

Storage and Access Procedures in Schizophrenia: Evidence for a Two Phase Model of Lexical Impairment

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Storage and Access Procedures in Schizophrenia: Evidence for a Two Phase Model of Lexical Impairment

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*Evidence has accumulated to show that schizophrenia is characterized by lexical-semantic difficulties; however, questions remain about whether schizophrenics have 15
 problems in accessing intact representations or a loss of the representations themselves. Both access and storage types of disorder have been reported and it has been
 speculated that this may reflect a transition from the former to latter with increasing
 length of illness. This study investigated whether illness duration, age or estimated pre- 20
 morbid IQ predict the size and accessibility of the lexical store. Fifty-six schizophrenic
 patients (chosen to represent a wide range of illness duration from 3–40 years) and 24
 matched healthy controls were asked to name 120 pictures on two occasions. Esti-
 mates of store size and retrieval probability were derived from a two parameter sto- 25
 chastic Markov chain model. This revealed that even early in the course of illness,
 schizophrenics appear to have suffered a reduction in lexical store size and that those
 with longer length of illness show deficits in both their store size and their ability to
 retrieve names from that store.*

Introduction

Semantic memory refers to a system that processes, stores and retrieves information about 30
 the meaning of words, objects, facts and concepts. Based on the notion that retrieval of
 knowledge reflects the spread of activation through the semantic memory network, criteria
 have been proposed for distinguishing between disorders that reflect either a loss of under-
 lying representations or a problem with accessing intact representations. In the former,
 knowledge is assumed lost while the latter describes temporarily inaccessible knowledge. 35
 Warrington and Shallice (1979) proposed criteria for distinguishing between the two dis-
 orders: store disorders are characterized by consistency over time, a greater preservation
 of familiar, frequent and superordinate information and no facilitation effect from cueing;
 by contrast, access disorders would show the reverse pattern. Although evidence indicates
 that schizophrenia is characterized by a semantic memory deficit (e.g., for a review, see

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Al-Uzri, in press) whether this dysfunction occurs because of a loss of representations or 40
difficulty accessing them is unclear.

Although not the major focus of some semantic verbal fluency studies in schizophren- 45
ics, some studies present data that are relevant to the access and store issue. For example,
Allen, Liddle, and Frith (1993) tested subjects on five separate occasions and showed that
schizophrenics generate fewer exemplars on each successive testing, but show less over-
lap than normal subjects in their choices between sessions, indicating a normal sized word
pool. In other words, their lexical store size is normal, but they have difficulty consistently
accessing items. Similarly, Joyce, Collinson, and Crichton (1996) found that the majority
of the schizophrenic patients they tested on a verbal fluency task, whilst showing poor
baseline scores, significantly improved with cueing (such as animals found on a farm, ani- 50
mals found in a jungle). These findings are also indicative of a disorder of semantic
access. Support for the impaired access interpretation of semantic memory impairment
also comes from inconsistent picture naming in patients with schizophrenia (McKenna,
Mortimer, and Hodges, 1995).

Chen, Chen, Chan, Lam, and Lieh-Mak (2000), however, failed to find supporting 55
evidence for an intact semantic store when they attempted to replicate Allen et al.'s (1993)
study. They report that, in addition to retrieval difficulties, ". . . at least for some patients,
there is a semantic store reduction". Laws, Al-Uzri and Mortimer (2000) examined consis-
tency over time in picture naming and found that almost all their schizophrenic subjects
showed characteristics of a store disorder on this criterion. 60

These varying accounts of the nature of the semantic deficit occurring in schizo-
phrenic patients suggest that there could be an additional factor determining the type of
impairment in the disorder. Laws, McKenna, and Kondel (1998) examined a cohort of
schizophrenic patients on a familiar face-naming task, assessing effects of cueing, fami-
liarity and consistency over time. They found that when patients' individual profiles were 65
examined, six out of twelve patients showed characteristics of a store disorder, two
evinced an access disorder, two showed a mixed access and store profile and two appeared
to be within the normal range. The authors suggest that this variability between patients'
profiles could be due to chronicity of illness since the chronically hospitalized patients in
their cohort all displayed the more store-like profile. 70

A recent review of access and store studies in patients with schizophrenia (Al-Uzri, in
press; see also Al-Uzri, Laws and Mortimer, in press) indicates that patient age is a related
to whether patients show an access or storage profile. Similarly, some evidence shows that the
type of semantic memory deficit in schizophrenia may be related to length of illness. Two
studies that have found more store type characteristics used older, chronic patients (Chen 75
et al., 2000; Laws et al., 2000) and Chen et al. (2000) suggest that differing illness duration
could be responsible for the difference between their findings and those of Allen et al. (1993).

These comparisons between studies are suggestive; however, research directed spe-
cifically at this hypothesized transition from an access to store type deficit is necessary.
Two studies have attempted to do so using longitudinal methodology (Laws et al., 1998; 80
Laws et al., 2000). These studies have used relatively short time periods (6 months – 3
years) and provide little or no evidence of any transition within subjects.

To allow exploration of a wide range of illness duration, the current study uses
regression techniques to determine if picture naming is predicted by length of illness
and/or other factors including estimated premorbid IQ. If patients show a transition 85
from access to storage profiles then we would hypothesize that with increasing illness
initial retrieval difficulties will diminish and be replaced by a reduction in the lexical
store size.

Materials and Methods

Subjects 90

The patient sample consisted of 56 patients (37 males and 19 female) who fulfilled Research Diagnostic Criteria (Spitzer, Endicott, and Robins, 1978) for schizophrenia. These were drawn from a study population under the care of one of the authors (PJM). None of the patients had a history of head injury, neurological disorder, and drug or alcohol misuse. The age range was 22–64 years (mean = 43.1, SD = 11.67), and mean pre-morbid NART IQ (Nelson, 1982) was 101.4 (SD = 13.55). For the purpose of this study, length of illness was taken to be amount of time since the patient first presented to either their GP or mental health services with psychotic symptoms. This was established from case notes supplemented by further enquiries where necessary. Length of illness ranged from 3–40 years (mean = 19.3, SD = 9.79) 100

A further 24 healthy control subjects were tested (mean age = 38.7, SD = 11.12; mean NART IQ = 107.3, SD = 10.31). The two groups were not significantly different in term of age or NART IQ (age: $t_{78} = 1.56, p > 0.05$; IQ: $t_{78} = 1.93, p > 0.05$)

Procedure

Subjects were administered a picture-naming task consisting of 120 color images (McKenna, 1997). This task consists of four sets of 30 items from the superordinate categories: *fruit and vegetables* (e.g., mushroom, lychee), *animals* (e.g., fox, platypus), *praxic* (objects with a specific skilled action entailed in their use, e.g., darts, kaleidoscope) and *non-praxic* (objects that do not have a specific action entailed in their use, e.g., cushion, snorkel). The items in each category are graded for normative difficulty. The pictures were shown, one at a time, on a laptop computer screen. The order of presentation was from easiest to most difficult items (according to test norms from 400 healthy controls: McKenna, 1997) and no time limit was imposed. Eight to sixteen weeks later, the same test was re-administered. 110

At retesting, all participants were administered the National Adult Reading Test (NART; Nelson, 1982). The NART requires subjects to accurately read and pronounce 50 irregularly spelled words that become increasingly less familiar (e.g., ache, debt, syncope, prelate). The NART was developed as a measure for estimating premorbid intelligence in patient groups (for a review, see O’Carroll, 1995) and is viewed as providing a good estimate of premorbid IQ because it: (a) predicts much of the variance in current WAIS IQ; (b) has high reliability in normal subjects; (c) is resistant to cerebral dysfunction (Nelson & Willison, 1991). The NART appears to provide a valid and reliable estimate of premorbid IQ in patients with schizophrenia (Crawford, Besson, Bremner, Ebmeier, Cochrane, & Kirkwood, 1992; Kondel, Mortimer, Leeson, Laws & Hirsch, 2003). 115
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Results

Between Groups 125

Comparison of the schizophrenic group with the control group revealed a large difference in the mean number of correct responses between the groups on both the first ($t_{78} = 6.29, p < 0.001$) and the second test occasion ($t_{78} = 6.63, p < 0.001$). This reflected poorer overall naming in the schizophrenic group (who showed no significant change between the first and second testing: $t_{56} = -1.49, p > 0.05$). Table 1 shows the mean naming scores on 130

Table 1
Mean scores for the schizophrenic and control group

Group	Naming Test 1*	Naming Test 2*	s^*	r_d^*	r_i^*
Schizophrenics (n = 56)	65.96 (15.55)	66.98 (16.17)	67.52 (15.76)	59.16 (15.84)	104.38 (5.60)
Controls (n = 24)	89.46 (16.32)	92.54 (15.66)	90.05 (15.39)	82.82 (17.17)	109.60 (5.60)

* Standard deviations given in parenthesis.

both test occasions for the schizophrenic and control groups and Figure 1 shows the scores for each patient on the first naming test occasion.

Using the norms for 400 healthy controls (mean NART IQ =101; age 19–70) published in the Category Specific Naming Test manual (McKenna, 1997), 16 (29%) of the schizophrenic patients' scores from the first test occasion fell below the 5th percentile. 135

Consistency Analysis

A two parameter stochastic Markov chain model (Faglioni and Botti, 1993) was used to examine naming consistency across two test occasions. This model accounts for random variability and for each patient, provides the probability that a name is stored [s] and will

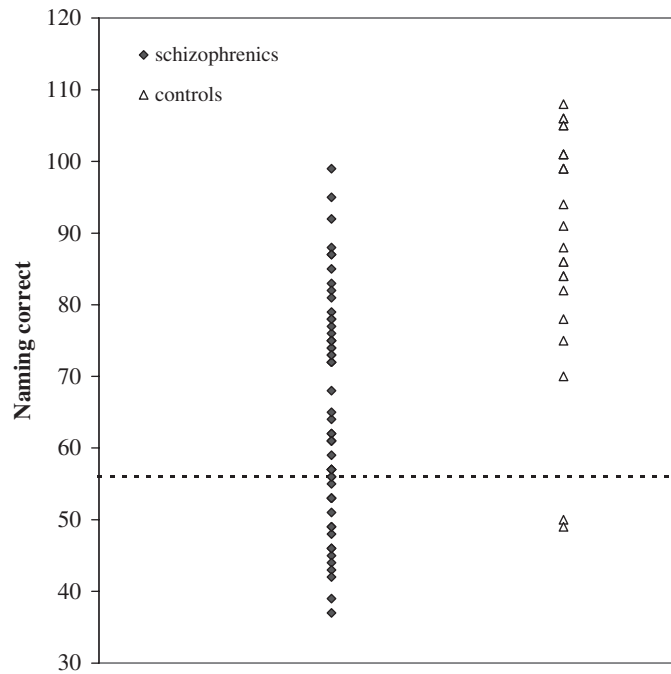


Figure 1. Naming scores for each individual subject in the schizophrenic and control group. The 5th percentile cut-off (determined from the published norms: McKenna, 1997) is indicated on the y axis by the unbroken line.

be retrieved [r]. Probability [r] signifies the likelihood that a stored representation would be accessed and probability [s] reflects the integrity of the semantic store itself where a probability of 1 indicates no impairment. Values for [s] and [r] probabilities were calculated using:

$$\begin{aligned} \text{Retrieval probability } [r] &= 2S_2/S_1 + 2S_2 \\ \text{Storage probability } [s] &= S_1 + 2S_2/2r \end{aligned} \quad 145$$

For each subject, [s] probabilities were converted to a predicted score based on the total possible number of correct responses (120) multiplied by the [s] probability. For example, a [s] probability of 0.8 would yield an estimated storage [s] of $120 \times 0.8 = 96$. Similarly, a retrieval score was calculated. Whilst it is true that one can only retrieve what is held in the semantic store, this score was based on the assumption that [s] = 1 (i.e., the subject had a complete semantic store) to allow for analysis of retrieval independent of storage. This estimated independent retrieval [r_i] was calculated by multiplying the total number of possible correct response (120) by the [r] probability.

Since retrieval is dependent on, not only the retrieval probability, but also the item being held in the semantic store, a dependent retrieval [r_d] was calculated based on [s] multiplied by the [r] probability. This score can be considered the true score a subject would be expected to achieve considering *both* their [r] and [s] probabilities

The predicted storage and retrieval scores for the control group were significantly higher than for the schizophrenic group ([s]: $t_{78} = 5.90, p < 0.001$; [r_d]: $t_{78} = 5.97, p < 0.001$; [r_i]: $t_{78} = 3.82, p < 0.001$). Table 1 shows the mean predicted scores for both groups.

Within Group

Stepwise regression was used to determine if any of the potential predictors, i.e., age, length of illness and NART IQ, were significantly influencing the storage and retrieval scores in the schizophrenic group. Since age and length of illness are significantly correlated ($r = 0.73, n = 56, p < 0.001$), these two factors were examined independent of each other for the schizophrenic group by excluding age from the initial regression analyses then repeating them with age substituted for length of illness.

Factors Influencing Storage

The first regression was performed on the schizophrenic group data with [s] as the dependent variable and length of illness and NART IQ entered as potential predictors. This revealed that both NART IQ and length of illness were significant predictors of [s] ($F_{2,53} = 5.73, p = 0.006$). However, the model showed poor goodness of fit ($r^2 = 0.18$). When age was substituted for length of illness in the stepwise analyses it was not found to be a significant predictor of [s] but NART IQ remained a significant predictor ($F_{1,54} = 5.87, p = 0.02, r^2 = 0.10$). The correlations for healthy controls and schizophrenic patients are shown in Tables 2 and 3 respectively.

Stepwise regression of the control group data, using NART IQ and age as potential predictor variables, found IQ to be a significant predictor of [s] ($r^2 = 0.25, F_{1,22} = 7.28, p = 0.013$). Figure 2 shows [s] increasing as NART IQ increases in the schizophrenic and control groups.

Table 2
Correlations for the control group (n = 24)

	NART IQ	Retrieval	Storage
Age	.15	-.01	.13
NART IQ		.32	.49*
Retrieval			.83**

* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.

Table 3
Correlations for the schizophrenic group (n = 56)

	Length of illness	NART IQ	Retrieval	Storage
Age	.73**	.04	-.39**	-.10
Length of illness		.09	-.45**	-.25
NART IQ			.09	.31*
Retrieval				.59**

* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.

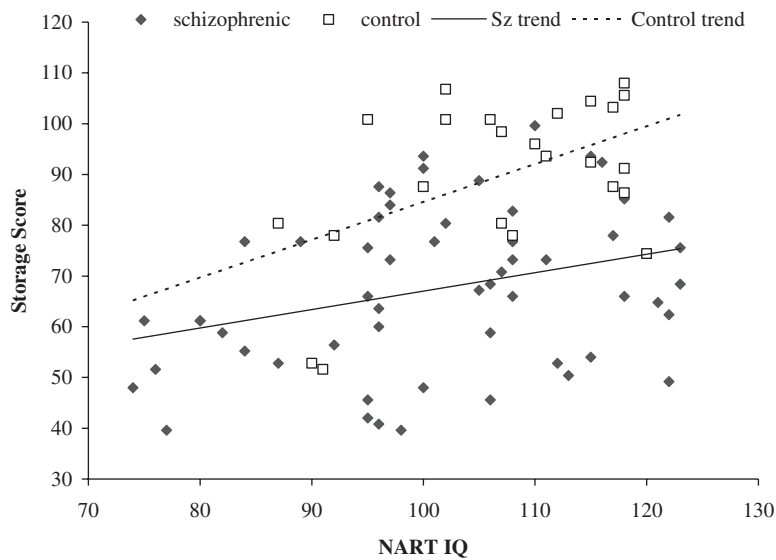


Figure 2. The relationship between NART IQ and storage size in the schizophrenic and control groups.

Factors Influencing Retrieval

For the schizophrenic group, stepwise regressions showed both premorbid IQ and length of illness to be significant predictors of $[r_d]$ ($F_{2,53} = 6.19, p = 0.004$), but only length of illness to be a significant predictor of $[r_i]$ ($F_{1,54} = 13.94, p < 0.001$). Both these models also showed poor goodness of fit ($[r_d]: r^2 = 0.19; [r_i]: r^2 = 0.21$). When age was substituted for length of illness in the stepwise analyses it was not found to be a significant predictor of $[r_d]$ but NART IQ remained a significant predictor ($F_{1,54} = 4.90, p = 0.03, r^2 = 0.08$). Age but not NART IQ was found to be a significant predictor of $[r_i]$ ($F_{1,54} = 9.88, p = 0.003, r^2 = 0.16$).

Stepwise regression for the control group data revealed that there was no significant effect of either IQ or age on $[r_i]$. NART IQ did, however, predict $[r_d]$ ($F_{1,22} = 5.99, p = 0.023, r^2 = 0.21$).

Changes in Retrieval and Storage as a Function of Length of Illness in the Schizophrenic Group

Since length of illness was found to be a significant predictor of all three scores in the schizophrenic group, a linear regression was performed for each of the three scores ($[s]$, $[r_d]$ and $[r_i]$) with length of illness entered as a predictor. This yielded an equation for each that was used to predict change in naming performance as a function of length of illness.

The patients were grouped by length of illness into four subgroups (1–10, 11–20, 21–30 and 31–40 years ill) and each subgroup compared to the control subjects for $[s]$, $[r_i]$ and $[r_d]$ scores (see Table 4). Figure 3 shows the change per year effected by storage, retrieval (independent retrieval) and the interaction of storage and retrieval (dependent retrieval) as predicted by these regression equations. Figure 3 also shows the reducing mean $[s]$, $[r_i]$ and $[r_d]$ scores for patients when grouped by length of illness (the four schizophrenic groups did not differ significantly in terms of NART IQ: $F_{3,55} = 0.25, p > 0.05$).

Discussion

When required to name color pictures that are graded in difficulty, schizophrenic patients showed generally poorer naming performance compared to healthy controls. Indeed, 29% of the patients fell below the 5th percentile of the published test norms from 400 healthy controls (McKenna, 1997). This substantiates several other studies reporting severe

Table 4
Results of t-tests comparing $[s]$, $[r_d]$, and $[r_i]$ for controls with patient cohorts (organised by length of illness)

Length of illness	1–10 years	11–20 years	21–30 years	31–40 years
Storage $[s]$	$t_{36} = 3.65,$ $p = 0.001$	$t_{39} = 4.17,$ $p < 0.001$	$t_{37} = 4.10,$ $p < 0.001$	$t_{32} = 3.86,$ $p < 0.001$
Dependent retrieval $[r_d]$	$t_{36} = 3.53,$ $p = 0.001$	$t_{39} = 3.98,$ $p < 0.001$	$t_{37} = 4.05,$ $p < 0.001$	$t_{32} = 5.93,$ $p < 0.001$
Independent retrieval $[r_i]$	$t_{39} = 2.18,$ $p = 0.035$	$t_{37} = 2.92,$ $p = 0.006$	$t_{32} = 5.53,$ $p < 0.001$	$t_{36} = 1.57,$ $p > 0.05$

All comparison are significant except for $[r_i]$ for patients with 31–40 year length of illness.

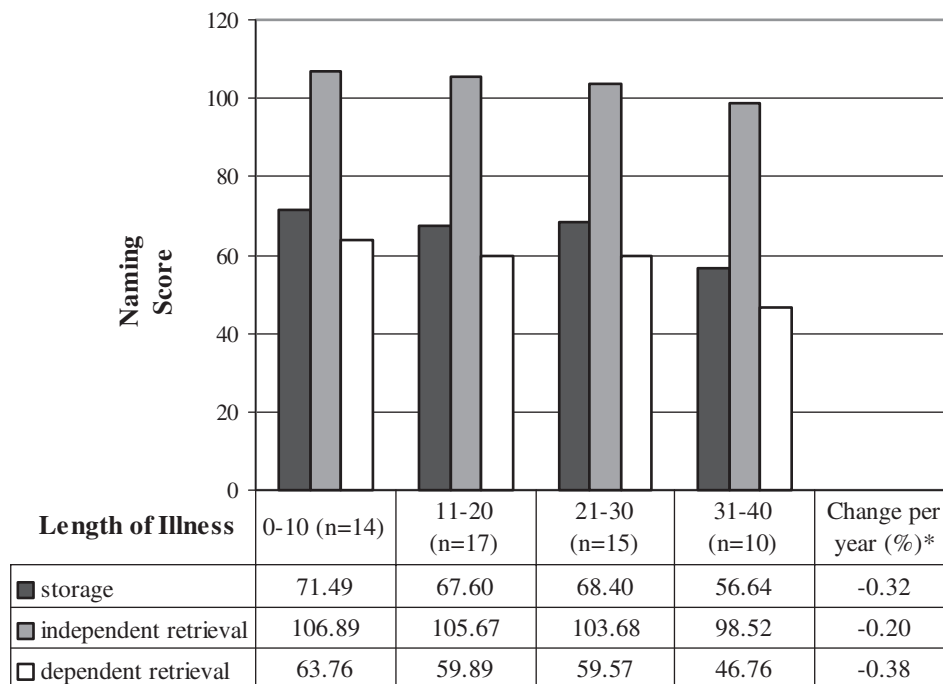


Figure 3. The influence of length of illness on storage (s), dependent retrieval (r_d) and independent retrieval (r_i) score for naming performance in the schizophrenic group.
 * Mean percentage change in naming performance since illness onset as predicted by linear regression.

anomia in schizophrenic patients (e.g. Gabrovskaja, Laws, Sinclair & McKenna, 2003; Laws et al., 2000; McKay et al., 1996). The patients were matched to controls for both age and NART IQ and so their anomia cannot be attributed to general problems associated with either of these factors.

A stochastic model revealed that, compared to healthy controls, schizophrenic patients showed significantly lowered storage and retrieval probabilities, thus supporting the notion that semantic memory is impaired in schizophrenia. This result indicates that the semantic memory deficit in schizophrenia is characterized by *both* storage and retrieval difficulties and confirms the findings of Laws et al. (2000), who reported both access and storage difficulties in the majority of the schizophrenic patients in their study using the same stochastic analysis of repeated naming performance. It also concurs with the results of Chen et al. (2000) who found evidence for both impaired retrieval and a reduced semantic store using a repeated verbal fluency task. Furthermore, the results can be seen to be in keeping with previous studies in this area that have examined semantic memory deficits in schizophrenia for *either* access or store disorder characteristics and found evidence for such characteristics (e.g. McKenna et al., 1995) since, as a group, schizophrenic patients evince both access and storage difficulties.

In both the patients and the healthy controls, $[s]$ and $[r_d]$, but not $[r_i]$ were significantly predicted by NART IQ (Nelson, 1982). This pattern emerged for both groups and so, seems to reflect a *normal* relationship rather than one that is specific to schizophrenia. It makes intuitive sense for lexical store size to be influenced by IQ since the naming test

is graded and we would expect a relationship between vocabulary size and intelligence. The $[r_d]$ reflects true performance of a given subject's effortful retrieval since one can only retrieve what is actually stored and is thus calculated using the estimated storage score as a maximal score. The $[r_i]$ value is a hypothetical score based on perfect storage. Although IQ significantly influenced $[r_d]$, it did not significantly affect $[r_i]$. Hence, estimated pre-morbid IQ appears to influence retrieval indirectly via the effect that it has on storage. 235

Examination of storage and retrieval scores did not provide support for the hypothesis that increasing length of illness correlates with a transition from an access to store type deficit. Length of illness did significantly influence storage, indicating a small reduction in the semantic store in more chronic patients and in keeping with the theory; however, both retrieval measures ($[r_d]$ and $[r_i]$) also showed reduction in patients that are more chronic. These findings indicate that storage and retrieval reduce in parallel and in proportion over the course of the illness. While the differences seems relatively small considering the long time periods examined here, the interaction between a depleting name store and increasing difficulty accessing the remaining representations could have substantial effects on naming. Although age predicted $[r_i]$ in the schizophrenic group, this relationship was not found in the control group. This suggests that increasing age does not 'normally' predict reduced ability to retrieve stored items, but that the finding for schizophrenics reflects the effect of length of illness on retrieval (since length of illness and age significantly correlate). 240 245 250

For the schizophrenic subjects, despite a significant amount of the variance in access and storage success being accounted for by one or more of the factors length of illness, estimated pre-morbid IQ and age, a large amount of the variance (over 75%) remained unexplained by the factors examined. The remaining variance may be attributable to any one of several illness related variables not investigated here (e.g., illness severity); however, a similar amount of the variance was unaccounted for in the control group and may therefore simply reflect normal variation in the ability to store and retrieve lexical information. 255

When the patients were grouped by length of illness and their storage and retrieval scores compared to the controls, this points to small, nonsignificant retrieval impairment early in the course of the illness, but a larger and significant reduction in the lexical store that has occurred early in the course of the illness. It is beyond the scope of this study to determine if this impaired storage capacity occurs around the time of first episode or in the prodrome. Furthermore, it should be acknowledged that although a low $[s]$ is assumed to reflect a 'loss' of items from the lexicon, it might also signify a failure to acquire that information in the first place¹. Nonetheless, we are inclined to believe the former explanation given the level of performance in matched IQ healthy controls. 260 265

Since access and store scores were predicted by variables such as pre-morbid IQ, length of illness and age, this may go some way to explaining the varied findings in previous studies. Not only do study cohorts undoubtedly differ on such variables (see Al-Uzri, in press), but they will be comprised of individual patients showing heterogeneous profiles. For example, Laws et al. (1998) examined their schizophrenic patients as individual case studies and found that the access and storage profile of each patient varied. Clearly, such individual and group variability is likely to contribute to variations across studies. 270 275

Whereas this study did find evidence for reduced access and store scores across cohorts organized by length of illness, previous longitudinal analyses of the access-store

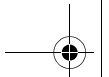
¹ Whilst the effect of creating the appearance of store type difficulties in subjects with lower IQ was due to the difficulty of the naming test utilized in this study, it was necessary to use a test where performance was not at the ceiling in the control group thus we feel that this choice was justified.

issue have reported no significant change in schizophrenic patients across limited time periods (6 months – 3 years: Laws et al., 1998; Laws et al., 2000). Our findings suggest an initial impairment followed by a significant, but gradual worsening during the course of illness. Whilst this is greater than any decline in healthy controls (since age was not a significant predictor of their access or store scores), capturing any slow deterioration would necessitate a longitudinal study spanning many years; and this may explain why extant longitudinal studies report different findings to those presented here (see also Kondel et al., 2003).

In conclusion, in addition to a ‘normal’ effect of estimated premorbid IQ on store size, both storage and retrieval scores appear to reduce over the course of schizophrenia, pointing to a gradual loss of lexical representations alongside an increasing difficulty accessing the remaining representations. Indeed, the data presented here indicates a two-phase character to the lexical problems associated with schizophrenia: first an early large loss of representations, followed over the course of illness by a further gradual depletion that is accompanied by increasing retrieval difficulty. Although the latter phase occurs slowly, it does culminate in many older patients suffering a severe anomia. The heterogeneity of cognitive performance in schizophrenic patients is often presented as an unexplained problem. The current suggests ways in which studies may begin to understand the varying cognitive profiles of patients. In this context, it should be noted that the data and conclusions presented here apply to schizophrenic patients with typical onset and not, for example, to those with late onset. Future studies might examine how access and storage procedures are influenced by measures of current intellectual functioning (such as the WAIS) as well as medication and even symptom profiles.

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