Department of Veterans Affairs

JRRD Journal of Rehabilitation Research & Development
Volume 44, Number 6, 2007
Pages 827–836

Is learning potential associated with social skills in schizophrenia?

Wendy N. Tenhula, PhD;[1–2]* Joanna E. Strong Kinnaman, PhD;[1] Alan S. Bellack, PhD[1–2]
[1]Department of Veterans Affairs Capitol Health Care Network (Veterans Integrated Service Network 5), Mental Illness Research, Education, and Clinical Center, Baltimore, MD; [2]Department of Psychiatry, University of Maryland School of Medicine, Baltimore, MD

Abstract—Cognitive deficits are a primary factor in the social and functional impairments characteristic of schizophrenia and an important predictor of treatment success in psychosocial rehabilitation. This study examined the association between abstract reasoning and social functioning by assessing whether learning potential on the Wisconsin Card Sorting Test (WCST) relates to changes in social competence following social skills training (SST). Fifty-six veterans with schizophrenia or schizoaffective disorder completed a series of assessments followed by eight SST sessions. To evaluate learning potential, we assessed participants with the WCST and Category Test (CT), taught them a training protocol for the WCST, and retested on both measures. Participants learned the WCST, generalized this learning to improve their performance on the CT, and retained these gains for several weeks. Participants showed small improvements on the Maryland Assessment of Social Competence (MASC), but WCST learning potential and CT generalization were unrelated to improvement on the MASC.

Key words: executive function, functional outcome, learning, learning potential, neurocognition, neuropsychology, problem solving, rehabilitation, schizophrenia, social functioning, social skills training.

INTRODUCTION

During the past decade, interest in the role of cognitive impairments in schizophrenia has increased. Neurocognitive deficits are now widely recognized as a core aspect of schizophrenia, with impairments in the executive function, verbal memory, and sustained attention domains most consistently reported in the literature [1]. Although which specific cognitive measures correlate with which specific social and functional outcomes is not completely uniform across studies, cognitive deficits appear to be a primary factor in the social and functional impairments characteristic of schizophrenia and an important determinant of the ability to profit from psychosocial rehabilitation or skills training interventions [1–6]. The importance of cognitive deficits is not surprising, since the ability to attend to, remember, and plan based on teaching would be expected to have a major impact on the acquisition and application of new skills or knowledge. In Green et al.'s review of this literature, they report that neurocognition accounts for 20 to 60 percent of the variance in functional outcome among patients with schizophrenia [1].

Abbreviations: BPRS = Brief Psychiatric Rating Scale, CT = Category Test, GS = generalization score, LS = learning score, MASC = Maryland Assessment of Social Competence, SCID-I = Structured Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition, SD = standard deviation, SST = social skills training, VA = Department of Veterans Affairs, WCST = Wisconsin Card Sorting Test.

***Address all correspondence to Wendy N. Tenhula, PhD; Mental Illness Research, Education, and Clinical Center, 10 North Greene Street, 6A-162, Baltimore, MD 21201; 410-605-7455; fax: 410-605-7739. Email: wendy.tenhula@va.gov**
DOI: 10.1682/JRRD.2006.09.0113

In the current study, we attempted to clarify the relationship between abstract reasoning and problem solving as measured by a card sorting task and social competence as demonstrated by the outcome of a social skills training (SST) intervention. Since people with schizophrenia have prominent deficits in social problem solving, studies using the Wisconsin Card Sorting Test (WCST) [7] and other measures of problem solving or abstract reasoning may have particular relevance for questions about the generalizability of psychosocial interventions [8–11]. Specifically, such studies may help delineate the role of neurocognitive problem-solving deficits in the social problems that individuals with schizophrenia and other serious mental illnesses exhibit. Previous studies reported varying results regarding the relationship between social skills and performance on the WCST [12–14].

One promising approach to understanding the relationship between WCST performance and psychosocial treatment outcomes uses a WCST training paradigm to assess "learning potential." Learning potential studies have examined the ability to learn new skills as an index of the ability to benefit from a range of psychosocial interventions. Assessment of learning potential typically involves standard administration of the WCST, followed by participant training on how to do the test and then a retest to see whether participant performance on the WCST improves. Fairly consistent evidence shows that at least some individuals with schizophrenia can learn how to do the WCST [15–16] and that this training may generalize to other assessments of abstract reasoning, such as the Category Test (CT) [15].

However, the relationship between learning potential and functional outcomes (e.g., improvements in social interactions) is less well established. For example, Wiedl reported that individuals with schizophrenia who were classified as either "high scorers" (i.e., scored ≥43 on the WCST) or "learners" (i.e., showed >15-point improvement in performance after a training protocol) on the WCST were more likely than "nonretainers" (i.e., did not score >43 or show >15-point improvement) to benefit from brief problem-solving skills intervention [16]. Similarly, Sergi et al. found that learning potential on the WCST predicted performance on a work-skill acquisition task [17]. The work-skill acquisition task involved a single session of training with either errorless learning or a conventional training paradigm. In a more recent study, Fiszdon et al. assessed learning potential by training subjects on a test of verbal learning and memory [18]. They reported that learning potential predicted performance on the micromodule learning test [19], a task that measures responsiveness to skills training interventions.

However, when Woonings and colleagues examined the relationship in the context of a longer, more comprehensive rehabilitation program, they did not find an association between learning potential and social functioning or rehabilitation outcome [20]. Thus, although mounting evidence favors a role for learning potential in outcome prediction, the relationship between assessments of learning potential and function among persons with schizophrenia still remains unclear.

In the current study, we attempted to clarify this issue by examining whether learning potential on the WCST was related to improvements on another test of abstract reasoning (i.e., the CT) and also related to improvements in social skills following a social skills intervention. We predicted that at least some participants would improve on the WCST following training and that this learning would be associated with improvement on the CT, as well. In addition, we hypothesized that learning on the WCST and CT would be associated with learning on a social skills measure administered before and after a brief SST intervention.

METHODS

Participants

The data in the current study were collected as part of a parent investigation of veterans with schizophrenia enrolled in a vocational rehabilitation program. Participants met diagnostic criteria for schizophrenia or schizoaffective disorder as assessed by the Structured Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition (SCID-I) [21–22]. The treating mental health clinician judged eligible participants to be able to participate and provide informed consent. The participants were also stabilized on a medication regimen for a minimum of 4 weeks with no changes in dose for at least 2 weeks before study entry and no expected medication or dosage changes for the project duration. Exclusion criteria were evidence of past or current neurological disorder, head injury with ongoing cognitive sequelae, or mental retardation.

Of the 70 individuals who provided signed consent to participate, 56 completed baseline assessments. These 56 participants were mostly male (92.9%), with a mean ±

standard deviation (SD) age of 49.4 ± 6.2 years. Most (62.5%) were African American and the remainder (37.5%) was white. Many participants lived in supervised housing (65.45%) and reported that they had never married (63.6%). The average length of education was 12.51 ± 1.65 years. The reported average age of onset of mental illness was 23.28 ± 6.29 years and the participants reported an average of 10.70 ± 9.33 psychiatric hospitalizations. Most (87.5%) of the participants had a diagnosis of schizophrenia, while the remainder (12.5%) was diagnosed with schizoaffective disorder. Scores on the 20-item Brief Psychiatric Rating Scale (BPRS) [23] ranged from 21 to 57 (mean ± SD = 35.56 ± 8.23) indicating, on average, a mild-to-moderate level of psychiatric disturbance at baseline. Regarding employment history, the mean ± SD time since their last competitive job was 12.93 ± 10.60 years. The majority of the positions they had held in the past were in skilled (30.61%) or unskilled labor (38.78%). The participants were employed in their current work assignments through Department of Veterans Affairs (VA) vocational rehabilitation services and worked a mean ± SD 15.85 ± 7.82 hours a week.

Procedures

The University of Maryland Institutional Review Board and the local VA Research and Development Committee approved all study procedures. We reviewed medical records to determine preliminary eligibility. Trained recruiters first received clinician approval for patient study participation and then potential subjects participated in a standardized informed consent process. Participants in the parent study completed a series of baseline assessments, a month-long wait-list period, and then an eight-session group SST intervention focused on social interactions at work.

For the current investigation, participants completed four assessment phases (see **Figure** for flow of study procedures). In Phase 1, participants completed baseline assessments, including diagnostic assessments, collection of demographic information, social skills assessment via the Maryland Assessment of Social Competence (MASC) [24–25], and a brief neuropsychological battery that included the WCST [7] and CT [26]. Before Phase 2, participants completed a brief standardized training protocol for the WCST. The WCST training protocol was presented as a general way to solve problems by using a six-point problem-solving mnemonic. Specifically, we guided participants through the process of identifying the problem, identifying and then selecting a potential strategy for solving the problem, assessing whether the strategy they chose was successful, and then either continuing to use a successful strategy or revising their approach if their strategy was unsuccessful. We demonstrated the problem-solving mnemonic with the WCST and then conducted a modified administration of the WCST with direct feedback and guidance as the participant practiced applying the mnemonic to this task. The training script is available from the first author upon request. After WCST training, participants again completed the WCST and CT, which were administered with standard instructions (Phase 2). In Phase 3, which occurred 1 month later, participants were retested on the MASC, WCST, and CT, which were administered with standard instructions (i.e., with no additional training or prompting) as a measure of retention of the neuropsychological training protocol. Phase 4 occurred after the participants had completed a 4-week, eight-session SST intervention; the assessments again included the WCST, CT, and the MASC. Because the data presented here were part of a parent study on work-related SST, our SST intervention focused on work-related social skills such as starting, joining, and ending conversations with coworkers; asking for information; asking for feedback about job performance; and responding to criticism.

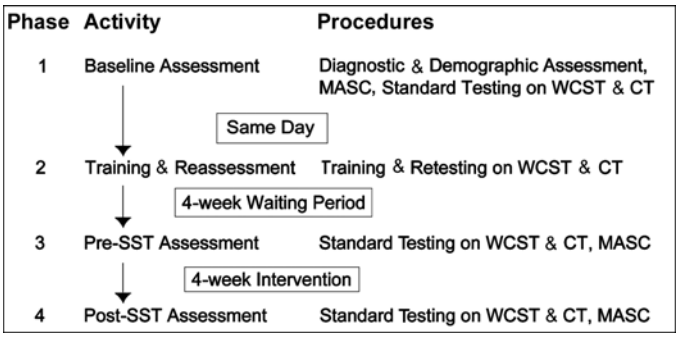

Figure.
Flow of study procedures. CT = Category Test, MASC = Maryland Assessment of Social Competence, SST = Social Skills Training, WCST = Wisconsin Card Sorting Test.

Measures

Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition

Doctoral- or master's-level clinicians conducted the diagnostic assessment to determine study eligibility using

all available information for the potential participant (patient report, medical records, treatment providers). To prevent rater drift, all interviewers received bimonthly supervision during which randomly selected videotapes of diagnostic assessments were viewed and consensus ratings obtained.

Wisconsin Card Sorting Test

The WCST requires participants to match stimulus cards containing different geometric shapes that vary in color and number of items per card. In the standard administration, the examiner does not inform the participant of the rule for correct matching (e.g., color, shape, number of items on card) but simply responds "right" or "wrong" after each guess. In addition, the rule for correct matching changes without warning after the participant correctly matches 10 consecutive cards. The WCST is sensitive to impairments in information processing, concept formation, and abstract thought [27]. Persons with schizophrenia have been commonly observed to perform poorly on the WCST.

We used the 64-item version of the WCST for this investigation. Results from the WCST include total number of errors, number of perseverative errors, and number of categories correct. Using Bellack et al. as a model [15], we used change scores to calculate two separate WCST learning scores (LSs) for each subject. In this study, the LS was calculated from the residualized change score for the Phase 1 to Phase 2 WCST raw number of errors and the residualized change score for the Phase 1 to Phase 2 correct categories. We obtained residualized change scores by conducting regression analyses in which the pretest scores were used to predict the posttest scores, with the residual scores retained as the change scores. Residualized change scores are preferable to raw change scores (i.e., pre- minus post-) because they control for baseline performance on a given measure.

Category Test

We administered the first four subtests of the CT. This shortened version is more conducive to repeat administrations and correlates highly with the full 208-item version [26,28]. The CT requires participants to identify a principle for categorizing geometric shapes and symbols and select the correct match from among a set of four choices. Each subtest uses different types of stimuli involving progressively more difficult categorization principles. The examiner responds "correct" or "incorrect" after each answer but does not provide information about the correct categorization rule. We calculated a CT generalization score (GS) for each subject as the Phase 1 to Phase 2 number of errors residualized change score on the CT [15].

The CT was of particular interest for this study for several reasons: (1) replicated evidence exists that persons with schizophrenia perform poorly on the test [29–31]; (2) it is widely considered to measure novel problem solving and hypothesis testing and, thus, both the WCST and CT draw on some of the same cognitive processes; (3) the administration format involving trial-by-trial learning based on examiner feedback is similar to the WCST, increasing the possibility of generalization; and (4) despite these similarities, the two tests are only modestly correlated [32–33], preventing generalization simply on the basis of equivalence of the two tests.

Maryland Assessment of Social Competence

The MASC is a role-play task in which participants engage in a series of 3-minute conversations with a confederate. The MASC administration procedures used for this study were identical to those for the role-play task described in Bellack et al. [25]. Three parallel sets of five scenarios are matched for repeated administration. Four of the MASC scenes used for this study were work-related (e.g., assertion with one's work supervisor, initiating a conversation at work) and one was more general (i.e., assertion with the landlord). The psychometric characteristics of the MASC indicate that the content of the MASC scenes can be adapted for application in different contexts [24]. The interactions were videotaped and rated on Verbal Content, Nonverbal Skill (a measure of paralinguistic style, eye contact, and gestures), and Overall Effectiveness (ability to maintain focus and achieve the goal of the scenario). Appropriate controls were used to prevent rater drift and keep raters blind to all information, including study time point, which might have biased their judgments. Regular supervision ensured adherence to the protocol and consistency across participants. Interrater reliability was acceptable (0.80) based on 20 percent of randomly chosen MASC tapes rated by two independent raters. In the present study, the scores on the four work-related scenarios were combined for a single overall MASC score. Change scores on the MASC were calculated with residualized pre- to post-SST (i.e., Phase 3 to Phase 4) overall MASC scores.

RESULTS

Change on Wisconsin Card Sorting Test and Category Test After Training

Results demonstrate that the participants improved on the WCST in terms of number of errors, preservative errors, and categories correct after the WCST training (**Table 1**). Data are shown as mean ± SD unless otherwise noted. Pairwise comparisons demonstrated that the number of correct WCST categories at Phase 1 (1.56 ± 1.37) was significantly lower than at Phase 2 (2.52 ± 1.64) and Phase 3 (2.44 ± 1.74), which occurred approximately 1 month after the WCST training. Phase 1 WCST number of errors (28.76 ± 12.89) and perseverative errors (16.36 ± 11.27) were significantly higher than at Phase 2 (20.16 ± 10.96 and 10.92 ± 8.50, respectively) and Phase 3 (22.10 ±12.29 and 12.18 ± 9.52, respectively). Phase 2 and Phase 3 did not differ on any of the WCST scores.

Participants also made fewer errors on the CT after they received WCST training. Phase 1 errors on the CT (52.32 ±15.89) were significantly greater than both Phase 2 (43.54 ± 21.79) and Phase 3 (37.58 ± 21.87) error scores. Interestingly, participants also had a significantly lower number of CT errors in Phase 3 than in Phase 2 ($p < 0.05$).

Concurrent Relationships Between Neuropsychological Functioning and Social Skills

We next examined the relationships between the measures of neuropsychological functioning (i.e., WCST and CT) and a concurrent measure of social skills functioning (i.e., MASC) at Phase 3 (after WCST training but before SST) and Phase 4 (following SST) (**Table 2**). We used Spearman rank correlation coefficients to examine these relationships because the variables generally did not meet the assumption of normality needed to perform parametric procedures.

Results demonstrate that the Phase 3 MASC score was related to the Phase 3 WCST total correct categories ($r = 0.37$) and the total number of WCST errors ($r = –0.29$) (**Table 2**). The MASC did not demonstrate a significant relationship with WCST preservative errors or the CT total errors score. Results for the Phase 4 assessments show that the MASC score at Phase 4 was not significantly correlated with the Phase 4 WCST categories ($r = 0.25$), the WCST perseverative errors ($r = –0.26$), or the CT errors ($r = –0.24$) at Phase 4. The correlation between the MASC and WCST errors approached significance ($r = –0.27$, $p = 0.07$).

At both time points, the WCST scores were all highly interrelated ($r = –0.75$ to 0.95). The total number of errors on the CT at Phase 3 was significantly related to the number of errors ($r = 0.30$) and perseverative errors on the WCST ($r = 0.29$) at $p < 0.05$; correlation between the CT errors and WCST total categories was not significant ($r = –0.24$, $p = 0.10$). At Phase 4, all WCST indices were significantly related to the CT errors at $p < 0.01$ (r values ranged from –0.43 to 0.54).

Relationship Among Wisconsin Card Sorting Test, Category Test, Learning, and Social Skills Learning

Finally, we examined relationships between change on the MASC and learning on the neuropsychological measures. We first examined participant functioning on

Table 1.
Performance (mean ± standard deviation) on Wisconsin Card Sorting Test (WCST) and Category Test (CT) before and after WCST training ($n = 50$).

Test	Phase 1 (pretraining)	Phase 2 (posttraining)	Phase 3 (1-month posttraining)	*F*-Statistic* (*p*-Value)
WCST				
Categories (raw No.)†	1.56 ± 1.37	2.52 ± 1.64	2.44 ± 1.74	11.82 (<0.001)
Errors (total raw No.)‡	28.76 ± 12.89	20.16 ± 10.96	22.10 ± 12.29	12.48 (<0.001)
Perseverative Errors (total raw No.)‡	16.36 ± 11.27	10.92 ± 8.50	12.18 ± 9.52	8.34 (0.001)
CT				
Errors (total raw No.)§	52.32 ± 15.89	43.54 ± 21.79	37.58 ± 21.87	39.02 (<0.001)

*F-statistic is estimation of Greenhouse-Geisser test; least significant difference used for post hoc pairwise comparisons.
†Pretraining < posttraining & 1-month posttraining at $p < 0.05$, pairwise comparison.
‡Pretraining > posttraining & 1-month posttraining at $p < 0.05$, pairwise comparison.
§Pretraining > posttraining > 1-month posttraining at $p > 0.05$, pairwise comparison.

Table 2.
Relationship between social functioning and neuropsychological functioning before (n = 46) and after (n = 44) social skills training (SST).

Test	MASC	
	Phase 3 (Pre-SST)	Phase 4 (Post-SST)
WCST		
Categories Correct	0.37*	0.25
Errors	–0.29*	–0.27†
Perseverative Errors	–0.24	–0.26
CT		
Errors	–0.15	–0.24

Note: Coefficient is Spearman rank correlation coefficient.
*$p < 0.05$.
†$p = 0.07$.
CT = Category Test, MASC = Maryland Assessment of Social Competence, WCST = Wisconsin Card Sorting Test.

the MASC. The average Phase 3 (pre-SST) score on the MASC was 3.69 ± 1.11, which corresponds to an overall rating between "neither good nor poor" and "somewhat good." The average Phase 4 (post-SST) score on the MASC was 3.74 ± 1.24 for this sample. The amount of change on the MASC was evaluated by calculation of effect size (i.e., the average difference between Phase 3 and Phase 4 scores for the entire group divided by the Phase 3 SD). The average effect size (0.10) was small, primarily because half the participants (n = 23) had a Phase 3 score >4.00 on the MASC, which has a maximum score of 5.00. Therefore, many of these individuals may have displayed a "ceiling effect" and did not have enough room to improve from pre- to postintervention. We therefore examined the effect size of the MASC from Phase 3 to Phase 4, excluding high scorers on the MASC (i.e., scored above the median split of 4.00), and found a large effect size (0.77).

To examine whether change on the MASC was related to change on neurocognitive measures of change, we examined the relationship between the Phase 3 to Phase 4 (pre- to post-SST) residualized change on the MASC, the residualized LS on the WCST total errors, the residualized LS on the WCST categories, and the residualized GS on the CT total errors (**Table 3**). We only examined change for the 23 participants who demonstrated change on the MASC as defined by a Phase 3 mean overall MASC score below the median (4.00). Once again, Spearman rank correlations were used to examine these relationships because several measures did not meet assumptions of normality. Results showed no significant correlations between change on the MASC social skills assessment and LSs on the WCST. The MASC change was also unrelated to participants' ability to generalize WCST learning to the CT, and ability to learn on the WCST was not related to ability to generalize learning and improve performance on the CT. The two WCST LSs were significantly related ($r = –0.93$, $p < 0.001$).

Post Hoc Analyses

To ensure that our analysis of the subsample of participants whose MASC scores were <4.00 (n = 23) did not distort the results, we conducted two sets of post hoc analyses. First, to confirm this subsample's learning on the WCST and generalization to the CT, we examined whether they demonstrated improvements on the WCST and CT after training on the WCST. Analyses demonstrated that these participants' results generally paralleled results for the entire sample (**Table 1**). Second, we examined whether the measures of neurocognitive change were related to change on the MASC with the entire sample (n = 56). We examined relationships among the WCST, CT, and MASC residualized change scores and found that they paralleled the results with the subsample (**Table 3**).

Table 3.
Relationship between Wisconsin Card Sorting Test (WCST) residualized learning scores, Category Test (CT) generalization scores, and Maryland Assessment of Social Competence (MASC) change.

Score	Score			
	1	2	3	4
1. MASC Total Change	—	—	—	—
2. WCST Learning Score Total Categories	0.07	—	—	—
3. WCST Learning Score Total Errors	–0.11	–0.93*	—	—
4. CT Generalization Score Total Error	–0.04	0.15	–0.13	—

Note: n = 21–23 because of missing data. Coefficient is Spearman rank correlation coefficient.
*$p < 0.001$.

DISCUSSION AND CONCLUSIONS

As expected, results show that the participants with schizophrenia in this study could learn how to perform the WCST and generalize this learning to improve their performance on the CT. Once they learned how to do the WCST, they appeared to retain the training over a 1-month period. They also maintained generalization of the WCST training to the CT and improved their performance further on the CT over a 1-month period during which they received no additional training or study-related intervention. Executive function as measured by the WCST was generally related to concurrent social competence as measured by the MASC. This finding is consistent with Kurtz and Wexler's description of intact WCST performers performing better on a measure of functional assessment [14] and with Bell and Bryson's finding that social skills at work were linked to WCST performance [34].

Participants in our study showed small improvements on the MASC after a brief SST intervention. However, the ability to improve on the WCST after training as well as the ability to generalize learning from one task to the other was unrelated to improvement on the MASC following SST. While this finding coincides with Woonings and colleagues' finding that learning potential was not associated with a general behavior rating of rehabilitation outcome [20], it is contrary to our initial hypothesis and inconsistent with several other published studies of learning potential in schizophrenia [16–18]. Differences in the interventions and types of outcome measures used in the studies could possibly account for differences in reported results. Specifically, Wiedl used problem-solving interviews to assess change associated with problem-solving skills training [16]. Sergi and colleagues tested work skill acquisition on a specific work task for which the subjects received direct training [17]. Thus, the outcome measures in these two studies were fairly direct measures of problem solving on specific tasks that were closely related to the training provided to subjects. Fiszdon and colleagues used an analog measure of rehabilitation readiness rather than examining rehabilitation outcomes per se [18]. By contrast, we used the MASC to assess more general work-related social competence and Woonings and colleagues assessed general rehabilitation outcome [20]. Change on these more general or distal outcomes appear unrelated to learning potential, at least as measured by the WCST.

To summarize, executive function as measured by performance on some WCST indexes was related to concurrent social functioning as measured by the MASC such that poorer WCST performance was related to lower social competence. However, neither the ability to learn on the WCST nor the ability to generalize that learning to the CT was related to improvement in social skills. Thus, the additional time involved in assessing learning potential (versus standard WCST or CT administration) to determine ability to benefit from work-related SST is not supported by these results. However, these results should be considered preliminary and several limitations of the current study must be noted. First, the relationships reported here are correlational and do not control for other variables, such as overall level of cognitive function. Second, because of the aims of the parent study, the content of the SST in this study was work-related. There is no reason to think that work-related social competence would show a different pattern of results than general social skills regarding learning potential, but this cannot be determined based on the data available. Third, the number of participants in this study is relatively small. Particularly for the analyses that included only the subgroup with lower MASC scores, the potential for Type II error must be noted.

Other investigators have divided subjects into groups based on their WCST learning potential scores. We chose to use continuous measures of performance on the WCST and CT rather than categorizations to avoid a loss of statistical power. However, worthy of note is that exploratory analyses using Wiedl's classification scheme of high scorers, learners, and nonretainers yielded the exact same pattern of results reported earlier.

Finally, the small effect size on the MASC was possibly due to a ceiling effect. Half the sample had preintervention scores on the MASC of 4.00 or higher on a 5-point rating scale. Thus, many participants in the study demonstrated relatively high social competence before the SST intervention. In addition, most participants in this study had had their mental illness for more than 20 years and been in their current vocational assignments for a relatively long time. Thus, this sample consisted of a chronically ill group of individuals who may have achieved the maximum level of functional recovery that they were capable of achieving. Possibly, a greater potential for functional change (and also a stronger relationship between neurocognitive status and functional change)

would be observed with younger individuals who are earlier in their recovery.

Learning potential is relatively understudied, with only a few reports in the literature. It is a theoretically appealing construct, particularly given the drive to understand which variables may mediate the relationship between cognition and functional outcomes in schizophrenia. In the current study, the generalization of training from the WCST to the CT suggests that participants did not simply learn how to do the trained task (i.e., the WCST) better, but that higher order problem solving can, in fact, be improved among persons with schizophrenia. However, the implication of these improvements for functional and rehabilitation outcomes remains unclear. In light of this and the mixed results in the literature to date, further research in this area is warranted. Most studies of learning potential have used the WCST and examined participants' ability to learn executive function tasks. Fiszdon and colleagues' use of a list-learning paradigm to assess learning potential points to the importance of examining different methods of assessing this construct (e.g., executive function tests versus verbal learning and memory tests) as well as of understanding the relationship between learning potential with explicit training and learning capacity (i.e., learning that occurs in the absence of explicit training) [18].

Another promising area that future studies should address is the possible use of learning potential to assess ability to benefit from cognitive remediation interventions. Since learning potential studies that examined more proximal outcomes than the current study had more positive results, the outcomes measured in this study may be too general and mediated by overall cognitive capacity or status. The literature is growing on cognitive remediation interventions aimed at directly improving cognitive function in schizophrenia, with the ultimate goal of improving social functioning, work function, and self-care. However, the individuals most likely to benefit from cognitive remediation and whether the modest gains in cognitive function translate into functional improvements are as yet unclear. If we hope to develop cognitive remediation programs that will provide maximum benefit, we will need to determine whether specific cognitive factors are associated with positive rehabilitation outcomes. Learning potential assessments may help us predict who is most likely to benefit from cognitive remediation, which if properly targeted and executed will hopefully lead to improved functional outcomes for those individuals.

ACKNOWLEDGMENTS

Dr. Kinnaman is now Assistant Professor in the University of Vermont Department of Psychiatry and Clinical Director of the Fletcher Allen Health Care DayOne Outpatient Substance Abuse Clinic.

This material is the result of work supported with resources of the VA Medical Research Service, Merit Review Entry Program (Wendy Tenhula, PhD), and the Veterans Integrated Service Network 5 Mental Illness Research, Education, and Clinical Center.

The authors have declared that no competing interests exist.

REFERENCES

1. Green MF, Kern RS, Braff DL, Mintz J. Neurocognitive deficits and functional outcome in schizophrenia: Are we measuring the "right stuff"? Schizophr Bull. 2000;26(1): 119–36. [PMID: 10755673]
2. Brekke J, Kay DD, Lee KS, Green MF. Biosocial pathways to functional outcome in schizophrenia. Schizophr Res. 2005;80(2–3):213–25. [PMID: 16137859]
3. Dickerson F, Boronow JJ, Ringel N, Parente F. Neurocognitive deficits and social functioning in outpatients with schizophrenia. Schizophr Res. 1996;21(2):75–83. [PMID: 8873775]
4. Dickerson F, Boronow JJ, Ringel N, Parente F. Social functioning and neurocognitive deficits in outpatients with schizophrenia: A 2-year follow-up. Schizophr Res. 1999; 37(1):13–20. [PMID: 10227104]
5. Green MF. What are the functional consequences of neurocognitive deficits in schizophrenia? Am J Psychiatry. 1996;153(3):321–30. [PMID: 8610818]
6. Lysaker PH, Bell MD, Zito WS, Bioty SM. Social skills at work. Deficits and predictors of improvement in schizophrenia. J Nerv Ment Dis. 1995;183(11):688–92. [PMID: 7595430]
7. Heaton RK, Chelune GJ, Talley JL, Kay GG, Curtiss G. Wisconsin Card Sorting Test manual: Revised and expanded. Odessa (FL): Psychological Assessment Resources; 1993.
8. Brenner HD, Hodel B, Roder V, Corrigan P. Treatment of cognitive dysfunctions and behavioral deficits in schizophrenia. Schizophr Bull. 1992;18(1):21–26. [PMID: 1553495]

9. Liberman RP, Mueser KT, Wallace CJ, Jacobs HE, Eckman T, Massel HK. Training skills in the psychiatrically disabled: Learning coping and competence. Schizophr Bull. 1986;12(4):631–47. [PMID: 3810067]
10. Morris SE, Bellack AS, Tenhula WN. Social problem solving and schizophrenia. In: D'Zurilla TJ, Chang EC, Sanna LJ, editors. Social problem solving: Theory, research, and training. Washington (DC): American Psychological Association; 2004. p. 83–98.
11. Penn DL, Van der Does AJ, Spaulding WD, Garbin CP, Linszen D, Dingemans P. Information processing and social cognitive problem solving in schizophrenia. Assessment of interrelationships and changes over time. J Nerv Ment Dis. 1993;181(1):13–20. [PMID: 8419510]
12. Lysaker P, Bell M, Beam-Goulet J. Wisconsin Card Sorting Test and work performance in schizophrenia. Psychiatry Res. 1995;56(1):45–51. [PMID: 7792341]
13. Lysaker PH, Bryson GJ, Davis LW, Bell MD. Relationship of impaired processing speed and flexibility of abstract thought to improvements in work performance over time in schizophrenia. Schizophr Res. 2005;75(2–3):211–18. [PMID: 15885512]
14. Kurtz MM, Wexler BE. Differences in performance and learning proficiency on the Wisconsin Card Sorting Test in schizophrenia: Do they reflect distinct neurocognitive subtypes with distinct functional profiles? Schizophr Res. 2006;81(2–3):167–71. [PMID: 16243489]
15. Bellack AS, Weinhardt LS, Gold JM, Gearon JS. Generalization of training effects in schizophrenia. Schizophr Res. 2001;48(2–3):255–62. [PMID: 11295378]
16. Wiedl KH. Rehab rounds: Cognitive modifiability as a measure of readiness for rehabilitation. Psychiatr Serv. 1999;50(11):1411–13,1419. [PMID: 10543848]
17. Sergi MJ, Kern RS, Mintz J, Green MF. Learning potential and the prediction of work skill acquisition in schizophrenia. Schizophr Bull. 2005;31(1):67–72. [PMID: 15888426]
18. Fiszdon JM, McClough JF, Silverstein SM, Bell MD, Jaramillo JR, Smith TE. Learning potential as a predictor of readiness for psychosocial rehabilitation in schizophrenia. Psychiatry Res. 2006;143(2–3):159–66. [PMID: 16860881]
19. Silverstein SM, Wallace CJ, Schenkel LS. The micro-module learning tests: Work-sample assessments of responsiveness to skills training. Schizophr Bull. 2005;31(1):73–83. [PMID: 15888427]
20. Woonings FM, Appelo MT, Kluiter H, Slooff CJ, Van den Bosch RJ. Learning (potential) and social functioning in schizophrenia. Schizophr Res. 2003;59(2–3):287–96. [PMID: 12414086]
21. First MB, Spitzer RL, Gibbon M, Williams JB. Structured clinical interview for axis I DSM-IV disorders. New York (NY): Biometrics Research Department, New York State Psychiatric Institute; 1994.
22. Spitzer RL, Williams JB, Gibbon M, First MB. The Structured Clinical Interview for DSM-III-R (SCID): I. History, rationale, and description. Arch Gen Psychiatry. 1992;49(8): 624–29. [PMID: 1637252]
23. Overall J, Gorham D. The Brief Psychiatric Rating Scale. Psychol Rep. 1962;10:799–812.
24. Bellack AS, Brown CH, Thomas-Lohrman S. Psychometric characteristics of role-play assessments of social skill in schizophrenia. Behav Ther. 2006;37(4):339–52. [PMID: 17071212]
25. Bellack AS, Sayers M, Mueser KT, Bennett M. Evaluation of social problem solving in schizophrenia. J Abnorm Psychol. 1994;103(2):371–78. [PMID: 8040506]
26. DeFilippis NA, Campbell E. The booklet Category Test: Professional manual. 2nd ed. Odessa (FL): Psychological Assessment Resources; 1997.
27. Green MF, Satz P, Ganzell S, Vaclav JF. Wisconsin Card Sorting Test performance in schizophrenia: Remediation of a stubborn deficit. Am J Psychiatry. 1992;149(1):62–67. [PMID: 1728187]
28. Sherrill RE Jr. Comparison of three short forms of the Category Test. J Clin Exp Neuropsychol. 1985;7(3):231–38. [PMID: 3998088]
29. Braff DL. Information processing and attentional abnormalities in the schizophrenic disorders. In: Magaro PA, editor. Cognitive bases of mental disorders. Newbury Park (CA): Sage Publications; 1990. p. 262–307.
30. Goldberg TE, Gold JM, Greenberg R, Griffin S, Schulz C, Pickar D, Kleinman JE, Weinberger DR. Contrasts between patients with affective disorders and patients with schizophrenia on a neuropsychological test battery. Am J Psychiatry. 1993;150(9):1355–62. [PMID: 8352346]
31. Klonoff H, Fibiger CH, Hutton GH. Neuropsychological patterns in chronic schizophrenia. J Nerv Ment Dis. 1970; 150(4):291–300. [PMID: 5436955]
32. Pendleton MG, Heaton RK. A comparison of the Wisconsin Card Sorting Test and the Category Test. J Clin Psychol. 1982;38(2):392–96. [PMID: 7068880]
33. Perrine K. Differential aspects of conceptual processing in the Category Test and Wisconsin Card Sorting Test. J Clin Exp Neuropsychol. 1993;15(4):461–73. [PMID: 8354701]
34. Bell MD, Bryson G. Work rehabilitation in schizophrenia: Does cognitive impairment limit improvement? Schizophr Bull. 2001;27(2):269–79. [PMID: 11354594]

Submitted for publication September 15, 2006. Accepted in revised form January 29, 2007.