Psychological Medicine, 2005, **35**, 1165–1173. © 2005 Cambridge University Press
doi:10.1017/S0033291705004575 Printed in the United Kingdom

Neurocognitive correlates of recovery from schizophrenia

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ABSTRACT

Background. Evidence has mounted that some patients with schizophrenia experience remission of symptoms and restoration of social and vocational functioning. The purpose of this study was to identify neurocognitive variables associated with recovery from schizophrenia.

Method. Twenty-eight patients diagnosed with DSM-IV schizophrenia or schizoaffective disorder and who met our operational definition of recovery from schizophrenia underwent a battery of neurocognitive tests. These subjects were matched with schizophrenia patients who did not meet recovery criteria ('non-recovered') and with normal controls.

Results. On tests of executive functioning, verbal fluency and verbal working memory, recovered subjects performed significantly better than non-recovered subjects and were comparable to normal controls. Patient groups did not differ on a test that assessed early visual processing, but both groups performed significantly worse than normal controls.

Conclusions. Three measures of frontal lobe functioning appear to be neurocognitive domains associated with recovery from schizophrenia. These findings help narrow the search for targets for cognitive remediation that may have implications for improving community functioning.

INTRODUCTION

Over the past 25 years, evidence has mounted that some individuals with schizophrenia experience symptomatic remission and restoration of social and vocational functioning (Harding *et al.* 1987). More recent reports suggest that rates of symptomatic and functional recovery may be even higher in recent onset cases, provided that treatment is provided in an assertive and targeted manner (Edwards *et al.* 1998; Robinson *et al.* 2004).

Despite the increasing recognition of a remitted and 'high functioning' subgroup within the schizophrenia spectrum, research on this topic has been impeded by the lack of consensus on the definition of recovery. To overcome this barrier, Liberman *et al.* (2002) proposed an operational definition of recovery. In this paper we present the results of a study that used these criteria to identify a cohort of individuals who have recovered from schizophrenia and to investigate the neurocognitive correlates of recovery. If operational definitions of recovery are associated with predictive, moderating and mediating variables – such as neurocognition – various directions of empirical research could be opened. These would include validation studies, longitudinal studies on the stability of the construct of recovery and intervention research that targets variables that may promote or impede recovery.

Neurocognitive functions were selected as the independent variable in this study rather than other putative correlates and mediators of recovery because extensive research has

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Table 1. *Clinical history and demographic characteristics of recovered patients with schizophrenia, non-recovered patients with schizophrenia and healthy comparison subjects in a study of neuropsychological functioning*

Characteristic	Recovered group ($N=28$) n (%)	Non-recovered group ($N=28$) n (%)	Healthy group ($N=26$) n (%)
Male sex	21 (75)	19 (68)	15 (58)
Race			
White	17 (61)	14 (50)	12 (46)
Hispanic	7 (25)	10 (36)	9 (35)
Other	4 (14)	4 (14)	5 (19)
Diagnosis			
Schizophrenia	21 (75)	20 (71)	N.A.
Schizoaffective	7 (25)	8 (29)	N.A.
Atypical antipsychotic	22 (79)	23 (82)	N.A.
	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)
Age (years)	38·2 (10·6)	40·0 (11·5)	40·6 (11·4)
Age at first diagnosis (years)	25·0 (8·9)	24·0 (7·8)	N.A.
Lifetime number of hospitalizations	3·6 (3·3)	4·2 (3·8)	N.A.
Subject's education (years)	14·5 (3·6)	12·4 (1·8)	16·7 (2·5)
Parent's education (years)	13·9 (3·6)	13·3 (2·8)	14·3 (3·3)
Sum of 4 BPRS positive symptom items	6·8 (2·5)	7·7 (2·3)	N.A.
Sum of 3 BPRS negative symptom items	5·5 (1·1)	6·7 (1·8)	N.A.
Medication dosage (chlorpromazine equivalents)	253·6 (482·7)	323·2 (95·7)	N.A.

BPRS, Brief Psychiatric Rating Scale.

documented the enduring nature of cognitive deficits in schizophrenia (Hyde *et al.* 1994; Harvey *et al.* 1995; Russell *et al.* 1997; Rund, 1998; Hoff *et al.* 1999; Kelly *et al.* 2000; Seidman *et al.* 2003). Cognitive capacities have also been shown to have robust relationships to psychosocial and vocational adaptation (Green, 1996), which places them squarely in the forefront of salience for correlational, longitudinal and treatment studies on recovery from schizophrenia.

METHOD

Participants

A total of 82 individuals participated in this study: 28 subjects met DSM-IV criteria for schizophrenia or schizoaffective disorder and our criteria for recovery from schizophrenia, 28 subjects met DSM-IV criteria for schizophrenia or schizoaffective disorder but did not meet our recovery criteria, and 26 were healthy volunteer comparison subjects. The clinical history and demographic characteristics of the sample are presented in Table 1.

Procedure

Three of the authors (A.K., J.V., R.P.L) searched research records of three university-affiliated mental health clinics for individuals diagnosed with schizophrenia or schizoaffective disorder who were likely to meet our criteria for recovery on the basis of record reviews and personal knowledge of the individual. To be considered as recovered, subjects had to meet all of our selection criteria which included two consecutive years of: (*a*) freedom from clinically significant positive and negative symptoms (i.e. scores of '3' or less on the key psychotic symptoms of the Brief Psychiatric Rating Scale (BPRS) including grandiosity, suspiciousness, unusual thought content, hallucinations, conceptual disorganization, bizarre behavior, self-neglect, blunted affect and emotional withdrawal); (*b*) adaptive social and work functioning (i.e. at least half-time employment in a job in the competitive sector or successful attendance in a school); (*c*) cordial familial and peer relationships (i.e. at least once per week, having a meeting, social event, meal, recreational activity, phone conversation or other joint interaction); and (*d*) independent living (i.e. living on

one's own without day-to-day supervision for medication compliance, money management, shopping, food preparation, laundry, personal hygiene or need for structured recreational or avocational activities). All 28 recovered subjects who were contacted agreed to participate in the study.

Non-recovered subjects with schizophrenia or schizoaffective disorder were recruited from the active caseload of the San Fernando Mental Health Center, a community mental health center operated by the Los Angeles County Department of Mental Health. Thirty-five subjects were identified who matched the recovered subjects in terms of age, gender, ethnicity and parental educational level, were clinically stable (i.e. psychotic symptoms well controlled, no psychiatric hospitalizations in over 1 year and no medication changes in the last 6 months), but did not meet the recovery criteria. Of these, 28 subjects agreed to participate in the study. In addition to patients with schizophrenia or schizoaffective disorder, 26 healthy control subjects matched on these same variables were recruited through newspaper advertisements. Healthy control subjects with a history of psychiatric disorders, current substance abuse, head injuries with concomitant loss of consciousness, seizures, central nervous system infection, diabetes or hypertension were excluded. This study was reviewed and approved by the Institutional Review Board of the UCLA School of Medicine and the Human Subject Research Committee of the Los Angeles County Department of Mental Health. Once identified as a potential study participant, written informed consent was obtained prior to data collection.

Upon entry into the study, an interviewer trained to levels of inter-rater reliability in excess of 0·85 conducted a confirmatory lifetime diagnostic assessment using the *Structured Clinical Interview for DSM-IV* (SCID; First *et al.* 1996). To verify that the recovery criteria had been met, an assessment of the subject's current and past psychiatric symptoms was conducted with the SCID and an expanded version of the BPRS (Ventura *et al.* 1993). The UCLA Recovery Criteria Checklist, developed by the authors, was used to verify that subjects met all of the recovery criteria. The checklist consists of eight items that reflect the content areas of recovery (Liberman *et al.* 2002). Additional assessments were conducted to obtain demographic and clinical data.

Neurocognitive assessments

A neuropsychological battery was administered that assessed cognitive domains of functioning that had been found in previous reviews to be related to adaptive community functioning (Green, 1996; Green *et al.* 2000). Using the battery, we evaluated the following domains of neurocognitive functioning: verbal learning [total items recalled on the California Verbal Learning Test (CVLT; Delis *et al.* 1987)]; executive functions [number of categories and perseverative errors on the Wisconsin Card Sorting Test (WCST; Heaton *et al.* 1993)]; verbal fluency [number of appropriate words on the FAS and Animals tasks of the Controlled Word Association Test (Benton & Hamsher, 1989)]; visuo-perceptual skills [based on a 36-point scoring system derived from the Rey–Osterreith Complex Figure Test (Rey-O; Waber & Holmes, 1985)]; verbal working memory [number of correctly recalled trigrams on the Auditory Consonant Trigrams test (ACT; Stuss *et al.* 1987)]; and vigilance or early visual processing [number of correctly detected targets (total possible = 64) for the 12-letter array on the Forced-Choice Span of Apprehension (SPAN; Asarnow & Nuechterlein, 1994)].

Wide Range Achievement Test – Revised (WRAT-R) Reading scores

All subjects received the Reading subtest of the WRAT-R (Jastak & Wilkinson, 1984) to obtain an estimate of pre-morbid intellectual levels. The Reading subtest of the WRAT-R is thought to reflect preserved abilities, since it is a test of decoding skills that are routinely acquired before the onset of disease and appear to remain largely unaffected by the disease process. Studies with schizophrenia patients have demonstrated reading scores to be viable measures of pre-morbid intellect (Kremen *et al.* 1996).

Data analysis

Because each neurocognitive task had multiple dependent variables, the analyses were restricted to those scales that were particularly informative and central to each task (e.g. perseverative errors and categories correctly identified on the

WCST), which yielded eight neurocognitive variables. A multivariate analysis of covariance (ANCOVA) was conducted using all eight of these variables. Next, a regression analysis with backward step-wise elimination was performed to study the relative contributions of each of the neurocognitive variables to the prediction of group membership (recovered, non-recovered and healthy controls). Variables were included in the model if they were significantly correlated with group membership at the $p<0{\cdot}05$ level. The analysis was repeated using a forward step-wise technique to confirm the results.

The results of the neuropsychological battery were also analyzed by domain of neurocognitive functioning. Scores of the three participant groups were compared using a one-way ANCOVA for all the continuous dependent variables. The three groups (recovered, non-recovered and normal controls) formed the independent variable and the covariates were age and parental level of education. These analyses were run because the matching of the groups on these two variables, as well as on gender and ethnicity, may have resulted in within-group correlations among age, parental level of education and the specific dependent variable being analyzed whose residualization would reduce the error term. A significant group effect was further analyzed with Tukey's HSD. These analyses were conducted with a level of alpha that reflected the balance between an acceptable probability of Type I errors for the task and the power of each specific ANCOVA. In addition, Bonferroni corrections were made based on the performance of eight separate tests. Finally, all analyses comparing the two schizophrenia groups had additional covariates of total positive and negative symptoms as measured on the BPRS.

RESULTS

Clinical history and demographic variables

As shown in Table 1, no differences were found among the three groups on age, gender, or ethnicity. There were no differences between the groups on parental level of education, but there was a significant difference between groups on subjects' level of education ($F=15{\cdot}75$, df$=2$, 79, $p<0{\cdot}001$). Subjects in the recovered group had, on average, 2 years more education than subjects in the non-recovered group ($t=2{\cdot}75$, df$=54$, $p<0{\cdot}01$) and 2 years less education than subjects in the healthy control group ($t=2{\cdot}48$, df$=52$, $p<0{\cdot}02$). There were no differences between the two patient groups on diagnostic subtype (schizophrenia *versus* schizoaffective disorder), age at first diagnosis, or lifetime number of psychiatric hospitalizations.

As determined by self-report, each patient was being seen monthly by a board-certified, academically affiliated psychiatrist for supportive psychotherapy and medication management and adherent to his/her medication regimen for the previous 6 months. This is the standard treatment provided to patients with serious mental disorders at these out-patient clinics. None of the patients were treated using formal pharmacological treatment guidelines such as the Texas Medication Algorithm Project (T-MAP), but all medication regimens fell within the parameters identified by the American Psychiatric Association (APA, 1997).

There were no differences between the recovered and non-recovered groups with respect to the proportion taking atypical *versus* typical antipsychotic medications, including four recovered patients and three non-recovered patients taking clozapine. However, subjects in the non-recovered group were taking a significantly higher dose of antipsychotic medication than subjects in the recovered group ($t=2{\cdot}91$, df$=54$, $p<0{\cdot}005$). Three subjects in each schizophrenia group were taking anticholinergic medications.

There were no differences on the BPRS positive symptom factor (i.e. the sum of hallucinations, unusual thought content, suspiciousness and grandiosity) between the two schizophrenia groups during the month prior to the interview, but non-recovered subjects had higher levels of negative symptoms (i.e. the sum of self-neglect, blunted affect and emotional withdrawal) than the recovered subjects ($t=3{\cdot}28$, df$=54$, $p<0{\cdot}002$). Table 1 includes the mean sums of each of these factors. There were no differences among the groups on the WRAT-R Reading scores ($F=2{\cdot}26$, df$=2$, 79, $p=0{\cdot}11$). All three groups performed in the normal range.

Neurocognitive variables

The results of the neurocognitive tests are presented in Table 2. The multivariate ANCOVA

Table 2. *Mean (S.D.) scores on neuropsychological scales and subscales among recovered patients with schizophrenia, non-recovered patients with schizophrenia and healthy comparison subjects*

Test	Recovered group ($N=28$)	Non-recovered group ($N=28$)	Healthy controls ($N=26$)	ANCOVA F	ANCOVA p	With Bonferroni correction
Visuo-perceptual skills (Rey-O)						
Copy score	3·1 (5·2)	31·4 (3·7)	33·4 (3·6)	1·52	0·22[a]	N.A.
Verbal learning (CVLT)						
T1-5	51·1 (9·3)	46·1 (11·4)	55·9 (9·4)	6·34	0·003[b]	0·02
Executive functioning (WCST)						
Categories	3·7 (1·2)	1·9 (1·5)	3·6 (1·5)	15·49	0·0001[c]	0·001
Perseverative errors	7·5 (4·3)	14·9 (11·2)	6·8 (4·7)	9·24	0·0003[c]	0·002
Verbal fluency						
FAS	38·3 (12·0)	30·0 (10·7)	38·5 (7·7)	5·64	0·005[d]	0·04
Animals	19·3 (4·6)	15·7 (4·8)	21·7 (4·3)	10·92	0·0001[d]	0·001
Verbal working memory (ACT)						
Total correct	46·0 (9·0)	36·2 (8·3)	43·2 (9·0)	8·74	0·0004[e]	0·003
Early visual processing (SPAN)						
12-letter array	48·0 (8·2)	47·3 (5·6)	51·9 (4·6)	6·56	0·002[f]	0·02

Rey-O, Rey–Osterreith Complex Figure test; CVLT, California Verbal Learning Test; WCST, Wisconsin Card Sorting Test; FAS, Verbal Fluency Test; ACT, Auditory Consonant Trigrams test; SPAN, Span of Apprehension test.

[a] No difference among the groups on the Rey-O.

[b] On the CVLT, healthy controls recalled significantly more items than recovered subjects ($t=2·63$, df = 52, $p=0·01$) and non-recovered subjects ($t=3·56$, df = 52, $p=0·0006$). Recovered subjects recalled more items than non-recovered subjects ($t=1·96$, df = 54, $p=0·05$).

[c] On the WCST, there were no differences between recovered subjects and normal controls on either perseverative errors ($t=0·43$, df = 52, $p=0·67$) or categories completed ($t=0·04$, df = 52, $p=0·96$). Non-recovered subjects made more perseverative errors (non-recovered *v.* recovered: $t=3·53$, df = 54, $p=0·0007$; non-recovered *v.* normal: $t=3·88$, df = 52, $p=0·0002$) and completed fewer categories (non-recovered *v.* recovered: $t=4·84$, df = 54, $p=0·0001$; non-recovered *v.* normal: $t=4·77$, df = 52, $p=0·0001$) than the other groups.

[d] On the FAS, non-recovered subjects named significantly fewer words than recovered subjects ($t=2·87$, df = 54, $p=0·005$) and normal controls ($t=2·92$, df = 52, $p=0·005$), with no statistical difference between recovered subjects and normal controls ($t=0·09$, df = 52, $p=0·93$). On the Animals test, non-recovered subjects named significantly fewer animals than recovered subjects ($t=2·83$, df = 54, $p=0·006$) and normal controls ($t=4·63$, df = 52, $p<0·0001$). No significant difference between recovered subjects and normals ($t=1·83$, df = 52, $p=0·07$).

[e] On the ACT, non-recovered subjects identified significantly fewer trigrams correctly than recovered subjects ($t=4·08$, df = 54, $p=0·0001$) and normal controls ($t=2·80$, df = 52, $p=0·007$). No statistically significant difference between recovered subjects and normal controls ($t=1·22$, df = 52, $p=0·23$).

[f] On the SPAN, normal controls performed significantly better than non-recovered subjects ($t=3·31$, df = 54, $p=0·002$) and recovered subjects ($t=2·15$, df = 52, $p=0·036$). No statistical difference between patient groups ($t=0·38$, df = 52, $p=0·71$).

using all eight of the neurocognitive variables was statistically significant (Wilks' lambda: $F=3·32$, df = 16, 126, $p<0·0001$). The discriminant analysis with backward step-wise elimination included three variables in the final model: WCST categories ($F=13·60$, $p<0·0001$); ACT ($F=5·68$, $p=0·005$); Animals ($F=4·44$, $p<0·02$). Repeating the analysis using a forward step-wise technique yielded the same results.

Follow-up ANCOVAs showed significant differences among the groups on tests of verbal learning ($F=6·34$, df = 2, 79, $p=0·003$), executive functioning (perseverative errors: $F=9·24$, df = 2, 79, $p=0·0003$; categories completed: $F=15·49$, df = 2, 79, $p<0·0001$), verbal fluency (phonological: $F=5·64$, df = 2, 79, $p=0·005$; semantic: $F=10·92$, df = 2, 79, $p<0·0001$), verbal working memory ($F=8·74$, df = 2, 79, $p=0·0004$) and early visual processing ($F=6·56$, df = 2, 79, $p=0·002$). There were no significant differences among the groups on visuo-spatial perception ($F=1·52$, df = 2, 79, $p=0·22$). All differences remained statistically significant after making Bonferroni corrections for eight tests.

On the verbal learning test, recovered subjects recalled statistically more items than non-recovered subjects and statistically fewer items than normal controls. On executive function tests, recovered subjects made significantly fewer perseverative errors and completed more categories than non-recovered subjects. On tests of both phonological and semantic fluency, recovered subjects named significantly more words than non-recovered subjects. On a test of verbal working memory, recovered subjects identified significantly more trigrams correctly

than non-recovered subjects. Moreover, there were no statistical differences between recovered subjects and normal controls on tests of executive functions, verbal fluency and verbal working memory. However, on a test of early visual processing, normal controls correctly identified more letters than both the non-recovered subjects and recovered subjects, with no statistical difference in performance between the patient groups.

DISCUSSION

This study was designed to identify neurocognitive correlates of recovery from schizophrenia. We found evidence for a pattern of cognitive dysfunction associated with recovery from schizophrenia. Specifically, patients who met our operational criteria for recovery from schizophrenia performed better than non-recovered, but stable, out-patients with schizophrenia on tests of verbal learning, executive functioning, verbal fluency and verbal working memory. Additionally, recovered patients performed as well as healthy controls matched for age, gender, ethnicity and parental level of education on tests of executive functioning, verbal working memory, verbal fluency and visuo-perceptual skills. Recovered patients performed significantly worse than healthy controls on tests of verbal learning and early visual processing. However, the recovered patients' scores on these tests were midway between the non-recovered and healthy controls.

Recovered patients performed within the normal range on the WCST, a measure of executive functioning. This finding is consistent with the results of several studies which have found that executive functioning is a strong predictor of successful community adaptation among individuals with schizophrenia (Green, 1996; Green *et al.* 2000). Similarly, recovered subjects performed at near normal levels on verbal working memory and verbal fluency, two other cognitive domains that have been associated with good community functioning (McGurk & Meltzer, 2000). Conversely, on a test of verbal learning, recovered subjects performed better than non-recovered patients, but not as well as healthy controls. Although consistent with the finding that verbal learning is associated with higher community functioning (Green *et al.* 2000), our results suggest that higher levels of verbal learning ability, albeit not within the normal range, may be associated with recovery from schizophrenia.

The only other measure in which recovered patients and healthy controls did not differ was visuo-perceptual skills. Performance on the Rey-O indicated that the recovered subjects did not have difficulty processing complex visual information. Non-recovered patients also performed at normal levels on this test, consistent with evidence that visuo-perceptual skills are intact in all but the most severely impaired patients with schizophrenia (Velligan *et al.* 1997).

Compared to normal controls, patient groups did equally poorly on the Span of Apprehension, a test of early visual processing. This finding is consistent with several studies that suggest that a deficit of early visual processing is an enduring indicator of vulnerability to schizophrenia (Nuechterlein *et al.* 1994) rather than a predictor of community functioning. These results suggest that recovered patients may have the same vulnerability as lower functioning patients to develop schizophrenia, but have retained or developed an intact repertoire of cognitive abilities, which allows them to overcome the impairments associated with the disorder.

One interpretation of these findings is that heterogeneity among patients in terms of functional outcome may be related to variability among brain × behavior × environment interactions (Kopelowicz *et al.* 2002). Genetic predisposition to developing the disorder, neurodevelopmental anomalies and dysfunctional neural circuits between prefrontal cortex and temporal lobe structures may differentially affect neurocognitive capacities. Individuals with higher neurocognitive functioning from an early age may be more socially competent, enabling them to have more success in a wide variety of socio-environmental tasks and activities with consequent higher levels of reinforcement and social support. These interactions, repeated over many years, may generate more protective factors (e.g. problem solving and social skills) for the individual resulting in greater community adaptation.

This study has several limitations. Medications were not controlled. Although the non-

recovered subjects were taking more antipsychotic medication, there was no difference in the percentage of patients taking atypical antipsychotic drugs and few patients in either group were taking anticholinergic medications. Moreover, antipsychotic medications have not been conclusively shown to significantly affect neurocognition (Green *et al.* 2002).

The three study groups differed on level of education, which is to be expected given that the illness often strikes before education is completed. We sought to offset this difference by matching subjects on the basis of parental level of education, a common strategy that is used in neurocognitive research to ensure a reasonable comparison. Moreover, groups did not differ on the WRAT-R, which has been demonstrated to be a good indicator of pre-morbid intelligence in schizophrenia patients (Kremen *et al.* 1996).

The lack of differences between the recovered and non-recovered subjects on positive psychotic symptoms is very likely a result of the high quality pharmacotherapy offered to subjects in both groups. Positive symptoms respond to antipsychotic medications more readily than negative symptoms; thus, the similarly low levels of positive symptoms serve as a kind of control on the treatment offered to both cohorts.

Although both patient groups manifested relatively low levels of negative symptoms as measured by the 7-point BPRS (mean scores ranged from 1·2 on self-neglect for the recovered subjects to 2·6 on emotional withdrawal for the non-recovered subjects), the difference between the groups on the mean sums of the three negative symptom items was statistically significant. However, negative symptom scores did not correlate to a statistically significant level with any of the cognitive measures (Pearson correlations ranged from $r=0{\cdot}09$, $p=0{\cdot}48$ on verbal learning to $r=0{\cdot}21$, $p=0{\cdot}11$ on executive functioning), and the inclusion of negative symptoms as a covariate in the ANCOVAs did not appreciably change the results.

Another limitation of this correlational study is its cross-sectional design. Two elements in the study design help to compensate for this methodological constraint. First, because neurocognition in adults remains relatively constant over long periods of time, this biobehavioral domain may be extended backward and forward over time (Harvey *et al.* 1995; Rund, 1998; Hoff *et al.* 1999). In a 1-year follow-up study of 114 homeless persons who moved to residential care and independent housing, there were little or no changes in neurocognition such as executive functions, visuo-motor functions or verbal ability. Neurocognition remained stable despite the fact that most of these individuals had less substance abuse and fewer symptoms at the 1-year follow-up point (Seidman *et al.* 2003).

A second point derives from the very definition we used for recovery. Each of our subjects met criteria for recovery in a sustained fashion over a 2-year period. While 2 years may appear to be relatively brief, nonetheless it is the customary time period for the vast majority of treatment studies and far longer than is found in the plethora of correlational studies comparing neuroimaging and other biological indicators of schizophrenia with cohorts of persons having schizophrenia. Thus, while lacking the greater validity that would be obtained from a longitudinal study design, the significance of the results can be viewed as going beyond a single point in time. This study is a hypothesis-generating starting point for future work that will utilize longitudinal and experimental designs to test the relevance of various factors for their role in recovery from schizophrenia.

Increasing our knowledge about the neurocognitive correlates of recovery from schizophrenia will help identify the moderating and mediating factors associated with improved outcomes and might aid the development of novel interventions for promoting recovery. Following the documentation that direct training, or cognitive remediation, can normalize some of the key neurocognitive functions related to community adaptation (Kern *et al.* 1996; Van den Gaag *et al.* 2002), recent, randomized controlled treatment trials with schizophrenia patients have translated these findings into cognitive enhancement strategies that have resulted in improved vocational and social functioning (Bell *et al.* 2001; Hogarty *et al.* 2004).

An alternative strategy for promoting recovery has emerged from studies that have designed techniques for compensating patients' neurocognitive deficits. These include home visits to post reminders on doors and appliances that compensate for memory problems, placing

medication containers in plainly visible locations where they are encountered daily, modifying placement of foods, personal items and clothing to make activities of daily living more readily accomplished (Velligan *et al.* 2000). Recovered patients from the current study remarked that they carried daily planners or personal digital assistants to overcome their problems with verbal learning and memory. Developing techniques that make use of new electronic and wireless technologies may serve to improve the course and outcome of schizophrenia.

ACKNOWLEDGEMENTS

This study was supported by a Young Investigator Award from the National Alliance for Research in Schizophrenia and Depression to Dr Kopelowicz and by the UCLA Clinical Research Center for Schizophrenia and Psychiatric Rehabilitation (NIMH grant MH30911; Robert Paul Liberman, M.D., P.I.). The authors thank Veronica Gonzalez-Smith, M.A. and Daniel Gutkind, M.S., for their help in recruitment and conducting the neurocognitive tests; Michael Green, Ph.D. and Keith Nuechterlein, Ph.D. for their consultation on the design of the study; and the study subjects for their participation and support of this project.

DECLARATION OF INTEREST

None.

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