

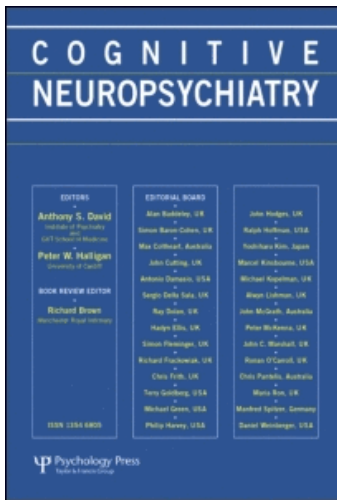
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Material-specific episodic memory associates of the psychomotor poverty syndrome in schizophrenia

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Material-specific episodic memory associates of the psychomotor poverty syndrome in schizophrenia

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Introduction. Episodic memory deficits consistently correlate with the presence of negative symptoms in schizophrenia, suggesting overlap between the underlying neural systems. Functional neuroimaging and lesion studies suggest that prefrontal hypoactivity may underlie both. The purpose of the present study was to further characterise this association in terms of functional lateralisation. A more pronounced association between psychomotor poverty and verbal memory deficits would suggest more left prefrontal overlap than right, and vice-versa for a more pronounced association with nonverbal memory deficits.

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Methods. A total of 68 inpatients (48 males, 20 females) diagnosed with schizophrenia or schizoaffective disorder participated in this study. We evaluated the correlation between verbal and nonverbal memory performance (assessed using the RAVLT and BVMT, respectively) and psychomotor poverty (assessed using the SSPI).

Results. A trend towards a more pronounced association for nonverbal compared to verbal material was not upheld by conservative statistical testing.

Conclusions. Bilateral prefrontal overlap between psychomotor poverty and episodic memory is the most conservative interpretation of these data.

Cognitive impairment is now widely recognised as an important manifestation of schizophrenia. Of the various affected aspects of cognition, reviews have concluded that episodic memory deficits are perhaps the most prominent (Heinrichs, 2001; Heinrichs & Zakzanis, 1998). Moreover, episodic memory impairment is consistently associated with the negative aspects of schizophrenia (Aleman, Hijman, de Haan, & Kahn, 1999), suggesting substantial overlap between the neural systems underlying the negative aspects of schizophrenia and those underlying episodic memory. The purpose of the present study was to utilise neuropsychological testing to extend our understanding of the overlap between these symptom- and memory-based neural systems.

The covariation between the negative aspects of schizophrenia (e.g., flat affect and poverty of speech) and episodic memory is evident in both single-sample studies (Frith, Leary, Cahill, & Johnstone, 1991; Goldberg, Weinberger, Pliskin, Berman, & Podd, 1989; Green & Walker, 1985; Moritz, Heeren, Andresen, & Krausz, 2001b; Norman et al., 1997; O'Leary et al., 2000; Perlick, Mattis, Stastny, & Silverstein, 1992), and meta-analytical reviews (Aleman et al., 1999). A complementary line of research has demonstrated that negative aspects of schizophrenia are consistently associated with bilateral prefrontal hypoactivity in cerebral blood flow (Andreasen et al., 1997; Andreasen et al., 1992; Ebmeier et al., 1993; Liddle et al., 1992; Wolkin et al., 1992; Yuasa et al., 1995). Furthermore, the important role of the prefrontal cortex in episodic memory (in addition to the traditional involvement of temporal regions; Scoville & Milner, 1957) has recently been established, and has been widely replicated in neuroimaging studies (Buckner, Kelley, & Petersen, 1999; Buckner, Logan, Donaldson, & Wheeler, 2000; Buckner & Wheeler, 2001). This points to the prefrontal cortex as a viable location for the neural system which underlies both negative aspects of schizophrenia, and episodic memory.

Traditionally, lesion studies have provided evidence for left/right lateralisation of verbal/nonverbal memory function (Glosser, Cole, Khatri, DellaPietra, & Kaplan, 2002; Incisa della Rocchetta & Milner, 1993; Kimura, 1963; Milner, 1972; Milner & Petrides, 1984; Taylor, 1969). Recently, it has been reported that verbal and nonverbal episodic memory processes are left- and right-lateralised in prefrontal regions, respectively (Buckner et al., 2000; McDermott, Buckner,

Petersen, Kelley, & Sanders, 1999; Wheeler, Stuss, & Tulving, 1995). From this it follows that a closer association between nonverbal compared to verbal memory measures and the negative aspects of schizophrenia would imply an increased involvement of the right-lateralised prefrontal regions in the association between the negative aspects of schizophrenia and episodic memory, whereas the reverse pattern would imply more involvement of left-lateralised prefrontal regions.

Available standardised neuropsychological instruments allow hypothesis testing of whether the left and right frontal dysfunction associated with the negative aspects of schizophrenia contribute equally or differentially to memory performance. However, to date, neuropsychological investigations of associations between the negative aspects of schizophrenia and verbal and nonverbal memory have not been carried out in a systematic and comprehensive manner due to discordant test structure. Specifically, most of the nonverbal tests used to date employ one nonrepeated presentation of the stimulus display (e.g., the Rey-Osterrieth Figure, the Benton Visual Retention Test, the Recognition Memory Test), thereby excluding the acquisitional component of nonverbal memory. Moreover, often delayed recall and/or recognition measures are not assessed, or are not reported (Goldberg et al., 1993; Green & Walker, 1985; Gruzelier, Wilson, Liddiard, Peters, & Pusavat, 1999; Hammer, Katsanis, & Iacono, 1995; Norman et al., 1997; O'Leary et al., 2000; Perlick et al., 1992).

These limitations can be overcome by using verbal and nonverbal tests with comparable measures of encoding and recall. An available nonverbal instrument that affords measures of the acquisitional component of nonverbal memory, as well as total score, delayed recall and recognition, is the Brief Visuospatial Memory Test (BVMT). Comparable verbal measures are readily available, but the Rey Auditory Verbal Learning Test (RAVLT) has been commonly used in the literature, has good psychometric properties, and provides parallel measures of total score, acquisition, delayed recall and recognition. Thus, in the present study both the RAVLT and the BVMT were administered to assess nonverbal and verbal memory, respectively.

In addition to incompatible test formats, in past research, methodology for measurement of the negative aspects of schizophrenia may have obscured consistency. Typically, the construct of "negative symptoms" includes items reflecting a broad range of everyday life, including "poor grooming and hygiene", "impersistence at work", "social withdrawal", and "social inattentiveness" (Andreasen, 1984). These items may be influenced by other aspects of schizophrenia beyond a reduction in mental activity, such as disorganisation of thought, or paranoid delusions, possibly confounding these positive and negative aspects of psychosis. The relatively circumscribed *psychomotor poverty syndrome* (Liddle, 1987) consists of only the core symptoms of poverty of speech, blunted affect, and decreased spontaneous movement (Liddle, 2001). These items are less likely to be confounded by the disorganised

and paranoid aspects of schizophrenia. Among other constructs, psychomotor poverty is effectively captured in a brief interview using a recently developed rating scale, the Signs and Symptoms of Psychotic Illness (SSPI; Liddle, Ngan, Duffield, Kho, & Warren, 2002).

The purpose of the present study was to utilise neuropsychological testing to extend our understanding of the overlap between symptom- and memory-based neural systems. More specifically, our goal was to describe lateralisation of the prefrontal neural system overlap between psychomotor poverty and episodic memory using neuropsychological testing. Thus, we compared the association between verbal versus nonverbal memory performance and the psychomotor poverty syndrome. Parallel measures of total score, acquisition, delayed recall, and recognition were recorded for verbal and nonverbal material. A more pronounced association with verbal deficits would suggest more left prefrontal overlap than right, whereas a more pronounced association with nonverbal deficits would suggest more right prefrontal involvement than left.

METHODS

Participants

A total of 68 inpatients (48 males, 20 females) diagnosed with schizophrenia or schizoaffective disorder according to DSM-IV criteria were recruited from Riverview Hospital and the Forensic Psychiatric Services Commission, Port Coquitlam, BC, Canada. Within this sample, the following subsamples were observed: paranoid ($n = 34$), undifferentiated ($n = 24$), disorganised ($n = 4$), catatonic ($n = 2$), and schizoaffective ($n = 4$). Their mean age was 35.84 years ($SD = 9.56$), and their mean years of education was 12.31 ($SD = 2.34$). The mean length of illness (since first hospitalization) was 9.92 years ($SD = 9.61$), indicating that this sample of patients can be considered chronic. Patients were excluded if their premorbid IQ as assessed by the National Adult Reading Test (NART; Nelson, 1982) was less than 70 ($M = 103.28$, $SD = 9.04$), if they had a history of acquired brain damage or traumatic head injury (e.g., a loss of consciousness for more than 10 minutes), epilepsy, encephalitis, diabetes, HIV, hepatitis C, or hypothyroidism. Patients with an Axis I diagnosis in addition to schizophrenia (e.g., polysubstance abuse) were also excluded. Finally, for all patients their primary language was English, their colour vision was intact, and their eyesight (assessed corrected and bilaterally) was 20/50 or better. At the time of testing, all patients, except for one not treated with medication, were receiving atypical neuroleptic medication (chlorpromazine equivalent dosage in mg: $M = 731.34$, $SD = 571.95$) (Bezchlibnyk-Butler & Jeffries, 2000); 11% of patients were left handed, 4% were ambidextrous, and 85% were right handed (assessed by self-report on 55 patients).

Measures

Symptoms. Psychopathology was assessed using the SSPI (Liddle et al., 2002). The SSPI is a 20 item, 5-point rating scale, which can be completed after a 25–30 minute semistructured interview with 15 direct questions about symptoms. The severity of each item is rated in the range of 0 to 4. The SSPI is criterion referenced, providing specific examples of behaviour that correspond to severity levels for each item. Generally, a score of 1 denotes questionable abnormality, 2 denotes definite but mild abnormality, 3 denotes pathology of moderate severity that has a substantial impact on mental functioning, and 4 indicates severe psychopathology. The following core items from the SSPI were used to quantify the three-syndrome model of psychotic illness: underactivity, flattened affect, and poverty of speech for psychomotor poverty; inappropriate affect and disordered form of thought for disorganisation, and delusions and hallucinations for reality distortion. All reported symptom ratings were carried out by TSW. Twenty-one of the interviews were videotaped and reviewed by both TSW and CCR. Interrater reliabilities on the symptom aggregates, assessed using Pearson's r , were as follows: Reality Distortion ($r = .83$), Psychomotor Poverty: ($r = .76$). Disorganisation: ($r = .75$). TSW was blind with respect to neuropsychological test performance.

Verbal memory. A clinical neuropsychologist (AET) oversaw all neuropsychological testing. Verbal memory was assessed using the *Rey Auditory Verbal Learning Test* (RAVLT; Rey, 1964). Participants heard a list of 15 words (List A), read by the experimenter at the rate of one word per second. List A was presented five times (A1–A5). After each list presentation, participants were instructed to recall as many words as possible, in any order, regardless whether these words had been successfully recalled in a previous trial or not.

After List A was presented five times (A1–A5), list B1, consisting of 15 new words, was read to the participant, with instructions to recall as many words as possible from this list. Following this, the participant was instructed to recall as many words as possible from List A without hearing the list again (A6). After approximately 20 minutes, the participant was again instructed to recall as many words as possible from list A without hearing the list again (A7). Finally, a recognition list was presented to the subject on a sheet of paper. This list contained 15 words from List A, and 15 new words. Participants were asked to circle words that they recognised as part of List A. Subjects were given no feedback as to whether or not their responses were correct.

Nonverbal memory. This was assessed with the *Brief Visuospatial Memory Test* (BVMT; Benedict, 1997), Form 1. Participants were presented with a blank sheet of paper. The experimenter then held up a sheet with six line figures on it. They were instructed to study the figures for 10 seconds, with the knowledge

that they would later be asked to draw each figure exactly as it appeared, and in its correct location on the page. When the participant had drawn the figures as completely as possible, the participant was given a new sheet, and the procedure repeated. In total, the sheet of line figures was presented three times (T-1, T-2, and T-3). In accordance with the test protocol, after these three presentations, the patient was told: "Try not to forget the display because I may ask you to remember the figures later". After a delay of approximately 20 minutes, a delayed recall trial was administered, on which a blank sheet was placed in front of the participant, and they were asked to "draw as many of the figures as you can in their correct location on the page". Immediately after this delayed recall test, a recognition test consisting of 12 designs was presented sequentially to the subject. Six previously presented designs, and six foils were presented. Participants were asked to indicate whether they had seen the presented design previously. Subjects were given no feedback as to whether or not their responses were correct. The accuracy of each drawing, and the placement of the drawing on the page, were scored according to procedures outlined in the BVMT testing manual (Benedict, 1997).

Memory parameters. The parameters of interest computed for the RAVLT and the BVMT were as follows:

1. *Total score:* The sum of number of correctly recalled items. For the RAVLT, this was the sum of words recalled in A1 to A5. For the BVMT, this was the sum of credits given over T-1 to T-3.
2. *Acquisition:* For RAVLT, this was computed as the number of correctly named words in A5 minus the number of correctly named words in A1. For BVMT, this was computed as the credits assigned in T-3 minus the credits assigned in T-1.
3. *Delayed recall:* For both tests, this was scored as the number of correctly named words, or credits earned, 20 minutes after learning.
4. *Recognition:* For both tests, this was scored as the number of correctly recognised items.

Available test-retest reliabilities for RAVLT are estimated to be between .63 and .84 for the Total score, between .57 and .78 for Delayed Recall, and between .28 and .64 for Recognition (Schmidt, 1996, p. 48). For the BVMT, available test-retest reliabilities are estimated to be .80 for Total score, and .79 for Delayed Recall (Benedict, 1997).

Data reduction

Symptom ratings for the items delusions, hallucinations, underactivity, flattened affect, inappropriate affect, poverty of speech, and disordered form of thought were submitted to a principal component analysis with a varimax rotation. In

accordance with prior results and theory (Arndt, Alliger, & Andreasen, 1991; Bilder, Mukherjee, Rieder, & Pandurangi, 1985; Liddle, 1987; Moritz et al., 2001a; Woodward, Ruff, Thornton, Moritz, & Liddle, 2003), three factors were extracted (the eigenvalue-greater-than-one rule also indicated that three factors should be extracted). Factors corresponding to psychomotor poverty, disorganisation and reality distortion emerged (see Table 1). The factor scores were saved for the subsequent correlations with memory measures.

A second principal component analysis was carried out to test the hypothesised structure of variance common to the memory measures. In accordance with prior reports that verbal and nonverbal tests should load on separate factors (Bornstein & Chelune, 1988), two factors were extracted (this was confirmed by the eigenvalue-greater-than-one rule). The orthogonal solution suggested correlated factors; therefore, a nonorthogonal oblimin rotation is reported. Clear verbal and nonverbal memory factors emerged (see Table 2). The factor scores were saved for the subsequent correlations with symptoms; the interfactor correlation was .63.

RESULTS

For the analysis of the association of psychomotor poverty and the memory measures, we computed Pearson's correlation coefficients. When decreased performance was expected to be associated with increased symptoms, significance was assessed with one-tailed tests. All exploratory correlations were assessed with two-tailed tests (as specified in the text). The cut-off for significance was set to $\alpha = .05$. To test the association between memory test items and syndrome scores, verbal total score ($M = 39.31$, $SD = 11.00$), acquisition ($M = 5.31$, $SD = 2.74$), recall ($M = 7.30$, $SD = 3.69$), and recognition ($M = 12.82$, $SD = 2.34$), and nonverbal total score ($M = 17.78$, $SD = 8.01$), acquisition ($M = 4.23$,

TABLE 1
Rotated component matrix for Signs and Symptoms of Psychotic
Illness items ($N = 68$)

	<i>Psychomotor poverty</i>	<i>Disorganisation</i>	<i>Reality distortion</i>
Underactivity	<i>0.87</i>	-0.10	0.04
Flattened affect	<i>0.87</i>	-0.07	-0.23
Poverty of speech	<i>0.67</i>	-0.29	-0.40
Inappropriate affect	-0.27	<i>0.75</i>	-0.02
Disordered form of thought	0.00	<i>0.88</i>	0.08
Delusions	-0.19	0.17	<i>0.80</i>
Hallucinations	-0.07	-0.10	<i>0.82</i>

Note: Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalisation. All loadings above .60 are in italics.

TABLE 2
Rotated pattern matrix for memory items ($N = 68$)

	<i>Verbal memory</i>	<i>Nonverbal memory</i>
Verbal Total Recall	<i>0.85</i>	0.03
Verbal Acquisition	<i>0.91</i>	-0.20
Verbal Delayed Recall	<i>0.94</i>	-0.06
Verbal Recognition	<i>0.74</i>	0.00
Nonverbal Total Recall	0.05	<i>0.86</i>
Nonverbal Acquisition	-0.21	<i>0.86</i>
Nonverbal Delayed Recall	-0.08	<i>1.00</i>
Nonverbal Recognition	0.04	<i>0.72</i>

Note: Extraction method: Principal component analysis. Rotation method: Oblimin (.3). All loadings above .60 are in italics.

$SD = 2.65$), recall ($M = 7.43$, $SD = 3.62$), and recognition ($M = 5.29$, $SD = 0.92$) were correlated with the syndrome scores, as were the verbal and nonverbal memory factor scores.

The results are listed in Table 3. For verbal material, only recognition and the verbal memory factor were significantly associated with psychomotor poverty. For nonverbal material, all nonverbal memory measures, and the nonverbal memory factor, were significantly associated with psychomotor poverty. However, the *difference* between the verbal and nonverbal factor correlations did not survive a test of significance (Meng, Rosenthal, & Rubin, 1992), $Z = 1.18$, $p = .24$, two-tailed. The verbal-nonverbal comparison of correlations for the corresponding individual items (e.g., verbal total score vs.

TABLE 3
Correlations between symptom component scores and memory measures ($N = 68$)

	<i>Psychomotor poverty</i>	<i>Disorganisation</i>	<i>Reality distortion</i>
Verbal Total Recall	-0.15	0.11	0.07
Verbal Acquisition	-0.12	0.04	0.14
Verbal Delayed Recall	-0.14	0.05	0.20
Verbal Recognition	-0.26*	0.06	0.03
Verbal Memory Factor	-0.22*	0.08	0.14
Nonverbal Total Recall	-0.26*	0.01	0.05
Nonverbal Acquisition	-0.22*	-0.05	-0.09
Nonverbal Delayed Recall	-0.28*	0.02	0.10
Nonverbal Recognition	-0.38***	0.01	0.09
Nonverbal Memory Factor	-0.34**	0.00	-0.05

* $p < .05$; ** $p < .01$; *** $p < .001$ (one-tailed).

nonverbal total score) also did not reach significance. Factor scores from a one-factor solution (i.e., a general memory factor) were significantly associated with psychomotor poverty, $r(66) = -.31, p < .01$. No memory measures correlated significantly with the disorganisation or reality distortion syndromes (see Table 3).

The trend for recognition memory to show higher associations with psychomotor poverty than the other memory measures was statistically tested *post hoc*. A test of the contrast between the recognition correlation and that for the other memory measures (i.e., total score, acquisition, and recall) (Meng et al., 1992) was nonsignificant for both the verbal and nonverbal items, $Z = 1.42, p = .16$, and $Z = 1.52, p = .13$, respectively (two-tailed).

A possible mediator of the observed symptom-memory associations is neuroleptic dosage (recorded at the time of testing, and converted to chlorpromazine equivalent units in mg). Although it is interesting to note that the nonverbal memory factor was significantly correlated with neuroleptic dosage, $r(66) = .25, p < .05$, two-tailed, neuroleptic dosage was not significantly associated with psychomotor poverty, $r(66) = .01, p = .94$, two-tailed. Therefore, it did not function as a mediator variable. Correspondingly, the semipartial correlation between nonverbal memory and psychomotor poverty (medication dosage partialled out of both; $r = -.29, p < .01$) did not differ from the originally reported value ($r = -.34, p < .01$). Neuroleptic dosage was not significantly correlated with verbal memory performance ($p > .50$).

Age, sex, education, and length of illness (computed from first hospitalisation) were not significantly associated with psychomotor poverty; however, SSPI total score was, $r(66) = .34, p < .01$, two tailed. A subsequent partial correlation analyses revealed that controlling for SSPI total score resulted in a slight decrease in the correlation between the nonverbal memory factor and psychomotor poverty (from $r = -.34$ to partial $r = -.31$), but the partial correlation coefficient remained significant ($p < .01$). For the verbal memory factor, the same partial correlation analyses resulted in a slight increase in the correlation with psychomotor poverty (from $r = -.22$ to partial $r = -.26$). Therefore, severity of illness cannot be considered a mediator of the relationship between nonverbal or verbal memory and psychomotor poverty.

DISCUSSION

The purpose of this study was to describe the prefrontal neural system overlap between psychomotor poverty and episodic memory, in terms of lateralisation, using neuropsychological testing. We evaluated the association between verbal and nonverbal memory performance and the psychomotor poverty syndrome on parallel measures of total score, acquisition, delayed recall, and recognition. For verbal material, recognition and the verbal memory factor correlated significantly with psychomotor poverty. In contrast, for nonverbal memory, all

individual nonverbal memory measures and the nonverbal memory factor were significantly correlated with psychomotor poverty. Although this pattern of results suggests a more pronounced association between psychomotor poverty and nonverbal memory, formal significance tests could not discount the possibility that these differences were spurious. In neurocognitive terms, although there is a suggestion of right > left lateralised overlap between psychomotor poverty and episodic memory, a conclusion implicating bilateral involvement is the most conservative interpretation of the present data.

At first glance, the trend for recognition memory to show higher associations with psychomotor poverty than the other memory measures may be interpreted as additional evidence of right > left lateralised overlap between psychomotor poverty and episodic memory. The hemispheric encoding retrieval asymmetry (HERA) model of episodic memory (Lepage, Ghaffar, Nyberg, & Tulving, 2000; Nyberg et al., 1996; Wheeler, Stuss, & Tulving, 1997) states that encoding and "retrieval mode" aspects of memory are left and right lateralised, respectively (due to experimental design requirement of functional neuroimaging, recognition was used as the paradigm eliciting retrieval processes in these studies). However, questions must be raised regarding the relevance of such an account to the present set of results. First, the utility of the HERA model has been weakened by the demonstration that although right prefrontal regions were active during different forms of retrieval, the activation was not more marked for successful retrieval than for failures of this operation (Wagner, Desmond, Glover, & Gabrieli, 1998). Second, the presently reported pattern of higher associations for recognition has not been replicated in the schizophrenia literature. Although acquisition, recall and recognition were rarely reported within one study, when they were, increased associations between recognition and the negative aspects of schizophrenia were absent (Berman et al., 1997; Goldberg et al., 1989; Moritz et al., 2001b). In accordance with this trend in the literature, the differential pattern of associations observed in the present study did not survive formal significance testing.

Despite the failure of the verbal/nonverbal differential associations with psychomotor poverty to reach statistical significance, we briefly consider alternative interpretations of this pattern of results. First, it should be considered that other cognitive components beyond pure laterality of memory functions may mediate this difference. For example, self-initiation in memory is thought to rely on frontal brain regions (Shimamura, Janowsky, & Squire, 1991; Wheeler et al., 1995), and self-initiation deficits are also hypothesised to underlie the psychomotor poverty syndrome (Frith & Done, 1988; Liddle, 2001). The simultaneous presentation of all BVMT material over a limited study period may place a high demand on internal cueing and self-study, relative to the serially presented auditory RAVLT material. Congruent with this interpretation, others have suggested that the poor initial acquisition of information is an important determinant of the poor memory performance in schizophrenia (Gold et al., 2000).

Another plausible explanation could be impairment in visual processing, which is associated with persistent negative symptoms (Green & Walker, 1986; McClure, 2001; Walker & Lewine, 1988). Performance on the BVMT obviously depends on visual processing to a greater extent than the RAVLT. However, in these referenced studies, visual processing was measured by backward masking, which taps cognitive processes operating in the order of milliseconds. This is very different from the time scale of the BVMT, for which patients have 10 seconds to study each configuration. More directly relevant is the finding that abnormal smooth-pursuit eye movements tend to be associated with persistent negative symptoms (Nkam et al., 2001; Ross et al., 1996), and that backward masking and smooth-pursuit eye movements may tax common cognitive mechanisms (Allen, 1995).

Finally, due to the required written response, the slowed/impaired motor abilities that comprise one aspect of psychomotor poverty may account for its significant association with the BVMT. Although this explanation cannot easily explain the relationship between psychomotor poverty and recognition measures, the face validity of this hypothesis makes it a reasonable candidate. To summarise, other plausible accounts for the pattern of results not directly related to the lateralisation of memory processes include impairments of self-initiation, visual processing and/or motor abilities.

It is necessary to acknowledge some shortcomings of the present study. First, participants may have created verbal labels for the nonverbal material, thereby reducing the lateralisation of the memory measures (Blaxton & Theodore, 1997; Moye, 1997). Although the BVMT was designed specifically to avoid verbal encoding strategies, by presenting subjects with complex visual stimuli for a brief period (Benedict, 1997), and there is evidence that similarly constructed "memory for design" tests have been reliably associated with right hemispheric dysfunction (e.g., Glosser et al., 2002), this confound could have contributed to our inability to statistically support a distinction between verbal and nonverbal material. Second, it is possible that some aspects of psychomotor poverty may be attributable to medication-induced motor side effects, or may be confounded by medication associated extrapyramidal side effects, which were not excluded at testing. However, all medicated patients were being treated with atypical antipsychotics, which minimises motor side effects (Breier et al., 1999; Chakos, Lieberman, Hoffman, Bradford, & Sheitman, 2001; Geddes, Freemantle, Harrison, & Bebbington, 2000), and avoids the correlation between negative symptoms and extrapyramidal side effects observed with typical antipsychotics (Allan, Sison, Alpert, Connolly, & Crichton, 1998).

In conclusion, the present pattern of results suggests a nonlateralised overlap between the prefrontal neural systems mediating psychomotor poverty and episodic memory. However, the precise neurocognitive mechanisms responsible for the associations between negative schizophrenic symptoms and neuropsychological measures of memory certainly deserve further investigation.

Apart from purely mnemonic operations, candidates for these operations include self-initiation of cognitive activity, attentional control of visual processing, or higher order motor control. Future work should attempt to independently investigate the contribution of these factors to the association of memory deficits and symptomatology in schizophrenia.

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