Predictors of Remediation Success on a Trained Memory Task

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Abstract: Cognitive remediation has led to improvements for some but not all individuals with schizophrenia. The goal of the current investigation was to determine which variables predicted response to cognitive remediation training. In a sample of 58 patients with DSM-IV schizophrenia or schizoaffective disorder, normalization of performance on a trained memory task was selected as the criterion for successful remediation. The contribution of demographic, symptom, treatment process, and cognitive variables in predicting successful remediation was examined using a series of logistic regressions. A final regression evaluated the combined contribution of these variables. From among patients who were impaired before training, 43% reached normal levels of performance. Measures of attention, immediate verbal memory, hostility, and latency between last training and assessment were retained in the final step of the regression, resulting in 83% classification accuracy. Findings suggest that in addition to cognitive factors, motivational and training variables also significantly affect remediation outcomes.

Key Words: Schizophrenia, cognitive remediation, cognition, memory, prediction.

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Mounting evidence indicates that impairments in neurocognition, particularly in memory, are strong predictors of social, community, and interpersonal function in schizophrenia (Green, 1996; Green et al., 2000; Semkovska et al., 2004; Smith et al., 1999; Silverstein et al., 1998). More recent reports suggest that neurocognitive impairments associated with schizophrenia are not necessarily static and may be remediated through training and practice (Bell et al., 2001; Cassidy et al., 1996; Fiszdon et al., 2004; Kurtz et al., 2001; Medalia et al., 1998; O'Carroll et al., 1999; Spaulding et al., 1999b; Tompkins et al., 1995; Wykes et al., 1999). Cognitive remediation has been shown to normalize previously impaired cognitive functions in as many as 50% of outpatients diagnosed with schizophrenia (Bell et al., 2003). It has also been shown that gains made through training are sustained over time (Bell et al., 2003; Fiszdon et al., 2004; Hogarty et al., 2004; Wykes et al., 2003).

Though there is clear evidence that cognitive remediation can improve cognition, the rate of improvement has not been uniform among patients receiving this intervention. Given the time and cost intensiveness of cognitive remediation, it is important to examine variables that will predict response to this treatment. The aim of the current study was to determine which factors are associated with success in cognitive remediation training.

Only a handful of studies have discussed potential predictors of response to cognitive remediation training. Based on their work, Sturm et al. (1997), for example, suggest that cognitive functions are organized hierarchically, and that remediation of specific deficits can be successful only if it focuses on training cognitive functions at that, or a subordinate, level. For example, if an individual has impairments in selective attention, remediation specifically targeting this aspect of attention can be successful only if the more basic components of attention, such as alertness and vigilance levels, are adequate. This position is borne out in the work of Silverstein et al. (2001), who, based on findings from their program of attention training, assert that particularly in the most severely impaired, chronic patients, remediation should focus on the basic cognitive functions necessary for the performance of any task. This view is also echoed in the work of Sohlberg et al. (2000), who, in a study comparing attention process training to education and therapeutic support in a sample of patients with brain injury, reported a differential treatment effect for patients with low versus high vigilance. Their results indicated that whereas for high vigilance patients, improvement on a task involving high-level executive function was equal in the two treatment groups, for low

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vigilance patients, improvements were greater in the group receiving attention process training. This supports the view of a hierarchical organization of cognitive functions and the need to train more basic functions before more complex ones can be remediated.

The work of Michel et al. (1998) also supports the view that cognitive task performance is predicated on adequate cognitive function at subordinate levels. These authors examined predictors of performance on a Tower of Toronto task and reported that poor performance was associated with poor problem-solving ability, impaired visual explicit memory, and lower IQ. Symptom, side effect, and medication levels were not associated with performance. When patients with impaired Tower of Toronto task performance were provided with additional trials and training, patients who did not improve were characterized by a severe memory deficit.

Additional hypotheses about potential predictors of remediation success can also be drawn from studies that examine the ability of patients to benefit from laboratory-based training interventions, frequently referred to as *learning potential*. These studies have been particularly important because they show that improvement on brief laboratory-based training interventions is in turn related to improvements in rehabilitative interventions such as problem solving or medication management (Wiedl et al., 2001a), as well as to performance of complex, work-related tasks (Sergi et al., 2003). Though still in its incipient stages, work in this area suggests that compared with individuals who do not respond to training, those who do respond show better target discrimination sensitivity (d-prime) on a continuous performance task (Wiedl et al., 2001b). This again suggests that the basic cognitive functions like attention need to be intact in order for a person to benefit from remediation.

In the current investigation, we sought to determine which variables are associated with success in a cognitive remediation training program. The first question to tackle was how to distinguish learners from nonlearners—in other words, individuals for whom the training has had a significant impact on performance. A statistically significant prepost training difference is one way of defining success and has the advantage of a threshold increase in performance. However, this approach does not take into account that even though performance has improved significantly, it may still be considerably impaired. Because the goal of cognitive remediation is to improve cognition so that the individual may in turn benefit more from other psychosocial interventions such as skill training, we rationalized that a more stringent, better measure of improved performance would be whether the individual reaches a threshold of normal performance—in other words, for the remediation to lead to cognitive performance that is similar to that of individuals who do not suffer from schizophrenia, and whose overall social, occupational, and interpersonal functioning is adequate. With this in mind, our criterion for successful remediation was task performance that was within 1 *SD* of healthy controls.

As a measure of remediation success, we selected a digit span memory task that was part of the training battery. A memory task was selected for investigation because of the importance of memory in rehabilitation. Indeed, memory in particular was selected because it has repeatedly been shown to correlate with schizophrenia patients' ability to benefit from psychosocial treatments such as skills training and problem solving (Green, 1996; Green et al., 2000; Mueser et al., 1991; Silverstein et al., 1998; Smith et al., 1999).

The task selected was one of two memory tasks on which patients received training, and for which data from healthy controls was available, making it possible to set a threshold for success of cognitive remediation. The digit span task was specifically selected because we have previously found a better improvement rate for this task (Bell et al., 2004b) because we have identified some potential confounds in the other available memory task, and because we have recently found a relationship between performance improvement on this task and a measure of functional outcome (occupational function), and concluded based on this that the task may be a good marker of responsiveness to cognitive remediation training (Bell et al., 2004a).

METHODS

Participants

The schizophrenia sample consisted of 58 individuals who participated in the neurocognitive enhancement therapy (NET) + work therapy (WT) condition of a larger study comparing NET + WT to WT alone (see Bell et al., 2001, for full description). Each participant had to meet the following inclusion criteria: outpatient status, no change in psychiatric medications in past 30 days, no change in housing in past 30 days, no alcohol or drug abuse in past 30 days, no documented developmental disability, no known neurological disorder, and a GAF score above 30. All participants were referred by their clinicians and were receiving treatment at the VA Connecticut Healthcare System. Informed written consent was obtained for every participant. The Structured Clinical Interview for DSM-IV (First et al., 1996) was administered by trained PhD-level psychologists to obtain DSM-IV (American Psychiatric Association, 1994) diagnoses. Forty of the participants met criteria for schizophrenia, and 18 met criteria for schizoaffective disorder. The mean age was 41.4 (9.7), with a mean education level of 13.2 (2.1) years. Seventy-six percent of the sample was male. The mean Positive and Negative Syndrome Scale (PANSS; Kay et al., 1987) score was 77.3 (16.0), indicating moderate levels of symptom severity.

Community control data used in this study had been obtained earlier, from a sample of 39 students attending a nearby technical college. There were no significant differences between the schizophrenia and community control participants on education levels (patients = 13.2 [2.1]; controls = 13.9 [1.9]; $t[95] = -1.73$; $p = 0.09$) or on the information subtest of the Wechsler Adult Intelligence Scale (WAIS-III; patients = 10.2 [3.5]; controls = 9.2 [2.5]; $t[95] = 1.57$; $p = 0.12$). As would be expected, on the WAIS-III digit span subtest, the schizophrenic sample scored significantly lower than the control sample (7.5 [2.0] vs. 9.2 [2.4]; $t[94] = -4.13$; $p < 0.001$). The community controls were also significantly younger than the patient sample (mean age, 29.6 [10]; $t[95] = 5.84$; $p < 0.0001$), and there was a significantly greater proportion of females in the control group (24% vs. 90%, respectively; $\chi^2[1] = 40.2$; $p < 0.0001$; refer to Bell et al., 2004b, for further description of this sample). These community controls received single administrations of the computerized cognitive remediation battery.

Measures and Design

At study intake, demographic and symptom (PANSS) data were collected along with neurocognitive measures, including the WAIS-III (Wechsler, 1997), the Continuous Performance Test (CPT; Loong, 1991), Trail Making Test A and B (Reitan and Wolfson, 1985), and the Hopkins Verbal Learning Test (HVLT; Brandt, 1991). In addition to participating in a 6-month work program, all schizophrenia participants also underwent a 6-month course of NET, consisting of up to five 45-minute computerized cognitive training sessions (using the PSS CogReHab software; Bracy, 1995) per week. Participants trained on a variety of computerized tasks involving memory, attention, and executive function. Throughout the training, task difficulty was modified based on performance according to predetermined criteria. Participants completed an average of 43 cognitive training sessions (*SD* = 33.00; range = 0–144). A follow-up assessment was administered at the end of the 6-month course of remediation. The average latency between last cognitive training session and the follow-up assessment was 35 days (*SD* = 57.76; range = 0–208).

The current article focuses on changes in performance on one of the tasks contained in the cognitive training battery: digit span. During the digit span task, participants are presented with digits, flashed one at a time for 1.5 seconds each. Five seconds after digit presentation, participants are instructed to click numbered tabs (on the bottom of the screen) to replicate the sequence of digits presented. The number of digits presented per trial (list length) begins at two and increases with success. Ten trials are administered, and the longest string length and the total number of digits successfully recalled across all trials are recorded. The maximum number of total digits recalled across all trials is 64. For the current analyses, intake and end of training (follow-up) total digits recalled scores were used. Total digits recalled score was used instead of longest string length because it provides for more variability in the range of scores. However, mean scores at intake and follow-up for the two groups are also reported for longest string length, since it is a commonly used variable.

Data Analyses

As a first step, data on the community sample's performance for the digit span task was used to set a threshold for what constitutes impaired (more than 1 *SD* below the community sample mean) or normalized (within 1 *SD* of the community sample mean) performance. The community sample's mean performance on the digit span task was 32.26 (*SD* = 6.1), making the minimum threshold for normalized performance a score of 27. Next, patients were categorized into normalized or impaired groups. The normalized group included those with impaired pretraining performance and normalized posttraining performance ($N = 21$). In the impaired group were those with impaired posttraining performance ($N = 28$). There were nine patients whose pretraining and posttraining performance was within the normal range. These patients were not included in the regression analyses detailed below. Table 1 contains a comparison of baseline demographic and clinical variables for all three groups.

A series of four logistic regressions with forward variable selection was conducted. Variables entered were from the baseline assessments and were chosen for entry into logistic regressions based on exploratory univariate analyses and relationships reported in previous research. These variables were categorized as demographics, treatment process, symptoms, and psychological test scores. Regressions were performed independently for each grouping to differentiate normalized and impaired groups optimally, and to optimize the subject to variable ratio.

Table 2 summarizes the variables initially entered into these four regressions. A fifth regression examined the combined contribution of significant predictors from the initial four analyses in optimally differentiating patients in the normalized and impaired groups. The probability statistic for the stepwise logistic regressions was set at .15 for entry and .19 for removal.

To ascertain that our normalization criterion was sufficiently stringent and did not reflect minor fluctuations around the normalization threshold we had set, we conducted a repeated-measures ANOVA with normalization as the between-subjects variable and digit task list length as the within subject variable.

RESULTS

When dichotomized into normalization and continued impairment groups, for patients whose performance was categorized as impaired, the longest digit string length was 5.11 (1.42) at study intake and 5.18 (1.12) at follow-up. For

TABLE 1. Baseline Demographic and Clinical Characteristics for Three Patient Groups: Those Whose Performance Continued to Be Impaired After Remediation ($N = 21$), Those Whose Performance Normalized After Remediation ($N = 28$), and Those Whose Performance Was Never Impaired ($N = 9$).

Variable	Subgroup	Mean (*SD*)	*F*(*df*)	Sig.	Significant pairwise comparisons*
Age	Impaired	42.89 (9.26)	.768 (2,55)	.469	
	Normalized	39.43 (9.13)			
	Never impaired	41.56 (12.17)			
Education	Impaired	12.86 (1.76)	2.45 (2,55)	.096	
	Normalized	13.10 (1.87)			
	Never impaired	14.56 (3.01)			
Age at onset	Impaired	20.56 (6.92)	2.60 (2,54)	.083	
	Normalized	21.95 (6.94)			
	Never impaired	27.00 (9.39)			
Lifetime hospitalizations	Impaired	10.36 (16.30)	1.12 (2,54)	.333	
	Normalized	6.45 (6.75)			
	Never impaired	4.11 (4.11)			
WAIS, Full Scale Intelligence Quotient	Impaired	83.89 (9.65)	6.56 (2,55)	.003	Impaired < never impaired
	Normalized	89.52 (12.27)			
	Never impaired	99.67 (14.66)			
Chlorpromazine equivalents	Impaired	790.37 (707.04)	1.11 (2,54)	.338	
	Normalized	759.90 (467.13)			
	Never impaired	464.44 (345.51)			
PANSS total	Impaired	84.71 (15.75)	7.18 (2,55)	.002	Impaired > normalized
	Normalized	69.48 (10.91)			
	Never impaired	72.78 (17.49)			
PANSS positive component	Impaired	20.18 (5.31)	2.03 (2,55)	.141	
	Normalized	17.10 (5.39)			
	Never impaired	18.22 (5.50)			
PANSS negative component	Impaired	22.61 (7.17)	1.37 (2,55)	.262	
	Normalized	19.38 (5.96)			
	Never impaired	20.56 (7.68)			
PANSS hostility component	Impaired	8.89 (3.20)	6.55 (2,55)	.003	Impaired > normalized; never impaired
	Normalized	6.38 (2.18)			
	Never impaired	6.11 (2.21)			
PANSS emotional component	Impaired	12.04 (2.91)	.375 (2,55)	.689	
	Normalized	11.38 (2.85)			
	Never impaired	11.33 (3.24)			
PANSS cognitive component	Impaired	21.00 (6.85)	6.44 (2,55)	.003	Impaired > normalized
	Normalized	15.24 (3.45)			
	Never impaired	16.56 (6.35)			

*$p < 0.05$ (pairwise t tests with Bonferroni correction).

patients whose performance was categorized as normalized, the longest digit string length was 5.29 (.72) at study intake and 7.57 (.87) at follow-up.

Variables chosen for entry into the first four logistic regressions are reported in Table 2. Table 3 presents the results of all the regressions, with the exception of the demographic regression, for which no variables met minimum inclusion criteria. For the combined model, the following variables were retained on the final step: CPT relative correct (number of correct responses/total number of re-

TABLE 2. Variables Chosen for Entry Into Four Domain-Specific Logistic Regressions Predicting Normalization of Performance on Digits Sequenced Recall Task

Model domain	Variables entered
Demographic model	Education, age, lifetime hospitalizations
Symptom model	PANSS components: positive, negative, hostility, cognitive, emotional
Process model	Number of training sessions; initial performance on digits sequenced recall task; latency between last training session and posttraining reassessment
Cognitive model	WAIS-III digit span; CPT relative correct; Trails B Time, WCST % conceptual level responses; WAIS-III Full Scale Intelligence Quotient, HVLT trials 1–3 total

TABLE 3. Forward Stepwise (Likelihood Ratio) Logistic Regressions Predicting Normalization of Performance on Digits Sequenced Recall Task From Pretraining Variables†

Variable	B	*SE*	Wald	*p* Value
Symptom model[a]				
Step 1				
PANSS cognitive component	–.213	.074	8.192	0.004
Step 2				
PANSS cognitive component	–.184	.079	5.428	0.020
PANSS hostile component	–.247	.139	3.179	0.075
Process model[b]				
Step 1				
Latency	–.021	.012	3.203	0.073
Cognitive model[c]				
Step 1				
WAIS digit span	.665	.224	8.821	0.003
Step 2				
CPT relative correct	.034	.025	1.880	0.170
WAIS digit span	.573	231	6.150	0.013
Combined model[d,†]				
Step 1				
WAIS digit span	.691	.226	9.339	0.002
Step 2				
WAIS digit span	.859	.275	9.763	0.002
PANSS hostile component	–.444	.169	6.929	0.008
Step 3				
CPT relative correct	.058	.028	4.376	0.036
WAIS digit span	.787	.293	7.194	0.007
PANSS hostile component	–.604	218	7.643	0.006
Step 4				
CPT relative correct	.088	.037	5.867	0.015
WAIS digit span	1.382	.533	6.715	0.010
Latency	–.063	.029	4.842	0.028
PANSS hostile component	–.736	.276	7.113	0.008

[a]Symptom model step 1, R^2 = .299; step 2, R^2 = .373.
[b]Process model step 1, R^2 = .157.
[c]Cognitive model step 1, R^2 = .30; step 2, R^2 = .350.
[d]Combined model step 1, R^2 = .328; step 2, R^2 = .520; step 3, R^2 = .602; step 4, R^2 = .736.
†Since no variables were retained for the demographic model (age, education, lifetime hospitalization), it is not included in the table.

sponses), WAIS-III digit span, latency (number of days between last training and follow-up testing), and PANSS hostile component. Together, these variables accounted for 74% of the variance. Overall classification accuracy for the final step of the combined model was 83% (89% for predicting normalized group and 75% for predicting impaired group membership).

A repeated-measures ANOVA with normalization status as the between-subjects variable and digit span list length as the within-subject variable showed a main effect of time on the digit list length variable ($F\,[1, 48] = 49.48$; $p < 0.001$) and a significant interaction between time and normalization status ($F\,[1, 48] = 46.37$; $p < 0.001$).

DISCUSSION

Results indicate that vigilance, immediate verbal memory, latency between last training and testing, and hostility combine to account for over 70% of the model variance. Having information on just those four variables provides an 83% accuracy rate in predicting who will normalize and who will remain impaired following cognitive remediation training. The interpretation of the above results is relatively straightforward. It appears that good attention, immediate memory, and a cooperative (less hostile) attitude are key elements to ensuring the success of cognitive remediation. Moreover, it appears that success in remediation is not related to illness chronicity, as indicated by no significant group differences on age at onset, lifetime hospitalizations, and other demographic variables. Though it is not surprising that intake WAIS-III digit span performance predicted response to cognitive remediation, it should be noted that both patient groups had very similar performances on the digit span training task at intake. It is also important to note that in the final regression, the most predictive power was associated with the CPT variable, which is a measure of vigilance. This may be a reflection of the importance of the ability to control conscious (or cognitive) activity, which has been proposed to be a key ingredient in the cognitive rehabilitation of schizophrenia by Spaulding et al. (1999a) as well as Silverstein and Wilkniss (In press). This is also consistent with the work of Sturm et al. (1997) as well as Sohlberg et al. (2000), who suggest that more basic cognitive functions must be intact before training of more complex tasks can be successful.

Finding that latency between training and retest was also a significant predictor suggests the possibility that performance may decay over time. However, there are several recent studies in the literature that directly address this issue (Bell et al., 2003; Fiszdon et al., 2004; Wykes et al., 2003) and indicate that training effects are usually sustained over time. These other studies used change scores as continuous variables, whereas our study had the stiffer criterion of reaching a normalized level of performance. It appears that latency has some effect on posttraining performance, but gains may be retained.

An important feature of this study that requires emphasis is our end-point criterion. Whereas most cognitive remediation studies focus on performance improvement, we focused on performance normalization. Critics of cognitive remediation have argued that even if this treatment results in significant improvements, these improvements may lack practical significance—individuals may still continue to be quite impaired in spite of making statistically significant gains. By characterizing task improvement in terms of normalization, we focused on what we consider clinically significant improvement—function within the normal range. We reasoned that this type of criterion would have more real-world applicability as far as determining the success of treatment, as well as readiness for other types of rehabilitation that put demands on memory. For example, we have shown that good working memory is important for continuing improvement in work performance (Bryson and Bell, 2003). Additional analyses on raw scores for digit list length support our use of the normalization criterion, with statistically significant improvements for the normalization group only.

This is an exploratory analysis of predictors of cognitive remediation success, as previously defined. We focused on a specific type of cognitive functioning, memory, and a specific performance task, digit span. Compared with the patient sample, the community controls were significantly younger and more likely to be female. The sample consisted of patients diagnosed with either schizophrenia or schizoaffective disorder. A single digit span task was used as a measure of immediate memory. All of these variables may limit the generalizability of the findings. Though it is unknown whether variables identified in this study also predict success on other tasks, even those within the memory domain, there are certain core cognitive functions (like attention and short-term memory) that likely underlie potential for improvement on most any task.

Future studies examining predictors of remediation success would benefit by better matching control data to patient data on demographic variables. Also of benefit would be the inclusion of treatment variables such as self-efficacy and motivation that have been repeatedly suggested as important components of treatment success, (e.g., Silverstein et al., 2001). Additionally, studies that use other benchmarks of remediation success, such as long-term episodic memory, which is more closely related to functional outcome than the immediate memory measure used here, may shed even more light on variables that increase the likelihood that remediation will be successful.

CONCLUSION

These preliminary results are encouraging and suggest that we may successfully predict under what sorts of conditions patients are most likely to benefit from cognitive remediation. Being able to predict the success of cognitive remediation training can in turn advise us to the types of psychosocial interventions best suited to individual patients, as well as assist in targeting and modifying specific variables related to remediation success, resulting in a more individualized approach to patient care.

REFERENCES

American Psychiatric Association (1994) *DSM-IV: Diagnostic and Statistical Manual of Mental Disorders* (4th ed). Washington DC: American Psychiatric Association.

Bell MD, Bryson G, Fiszdon JM, Greig T, Wexler B (2004a) Neurocognitive enhancement therapy and work therapy in schizophrenia: Work outcomes at 6 month and 12 month follow-up [abstract]. *Biol Psychiatry*. 55(suppl 8):94S.

Bell MD, Bryson G, Greig T, Corcoran C, Wexler B (2001) Neurocognitive enhancement therapy with work therapy: Effects on neuropsychological test performance. *Arch Gen Psychiatry*. 58:763–768.

Bell MD, Bryson G, Wexler BE (2003) Cognitive remediation of working memory deficits: Durability of training effects in severely impaired and less severely impaired schizophrenics. *Acta Psychiatr Scand*. 107:1–9.

Bell MD, Fiszdon JM, Bryson G, Wexler BE (2004b) Effects of neurocognitive enhancement therapy in schizophrenia: Normalization of memory performance. *Cognit Neuropsychiatry*. 9:199–211.

Bracy O (1995) *PSS CogRehab* (version 95). Indianapolis (IN): Psychological Software Services, Inc.

Brandt J (1991) The Hopkins verbal learning test: Development of a new memory test with six equivalent forms. *Clin Neuropsychol*. 5:125–142.

Bryson G, Bell MD (2003) Initial and final work performance in schizophrenia: Cognitive and symptoms predictors. *J Nerv Ment Dis*. 191: 87–92.

Cassidy JJ, Easton M, Capelli C, Singer A, Bilodeau A (1996) Cognitive remediation of persons with severe and persistent mental illness. *Psychiatr Q*. 67:313–321.

First MB, Spitzer RL, Gibbon M, Williams JBW (1996) *Structured Clinical Interview for DSM-IV Axis I Disorders—Patient Edition (SCID-I/P)* (version 2.0). New York: Biometrics Research Department, New York State Psychiatric Institute.

Fiszdon JM, Bryson GJ, Wexler BE, Bell MD (2004) Durability of cognitive remediation training on two memory tasks at 6-month and 12-month follow-up. *Psychiatry Res*. 125:1–7.

Green MF (1996) What are the functional consequences of neurocognitive deficits in schizophrenia? *Am J Psychiatry*. 153:321–330.

Green MF, Kern RS, Braff DL, Mintz J (2000) Neurocognitive deficits and functional outcome in schizophrenia: Are we measuring the "right stuff"? *Schizophr Bull*. 26:119–136.

Hogarty GE, Flesher S, Ulrich R, Carter M, Greenwald D, Pogue-Geile M, Kechavan M, Cooley S, DiBarry AL, Garrett A, Parepally H, Zoretich R (2004) Cognitive enhancement therapy for schizophrenia: Effects of a 2-year randomized trial on cognition and behavior. *Arch Gen Psychiatry*. 61:866–876.

Kay SR, Fiszbein A, Opler LA (1987) Positive and negative syndrome scale for schizophrenia. *Schizophr Bull*. 13:261–276.

Kurtz MM, Moberg PJ, Gur RC, Gur RE (2001) Approaches to cognitive remediation of neuropsychological deficits in schizophrenia: A review and meta-analysis. *Neuropsychol Rev*. 11:197–210.
Loong J (1991) *The Manual for the Continuous Performance Test.* San Louis Obispo (CA): Wang Neuropsychological Laboratory.
Medalia A, Aluma M, Tryon W, Merriam AE (1998) Effectiveness of attention training in schizophrenia. *Schizophr Bull*. 24:147–152.
Michel L, Danion JM, Grange D, Sandner G (1998) Cognitive skill learning and schizophrenia: Implications for cognitive remediation. *Neuropsychology*. 12: 590–599.
Mueser KT, Bellack AS, Douglas MS, Wade JH (1991) Prediction of social skill acquisition in schizophrenic and major affective disorder patients from memory and symptomatology. *Psychiatry Res*. 37:281–296.
O'Carroll RE, Russell HH, Lawrie SM, Johnstone EC (1999) Errorless learning and the cognitive rehabilitation of memory-impaired schizophrenic patients. *Psychol Med*. 29:105–112.
Reitan RM, Wolfson D (1985) *The Halstead-Reitan Neuropsychological Test Battery.* Tucson (AZ): Neuropsychology Press.
Semkovska M, Bedard MA, Godbout L, Limoge F, Stip E (2004) Assessment of executive dysfunction during activities of daily living in schizophrenia. *Schizophr Res*. 69:289–300.
Sergi MJ, Kern RS, Mitchell S, Herrera A, Kogler K, Doran D, Green MF (2003) How useful are learning potential assessments in predicting rehabilitation outcome in schizophrenia? [abstract] *Schizophr Res.* 60:328.
Silverstein SM, Schenkel LS, Valone C, Nuernberger SW (1998) Cognitive deficits and psychiatric rehabilitation outcomes in schizophrenia. *Psychiatr Q*. 69:169–191.
Silverstein SM, Menditto AA, Stuve P (2001) Shaping attention span: An operant conditioning procedure to improve neurocognition and functioning in schizophrenia. *Schizophr Bull*. 27:247–257.
Silverstein SM, Wilkniss S (In press) The future of cognitive rehabilitation of schizophrenia: What should we be rehabilitating and how should we be doing it? *Schizophr Bull.*
Smith TE, Hull J, Romanelli S, Fertuck E, Weiss K (1999) Symptoms and neurocognition as rate limiters in skills training for psychotic patients. *Am J Psychiatry*. 156:1817–1818.
Sohlberg MM, McLaughlin KA, Pavese A, Heidrich A, Posner MI (2000) Evaluation of attention process training and brain injury education in persons with acquired brain injury. *J Clin Exp Neuropsychol*. 22:656–676.
Spaulding WD, Fleming SK, Reed D, Sullivan M, Storzbach D, Lam M (1999a) Cognitive functioning in schizophrenia: implications for psychiatric rehabilitation. *Schizophr Bull*. 25:275–289.
Spaulding WD, Reed D, Sullivan M, Richardson C, Weiler M (1999b) Effects of cognitive treatment in psychiatric rehabilitation. *Schizophr Bull*. 25:657–676.
Sturm W, Willmes K, Orgass B, Hartje W (1997) Do specific attention deficits need specific training? *Neuropsychol Rehab*. 7:81–103.
Tompkins LM, Goldman RS, Axelrod BN (1995) Modifiability of neuropsychological dysfunction in schizophrenia. *Biol Psychiatry*. 38: 105–111.
Wechsler D (1997) *WAIS-III Manual*. New York: Psychological Corp.
Wiedl KH, Schottke H, Garcia DC (2001a) Dynamic assessment of cognitive rehabilitation potential in schizophrenic persons and in elderly persons with and without dementia. *Eur J Psychol Assess*. 17:112–119.
Wiedl KH, Wienobst J, Schottke HH, Green MF, Nuechterlein KH (2001b) Attentional characteristics of schizophrenia patients differing in learning proficiency on the Wisconsin Card Sorting Test. *Schizophr Bull*. 27:687–696.
Wykes T, Reeder C, Corner J, Williams C, Everitt B (1999) The effects of neurocognitive remediation on executive processing in patients with schizophrenia. *Schizophr Bull*. 25:291–307.
Wykes T, Reeder C, Williams C, Corner J, Rice C, Everitt B (2003) Are the effects of cognitive remediation therapy (CRT) durable? Results from an exploratory trial in schizophrenia. *Schizophr Res*. 61:163–174.