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Journal of Neurolinguistics ▮ (▮▮▮▮) ▮▮▮–▮▮▮

Journal of NEUROLINGUISTICS

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Schizophrenic patients exhibit hyper-reflexivity in a semantic categorical priming task

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Received 21 December 2005; received in revised form 17 May 2006; accepted 21 May 2006

Abstract

Semantic priming is a phenomenon that occurs when a semantically related "prime" word produces a faster response time to a sequentially presented "target" word than if they were semantically unrelated. This process of priming is thought to involve two distinct processes, one that is reflexive and unconscious, and the other, which is voluntary and intention-driven. It is believed that a dysfunction in one or both of these processes may result in the pattern of thought disorder in schizophrenia. In an attempt to better understand disorganized speech and thought disorder, we examine language processing in schizophrenia by separately studying reflexive and voluntary priming processes using a lexical decision semantic priming task, that is similar to the landmark study with controls by Neely [(1977). Semantic priming and retrieval from lexical memory: Roles of inhibitionless spreading activation and limited-capacity attention. *Journal of Experimental Psychology, 106*, 226–254]. In two experiments, we tested a total of 40 schizophrenic and 40 control subjects. In both Experiments 1 and 2, schizophrenic subjects showed greater semantic priming than control subjects in the reflexive task condition, demonstrating that they seem to exhibit excessive priming of the semantic network. On the other hand, in our study, there were no differences in priming between schizophrenic and control subjects in the voluntary task condition. These results support the idea of a dysfunction in the reflexive system (hyper-priming) as a core deficit in language processing in schizophrenia.
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Keywords: Schizophrenia; Priming; Lexical decision; Reflexive; Voluntary; Language

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0911-6044/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jneuroling.2006.05.002

1. Background

Verbal language deficits are well established in schizophrenia (Allen & Frith, 1983; Aloia, Gourovitch, Weinberger, & Goldberg, 1996; Barch et al., 1996; Chen, Wilkins, & McKenna, 1994). Much of the unusual verbal processing in schizophrenia is believed to be the result of odd or inefficient semantic networks. Recent findings indicate that slowed lexical retrieval (Allen, Liddle, & Frith, 1993; Himelhoch, Taylor, Goldman, & Tandon, 1996; Stolar, Berenbaum, Banich, & Barch, 1994), inappropriate lateral inhibition of multiple items in the same semantic store, (Ober & Shenaut, 1988), sub-optimal semantic organization (Hill, Beers, Kmiec, Keshavan, & Sweeney, 2004; Paulsen et al., 1995), and excessive semantic links (Gouzoulis-Mayfrank et al., 2003; Spitzer, Braun, Maier, Hermle, & Maher, 1993) may all contribute to idiosyncratic language processing found in schizophrenic subjects. These findings of idiosyncratic language processing in schizophrenic subjects commonly use tasks of verbal fluency and verbal memory to investigate semantic context. One such example, Hill et al. (2004), found that schizophrenic subjects perform poorer than controls on the California Verbal Learning Task, producing fewer words at total recall, short- and long-term free recall, and cued recall portions of the task. Besides verbal fluency and verbal memory, other tasks have been used to study idiosyncratic language processing in schizophrenic subjects. Another popular area of research investigates the actual storage, retrieval, and organization of semantic information. For example, Paulsen and colleagues (1995) found that the organization of semantic networks in schizophrenic subjects was more disorganized than that of controls and that this disruption of proper semantic organization was positively correlated with the severity of illness and verbal fluency performance. The results of studies such as Hill et al. (2004) and Paulsen et al. (1995) suggest a dysfunctional semantic network in schizophrenia and improper organization of the nodes in their networks.

In this study, we were interested in how semantic context influences word recognition. Specifically, we wanted to investigate if deficits to particular aspects of the semantic network could result in schizophrenic thought disorder. Thought disorder in schizophrenia is defined as a disruption to the conscious flow of verbal speech, and it is believed that this disordered speech results from disordered thought. We wanted to know if disorganization of the semantic network possibly due to improper activation of certain logogens in the brain could result in this odd pattern of verbal behavior. Many cognitive models of verbal and semantic processing have attempted to explain the unusual processing of words in schizophrenia. Specifically, a number of researchers have investigated semantic processing in schizophrenia, using some version of a semantic priming paradigm (Chapin, Vann, Lycaki, Josef, & Meyendorff, 1989; Condray, Siegle, Cohen, van Kammen, & Steinhauer, 2003). In a typical semantic priming task, subjects are given a "prime" stimulus, which is followed after some time delay by a "target" (a word or letter string). Subjects have to indicate by speeded response (e.g., a key press) whether a target is a valid word, or whether it is a non-word letter string (lexical decision task). The semantic priming effect is the decrease in reaction time to respond to targets (e.g., NURSE) if they are preceded by a related prime (e.g., DOCTOR–NURSE) than if by an unrelated prime (e.g., TABLE–NURSE). There have been a number of studies using the semantic priming task to study semantic memory in schizophrenia. However, these studies show a striking lack of consistency as to whether schizophrenic subjects show larger semantic priming effects than controls (Gouzoulis-Mayfrank et al., 2003; Henik, Nissimov, Priel, & Umansky, 1995;

Kwapil, Hegley, Chapman, & Chapman, 1990; Maher, Manschreck, Hoover, & Weisstein, 1987; Manschreck et al., 1988; Moritz, Mersmann, Kloss, Jacobsen, Andresen, et al., 2001; Moritz, Mersmann, Kloss, Jacobsen, Wilke, et al., 2001; Spitzer, Braun, Maier, et al., 1993; Spitzer et al., 1994; Weisbrod, Maier, Harig, Himmelsbach, & Spitzer, 1998), whether they show priming effects which are equal to those of controls (Barch et al., 1996; Blum & Freides, 1995; Chapin, McCown, Vann, Kenney, & Youssef, 1992), or whether their semantic priming effects are actually smaller than those of controls (Besche et al., 1997; Henik, 1992; Ober, Vinogradov, & Shenaut, 1997; Passerieux et al., 1997; Vinogradov, Ober, & Shenaut, 1992).

Semantic priming effects are thought to involve two different processes. "Automatic" priming effects may reflect "spreading activation" from one part of semantic memory to another, and occur regardless of the subject's intention. In addition, there are "voluntary" priming effects, where identification or classification of target words is facilitated by use of a limited capacity attentional system (e.g., by using expectancy or predictive strategies). Many of the aforementioned studies have not separately examined reflexive and voluntary semantic priming effects. The distinction between reflexive and voluntary processes has proven critical in studies of eye movements and attention in schizophrenia, where schizophrenic patients perform poorly on voluntary tasks but show normal or better (hyper) reflexive performance (e.g., Fukushima et al., 1988, 1990; Meyer & Schvaneveldt, 1973; Sereno, 1992; Sereno & Holzman, 1995). If an analogous pattern exists for semantic priming in schizophrenia, then the failure to control the influence of reflexive and voluntary processes in semantic priming tasks could potentially explain much of the variability that has heretofore been observed in the literature.

There are a handful of studies of semantic priming in schizophrenia that have attempted to systematically manipulate the involvement of voluntary attention systems and their associated voluntary priming effects (Barch et al., 1996; Henik, 1992; Henik et al., 1995; Ober et al., 1997; Spitzer et al., 1994). This has primarily been done by manipulation of the time interval, or stimulus-onset asynchrony (SOA) between the prime and target. The assumption is that short SOAs (250 ms or less) allow time for only reflexive processes to occur before the target appears. Longer SOAs allow time for voluntary attention to influence processing of the target. However, studies including this manipulation have still shown variable results. At short SOAs (i.e. when automatic semantic priming should be occurring) schizophrenics have been shown to have larger, equal, or smaller priming effects than controls. In fact, two studies by Henik came to opposite conclusions regarding the magnitude of reflexive semantic priming in schizophrenia, with one study reporting smaller effects (Henik, 1992) and one reporting larger effects (Henik et al., 1995). Likewise, at long SOAs (i.e. when controlled or voluntary priming effects should occur) semantic priming in schizophrenia populations also varies from study to study (Aloia et al., 1998; Barch et al., 1996).

It is questionable whether the manipulation of time interval (SOA) between prime and target item is sufficient by itself to control for the involvement of voluntary attention processes that can influence performance. It is well known that some voluntary effects can in fact occur even at short prime-target SOAs (e.g., Sereno & Holzman, 1996). In the priming literature, voluntary effects that facilitate the use of information about the target after it is identified are termed "post-lexical." There are many proposals concerning how such post-lexical voluntary effects might operate (for review, see Neely, 1991). Given the existence of post-lexical effects, using a short SOA between prime and target does not by

itself ensure that priming effects are due only to reflexive, automatic processes. Previous studies of reflexive and voluntary semantic priming in schizophrenia have not addressed post-lexical effects. Differences in post-lexical priming effects across different conditions or studies may account for the variability between studies.

2. Current study

Creating conditions where reflexive and voluntary semantic priming effects can be measured in isolation from each other is difficult. Perhaps a more productive and informative strategy is to create a situation where reflexive and voluntary processes are pitted against one another; i.e. where the operation of each leads to opposite influences on performance. Probably the best example in the semantic priming literature comes from Neely's (1977) classic study in normal subjects. We chose to replicate this study of reflexive and voluntary semantic priming in schizophrenic patients.

The goal of these experiments was to examine whether schizophrenic subjects would show different amounts of automatic and voluntary processing as compared to controls. Based on their patterns of dysfunctional semantic or associative processes, we predicted that schizophrenia patients would show equal or enhanced amounts of priming at the short time period (reflexive priming) and would be impaired or show less priming at the long time period (voluntary priming).

3. Experiment 1

3.1. Subjects

Experiment 1 was comprised of 20 controls and 19 schizophrenic patients (one patient was excluded for excessively long reaction times, over two standard deviations from the average response time for the schizophrenic group). All patients were recruited from Harris County Psychiatric Center in Houston, Texas. Control participants were recruited from nearby community colleges and adult education programs. The University of Texas Health Science Center at Houston's Internal Review Board (IRB), as well as Harris County Psychiatric Center's Review Board, approved all aspects of the study before it began. All subjects filled out consent forms and were paid a small amount for their participation in this study.

Schizophrenic patients were diagnosed by a trained, licensed psychiatrist who provided and recommended patients to us based on our criteria outlined below. We only tested DSM-IV diagnosed schizophrenic patients. Normal control subjects were screened for a family history of schizophrenia using a personal questionnaire. For both groups, exclusion criteria included brain or head trauma, epilepsy, Parkinson's disease, stroke, drug abuse, English not as a first language, and a reading level that was below a 4th grade level, as tested with the Wide Range Achievement Test Revision 3 (Jastak, 1946). Controls were matched with patients for age (34.4 versus 32.9 yr), education (11.8 versus 11.9 yr), and reading level (93.4 versus 94.7) (see Table 1A). For each of these factors, we conducted an ANOVA with age, education, or reading level as the dependent measure. There were no main effects or interactions between groups for these factors.

This experiment included 11 schizophrenic patients medicated with Haldol (dose range of 5–20 mg with a group average of 14 ± 4.9 mg, SD), 3 medicated with Prolixin (dose range

Table 1
Subject demographics from Experiments 1 and 2

	Age (SD) (years)	Gender	Education (years)	Reading
(A) *Experiment 1*				
Schizophrenics ($n = 19$)	32.9(9.3)	11M/8F	11.8(1.6)	93.4(14.3)
Controls ($n = 20$)	34.4(12.3)	7M/13F	11.9(1.5)	94.7(12.1)
(B) *Experiment 2*				
Schizophrenics ($n = 20$)	37.0*(8.8)	15M/5F	11.8(3.1)	92.0 (13.9)
Controls ($n = 20$)	28.0*(8.1)	11M/9F	11.2(1.5)	87.9(12.9)

Demographics chart: Depicts the age (in years), gender, education (in years), and reading level (as standard scores from the WRAT3) of schizophrenics and controls in Experiment 1 (A) and Experiment 2 (B).
Education: Number of years of education.
Reading scores: Standard scores from the Wide Range Achievement Test (WRAT3).
*$p < 0.05$.

of 10–15 mg with a group average of 13 ± 2.8 mg, SD), 3 medicated with Risperdal (dose range of 3–6 mg with a group average of 5 ± 1.7 mg, SD), 1 medicated with Zyprexa (15 mg), and 1 unmedicated. The average disease duration for these subjects was 10.3 years (SD:8.9) with an average age of onset of 22.6 years (SD:6.6). All schizophrenic subjects were administered the Positive and Negative Symptom Scale (PANSS) within 24 h of the experimental test session by a trained clinician. Patients' mean PANSS total score at the time of testing was 79.2 (SD:22.2). The average general, positive, and negative subscale scores for the PANSS were 38.5 (SD:16.6), 20.3 (SD:6.9), 20.4 (SD:3.6), respectively.

3.2. Methods

The following experiment involved the use of two participant groups, (normal controls and DSM-IV diagnosed schizophrenic inpatients), two SOAs (short versus long), and two category relations (related versus unrelated). This experiment used the prime categories Animal and Body Part.

Subjects performed a lexical decision task to the target item by pressing one of two buttons, indicating either word or non-word, using the index and middle finger of the subject's dominant hand. They received prime-target pairs of words, in which the prime was a category label (e.g., Animal or Body Part) and the target was a category member (e.g., dog or chin) or a pronounceable non-word (e.g., gomen or chault). It is important to note here that we did not use the exact same categories as those used by Neely (1977). Neely used the primes "Bird" and "Body Part." Our decision to use the category prime "Animal" over "Bird" was primarily based on the need for a better match as evidenced by the average word frequency of the target words for each category. That is, in attempting to balance the target words in frequency we consulted Kucera and Francis (1982). The category "Bird" had an average target word frequency that was statistically less frequent ($F(1, 38) = 15.60$, $p < .01$) than the target word frequency for "Body Part," 7.6 versus 26.6, respectively. When the average target word frequency for the prime "Animal" was calculated (22.9), there was no statistical difference between these target words and the target words for "Body Part" ($F(1, 38) < 1$). Expectancies were created such that subjects were told to expect a certain category of target items, given a particular prime item.

For example, if the prime category was "Animal," then 75% of the time the target, when a word, was a type of "Body Part" (Animal-chin, 75% likelihood; Animal-dog, 25% likelihood). This manipulation produces a situation wherein reflexive, associative processes were put in competition with voluntary processes.

Prediction—Short SOAs: In normal subjects, when situations favor reflexive semantic priming (short prime-target SOA), related but unexpected targets (Animal-dog) will be facilitated due to reflexive spreading activation within related semantic categories. However, expected items (Animal-chin) will show no priming effect at all, because they benefit from neither reflexive spreading activation (not being associated with the prime), nor voluntary expectancies (since the cognitive operations involved in switching from the Animal to Body Part categories take more time than the short SOA allows). Thus, performance at short SOAs would reflect the relative strength of reflexive, automatic semantic priming in semantic memory (Neely, 1977).

Prediction—Long SOAs: At longer prime-target SOAs, a different pattern is found. Once voluntary expectancies become active, the related but unexpected targets (e.g., Animal-dog) actually lead to inhibition in performance, since subjects are not expecting a member of the animal category to appear as the target (Neely, 1977). In contrast, expected but unrelated targets (Animal-chin) are facilitated, since these targets will be ones that subjects are expecting to appear. Thus performance at the long SOAs in the unrelated-but-expected condition reflects voluntary semantic priming. Hence, performance in the related-but-unexpected condition (Animal-dog) should show opposite effects at short and long SOAs (facilitation for short, inhibition for long), permitting independent assessment of reflexive and voluntary semantic priming effects.

3.3. Stimuli

Prime categories (for Experiment 1, "Animal" and "Body Part") were chosen based on Neely's (1977) original experiment and the categories listed in Battig and Montague (1969). Target words were chosen using Battig and Montague (1969). The top 20 words of each category that matched in frequency (Kucera & Francis, 1982) and letter length were chosen as the subset of target words for each category. For targets, letter length varied from 3 to 6 letters and the average word frequency was 22.9 and 26.6 for the "Animal" and "Body Part" categories, respectively. Examples of targets for the "Animal" category were cat, lion, and tiger and for the "Body Part" category were toe, chin, and ankle. The visual angle for the prime and target words varied from 4.8° to 7.6° and 2.7° to 4.8°, respectively. In addition to real word targets, there were also non-word targets that also varied from 3 to 6 letters in length. These were all pronounceable non-words that were neither homophones nor pseudohomophones, e.g., gomen and chault (see Appendix A). Fig. 1 shows example stimuli, the percentages of each condition, and ratios of words ("valid" trials) to non-words ("invalid" trials) for Experiment1. For each subject, there were 240 trials with 160 being "valid" and 80 being "invalid," giving a non-word ratio of 33% of all trials.

3.4. Apparatus

For both experiments, the stimuli were displayed on an Apple G3 laptop. SuperLab software was used to design and present the word pairs to each participant. The software also recorded response time latencies and error rates.

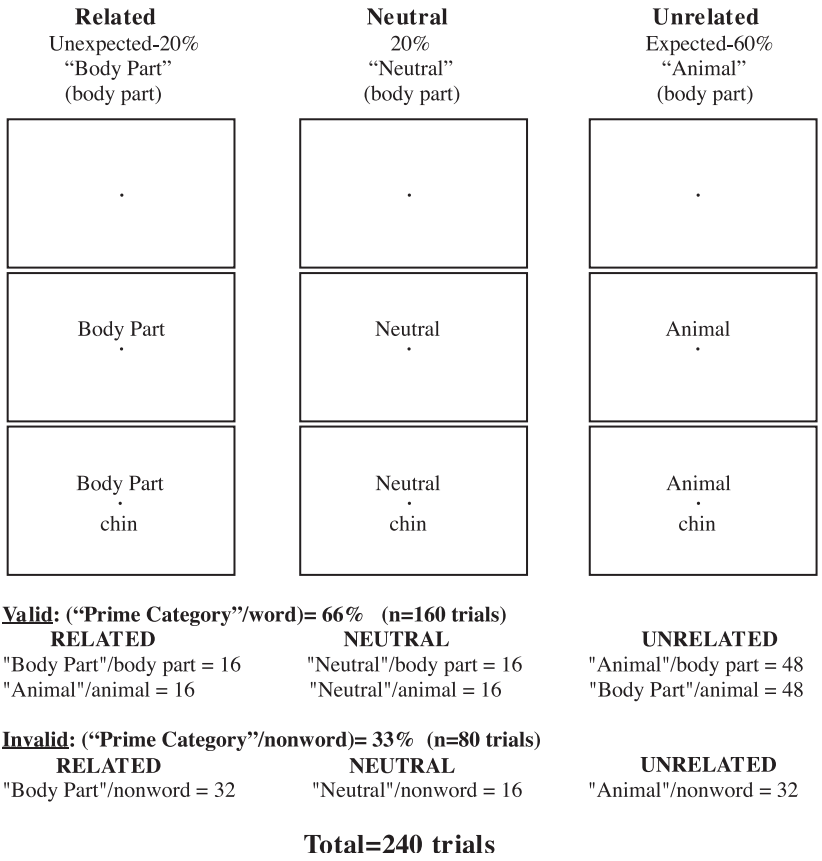

Fig. 1. Three example task conditions for valid trials in Experiment 1. Shown are the three task conditions and the percentage of the total number of trials that each condition represents (Related (20%), Neutral (20%), and Unrelated (60%)). The boxes from top to bottom represent the sequence of the stimuli presentation. There were a total of 240 trials with 66% being valid and 33% being invalid.

3.5. Procedure

All subjects first were administered consent forms. Upon signing these, subjects briefly were interviewed and then tested on a reading test (WRAT3) (see Table 1A for summary of subjects' demographics). All participants next were read the same set of formal priming task instructions and were given a practice block consisting of 24 trials. For the experiment, each subject received two blocks of random, counterbalanced trials separated by a 5-minute interblock interval. The blocks each were made up of 120 prime-target word pairs (240 pairs total for each subject) that had two intermixed SOAs, one short (250 ms) and one long (2000 ms). Each target word was repeated for the short and long SOAs of each prime category, which resulted in a total of 6 repetitions (3 prime categories $\times$ 2 SOAs) for each target word, and these repetitions were counterbalanced across all subjects. At the start of the second block, subjects were reminded of the instructions and asked to report to the researcher the specifics of the experiment instructions. This was done to ensure that each participant understood the task and was responding accordingly.

The task sequence of events was as follows: The prime word was presented above a fixation point for either 250 or 2000 ms. Following this, the target word would appear below the fixation point and remain on the screen until the subject made a lexical decision to the letter string (either it was a real word or it was a non-word) by pressing one of two buttons with his or her dominant hand's index (word) or middle finger (non-word). Following the response, a blank screen with just a fixation point would appear. Each trial was initiated by the experimenter throughout the entire experiment.

3.6. Analysis

The results of this experiment include the mean response times of 19 schizophrenic patients and 20 control subjects (see Fig. 2 and Table 2A). An individual subject's response time for each condition was trimmed based on 2 standard deviations above or below that schizophrenic or control subject's average mean response time in the following conditions: Unrelated-Expected, Related-Unexpected, and Neutral. We then conducted a three-way analysis of variance (ANOVA) on both mean response time and mean percent correct, with 1 between (Group) and 2 within (SOA and Priming) factors. In addition we conducted two-tailed planned *t*-tests within and between groups to test whether schizophrenic patients were hyper-reflexive or hypo-voluntary compared to the control group. For the *t*-tests we used the mean differences of each condition, in which we subtracted the mean response times of the related and unrelated conditions from the neutral condition for each group at each SOA.

4. Results

4.1. Response time data

4.1.1. Overall analysis

As stated earlier, a three-way ANOVA of response time was conducted with Group (schizophrenic, control), SOA (short, long) and Priming (Related, Neutral, Unrelated) as factors. This revealed main effects of Group $F(1, 74) = 29.37$, $p < .01$ (indicating that

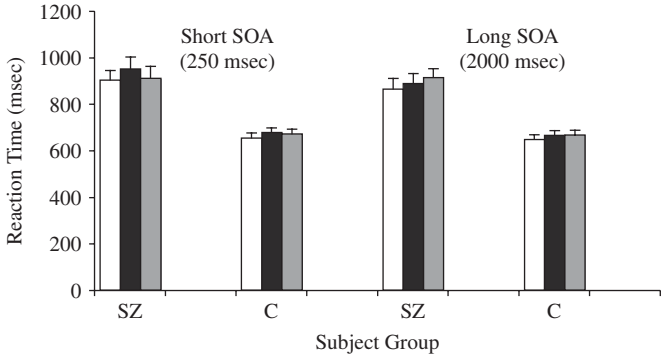

Fig. 2. Mean Reaction Time Graph for Experiment 1. Shown are the trimmed mean reaction times (msec) for schizophrenic (SZ) and controls (C) subjects at the Related-Unexpected (white), Neutral (black), and Unrelated-Expected (gray) conditions at both the short (250 msec) and long (2000 msec) SOAs.

schizophrenic patients were slower to respond than controls, 904 versus 663 ms, respectively) and Priming Condition $F(2, 74) = 7.02$, $p < .05$, indicating that subjects were faster to respond to the related condition than the unrelated condition (764 versus 787 ms, respectively). An interaction of Priming × SOA was also found, $F(2, 74) = 3.19$, $p < .05$. This interaction is difficult to interpret by itself, and planned *t*-tests were used to investigate group differences as reported below.

4.2. Planned t-tests

4.2.1. Short SOA

Schizophrenic subjects—All planned *t*-tests used the MSE from the Priming × SOA × Group interaction. These *t*-tests revealed that schizophrenics were faster to respond to the short Related-Unexpected (reflexive) condition than to the neutral condition, $F(1, 74) = 10.91$, $p < .01$. Furthermore, schizophrenic patients were faster to respond to the Unrelated-Expected condition at the short time period compared to the neutral condition, $F(1, 74) = 7.81$, $p < .05$.

Control subjects—In contrast, the controls did not show significant effects for either the Related-Unexpected condition compared to neutral, $F(1, 74) = 2.61$, $p > .10$, or the Unrelated-Expected condition compared to neutral, $F < 1$.

Schizophrenic subjects versus controls—The *t*-tests comparing the size of these effects in schizophrenics versus controls showed that the difference was marginal for the Related-Unexpected condition versus neutral $F(1, 74) = 3.06$, $p < .10$, and was significant for the Unrelated-Expected condition versus neutral $F(1, 74) = 5.87$, $p < .05$. Fig. 3 illustrates the mean differences between the neutral condition and the Related-Unexpected and Unrelated-Expected conditions, respectively, at the short and long SOAs for schizophrenics and controls. This figure nicely illustrates the significant effects and shows the related and unrelated conditions as a measure of facilitation (+) or inhibition (–) from the baseline, neutral condition.

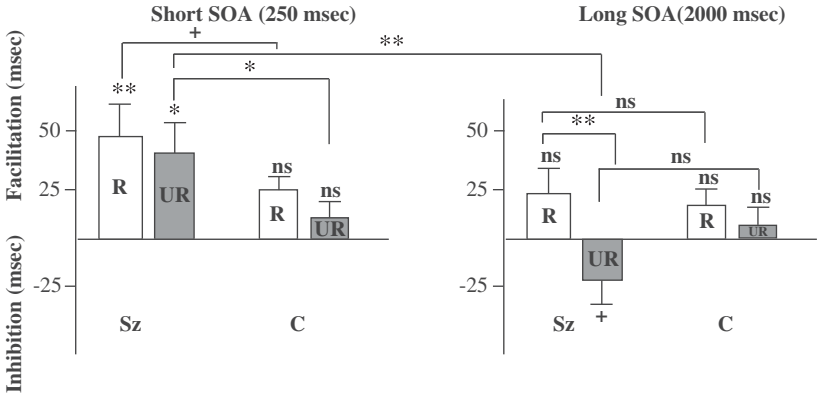

Fig. 3. Reaction Time Difference Graph for Experiment 1. Depicts the difference of Neutral-Priming Condition (Related or Unrelated), such that a positive number represents facilitation (condition faster than neutral) and a negative number represents inhibition (condition slower than neutral) for schizophrenics and controls at both short and long SOAs. The white bars represent the Related condition and the gray bars represent the Unrelated condition. **, $p < .01$, *, $p < .05$, +, $.05 < p < .10$.

4.2.2. Long SOA

Schizophrenic subjects—At the long time period, schizophrenics were not significantly faster to respond to the Related-Unexpected condition versus the neutral condition $F(1,74) = 2.63, p > .10$. They were marginally slower to respond in the Unrelated-Expected condition versus the neutral condition $F(1,74) = 2.79$, $p < .10$. As well, schizophrenic subjects were faster to respond to the Related-Unexpected condition versus the Unrelated-Expected condition $F(1,74) = 10.83$, $p < .01$.

Control subjects—The controls showed no significant effects for the Related-Unexpected versus neutral condition $F(1,74) = 1.47$, $p > .10$, and in addition, they showed no significant effects for the Unrelated-Expected versus the neutral condition, $F < 1$.

Schizophrenic subjects versus controls—Tests were again used to compare the size of these effects across schizophrenics and controls and no significant effects were found for either the Related-Unexpected condition, $F < 1$, or the Unrelated-Expected condition $F(1,74) = 2.51$, $p > .10$. Again, see Fig. 3 for a summary and illustration of these results.

4.3. Error data

Both schizophrenics and controls were very accurate with percentages of 98.2 and 99.5 correct, respectively. We conducted an ANOVA identical to response time with error rate as the dependent measure. The only significant effect was a main effect of Group, $F(1,74) = 7.48$, $p < .01$, indicating that controls were slightly more accurate, overall, than schizophrenic patients.

4.4. Clinical factors

We conducted separate repeated measures ANOVAs for diagnosis (paranoid, $n = 16$, versus non-paranoid, $n = 3$) and antipsychotic medication type (typical, $n = 14$, versus atypical, $n = 4$) with response time as the dependent measure (a single patient who was not on medication was dropped from the medication-type analysis). The diagnosis and antipsychotic medication-type ANOVAs revealed no significant main effects within the schizophrenic group (both F-values < 1). Due to the fact that our subgroups were of unequal size for each ANOVA, we used the harmonic mean of the two subgroup sizes (5.05 for diagnosis and 6.22 for antipsychotic medication type) to calculate the F-value and our degrees of freedom, increasing the likelihood of finding a significant difference. Hence, for example, for the effect of diagnosis, this analysis would have the same power as if we had tested 5.05 subjects per group for a total of 10.1 subjects. This adjustment is conservative and should account for the skewed weight due to unequal groups in this experiment. Nevertheless, due to the small sample sizes, these analyses are informative but not definitive.

Separate one-way ANOVAs were conducted between controls and schizophrenic subjects for reading raw scores, education, gender, and age with each factor as the dependent measure, and each of these ANOVAs revealed no significant differences between the groups.

Pearson's correlations: We conducted Pearson's correlations between mean reaction times and subscale scores of the PANSS. There was no correlation between mean response times for schizophrenia subjects at any priming condition (Related, Unrelated, or Neutral) and any subscale of the PANSS (Positive, Negative, or General), as measured by

a two-tailed Pearson's correlation. The correlations ranged from $r = -.310$ ($p > .10$) to $r = .120$ ($p > .10$).

5. Experiment 1 discussion

There are three main results of Experiment 1. First, schizophrenic patients are faster to respond to both the Related-Unexpected and Unrelated-Expected conditions at the short SOA when compared to neutral ($p < .01$ and $p < .05$, respectively). We expected schizophrenic subjects to show enhanced priming to the related condition at this SOA because of the automatic spread of activation, but we did not expect to see priming to the unrelated condition at the short SOA, since it should be dependent on voluntary processing, which takes several hundred milliseconds to take effect. In retrospect, we realized that this could be happening because of a methodological error on our part. Our two prime categories ("Animal" and "Body Part") were probably not distinct enough from each other to serve as separate, independent category primes, since animals have many of the body parts that were listed as target words (e.g., Animal-heart). Hence, the priming to the unrelated condition at the short SOA may not be due to an extraordinary early or fast voluntary facilitation but rather automatic spreading activation due to our related categories. Interestingly, schizophrenic patients but not control subjects show enhanced priming compared to controls in this "unrelated" condition at the short SOA.

The second main finding in this experiment is that schizophrenics respond faster at the long SOA for the related condition than the unrelated condition ($p < .01$). Hence, they show no evidence for voluntary facilitation at the long SOA. At this long time period voluntary processing should facilitate priming of the Unrelated-Expected condition and inhibit the Related-Unexpected condition. Instead of inhibition, we see either hyper-active reflexive functioning or deficient voluntary functioning, or both. We believe that this finding reflects a possible deficit in voluntary functioning, as evidenced by a trend for an increase in response time for the Unrelated-Expected condition ($.05 < p < .10$).

The third and final main finding of Experiment 1 is that schizophrenics showed more facilitation in the Unrelated-Expected condition at the short SOA than in the Unrelated-Expected condition at the long SOA ($p < .01$). This result is difficult to interpret but probably reflects the problem of prime category similarity, such that, it is possible that the subjects, because of excessive semantic matching, were facilitated at the short SOA for the unrelated words but not at the long time period when strategic processes were occurring. If this were true though, we would expect this result to disappear if the categories were made more distinct. Hence, given the confound of the similar prime categories of Experiment 1, in Experiment 2, we chose 2 categories that were more distinctive and yet could be matched according to frequency and all of the same variables as in Experiment 1. With this change for Experiment 2, we should be able to test whether schizophrenic subjects responded faster for the Unrelated-Expected condition than the neutral condition at the short SOA due to the relatedness of the categories. In addition we should also be able to test the second main finding, which showed that schizophrenic subjects were faster to respond to the Unexpected-Related condition at the short SOA compared to the long SOA. The changes in Experiment 2 may also address a fourth finding from Experiment 1, namely the fact that control subjects did not show any significant reflexive or voluntary priming effects at either the short or long SOA.

6. Experiment 2

6.1. Subjects

Experiment 2 was comprised of a separate set of 20 controls and 20 schizophrenic patients. These schizophrenic subjects were recruited in the same fashion as Experiment 1 and all completed consent forms. As well, we again attempted to match subject groups based on age, education and reading level. But after performing an ANOVA on these factors, we found that there was a significant difference in age for the schizophrenics, 37 years, and the controls, 28 years ($F(1,76) = 12.45$, $p < .05$). We do not expect that this age difference will bias our data in any way because recent work by Giffard, Desgranges, Kerrouche, Piolino, and Eustache (2003) has shown that there is no significant difference of age (between young and old subjects) on performance in a lexical decision semantic priming task. See Table 1B for a summary of the subjects' demographic characteristics.

In Experiment 2, there were 15 schizophrenic patients medicated with Haldol (dose range of 10–30 mg with a group average of 15 ± 4.8 mg, SD), 2 medicated with Prolixin (dose was 15 mg for each), 3 medicated with Navane (dose range of 20–30 mg with a group average of 26 ± 5.8 mg, SD), and 1 medicated with Clozaril (200 mg). The average disease duration for these subjects was 13.2 years (SD:7.4) with an average onset age of 24.3 (SD:6.5). Again, all schizophrenia subjects were administered the Positive and Negative Symptom Scale (PANSS) within 24 h of the experimental test session by a trained clinician. Patients' mean PANSS total score at the time of testing was 70.3 (SD:17.6). The average general, positive, and negative subscale scores for the PANSS were 30.6 (SD:6.9), 17.0 (SD:4.5), 22.7 (SD:11.9), respectively.

6.2. Stimuli

The main difference between Experiment 1 and 2 is that Experiment 2 used the more distinct prime categories, "Animal" and "Clothing." Prime and target words for Experiment 2 were chosen in the same manner as Experiment 1, based on Neely (1977) and Battig and Montague (1969). Target words were again matched in letter length and had a frequency of 22.9 and 22.6 for Animal and Clothing, respectively. Examples of prime and target word pairs are Animal-sock and Clothing-bear (see Appendix A for a full list of all words used). The non-words for Experiment 2 were the same as the ones used in Experiment 1. Finally, each subject received the same number of blocks and trials as in Experiment 1.

6.3. Apparatus and procedure

The apparatus and procedure for Experiment 2 were the same as that of Experiment 1.

7. Results

7.1. Experiment 2: animal/clothing

7.1.1. Analysis

The same analyses were conducted as in Experiment 1. Experiment 2 did not exclude any patients so there was a total of 20 schizophrenic patients and 20 controls included

in the results of this study. Again, mean response times for each subject were trimmed based on 2 standard deviations above or below that subject's individual average response time for each of the following conditions: Unrelated-Expected, Related-Unexpected, and Neutral. Table 2B lists the mean reaction times of each group broken down by Priming Condition and SOA, while Fig. 4 graphically depicts these means.

Table 2
Summary of the mean reaction times for Experiments 1 and 2

	Unexpected-Related	Neutral	Expected-Unrelated
(A) *Experiment 1—Mean reaction times in ms (SEM)*			
Short SOA (250 ms)			
Schizophrenics	902.46 (40.5)	950.88 (50.8)	909.92 (50.9)
Controls	654.17 (19.5)	677.29 (19.8)	671.40 (19.0)
Long SOA (2000 ms)			
Schizophrenics	864.72 (44.3)	888.48 (41.9)	912.96 (36.8)
Controls	648.23 (18.4)	665.58 (19.0)	667.11 (19.1)
(B) *Experiment 2—Mean reaction times in ms (SEM)*			
Short SOA (250 ms)			
Schizophrenics	1038.15 (83.9)	1179.05 (112.4)	1137.76 (111.5)
Controls	604.55 (17.9)	621.19 (21.9)	607.65 (20.2)
Long SOA (2000ms)			
Schizophrenics	1110.18 (116.1)	1140.65 (102.9)	1066.54 (94.0)
Controls	618.99 (20.9)	611.82 (18.9)	616.12 (20.9)

(A) Experiment 1 mean reaction times (ms) and standard error of the means (SEM) at the short and long SOAs for each condition, Related-Unexpected, Neutral, and Unrelated-Expected. (B) For Experiment 2.

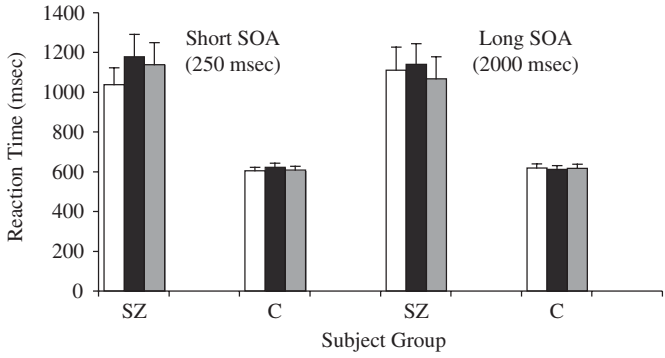

Fig. 4. Mean Reaction Time Graph for Experiment 2. Shown are the trimmed mean reaction times (msec) for schizophrenic (SZ) and control (C) subjects at the Related-Unexpected (white), Neutral (black), and Unrelated-Expected (gray) conditions at both the short (250 msec) and long (2000 msec) SOAs.

7.2. Response time data

7.2.1. Overall analysis

The three-way ANOVA for mean reaction times yielded main effects of Group $F(1,76) = 25.49$, $p < .01$ (in general, schizophrenic patients were slower to respond than controls, 1112 versus 613 ms, respectively) and Priming, $F(2,76) = 6.83$, $p < .05$ (all subjects were fastest to respond to the related condition compared to the neutral and unrelated conditions, with 842, 888, and 857 ms, respectively. In addition, there was a significant Priming × Group interaction, $F(2,76) = 5.4$, $p < .05$. Planned t-tests were used to investigate priming and group differences (see below).

7.3. Planned t-tests

7.3.1. Short SOA

Schizophrenic subjects—Just as in Experiment 1, all planned t-tests used the MSE from the Priming × SOA × Group interaction. These t-tests revealed that schizophrenic patients were faster to respond to the Related-Unexpected condition at the short SOA when compared to the neutral condition, $F(1,76) = 9.10$, $p < .05$ (1038 and 1179 ms, respectively). Furthermore, schizophrenic patients were not faster to respond to the Unrelated-Expected condition (1138 ms) compared to the neutral condition at the short SOA, $F < 1$. This lack of significant facilitation to the unrelated condition at the short SOA is in contrast to Experiment 1, indicating that this facilitation in Experiment 1 was probably due to the use of similar prime categories. Comparisons at the short SOA also revealed that schizophrenics showed more facilitation in the Related-Unexpected condition than in the Unrelated-Expected condition when compared to neutral, $F(1,76) = 4.55$, $p < .05$. Fig. 5 illustrates the mean differences between the neutral

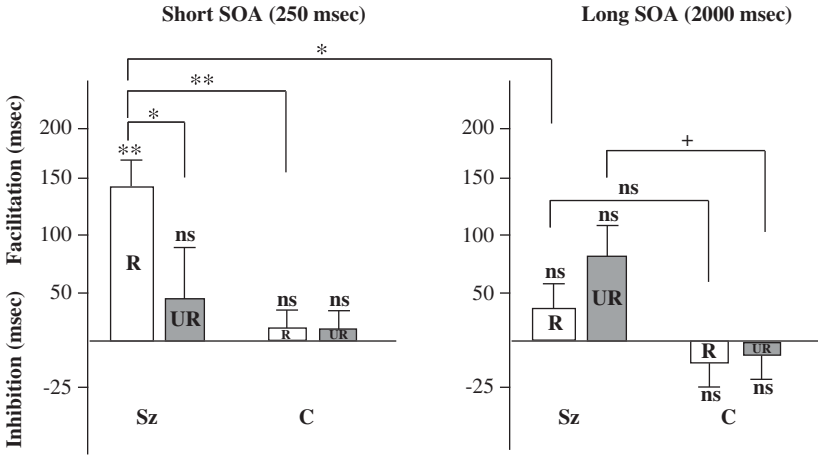

Fig. 5. Experiment 2: Reaction Time Difference Graph. Depicts the difference of Neutral-Priming Condition (Related or Unrelated), such that a positive number represents facilitation (condition faster than neutral) and a negative number represents inhibition (condition slower than neutral) for schizophrenics and controls at both short and long SOAs. The white bars represent the Related condition and the gray bars represent the Unrelated condition. **, $p < .01$, *, $p < .05$, +, $.05 < p < .10$.

condition and the Related-Unexpected and Unrelated-Expected conditions, respectively, at the short and long SOAs for schizophrenic and control subjects. In addition, one final finding was that schizophrenic subjects showed more facilitation for the Unexpected-Related condition at the short SOA versus the long SOA, $F(1,76) = 5.59$, $p < .05$.

Control subjects—In contrast, for the control subjects, *t*-tests revealed that there were no significant effects for either the Related-Unexpected condition versus neutral or the Unrelated-Expected condition versus neutral $F < 1$ for both, indicating that control patients lacked any significant facilitation or inhibition at the short SOA. Control subjects exhibited reaction times of 604, 621, and 607 ms for the Related-Unexpected, Neutral, and Unrelated-Expected conditions, respectively.

Schizophrenic subjects versus controls—Tests comparing the size of effects in schizophrenics versus controls at the short SOA confirmed that schizophrenics showed more facilitation in the Related-Unexpected condition $F(1,76) = 7.08$, $p < .01$.

7.3.2. Long SOA

Schizophrenic subjects—There were no significant effects for either the Related-Unexpected or Unrelated-Expected conditions for schizophrenics at the long SOA, $F < 1$ for both. Schizophrenic subjects had response times of 1110, 1140, and 1067 ms for the Related-Unexpected, Neutral, and Unrelated-Expected conditions, respectively.

Controls—The controls also did not show any significant effects for either the Related-Unexpected ($F(1,76) = .023$, $p > .10$) or the Unrelated-Expected ($F(1,76) = .008$, $p > .10$) conditions at the long SOA. Control subjects exhibited reaction times of 619, 611, and 616 ms for the Related-Unexpected, Neutral, and Unrelated-Expected conditions, respectively.

Schizophrenic subjects versus controls—Tests were again used to compare the size of the priming effects across schizophrenic and control subjects. It revealed no significant difference for the Related-Unexpected condition, $F < 1$, but did reveal a marginal difference for the Unrelated-Expected, $F(1,76) = 2.82$, $.05 < p < .10$. See Fig. 5 for an illustration of these results.

7.4. Error data

Both schizophrenics and controls were again very accurate in Experiment 2 with percentages of 96.7% and 98.1% correct, respectively. We conducted an ANOVA with Error Rate as the dependent measure. There was a significant main effect of Group $F(1,76) = 3.90$, $p < .05$. No other significant effects or interactions with error rates were found.

7.5. Clinical factors

The one-way ANOVA for diagnosis (6 paranoid versus 13 non-paranoid), revealed no main effects (*F*-value < 1). Just as in Experiment 1, for the effect of diagnosis, the harmonic mean was calculated and used as a conservative adjustment of power for our unequal groups. The harmonic mean calculated was 8.21 subjects for each group, giving a new subject total of 16.42. Despite using the harmonic mean, diagnosis was still was not significant (*F*-value < 1). To reiterate as in Experiment 1, this diagnosis analysis is only meant to be informative and is not definitive. All subjects in Experiment 2 were on typical

medications. Separate one-way ANOVAs were also conducted between controls and schizophrenic subjects to test for differences between groups in reading raw scores, education, and gender with each of these factors as the dependent measure, and they revealed no significant differences between groups. The one-way ANOVA for age yielded a significant effect of age $F(1, 38) = 12.45$, $p < .05$ (controls had an average age of 28 years, while schizophrenics had an average age of 37 years).

Pearson's correlations—Again, we conducted Pearson's correlations between mean reaction times and subscale scores of the PANSS. There was no correlation between response time and any subscale of the PANSS, as measured by a two-tailed Pearson's correlation. The correlations ranged from $r = .387$ ($p > .10$) to $r = -.043$ ($p > .10$).

7.6. Combined analysis and results

In order to increase the power and maximize our chances of detecting any effects that were there, we did a combined analysis including the results of both Experiments 1 and 2. We performed a three-way ANOVA as stated before for Experiments 1 and 2. A significant main effect of Group $F(1, 154) = 43.37$, $p < .01$ was found, indicating that controls were faster to respond than schizophrenics overall (638 and 1011 ms, respectively). In addition, a main effect of Priming was also significant, $F(2, 154) = 11.95$, $p < .01$, demonstrating that subjects responded faster to the related category than the neutral or unrelated (804, 840, and 822 ms, respectively). There was also an interaction of Priming × Group, $F(2, 154) = 5.34$, $p < .01$, indicating that schizophrenic subjects showed more facilitation in the Related-Unexpected condition compared to the Neutral condition than did control subjects.

We conducted the non-parametric Wilcoxon signed rank test to help us better understand whether control or schizophrenic subjects were showing facilitation or inhibition independent of the results of the ANOVAs and planned *t*-tests we had previously conducted. The Wilcoxon signed rank test does not require a normal distribution and was used to look at 8 specific comparisons: Neutral versus Related and Neutral versus Unrelated at both the short and long SOAs for each group (controls and schizophrenics). There was only one significant effect for the controls. At the short SOA, there were more control subjects who were faster in the Related condition than in the Neutral (26 and 14, respectively). This 20 ms effect was not significant with a *t*-test, but with the Wilcoxon it was significant at $p < .01$ (z-value $= -2.487$). In addition, there were 3 significant effects for schizophrenic subjects. At the short SOA, schizophrenic subjects in both the Related and Unrelated conditions were faster to respond than in the Neutral condition, $p < .01$ (z-value $= -2.707$) and $p < .05$ (z-value $= -2.163$), respectively. And finally, schizophrenic subjects were faster to respond to the Related condition than the Neutral at the long SOA, $p < .05$ (z-value $= -2.093$).

8. Experiment 2 discussion

Experiment 2 was intended to correct for any results in Experiment 1 that may have been due to our choice of prime categories, which may have inadvertently been semantically related. This experiment was carried out using the prime categories "Animal" and "Clothing," as well as the term "Neutral." There are three main findings in this experiment. The first is that once again schizophrenic patients are faster to respond (exhibit

facilitation) to the Related-Unexpected condition when compared to the neutral at the short SOA. Schizophrenics also, at the short SOA, show greater facilitation for the related condition compared to the neutral condition than do the control subjects, which seems to support the idea of an overactive reflexive system in schizophrenia. This hyper-reflexivity may be a property of the reflexive system per se or due to a defunct but not completely absent voluntary system. Figs. 4 and 5 suggest the latter, in that schizophrenic subjects increase their response times (slow their performance) from the short to the long SOA for the Related-Unexpected condition ($F(1,76) = 5.59$, $p < .05$). And additionally, although not significant because of large variability in response time for patients, response times seem to decrease for the unrelated condition when moving from the short to long SOA. Taken together, these results suggest some amount of task compliance, understanding, and voluntary functioning in that schizophrenic subjects are beginning to inhibit their response times in the Related-Unexpected condition and facilitate it in the Unrelated-Expected condition.

9. General discussion

The purpose of this study was to separately examine reflexive and voluntary priming effects in patients with schizophrenia. Based on the idea of a disrupted reciprocal communication between the prefrontal cortex and the temporal lobe (Friston & Frith, 1995; Grasby et al., 1993; Weinberger, Berman, Suddath, & Torrey, 1992) and fMRI studies of verbal fluency in schizophrenia (Ragland et al., 2004; Yurgelun-Todd et al., 1996) we hypothesized that schizophrenic subjects would show deficits in voluntary priming and over-activity in reflexive priming conditions. The results of this study partially confirm these predictions in attempting to shed light on the complex processes that underlie thought disorder.

The most consistent and striking result of these two experiments is that schizophrenic subjects exhibit hyper-reflexivity (more facilitation) when compared to controls on a semantic priming task. Evidence for this finding is demonstrated by schizophrenic subjects having faster response times than controls for the Unexpected-Related condition compared to the Neutral condition. As stated earlier, we originally used two categories that were similar and shared some of the same target words as part of their subordinate level members. This inadvertently allowed us to compare Experiment 1 with Experiment 2, in terms of high relatedness proportion (due to Experiment 1 having more related words from the animal-body part pairings) and semantic processing. Schizophrenic subjects showed facilitation for the Expected-Unrelated condition relative to the Neutral condition ($p < .05$) in Experiment 1, an effect that was not significant in Experiment 2. Control subjects did not show facilitation in this condition in either Experiment. This finding supports the idea of a dysfunction in "context irrelevant" processing in schizophrenia, an idea that is supported by Sitnikova, Salisbury, Kuperberg, and Holcomb (2002), who used ERP experiments to better understand how schizophrenic performance differed from control performance on a language congruency task. In a task looking at the N400 response to sentence congruency, Sitnikova et al. (2002) found that schizophrenic subjects compared to control subjects were more likely to inappropriately link more distantly related words, as if they were related, which was exhibited by their lack of an N400 response to incongruent context in a sentence. This result, together with our finding, support the notion that schizophrenic subjects exhibit hyper-reflexivity, as evidenced by

their propensity to link more distantly related or unrelated words as if they were actually more closely related.

Despite our strong findings showing increased automatic processing in schizophrenia, we cannot state anything with certainty about voluntary processing because of our lack of findings with control patients at the long SOA. Given that Neely (1977) had shown such robust results with his controls, we were very intrigued by this lack of priming for the Unrelated-Expected condition in *both* experiments, especially in Experiment 2 when the confounding factors of related category primes had been eliminated. One possibility for this lack of voluntary or expectancy-induced priming may be due to the fact that there was some repetition of the target words within each block. It is possible that the first presentation of each target word biased the response to that same target when it was repeated later. Therefore, the response time to the repeat presentation would be faster than to the original presentation, and perhaps then, the priming effects would be disrupted. Although this idea seems plausible, it does not explain why Neely's (1977) results were unaffected by the repeated target words he used to represent varying SOAs. A more likely possibility for our lack of priming at the long SOA may have been because of the difference in the construction of our practice trials. Neely (1977) and shortly thereafter Favreau and Segalowitz (1983), reported that their practice trials were (1) 100% expected and (2) many in number. In this experiment, our practice trials were not 100% expected. They contained the same percentage of expected (60%), unexpected (20%), and neutral (20%) trials as the actual test blocks. This difference may be crucial for inducing robust expectancy. As well, our subjects were not as highly practiced as Neely's (1977) or Favreau & Segalowitz's (1983). Each of these studies had at least 72 practice trials, whereas our subjects had just 21 practice trials. When designing this study with a clinical population, we tried to constrain the design to minimize the duration of the practice trials in order to maximize our ability to complete the experiments successfully. We did not realize that 100% expectancy in the practice trials and a larger number of practice trials in general may be necessary to induce robust expectancy. Therefore, it is possible that with fewer practice trials and the lack of 100% expectancy on these practice trials, our groups never strongly induced an expectancy for the opposite category.

Despite our lack of certainty about our ability to significantly activate the voluntary, expectancy-based priming system, our results strongly support the idea of an automatic dysfunction in schizophrenia as a core deficit in language processing. Furthermore, in doing so, our data seem to support the spreading activation model of formal thought disorder (Maher et al., 1987; Spitzer, Braun, Maier, et al., 1993; Spitzer et al., 1994). But, if we adapt the "tonic inhibition" model of orienting from Sereno (1992), to the domain of language, it becomes clearer to understand that these deficits, whether in automatic or voluntary processing, are not unitary problems, but part of a more complex system dysfunction. With respect to spatial attention, Sereno's tonic inhibition model argues that the voluntary system exerts tonic inhibition on the reflexive system in such a way that it controls and modulates reflexive attention and reflexive eye movements. Thus, a dysfunction in the voluntary system would lead to a deficit or hyper-activity in the reflexive system. Hence, similarly, it may be argued that a lack of voluntary control in priming may result in less inhibition over the reflexive system and thus hyper-sensitivity or hyper-priming. Due to the lack of voluntary expectation-induced priming exhibited by the controls, it is difficult to assess the amount of voluntary control that schizophrenic patients are exhibiting in this lexical decision task. Voluntary control over language processing is

thought to critically involve the prefrontal cortex, an area of the brain commonly thought of as being abnormal in schizophrenia (Kubicki et al., 2003; Marvel, Schwartz, & Isaacs, 2004; Nestor et al., 1998; Saykin et al., 1991). Similarly, alterations in this area of the brain have been implicated in working memory, attention, and eye movement deficits in schizophrenia (Berman & Weinberger, 1990; Manoach, 2003; Ploner, Gaymard, Rivaud-Pechoux, & Pierrot-Deseilligny, 2005). Taken all together, it is logical to conclude that schizophrenic subjects probably exhibit some sort of altered voluntary language processing and that this voluntary abnormality is contributing to the excessive semantic activation demonstrated as hyper-priming. Consistent with this idea, the present study demonstrates excessive semantic priming in schizophrenic subjects.

Additionally, our study supports the notion that typical antipsychotic medications do not normalize verbal processing deficits. In these two experiments, we tested a total of 40 people with schizophrenia. Of the 40 schizophrenics we tested, 34 of them were on typical neuroleptics, 5 on atypical, and 1 was unmedicated. We found no differences in performance between the typical, atypical, and unmedicated subjects, which we believe is simply due to a low number of subjects in the atypical and unmedicated groups. There is much evidence to support the idea that atypical antipsychotics help certain types of cognitive processes, including verbal fluency, verbal memory, general intelligence, continuous performance test, and spatial working memory, among others (Harvey, Green, McGurk, & Meltzer, 2003; Weickert et al., 2003). It has also been found that certain atypical medications (e.g., olanzapine, risperidone, and quetiapine) have a more advantageous effect than typical medications (e.g., haloperidol) on such cognitive processes as attention, motor function, visuospatial tasks, immediate recall tasks, verbal memory, and verbal fluency (Keefe et al., 2006; Purdon, Malla, Labelle, & Lit, 2001; Velligan et al., 2002). Our findings of a persistent semantic priming deficit (i.e., hyper-reflexivity) for schizophrenics treated with typical antipsychotics agree with previous reports of a lack of improvement on various cognitive processes (Bilder et al., 2002; Harvey, Rabinowitz, Eerdekens, & Davidson, 2005; Purdon et al., 2001) and support the idea that these medications do not seem to improve or normalize performance on this type of verbal processing task. These results are especially important given the recent findings suggesting that executive function, not clinical improvement (i.e., a reduction in positive symptoms), is the best predictor of outcome in schizophrenic patients (Green, 1996). Therefore, research that allows us to examine reflexive and voluntary processes separately may serve as an important tool in evaluating different types of antipsychotic medication effects on different types of cognitive processing.

10. Conclusion

Our study indicates that schizophrenic patients exhibit excessive semantic priming compared to controls, and it suggests that this over-activity may be a major underlying contributor to thought disorder in these patients. However, as we have previously discussed, this over-activity may be the result of a deficit in the voluntary system. Hence, it may be important for future studies to control for the possibility of an interrelationship between these two systems and how they affect each other as a possible factor in interpreting disparate findings.

It is a complex task to parse apart semantic context into reflexive and voluntary processes. It is clear that techniques which can relate behavior to underlying physiological

responses, such as semantic priming tasks while recording ERPs or event related imaging, may be critical tools in being able to tease apart the effect of expectancy on more automatic processes.

Acknowledgments

The authors would like to thank Dr. Sara Sereno for the list of non-words, Keith Kline for his help in making the stimuli, John Eakin for his help in recruiting and testing control patients and Ashley Jagar, Drs. Silvia Amador and Kevin Briand for comments on the manuscript. Additionally, we would like to thank an anonymous reviewer for many excellent comments and suggestions for this manuscript. This research was supported by grants from the NIH (MH065492 and MH63340), the NARSAD Essel Investigator Award, and the NRSA 5 T32 NS41226.

Appendix A

Target word list used for each of the prime categories, Animal, Body Part, and Clothing, as well as, the non-words used in the two experiments.

Animal
Horse
Sheep
Rabbit
Lamb
Dog
Lion
Mouse
Tiger
Bear
Bull
Monkey
Rat
Cow
Fox
Pig
Goat
Cat
Deer
Turtle
Wolf

Body part
Foot
Knee
Lung
Wrist
Nose
Tongue

Liver
Thumb
Leg
Ear
Waist
Toe
Skin
Chin
Hip
Ankle
Brain
Tooth
Elbow
Kidney

Clothing
Hat
Sock
Coat
Shirt
Slip
Belt
Skirt
Dress
Blouse
Tie
Vest
Scarf
Cap
Gown
Apron
Jeans
Jacket
Show
Suit
Pants

Non-word
Une
Sile
Meast
Plist
Afe
Feer
Sask
Gowel
Tae
Dife

Anlet
Besume
Fod
Thad
Chorn
Sprith
Sep
Toit
Drale
Chault

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