Cognitive Inhibition and Schizophrenic Symptom Subgroups

by Leanne M. Williams

Abstract

Subgroups of patients with schizophrenia were examined in relation to repetition and semantic priming under conditions in which the prime stimulus was to be either attended to or ignored (unattended). Attended conditions normally would produce positive priming; and unattended conditions, negative priming (i.e., a delayed reaction resulting from inhibition of target information previously presented as a to-be-ignored stimulus). Cluster analysis of participants' ratings on the Schedule for the Assessment of Positive Symptoms and the Schedule for the Assessment of Negative Symptoms revealed three subgroups that aligned broadly previous research citing with disorganization, reality distortion, and psychomotor poverty syndromes, and a fourth episodic subgroup. The Disorganization, Reality Distortion, and Episodic subgroups were associated with reduced, indeed reversed, negative priming in unattended priming conditions, whereas the Psychomotor Poverty subgroup exhibited the usual negative priming effect. Participants in the former three subgroups also exhibited reversed positive priming for the repetition condition, while the Psychomotor Poverty group displayed the expected positive priming effect. These results indicate that weakening of inhibitory processes may underlie both the reality distortion and disorganization dimensions of positive schizophrenic symptomatology, including the latent presence of these symptoms. In contrast, negative symptoms contributing to the psychomotor poverty dimension of schizophrenia are not linked to reduced inhibition. The association of positive symptom subgroups with reversed positive priming suggested that, for these participants, stimuli and task differences have an impact on the preattentive activation of information underlying such priming. It is proposed that a "reduced inhibition" model of schizophrenic symptomatology may need to be extended to account for influences on preattentive processing.


A large body of evidence suggests that deficits in selective attention underlie schizophrenic phenomena (see Straube and Oades 1992 for a review). Dixon (1981) suggested that the intrusion of irrelevant information into consciousness seen in schizophrenia patients' performance on selective attention tasks (Payne et al. 1970; Marchbanks and Williams 1971; Neufeld 1977; Hemsley and Richardson 1980) may result from a defect in the mechanism that controls conscious awareness. More specifically, Frith (1979) proposed that this defect might represent a breakdown in the inhibitory mechanism that "controls and limits the contents of consciousness" (p. 225). As a result, unattended irrelevant information breaks into consciousness. This mechanism might be viewed as analogous to the inhibitory processes, described in attention

Reprint requests should be sent to Dr. L.M. Williams, Dept. of Psychology, University of New England, Armidale, NSW, 2351, Australia.
literature, that accompany the process of selection (Neill 1977).

Frith (1979) further suggested that a failure of cognitive inhibition might account in particular for the more cognitive symptoms of schizophrenia. For instance, the symptom of thought disorder may be interpreted as an inability to inhibit irrelevant word associations, ones that usually do not reach a conscious level of processing. This failure of inhibition may subsequently result in disordered speech, the behavior from which thought disorder is inferred. Auditory hallucinations might arise from a faulty preconscious perception of sounds that normally would not reach the level of conscious awareness. Similarly, delusions may stem from the need to explain and interpret the irrelevant information that has reached a conscious level through a breakdown in inhibitory processes.

The symptoms associated by Frith (1979) with a failure of cognitive inhibition appear to encompass two dimensions of positive symptoms, referred to by Liddle (1987) as the reality distortion and disorganization syndromes. Factor-analytic studies show that the reality distortion syndrome is distinguished by the presence of hallucinations and delusions, while the disorganization syndrome tends to be associated with positive formal thought disorder (Bilder et al. 1985; Liddle 1987; Arndt et al. 1991; Peralta et al. 1992) and sometimes with bizarre behavior (Bilder et al. 1985; Arndt et al. 1991; Thompson and Meltzer 1993). Evidence suggests that the disorganization syndrome also encompasses symptoms usually defined as negative: inappropriate affect and poverty of speech components of alogia, as well as attentional impairment (Liddle 1987; Peralta et al. 1992; Thompson and Meltzer 1993). More purely negative symptoms (e.g., lack of volition and blunted affect) that contribute to a third psychomotor poverty syndrome (Liddle 1987) are not accounted for in Frith’s reduced cognitive inhibition model. However, as these syndromes may coexist within individuals, particular combinations of positive and negative symptoms, as manifested within individuals, might be associated with a failure of inhibitory processes.

Empirical Investigation of Schizophrenic Symptomatology and Cognitive Inhibition

The negative priming paradigm is based on the premise that unattended irrelevant information is inhibited actively and does not decay passively (Tipper 1985). It therefore represents a pertinent methodology for investigating Frith’s (1979) reduced cognitive inhibition account of schizophrenic symptomatology. “Negative priming” refers to the delayed target response latency that occurs when a distractor stimulus from a priming display becomes the target on a subsequent display. This increased latency occurs when the stimulus becomes associated with inhibition when presented as a distractor. In contrast “positive (conventional) priming” refers to the shortened latency of response that usually occurs when a stimulus is presented as both prime and target.

The implication of Frith’s (1979) view of schizophrenic symptomatology is that schizophrenia patients with positive symptoms will show reduced inhibition in the form of decreased negative priming under conditions in which an increased latency of response would normally be expected. This hypothesis has been extended to include normal subjects with high scores on measures of positive schizotypal traits, in keeping with the view that psychosis is continuous with normality (Beech et al. 1989a, 1989b, 1991). Several recent studies have supported these predictions. Using a modified version of the Stroop task, Beech et al. (1989a) found that participants exhibiting high levels of positive schizotypal personality traits showed reduced—even reversed—negative priming. Reduced, but not reversed, negative priming was replicated for schizophrenia patients with predominantly positive symptoms using the same task (Beech et al. 1989b). Beech et al. (1990) provided some evidence that the absence of a reversed negative priming effect in this latter study may have resulted from the normalizing influence of antipsychotic medication for the sample of schizophrenia patients.

An alternative explanation of reduced or reversed negative priming among high-schizotypal people and those diagnosed with schizophrenia is that initial perceptual analysis of distractor stimuli is incomplete for these individuals. A further negative priming study conducted as a more definitive test of the reduced inhibition hypothesis (Beech et al. 1991) used unattended priming conditions for both semantically related and identical word stimuli. Since distractor information in this case was not physically related to the subse-
quent target, using semantically related stimuli ensured that any reversed negative priming could not be explained in terms of incomplete analysis of distractor stimuli that were perceptually identical to the targets. Corresponding conventional attended priming conditions were also included to establish that both high and low schizotypes exhibited the usual positive priming effect, differing only as a function of negative priming. The task was to say the name of the semantic category of each target word, followed by the category of the preceding prime. High schizotypes showed reversed negative priming (facilitation) when the previously ignored distractor was semantically related to the target, but they showed no effect if the distractor was identical to the target. Low schizotypes, on the other hand, exhibited negative priming for the identical condition but no effect for the semantic condition. For attended priming conditions both low and high schizotypes displayed the expected facilitation.

On the basis of these findings, Beech et al. (1991) argued that initial perceptual processing is equivalent in both low and high schizotypes (and in people with schizophrenia). Since perceptual processing of stimuli is generally held to be relatively automatic and to occur without conscious awareness, this stage of processing may be referred to as preattentive (Neisser 1976). Collins and Loftus (1975) further argued that the preattentive analysis of stimuli in these individuals, being equivalent, produces similar levels of spreading activation to associates. Differential negative priming effects among high schizotypes and people with schizophrenia therefore would arise specifically from disruptions to later selective inhibitory processes. This conclusion assumed that inhibition of related concepts is not as great as activation, such that high schizotypes showed not only a lack of negative priming but also facilitation in the unattended semantic condition.

Previous investigations of schizotypy and negative priming have used a single global measure of positive schizotypal traits (Beech et al. 1989a, 1991). Williams (1995a) extended this research by investigating negative priming in distinct schizotypal subgroups, defined by their scores on several schizotypy scales. Three subgroups were said to reflect the disposition to reality distortion, disorganization, and psychomotor poverty syndromes of schizophrenia. A fourth subgroup exhibited a low overall level of schizotypy. The study’s priming paradigm was based on that of Beech et al. (1991) but used a word-naming rather than semantic categorization task. Reality Distortion and Disorganization schizotypal subgroups were associated with reduced or reversed negative priming in unattended repetition and semantic priming conditions, while the Psychomotor Poverty and Low schizotypy subgroups exhibited the expected negative priming effect. Unexpectedly, in the conventional attended repetition priming condition, the Reality Distortion and Disorganization subgroups exhibited a delayed response latency rather than positive priming, a result that conflicts with that of Beech et al. (1991). To avoid confusion with the delayed response latency associated with unattended priming conditions, this effect will be referred to as reversed positive priming. Psychomotor Poverty and Low schizotypy groups displayed the usual positive priming effect for re-presentation of a stimulus.

Recent studies have shown that positive priming can be altered by the conscious influence of task demands over the relatively automatic (i.e., preattentive) processes involved in such priming (Dagenbach et al. 1989; Besner et al. 1990; Friedrich et al. 1991). Thus, the different task requirements in the Beech et al. (1991) and Williams (1995b) studies could account for the contradictory findings for the attended repetition priming condition in relation to positive schizotypal traits. In this light, the reduced inhibition account of schizophrenic symptomatology may need to account for preattentive as well as inhibitory attentional processes.

The next logical step was to examine the pattern of attended and unattended priming in relation to corresponding symptom subgroups in schizophrenia. In the present study it was hypothesized that schizophrenia subgroups defined by reality distortion, disorganization, and psychomotor poverty would show a pattern of attended and unattended priming similar to that of corresponding schizotypy subgroups (Williams 1995a). Since the study focused on within-subgroup differences, including a nonschizophrenia control group was not appropriate. However, normative data are provided to aid interpretation of results.

Methods

Participants. Forty-four patients or former patients of Cumberland, Gladesville, Rozelle, and Westmead
Hospitals in Sydney, Australia, and of Fairmile Hospital, Wallingford, Oxfordshire, England, volunteered for the study. Participants had to have been diagnosed with schizophrenia while hospitalized and to be between the ages of 18 and 50 at initial screening. Each participant was interviewed according to Sections G (schizophrenia and other psychotic disorders), M (organic mental disorders), and P (interviewer observations) of the Composite International Diagnostic Interview (CIDI; Robins et al. 1988). Schizophrenia diagnoses were confirmed according to either DSM-III-R (American Psychiatric Association 1987) criteria or the International Classification of Diseases (ICD-10; World Health Organization 1993). To be accepted, patients could not exhibit signs of organic brain syndrome or mental retardation per CIDI Section M or report recent alcohol or drug abuse. Since the objective was to obtain a heterogeneous, and thus generalizable, sample, no further screening criteria were used.

Individual symptom severity, based on participants' responses to Sections G and P from the CIDI, was rated using the Scale for the Assessment of Negative Symptoms (SANS; Andreasen 1984a) and the Scale for the Assessment of Positive Symptoms (SAPS; Andreasen 1984b). To evaluate rating reliability, SANS and SAPS ratings were made independently by a second interviewer for 18 participants. Interrater reliability (kappa) was 0.81.

The data from three participants were subsequently excluded when their schizophrenia diagnoses were not confirmed. Seven more participants were unable to complete the cognitive task because of intrusive ideas of reference or blurred vision caused by medication. The mean age of the 34 participants in the final sample was 30.1 years (range = 18-41). The mean chlorpromazine-equivalent medication level was 432.6 mg (range = 0-1,750). Seven participants were taking no neuroleptic medication at the time of testing, and the distribution of dosages for medicated participants was positively skewed. The mean duration of illness was 9.15 years (range = 1-23).

Design. The experiment, which replicated the design of the Williams (1995b) study, was based on the procedure reported by Beech et al. (1991) with alterations to encourage an orthographic (perceptual) rather than semantic attentional focus. A word-naming rather than semantic categorization task was used, and both concrete and abstract words of low and medium frequency were included. Also, more prime and target words were used to decrease the effects of familiarity resulting from repetition of experimental stimuli (Seidenberg and McClelland 1989).

The within-subject design consisted of two blocks of 40 trials randomized for each participant. There were five 16-trial conditions, randomized within each block, which took the forms listed below. The first two words of the three in parentheses comprise the simultaneously presented to-be-attended and to-be-ignored (distractor) primes; the third word is the to-be-attended target. The to-be-attended prime and target words were presented randomly in red or green and the to-be-ignored distractor word in another color. In the examples below, to-be-attended prime and target words are signified by underlining.

1. **Attended Repetition (AR).** The attended prime is identical to the subsequent target word (Chair/Fork; Chair).
2. **Attended Semantic (AS).** The attended prime is semantically related to the subsequent target word (Stool/Fork; Chair).
3. **Ignored Repetition (IR).** The ignored distractor prime is identical to the subsequent target word (Fork/Chair; Chair).
4. **Ignored Semantic (IS).** The ignored distractor prime is semantically related to the subsequent target word (Fork/Stool; Chair).
5. **Control (CO).** The attended prime and ignored distractor prime are unrelated to the subsequent target word (Monk/Fork; Chair).

**Apparatus and Stimuli.** Stimuli were displayed on a TVM EGA monitor linked to a President Turbo XT IBM PC clone (640K available RAM). Presentation of stimuli was programmed by the Micro Experimental Laboratory (MEL; 1990) program, version 1.0.

The procedure for selecting semantic priming stimuli is described in detail by Williams (1995b). In the final set of 16 semantically related word pairs, the targets were either low- or medium-frequency words, while the primes consisted of equal numbers of low-, medium-, medium-high-, and high-frequency words (Thorndike and Lorge 1944). These pairs had a mean associative strength of 2.6 (range = 1.8-3.2) on a scale of 0 to 5. To prevent participants from anticipating the target words, higher associates were excluded, as were lower associates that could not be regarded as semantically related word pairs. Half of these word pairs included concrete words and half included abstract...
words, as determined by Paivio et al.'s (1968) concreteness and imagery criteria. Half the word pairs contained one-syllable words and half two-syllable words. The frequency, concrete/abstract status, and number of syllables for each word pair (and associated repetition priming items) were counterbalanced across each block of trials. Unrelated primes in the control items were selected from semantic primes in items from the alternate block. The effects of graphemic and phonemic priming were avoided by ensuring that word pairs shared no more than one letter in the same position and that they never shared the first letter.

Procedure. Each trial item consisted of the simultaneous presentation of a to-be-attended and a to-be-ignored word (thus, either an attended or unattended distractor prime), followed by a target word. In contrast to the Beech et al. (1991) procedure, no to-be-ignored word accompanied target word presentations. Neill and Westberry (1987) argue that such duplex displays are necessary to produce the negative priming effect only when distractor and target stimuli are dissimilar (e.g., color patches and words). The to-be-attended word was presented in the center of the screen and the distractor either above or below it (with equal probability), subtending a vertical visual angle of 1.56 degrees above or below fixation with participants positioned 60 cm from the screen. Target words were also presented centrally. Word stimuli were in upper-case characters 5 mm high and subtending a vertical angle of 0.50 degrees to the observer. One-syllable words subtended a horizontal angle of 1.5 to 1.75 degrees, two-syllable words, 3.25 to 3.5 degrees.

Each trial consisted of the successive presentation of a fixation cross for 500 ms, attended and distractor words for 100 ms, a pattern mask for 500 ms, a blank screen for 500 ms, a second fixation cross for 500 ms, a target word for 100 ms, and a target pattern mask lasting until the participant responded. Following target word responses on 20 percent of randomly selected trials, a question appeared on the screen, prompting participants to name the first attended word. This intermittent prompting was used to maximize attention to the first attended word. Precision of presentation times was maximized to 1 ms resolution by using the MEL program's "waittop" screen refresh option.

Participants were instructed to attend to red (or green) and ignore green (or red) words. They were asked to name the target word as quickly and accurately as possible and, when prompted, to name the preceding attended prime as accurately as possible. Data recorded for each trial included participants' verbal response to the target and the reaction time (RT), the latter determined via a voice-activated relay and entered directly into MEL data files with a resolution of 1 ms. Responses to the occasional question about the attended prime were recorded without RT. Participants were instructed to respond with "Pass" if they did not identify either the target or the attended prime on any trial. Verbal responses to target words and attended primes were manually recorded for later error analysis. The MEL program logged the order of trials presented to each subject to enable matching of word stimuli with actual responses.

A number of practice items were presented before the experiment trials began. Feedback on RT was displayed on the monitor screen for these practice trials. Practice continued until the RT to five successive items was below at least 1.0 second and the subject had fully comprehended the experimental procedure.

Results

Symptom subgroups were determined through cluster analysis of SANS and SAPS subscale ratings. This method of analysis produces natural, rather than a priori, groups of cases that have high internal and external heterogeneity (Blashfield 1984). Maximizing the distance between subgroups in this way was considered necessary for subsequent within-sample comparison between subgroups. These subgroups were examined first in relation to priming data. In a further analysis, these priming data were compared to those from a nonclinical sample (Williams 1995b). A third analysis investigated the error rate for prime and target words in relation to symptom subgroups.

Cluster Analysis of Symptom Variables. An agglomerative hierarchical cluster analysis based on minimum variance within groups (Statistical Package for the Social Sciences 1983) was conducted with standardized SANS and SAPS subscale ratings to identify empirically distinct subgroups of participants. Clustering was stopped at four clusters, based on the values of
the fusion coefficient derived during the analysis. That is, the difference between the coefficients for the four- and three-cluster solutions was almost twice that of the coefficients for the four- and five-cluster solutions. Visual inspection of the dendogram plot also supported a four-cluster solution. Mean standardized ratings for the SAPS hallucination (HA), delusion (DE), positive formal thought disorder (PF), and bizarre behavior (BB) subscales and for the SANS affecting flattening (AF), alogia (AL), avolition/apathy (AV), anhedonia/asociality (AN), and attention (ATT) subscales are shown in figure 1.

Standardized SANS and SAPS ratings are depicted to facilitate interpretation relative to the distribution average. Figure 1 also presents the variance (eta-squared) in these subscales accounted for by the final four clusters. With the exception of the PF subscale, the eta-squared values for the SANS and SAPS subscales indicate that each subscale contributes substantially to this cluster solution, thus confirming the internal validity of such a cluster breakdown. The apparent omission of standard error bars for the mean PF rating for Cluster 4 (figure 1) is due to the fact that all participants in this cluster received a rating of zero for this subscale.

Cluster 1 included participants with high to very high ratings on all SANS and SAPS subscales. Cluster 2 consisted of those with moderate to high SANS ratings (except for the ATT scale) and very low to moderate SAPS ratings. Cluster 3 comprised participants with moderate to high ratings on all SAPS subscales as well as the SANS ATT scale, along with low to very low ratings on the remaining SANS subscales. Participants in Cluster 4 exhibited low to very low ratings on all SANS and SAPS subscales with the exception of the SAPS PF and SANS AN subscales, which showed moderate elevations. These clusters may usefully be referred to in terms of schizophrenic syndromes revealed in factor-analytic studies (e.g., Liddle 1987).

Clusters 1 and 3 may correspond broadly to the disorganization and reality distortion dimensions of positive symptomatology, respectively. While both clusters are characterized by a strong presence of hallucinations and delusions, Cluster 1 is distinguished from Cluster 3 by higher levels of thought disorder, bizarre behavior, alogia, and attentional deficits. These clusters were therefore referred to as the Disorganization and Reality Distortion subgroups, respectively. Cluster 2, on the other hand, most likely corresponds with Liddle’s (1987) psychomotor poverty dimension, and was thus referred to as the Psy-

![Figure 1. Mean standardized rating for cluster on SANS and SAPS subscales](image_url)

Note.—HA = hallucination; DE = delusion; PF = positive formal thought disorder; BB = bizarre behavior; AF = affective flattening; AL = alogia; AV = avolition/apathy; AN = anhedonia/asociality; ATT = attention. SANS = Scale for the Assessment of Negative Symptoms (Andreasen 1984a); SAPS = Scale for the Assessment of Positive Symptoms (Andreasen 1984b).
chomotor Poverty subgroup. While factor-analytic studies have not specifically identified a remitted or episodic syndrome, the general absence of symptoms for Cluster 4 suggests that one exists. Given the presence of some symptomatology in this subgroup and the fact that most of its participants reported intermittent experiences of positive symptoms, Cluster 4 is referred to as the Episodic subgroup.

A second cluster analysis including the seven participants who were unable to complete the cognitive task revealed four clusters conceptually similar to those in the first analysis, indicating that omitting these participants did not create a biased final sample.

Symptom Clusters and Priming. Table 1 shows the means and standard deviations for the Disorganization, Psychomotor Poverty, Reality Distortion, and Episodic subgroups on RTs across the five experimental conditions. The amount of priming for each experimental condition was derived by subtracting the mean RT for the control condition from the mean RT for the experimental condition of interest. Pass responses were treated as missing values in this procedure. The derived priming measures for attended priming were repetition positive priming (RP) and semantic positive priming (SP). For unattended (ignored) priming they were repetition negative priming (RNP) and semantic negative priming (SNP). These priming measures for each SANS/SAPS cluster are presented in figure 2.

RT data were initially analyzed using a three-way mixed design multivariate analysis of variance (MANOVA) (Statistical Package for the Social Sciences 1983). The between-subjects factor was cluster. The within-subject factors, with repeated measures on each factor, were type of priming (repetition vs. semantic) and priming category (attended vs. unattended). The dependent measures were RP, SP, RNP, and SNP. Because the primary goal of the study was to examine the differential impact of symptom subgroups, the crucial effects were considered to be those interactions involving both SANS/SAPS cluster and priming measures.

MANOVA results revealed a significant three-way interaction between cluster, type of priming, and priming category (F = 6.44, df = 3,30, p < 0.01). Figure 2 shows that, for the attended repetition priming condition, the Psychomotor Poverty subgroup was associated with positive priming while the Disorganization, Reality Distortion, and Episodic subgroups were associated with longer response latencies (i.e., reversed positive priming). Post hoc Tukey's honestly significant difference analysis, using the procedure for logical groupings of means (Winer 1971, p. 442) and the method of harmonic n (for unequal group sizes), showed a significant difference in RP between the Psychomotor Poverty subgroup and the Disorganization (p < 0.05), Reality Distortion (p < 0.01), and Episodic (p < 0.01) subgroups. Unexpectedly, the Episodic subgroup also showed a significantly greater (p < 0.01) reversal in positive priming for this condition than both the Disorganization and Reality Distortion subgroups. In contrast, all four subgroups were associated with positive priming for the SP condition. Post hoc analysis revealed no significant differences between subgroups in relation to SP.

Table 1. Means (standard deviations) for Disorganization, Psychomotor Poverty, Reality Distortion, and Episodic clusters across priming conditions (ms)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Disorganization (n = 8)</th>
<th>Psychomotor Poverty (n = 8)</th>
<th>Reality Distortion (n = 12)</th>
<th>Episodic (n = 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR</td>
<td>847.2 (192.0)</td>
<td>776.9 (130.4)</td>
<td>840.2 (161.4)</td>
<td>794.6 (184.3)</td>
</tr>
<tr>
<td>AS</td>
<td>734.0 (165.7)</td>
<td>765.9 (141.8)</td>
<td>731.8 (138.8)</td>
<td>642.2 (178.4)</td>
</tr>
<tr>
<td>IR</td>
<td>800.8 (158.2)</td>
<td>841.1 (132.5)</td>
<td>750.7 (164.5)</td>
<td>663.0 (180.9)</td>
</tr>
<tr>
<td>IS</td>
<td>805.7 (169.6)</td>
<td>836.6 (140.2)</td>
<td>768.5 (134.5)</td>
<td>643.8 (204.1)</td>
</tr>
<tr>
<td>CO</td>
<td>821.3 (177.1)</td>
<td>803.5 (144.0)</td>
<td>780.3 (172.4)</td>
<td>669.0 (191.3)</td>
</tr>
</tbody>
</table>

Note.—AR = attended repetition; AS = attended semantic; IR = ignored repetition; IS = ignored semantic; CO = control.
Figure 2. Priming for SANS and SAPS clusters

RP = repetition positive priming; SP = semantic positive priming; RNP = repetition negative priming; SNP = semantic negative priming. SANS = Scale for the Assessment of Negative Symptoms (Andreasen 1984a); SAPS = Scale for the Assessment of Positive Symptoms (Andreasen 1984b).

For unattended (ignored) priming, the Disorganization and Reality Distortion subgroups, and to a lesser extent the Episodic subgroup, showed reversed negative priming (i.e., facilitation) for the RNP condition, while the Psychomotor Poverty subgroup exhibited the usual negative priming effect for this condition. Post hoc Tukey’s analysis showed significant differences (p < 0.05) in RNP between the Psychomotor Poverty subgroup and both the Disorganization and Episodic subgroups. These differential group priming effects probably account for the significant cluster by type of priming (F = 4.21, df = 3.30, p < 0.05) and cluster by priming category (F = 19.36, df = 3.30, p < 0.0001) interaction, as well as the significant main effect for type of priming (F = 28.97, df = 1.30, p < 0.0001) also revealed in the MANOVA analysis.

Given the variability in RT data, which would have been compounded through the use of difference scores, it was important to determine that initial differences in RT (control condition, or CO) did not account for the differential priming effects across SANS/SAPS clusters. One option was to repeat the MANOVA with mean RT for CO as a covariate. However, this option was dismissed because covariates should represent stable characteristics, that is, they should exist before the study (Tabachnick and Fidell 1989). RT for CO did not represent such a characteristic. Instead, the MANOVA for SANS/SAPS clusters was repeated using log_{10} transformations of the data. In this analysis, CO was treated as a different level of the independent variable (namely, the experimental priming condition). The analysis therefore did not rely on priming measures derived from difference scores. By means of an explicit set of contrasts, CO was first compared to all priming conditions (AR, AS, IR, and IS); these priming conditions were then compared to each other. Results for this analysis confirmed those for untransformed difference scores. In this analysis the main effect for priming category was also significant (p < 0.05). Difference score data therefore could be interpreted with some confidence.

A third MANOVA, with chlorpromazine-equivalent medication level and duration of illness in years as covariates, was conducted to examine the possible confounding of these variables with symptom cluster and priming data. Medication level and duration of illness were not found to covary significantly with SANS/SAPS clusters and priming (F = 1.09, df = 2.28, p = 0.35). That is, priming data for these clusters were not found to be linearly dependent on medication level or duration of illness. It remains possible nonetheless that a nonlinear
physician's office. It was not possible to address this issue with the present data.

Comparisons for Symptom Cluster and Normative Priming Data. To facilitate interpretation of results for SANS/SAPS clusters, providing normative priming data from a nonclinical sample was considered appropriate. The Williams (1995a) study, using a priming procedure identical to the one used in the present study, was conducted with such a sample (n = 70). The mean derived priming values—RP, SP, RNP, and SNP—for nonpsychosis subjects were -8.6, -32.0, 15.0, and 9.2 ms, respectively. These values indicated that positive priming occurred for attended conditions (repetition and semantic), and negative priming for unattended conditions. Mean derived priming values for Disorganization, Psychomotor Poverty, Reality Distortion, and Episodic subgroups (figure 2) were compared with those for nonpsychosis subjects by means of Dunnett's formula (Kirk 1982, p. 112) for contrasts involving a control mean. For RP, nonpsychosis subjects differed significantly from Disorganization (p < 0.05), Reality Distortion (p < 0.01), and Episodic (p < 0.01) subgroups but not from the Psychomotor Poverty subgroup. For SP, the Reality Distortion subgroup showed significantly more (p < 0.05) positive priming than nonpsychosis subjects; no other comparisons were significant. For RNP, nonpsychosis subjects differed significantly from Disorganization (p < 0.01), Reality Distortion (p < 0.01), and Episodic (p < 0.05) subgroups. The Psychomotor Poverty subgroup also differed significantly (p < 0.05) from nonpsychosis subjects for RNP, although this result indicated greater rather than reduced negative priming for the former group. For SNP, each subgroup except the Psychomotor Poverty subgroup differed significantly (p < 0.05) from nonpsychosis subjects. These findings largely confirm indications from MANOVA results that the Psychomotor Poverty subgroup is associated with the normal pattern of positive and negative priming, while the Disorganization, Reality Distortion, and Episodic subgroups are associated with a reversal of this pattern.

Error Analysis. Three error scores for each participant were computed for target word responses by calculating separately the number of full word errors, part word errors, and Pass responses. Similarly, three error scores were calculated for prime responses. Stem and leaf displays for each of these six error score categories were produced. Visual inspection of the displays suggested that the point of discrimination for full word and part word errors on responses to primes and for full word errors for target words was zero or greater than zero errors. Points of discrimination for the remaining error types were whether the participant produced either zero, one to six, or seven or more errors. Participants therefore were assigned to one of these categories for each error type. A chi-square analysis was conducted to test for the association between cluster and number of errors for each error type. A significant relationship was revealed for the four subgroups and full word errors for target word responses (χ² = 9.45, df = 3, p < 0.05). Inspection of residuals revealed that a greater than expected number of errors for participants in the Disorganization subgroup was responsible for this result. No significant relationship was revealed for the remaining five analyses.

Discussion The purpose of this study was to identify distinct subgroups of schizophrenia patients that differed in symptom profile and to examine the performance for these subgroups in terms of both attended and unattended priming, in an attempt to determine the extent to which the findings would parallel those of schizotypal subgroups (Williams 1995b). Cluster analysis of participants' SANS and SAPS subscale ratings revealed the existence of four distinct symptom subgroups (figure 1). Given their small size, the stability of these clusters must be viewed with caution. However, two subsequent studies (Williams 1995a, 1995b) have reproduced these results with only minor variations.

The pattern of SANS and SAPS ratings for three clusters suggested that individuals are grouped in broad correspondence with the disorganization, reality distortion, and psychomotor poverty dimensions of schizophrenic symptomatology (Liddle 1987). The finding that the Disorganization subgroup exhibited high ratings not only for negative symptoms previously found to contribute to this syndrome but also for affective flattening, avolition, and anhedonia, may be due to the fact that a cluster rather than a factor-analytic approach...
was adopted. That is, within groups of individuals rather than measures, the severity and number of manifest negative symptoms have been found to be related to the overall severity of positive symptoms—particularly thought disorder (Morrison et al. 1990). A fourth cluster reflected the existence of an additional Episodic subgroup. Interview responses for these participants indicated that when psychotic episodes did occur they were characterized largely by positive symptoms. It is therefore likely that this subgroup represents the latent rather than over expression of these symptoms.

The results for unattended priming for the four subgroups in the present study were consistent with those revealed by Williams (1995b) for distinct schizotypal personality traits. While the cluster sizes were relatively small, the use of a repeated measures analysis of variance allowed for meaningful inferences to be made about the priming data. The prescribed case-to-variable ratio was not violated (Tabachnick and Fidell 1989).

The Reality Distortion and Disorganization subgroups were associated with reduced, indeed reversed, negative priming in unattended repetition and semantic priming conditions (figure 2). The finding that the Episodic subgroup showed a similar lack of repetition and semantic negative priming may be due to the latent (or less severe) presence in these participants of positive symptoms contributing to the reality distortion and disorganization syndromes. In contrast, the Psychomotor Poverty subgroup displayed negative priming for both repetition and semantic conditions. On the basis of this pattern of priming across subgroups, several tentative proposals may be made. The fact that priming data confirm findings for distinct schizotypal traits indicates that a weakening of inhibitory processes is associated with the development of positive schizophrenic symptoms that contribute to the reality distortion and disorganization syndromes. The different pattern of priming evident in the Psychomotor Poverty subgroup suggests that the negative symptoms that define this syndrome cannot be explained in terms of reduced inhibition. Thus, the coexistence of these negative symptoms in the Disorganization subgroup is not likely to be associated with the reduced inhibition exhibited by these participants.

Beech et al. (1990) suggested that the reduced inhibition effect may, to some extent, be normalized for schizophrenia patients taking neuroleptic medication. As neither medication nor length of illness was found to covary significantly with subgroups and priming conditions, this study did not support such a suggestion. It is unlikely that this null effect was due only to limited within-group variation of a heavily medicated sample, since approximately 20 percent of participants were unmedicated, and the range of dosages for medicated participants was positively skewed. Instead, it would appear that reduced inhibition is a stable phenomenon for patients experiencing manifest as well as latent positive symptoms. The fact that Beech et al. found medication increased negative priming for nonschizophrenia subjects may reflect the differential impact of its temporary use in a healthy sample compared to its long-term use in the present clinical sample.

The results for symptom subgroups in relation to attended repetition and semantic priming were also consistent with those for schizotypy subgroups (Williams 1995b). Each symptom subgroup showed positive priming in the attended semantic priming condition. However, while the Psychomotor Poverty subgroup exhibited facilitory attended repetition priming, the Reality Distortion, Disorganization, and Episodic subgroups were associated with a longer latency of response (i.e., reversed positive priming) in this condition.

The fact that this pattern of attended priming was revealed by Williams (1995b) but not in the Beech et al. (1991) study again points to an explanation in terms of the different stimuli and task employed in the present study. Apparently, while information about the orthographic (perceptual), phonological, and semantic features of priming stimuli is activated preattentively and simultaneously, the nature of the task employed determines which source of information is given attentional focus and thus priority in the allocation of processing resources (Seidenberg and McClelland 1989; Friedrich et al. 1991). While both the present study and the Beech et al. study required pronunciation of responses, the tasks employed may have promoted a difference in attentional focus in turn providing differences in earlier stages of processing. In contrast to Beech et al.'s (1991) semantic categorization task, the attentional focus required by the present word-naming task may have served to allocate processing resources to orthographic information in preference to semantic information. Characteristics of the stimuli themselves may also
have encouraged the processing of orthographic information (namely, the inclusion of relatively low-frequency and abstract words), as well as the use of a greater number of stimulus words to reduce the repetition and, thus the familiarity of stimuli (Seidenberg and McClelland 1989).

For some tasks, simultaneous activation of information from less relevant codes may cause interference and subsequent response impairment (Dagenbach et al. 1989; Seidenberg and McClelland 1989; Besner et al. 1990; Friedrich et al. 1991). In the present task, the simultaneous preattentive activation of less relevant semantic information might have interfered with the computation from orthography to phonology for Reality Distortion, Disorganization, and Episodic subgroups, thus delaying response times. Indirect support for this possibility may be seen in results for error analyses. In responses to target words, participants in the Disorganization subgroup made more full-word errors than expected. Visual inspection of their manually recorded responses revealed a surprising number of words semantically associated with the target but not otherwise used in the study. For example, “police” was given instead of “rules,” and “working” instead of “student.” Such errors point to the intrusive nature of irrelevant but semantically associated information in this subgroup, which, notably, contained participants with the highest overall positive symptom ratings. In this context it is worth noting that Kwapil et al. (1990) found heightened semantic activation among schizophrenia patients exhibiting thought disorder. The effects of such interference may not be as apparent in the negative priming conditions because distractor information is not required for appropriate responses and thus does not necessitate conscious attention (Neill and Westbury 1987).

The present priming data clearly point to a departure from the usual pattern of positive and negative priming for Disorganization, Reality Distortion, and Episodic subgroups, but not for the Psychomotor Poverty subgroup. Comparisons between these subgroups and nonschizophrenia subjects unselected for level of schizotypy (Williams 1995b) confirmed these indications. The finding that the Psychomotor Poverty subgroup displayed greater negative priming than nonschizophrenia subjects warrants replication, given the small size of that subgroup. Indications that the Reality Distortion subgroup is associated with greater semantic facilitation than nonschizophrenia subjects is consistent with Kwapil et al.’s (1990) findings. Nonetheless, this finding warrants further investigation with a larger sample.

In conclusion, results concerning unattended priming support the notion that reduced cognitive inhibition may play a role in the occurrence of positive symptoms that contribute to the reality distortion and disorganization syndromes of schizophrenia. Reduced inhibition might also be associated, perhaps in a less direct way, with particular negative symptoms that have been associated with the disorganization syndrome, namelyalogia and attentional deficits. In contrast, the present results indicate that reduced cognitive inhibition does not explain the development of negative symptoms that define the psychomotor poverty syndrome. Results concerning attended priming also revealed clear subgroup differences. Tentative indications are that the differential pattern of attended and unattended priming across symptom subgroups might eventually be explained by a model comprising differences in preattentive processing of stimuli as well as in selective inhibitory processes. Further clarification of this proposal may be achieved in priming studies in schizophrenia that pay specific attention to task demands and the influence of these demands on preattentive stages of processing.

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The Author

Leanne M. Williams, Ph.D., is a lecturer in Psychological Assessment in the Department of Psychology, University of New England, Armidale, New South Wales, Australia. She is also a research member of the Cognitive Neuroscience Unit, Department of Psychiatry, Westmead Hospital, Sydney, Australia.