</tr>
<tr>
<td></td>
<td>Total Group $(n = 42)$</td>
</tr>
<tr>
<td>Directly related</td>
<td>0.744 (0.27)</td>
</tr>
<tr>
<td>Neutral only</td>
<td>1.477 (0.41)</td>
</tr>
<tr>
<td>Negative only</td>
<td>0.731 (0.27)</td>
</tr>
<tr>
<td>Positive only</td>
<td>1.504 (0.43)</td>
</tr>
<tr>
<td>Indirectly related</td>
<td>0.810 (0.30)</td>
</tr>
<tr>
<td>Neutral only</td>
<td>1.357 (0.38)</td>
</tr>
<tr>
<td>Negative only</td>
<td>0.729 (0.31)</td>
</tr>
<tr>
<td>Positive only</td>
<td>1.529 (0.45)</td>
</tr>
<tr>
<td>Unrelated</td>
<td>0.731 (0.26)</td>
</tr>
<tr>
<td>Non word</td>
<td>1.485 (0.39)</td>
</tr>
<tr>
<td>Semantic priming</td>
<td>0.739 (0.27)</td>
</tr>
<tr>
<td>Indirect Priming</td>
<td>1.481 (0.42)</td>
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<tr>
<td>Negative only</td>
<td>0.718 (0.27)</td>
</tr>
<tr>
<td>Positive only</td>
<td>1.559 (0.50)</td>
</tr>
<tr>
<td>Unrelated</td>
<td>0.702 (0.23)</td>
</tr>
<tr>
<td>Non word</td>
<td>1.541 (0.42)</td>
</tr>
<tr>
<td>Semantic priming</td>
<td>0.814 (0.29)</td>
</tr>
<tr>
<td>Indirect Priming</td>
<td>1.336 (0.35)</td>
</tr>
<tr>
<td>Negative only</td>
<td>0.948 (0.28)</td>
</tr>
<tr>
<td>Positive only</td>
<td>1.136 (0.30)</td>
</tr>
<tr>
<td>Unrelated</td>
<td>0.069 (0.11)</td>
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<tr>
<td>Semantic priming</td>
<td>62.3 (239.9)</td>
</tr>
<tr>
<td>Indirect Priming</td>
<td>0.083 (0.09)</td>
</tr>
<tr>
<td>Semantic priming</td>
<td>2.29 (49.8)</td>
</tr>
</tbody>
</table>

*Note: Transformed data are in italics.*
unrelated 918 ms). Newman–Keuls comparisons showed that both patient groups were significantly slower than the controls on all three prime types ($p < .05$), but there was no difference between the deluded and nondeluded subgroups. The interaction between group and prime type is shown in Figure 1 which displays the mean RT across groups of the three prime types. All groups show slowest RT to the unrelated prime type, but the extent of priming differs according to diagnostic group.

In order to establish the role of emotionality on priming two further ANOVAs were performed, one for direct priming the other for indirect. First, a subject-wise $3 \times 4$ ANOVA involving three groups (controls, nondeluded, and deluded)

![Figure 1. Mean reaction times for the primed lexical decision task in the different subject groups.](image)

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1Considerable thought was given to how the ANOVA analysis proceeded at this stage. Calculating the ‘‘priming effects’’ or difference in RT between related and unrelated word pairs actually confounds the effects of slowed RT with the effects of primary interest. Therefore, if a single ANOVA with 3 groups $\times$ 2 priming effects (direct and indirect) $\times$ 3 emotional conditions was performed all the results would suffer from this confound. Thus, separate analyses for direct and indirect priming according to emotional valence were conducted without calculating the priming effect. This type of analysis does not allow comparison of the interaction between the two prime types, however, this can be inferred from the analysis and the mean scores.
and four prime-target relations (neutral directly related, negative directly related, positive directly related, and unrelated) revealed significant main effects for subject group, $F(2, 67) = 9.79$, $p < .0001$, and for relatedness, $F(3, 201) = 10.30$, $p < .0001$. There was also a group $\times$ priming effect interaction, $F(6, 201) = 2.25$, $p < .04$. Post-hoc analyses examining the main effect of subject group, with Newman–Keuls comparisons for unequal group sizes, indicated as noted earlier that deluded and nondeluded schizophrenic subgroups together had significantly increased overall RT to these prime-target pairs in comparison with the control group ($p < .05$), although there was no difference between them. For the main effect of relatedness, the shortest RT was for neutral, then positive directly related pairs, then the unrelated, followed by negative word pairs (RTs: neutral 840 ms, positive 854 ms, unrelated 918 ms, and negative 946 ms). These results suggest that for all the subjects, neutral and positive word pairs do show a priming effect whereas the negative directly related word pairs cause interference and do not prime. The interaction indicates that patients and controls showed different effects of relatedness for the four types of emotional word pairs (see later).

Second, a subject-wise $3 \times 4$ ANOVA involving three groups (controls, nondeluded, and deluded) and four prime-target relations (unrelated, neutral indirectly related, negative indirectly related, and positive indirectly related) revealed significant main effects for subject group, $F(2, 67) = 9.52$, $p < .0001$, and for relatedness, $F(3, 201) = 10.00$, $p < .0001$. There was no group $\times$ relatedness interaction, $F(6, 201) = 0.91$, $p < .49$. Post-hoc analyses examining the main effect of subject group, with Newman–Keuls comparisons for unequal group sizes, indicated as noted earlier that deluded and nondeluded schizophrenic subgroups had significantly increased overall RT to these prime-target pairs in comparison with the control group ($p < .05$), although there was no difference between them.

In order for us to test our specific hypotheses regarding delusional state and to aid understanding, planned comparisons$^2$ using one-way ANOVA with post-hoc Newman–Kuels analyses were carried out separately on direct and indirect priming data (see Table 3 for raw RT means and SDs). The degree of direct priming was calculated as the difference between the RT of the unrelated and directly related word pairs, whereas indirect priming was the difference between unrelated and indirectly related word pairs. The transformed priming effect measures were used as the dependent variables in the subsequent analyses. Paired $t$-tests were also performed to examine priming effects within each group and for each emotional category. These are indicated in Figure 2.

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$^2$ One-way ANOVA of the priming effect allowed direct comparison of the two patient groups on each of the three emotional types not available by contrasts.
Direct semantic priming (See Figure 2 throughout the next two sections). The one way ANOVA demonstrated a main effect of subject group when examining overall direct priming, $F(2, 67) = 4.79$, $p < .01$, with significant differences between the controls and both schizophrenic groups ($p < .05$), but no difference between the two schizophrenic groups. Post-hoc paired $t$-tests revealed that overall only controls showed a direct priming effect, $t(1, 29) = 4.8$, $p < .0001$. Further, one-way, ANOVA’s separately examining emotionality revealed significant main effects of group for neutral, positive, and negative direct priming, $F(2, 67) = 3.72$, $p < .03$, $F(2, 67) = 3.45$, $p < .04$, $F(2, 67) = 6.73$, $p < .002$ respectively. Post-hoc Newman–Kuels showed significant differences between controls and nondeluded subjects on neutral direct priming ($p < .05$). For positive direct priming both schizophrenic subgroups were significantly different from the controls ($p < .05$) but not from each other, and last, controls differed from the deluded patients in negative direct priming ($p < .05$), with the deluded group in fact demonstrating interference, that is, a longer reaction time to prime directly related negative material: paired $t$-test unrelated pairs with negative directly related $t(25) = 2.06$, $p < .05$. However, the two patient groups did not differ from each other on direct negative priming. We can see from Figure 2 direct and indirect priming effects of the three groups across each emotional category.
Indirect Semantic Priming. One-way ANOVA examining overall indirect priming showed a nonsignificant trend toward a main effect for subject group, \( F(2, 67 = 2.53, p < .08 \), and there were no significant contrasts between any of the three groups. Further, one-way, ANOVA examining the effects of emotionality demonstrated only a main effect for subject group for indirect negative priming, \( F(2, 67) = 2.97, p < .05 \), with a significant difference between the controls and the nondeluded subjects; the nondeluded subjects failing to show significant negative indirect priming, \( t(15) = 1.15, p < .27 \). There were no group effects for neutral or positive indirect priming. The interactions between stimuli and direct and indirect priming for deluded subjects are illustrated in Figure 3. This shows the contrast between direct and indirect priming of negative word pairs which appears to be specific to the deluded group.

Psychiatric characteristics

In order to examine the effects of general severity of psychiatric symptoms on the priming measures in the schizophrenic subjects, the total/global score for each subgroup on the SANS/ SAPS was entered into a bivariate correlation with the priming scores. One significant correlation worth noting here is between negative indirect priming and the global hallucinations score \( (r = - .39, p < .02 \) (most patients demonstrated a significant degree of auditory verbal hallucina-
tions). Thought disorder\(^3\), overall severity of total symptoms, attention and mood did not significantly correlate with any priming scores.

The possible effects of medication were examined since Barch et al. (1996) recorded significant effects at SOA < 950 ms. Correlations using Pearson’s Product Moment were performed between medication in chlorpromazine equivalent units and direct priming (\(r = .05\), n.s.); indirect priming (\(r = -.06\), n.s.); overall reaction time (\(r = -.10\), n.s.). There were also no significant correlations between medication and the demographic characteristics of the patients.

**Age**

The possibility that there could be a relationship between priming and the age of the subject was also investigated. In the schizophrenic subjects there was one significant correlation, between age and negative direct priming (\(r = -.42\), \(p = .006\)).

**Length of illness**

Maher, Manschreck, Redmond, and Beaudette, (1996) reported a significant correlation between priming and length of illness in schizophrenic patients. However, we failed to confirm this for either direct priming (\(r = -.06\), n.s.) or indirect semantic priming (\(r = .12\), n.s.). A correlation between priming and length of illness was again computed this time partialling out the effects of age. The results failed to demonstrate any relationship between length of illness and direct (\(r = .18\), n.s.) or indirect priming (\(r = .24\), n.s.).

**Education and IQ**

There were no significant correlations between either priming score and estimated premorbid IQ or years of education, in either patients or controls.

**DISCUSSION**

Looking at the pattern of results, we can summarise the findings as follows: indirect semantic priming is reliably present in the normal controls, nondeluded, and deluded subjects at a 700 ms SOA. Direct priming is significantly attenuated in both patient groups compared to controls. Emotional content has an effect on priming (the prime effect by emotion interaction). Furthermore, subtle

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\(^3\)Owing to the recruitment strategy (i.e., according to whether the subjects were deluded or nondeluded), none of the subjects in this sample had a significant degree of thought disorder; only two subjects scored 3 on the SAPS scale and six scored 2, all other subjects scored lower. We therefore could not replicate group comparisons for thought disorder.
differences according to psychopathology emerge when the emotional material is considered. Negative word pairs did not show direct priming in any subject group whereas positive pairs were primed only in normal controls. Indirect semantic priming seemed to reveal important differences between deluded and nondeluded patients only when negative material was considered.

These results suggests inconsistencies in the priming literature using patients with schizophrenia could be due at least in part to the different emotional salience attached to alternative stimulus sets, positive and neutral sets producing a normal pattern of priming and negative emotional sets resulting in deficient priming in schizophrenia. Additionally, contrary to our hypotheses, and unlike anxiety states (Richards & French, 1992), we found deficient direct semantic priming of emotional stimuli, especially negative, in schizophrenia to a greater extent in the deluded schizophrenics, suggesting that heightened preoccupation with such stimuli actually inhibits normal semantic associations, and thus may even produce interference on the priming paradigm. Significantly, the deluded schizophrenics did show direct priming of the positive stimuli in contrast to Matthews and Southall’s (1991) depressed patients, who demonstrated equivalent levels of decreased priming to both emotional word sets. This study therefore indicates that further manipulations examining priming differences between positive and negative word pair sets is essential using larger stimulus sets.

When considering neutral stimuli alone we could not confirm the findings of Spitzer et al. (1993a,b) of increased indirect priming at an SOA of 700 ms in schizophrenics with positive symptoms. It is not clear why there is a discrepancy between some of the previous literature (Balota & Lorch, 1986; McNamara & Altarriba, 1988; Sayette et al., 1996; Spitzer et al., 1993a,b) and this study with regard to controls and indirect priming of neutral stimuli. Only further investigation at different SOAs may elucidate the reasons for this. We would argue that controls and patients experience indirect priming of emotional stimuli, at least in part, due to associations between the prime-target words pairs being triggered by emotional factors. We would also argue that the results on patients suggest the importance of evaluating current symptoms during priming experiments. It may be that the decreased direct priming found in some of the literature might be influenced by state as well as trait features of schizophrenia especially in those with predominately positive symptomatology.

In agreement with our hypotheses it seems there is some suggestion that delusions are associated with erroneous connections between items in semantic memory demonstrated by greater (abnormal) indirect priming alongside lesser (normal) semantic priming especially when negative material is considered. Increased weight given to indirect associations could be the result of preoccupation with delusional themes during periods of active psychosis. This would imply that cognitive therapy techniques aimed at reducing or substituting such preoccupations may be effective (Garety, 1992). Negative stimuli appear to
cause interference to all subjects’ normal direct semantic associations but more so in deluded subjects (see also Kindermann, 1994), whose indirect associations remain strong and direct actually show inhibition (See Figure 3). It is important to note that this study can not predict direction of causality (i.e., whether delusions are the result of unusual associations or unusual association result from delusions), only that an association between the two exists. Clearly, indirect associations alone cannot explain delusions and it is also true to say that patients were not deluded about the actual prime-target pairs [i.e., “tea-(coffee)-bean’’] per se, the results are merely an indication of a pattern of behaviour.

As this study used a relatively long SOA it is unclear whether this abnormal pattern of priming seen in the deluded schizophrenics is the result of impaired extralexical processes for accessing semantic representations or abnormal intralexical associations; again, further work using a shorter SOA may shed light on this issue. Shorter SOAs rely on automatic spreading activation without extralexical strategies, thus if impaired in deluded patients, this would suggest abnormal storage of semantic associations. However, the nondeluded patients in this study show patterns of priming similar to control subjects (but reduced), although they all had experienced delusions at some point in their illness. This suggests that delusions or delusional thinking interferes with normal lexical processes but does not permanently alter the storage of semantic associations. Barch et al. (1996) also propose that higher level extralexical process are the source of language disturbances in schizophrenia.

The results of this study do conflict to some degree the existing literature with regards to the effect of the percentage of prime-target relations; this study has a high percentage (25%) of directly related and 12.5% indirectly related pairs (37.5% overall), and yet showed decreased direct priming between controls and patients. Clearly, all task parameters must be taken into account when interpreting the performance of schizophrenic patients on priming experiments.

It is also important to note that in contrast to previous studies (Barch et al., 1996; Maher et al., 1996), the priming results were not related to any demographic effects in either subject group (education or IQ), or medication and length of illness effects in the schizophrenics. The deluded patients, despite being on nonsignificantly greater doses of neuroleptics, did not show less priming than their nondeluded counterparts overall. These findings, therefore make it easier to relate the priming results to delusional state as opposed to other effects of being “ill”. In contrast to other investigations (Manschreck et al., 1988; Spitzer et al., 1993a,b) we could not relate our findings to the symptom of thought disorder (see footnote 3 on p. 286). However, the overlap between symptoms, such as delusions, hallucinations and thought disorder, cannot always be controlled for as such symptoms often coexist in the same patient. Additionally, a limitation of the study is that only male subjects were used preventing generalisation to female patients.

Further experimental manipulations may shed light on the priming differences between controls and schizophrenics, for example additional SOAs
investigating the possible effects of both shorter and longer intervals on direct and indirect semantic priming as reported on in the introduction. It could be predicted that deluded patients may show less interference of semantic priming of emotional stimuli at shorter SOAs and greater interference at longer SOAs. Second, the systematic study of different proportions of related and unrelated prime-target pairs must be completed in order to fully understand their influence on extralexical processes in schizophrenia. Another manipulation of particular interest would be to examine the effects of more delusions specific stimuli (i.e., word pairs related to persecutory/grandiose themes), and to compare subjects on the basis of such delusions. Last, although differences emerged between deluded and nondeluded patients, the inclusion of alternative control groups (e.g., patients with delusional disorders) would permit the examination of whether these findings with priming are specific to the delusions within schizophrenia or delusions in the context of other psychiatric disorders. The different patterns seen in anxious subjects (French & Richards, 1992) does suggest that the results in the deluded subjects, such as decreased direct semantic priming of emotional stimuli, are not merely a nonspecific effect of anxiety and arousal. It would also be valuable to re-examine priming performance if the current psychopathology of an individual changed, for example if a nondeluded subject became significantly deluded again.

In summary, we must be cautious in drawing firm conclusions from this study as some of our results are based on post-hoc analysis of data based on relatively few observations. Similarly, we have relied on patterns of results across the groups and conditions to infer the effects of presumably subtle interactions between mental state, word meaning, and priming effects. Furthermore, the findings relating to emotional words in this context are novel and require replication. Nevertheless, we have shown that priming in a lexical decision paradigm using a long SOA is sensitive to the emotional content of the word stimuli particularly when it is negative in tone, and that schizophrenia patients with delusions show differential effects compared to nondeluded patients.

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