A Controlled Trial of Cognitive Remediation in Schizophrenia

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Abstract

A randomized, controlled trial of a 3-month cognitive remediation program was examined for its efficacy at ameliorating deficits in social and emotion perception in 42 hospitalized patients with schizophrenia. Generalization of training effects to attention, memory, and executive functioning was also examined. The program included an eclectic mix of self-instruction, memory enhancement, inductive reasoning, and compensatory training procedures, while the control condition included participation in a leisure group that was matched to the experimental group for staff involvement time. Patient care management, including type and dose of antipsychotic medication, remained constant throughout the study period. The results indicated that the cognitive training program improved emotion perception, with some evidence of generalization to measures of executive functioning; other areas of neurocognitive functioning were largely unaffected. While cognitive training programs may improve targeted areas of neurocognitive processing, broad generalization effects to domains outside those targeted for intervention are not likely concomitants.

Keywords: Schizophrenia, cognitive remediation, psychiatric rehabilitation, attention, emotion perception, memory, executive functioning.

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Although the neurocognitive deficits of people with schizophrenia have been recognized and studied for more than a century, only recently have efforts been made to modify these deficits through training. One reason for the current interest in cognitive remediation comes from a growing body of research that supports a relationship between selected areas of neurocognition and psychosocial functioning. For example, in a study of more than 100 young people with recent onset of schizophrenia, working memory and vigilance were significant predictors of employment or school activity after 1 year of outpatient treatment (Nuechterlein et al., in press). Reviews of the research literature have documented the robust relationships among memory, vigilance, and decision making in neurocognition and community functioning, social problem solving, and skill acquisition (Green 1996; Green et al. 2000).

If neurocognitive factors can be identified that are "rate limiting" for the learning of socially relevant knowledge and skill, then it may be feasible to mount experimental studies with people having schizophrenia aimed at strengthening these neurocognitive functions, which, in turn, could promote improved (1) learning of psychosocial skills and (2) adaptation to the requirements of community life (Liberman and Green 1992; Green 1993). Thus, one might view effective modes of cognitive remediation as building a higher "platform" for the learning capacity of individuals with schizophrenia so they could benefit more fully from existing, evidence-based rehabilitation services (e.g., social skills training, supported employment) that facilitate social adjustment and quality of life (Heinssen et al. 2000).

The majority of research conducted in the United States on cognitive remediation with psychiatric patients has been limited to laboratory-based studies that target a single neurocognitive variable for intervention. For example, investigators have documented the normalization of deficits on the Wisconsin Card Sorting Test (Bellack et al. 1990; Goldman et al. 1992; Green et al. 1992; Kern et al. 1996), the Continuous Performance Test (Medalia et al. 1998), and the Span of Apprehension (Kern et al. 1995). In Europe, on the other hand, Brenner and his colleagues (1994) have taken a more clinically ambitious tack by utilizing a sequence of interventions, termed Integrated

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Psychological Therapy, for training in a hierarchy of cognitive and sociobehavioral constructs viewed as key deficits of schizophrenia disorders.

Both the American and European strategies in cognitive remediation have led to mixed results. While substantial improvements and even normalization of several neurocognitive functions have been achieved in focused laboratory studies, little generalization has been found to other neurocognitive domains that were not the focus of training, or to the wider context of psychosocial functioning. For example, remediation of deficits in cognitive flexibility and working memory has been attained, but with little generalization to other domains (Wykes et al. 1999). The broader scope of the European strategy for cognitive remediation has yielded meager, ambiguous, and indecisive results (Hermanutz and Gestrich 1987; Kraemer et al. 1987; Roder et al. 1987; Heim et al. 1989; Olbrich and Mussgay 1990; Theilemann 1993). For example, a controlled study of Integrated Psychological Therapy resulted in relatively isolated improvement in social problem-solving ability but had little or no effect on other neurocognitive or psychosocial areas (Spaulding et al. 1999).

The present project and its strategies of intervention were designed to (1) bridge the gap between American and European approaches to cognitive remediation; (2) target a neurocognitive function, social perception, that might be "rate limiting" in the learning capacity and social functioning of people with schizophrenia; (3) train in several different aspects of social perception; and (4) use repetition, memory enhancement, role-plays, and in vivo assignments to strengthen the training effects. Given the lack of evidence to support substantial links between positive psychotic symptoms and psychopathology in general on one hand, and performance on neurocognitive tasks and psychosocial functioning on the other (Corrigan and Addis 1995; Green et al. 2000), we did not expect the training program to produce changes in psychiatric symptoms. Similarly, because improvements in neurocognition require superimposed rehabilitation services or psychosocial skills training to generate superior social functioning, we did not anticipate effects on broader measures of adjustment.

Social perception was selected as the principal target for cognitive remediation because a number of investigators have found a relationship between this domain of neurocognition and various simple and complex forms of psychosocial functioning (Corrigan 1997; Mueser et al. 1997; Penn et al. 1997; Silverstein 1997). Emotion perception, for instance, requires the ability to selectively filter relevant from irrelevant stimuli in the expressions of others; in turn, emotion perception can influence the accuracy, satisfaction, and effectiveness of interpersonal relations. More complex aspects of social functioning—such as understanding context, norms, expectations, and rules of social interaction—depend, in part, on the abilities (1) to recall and use past memories of social situations, and (2) to use "on-line" processing of environmental cues. Because deficient social perception in schizophrenia appears to hamper interpersonal relations, we evaluated the effects of a multifaceted cognitive training program on social and emotion perception, and we examined generalization to measures of attention, memory, and executive functioning.

Method

Subjects. After we obtained informed consent, inpatients who had been admitted to the hospital for acute exacerbation of schizophrenia were interviewed independently by two psychiatrists who agreed on the diagnosis of schizophrenia according to *DSM–III–R* criteria (APA 1987). Patients with a history of a neurological disorder, mental retardation or other developmental disorder, or substance abuse were excluded. Level of education was rated on a seven-point scale ranging from 1 (some elementary school education) to 7 (graduated from a university). At the time of study entry, patients had been stabilized on antipsychotic medication for 2 to 3 months and were capable of participating in a 20-minute, pre–study-skills training session. Their impairments were largely characterized by functional deficits in self-care skills and social functioning. Most patients had had previous psychotic episodes requiring hospitalization; five patients were in their first episode. Six patients were being treated with clozapine, but the remaining patients were being treated with conventional antipsychotic medication. At the time of data collection, the newer atypicals were not available at the hospital. Closed envelopes with lots were used to randomly assign the patients to experimental or control groups of 21 patients each.

Three subjects dropped out of the experimental group. One patient quit training prematurely because he did not like the training exercises, and the other two patients were discharged from the hospital before study completion. The lots of these three patients were reentered into the group assignment procedure to achieve a comparable number of subjects in the two training groups.

Training Program. The cognitive training program consisted of a series of exercises that were hierarchically ordered according to increasing cognitive complexity. The program progressed from training on perception of simple, basic stimuli to training on more complex stimuli, to training on reasoning skills, and finally to training on emotion perception and apprehension of social situations. Social perception was the target skill, while attention, memory, and executive functioning were more basic skills viewed as necessary for emotion perception. The training program incorporated four strategies that were embedded within the exercises: self-instruction, memory enhancement, inductive reasoning, and compensatory training procedures.

Self-instruction. These procedures (Meichenbaum and Cameron 1973) were included in some exercises to enhance self-directed thought and behavior. During training, the instructor modeled performance on a given task, and then the subject was instructed to copy the instructor's actions while verbalizing the task aloud. The verbalizations made by the subject included statements about the demands of the task, self-guiding statements to facilitate task completion, coping statements to deal with possible task failure, and self-reinforcing statements. The aim was to improve vigilance and sustained attention, and reduce distractibility.

For instance, in session 8, the patient had to learn to instruct the trainer to make an exact copy of a geometric figure on grid paper. The patient was not allowed to show the figure but had to verbally instruct the trainer, step-by-step, in how to copy the figure. In this exercise, the patient had to develop a representational knowledge of what the other person (the trainer) was doing at each step. The trainer initially modeled how to perform these tasks. The following is a verbatim excerpt from this segment of the training procedure:

> We both have a piece of paper with a 6 × 6 grid on it. On my grid there is also a figure. I want you to copy this figure on your grid. I will not show you the figure but will tell you step-by-step how to copy it. You will have to listen carefully and follow the instructions. I will keep track of the steps. I also will give precise instructions like "Go straight down two lines" and not simply say, "Just go down." Are you still with me? . . . Can you repeat to me what the task is about? . . . My figure has four lines. To help me keep track of your progress, I will talk about the first line, the second, and so on. Making mistakes is inevitable in the beginning. Every mistake is an opportunity to learn. With a little practice you will succeed. Do you have any questions? . . . I will say aloud every thought I have and when we change roles with the next grid I want you to do the same. Do you have any questions? . . . Good, let's start.

Memory enhancement. These procedures included techniques that have been used in previous studies of memory training, such as rehearsal, categorization and chunking, visualization, and selected mnemonic aids. The aim of this strategy was to facilitate active mnemonic strategies. For instance, in session 1, the subject was asked to memorize a number of objects on the table. Then the subject was asked to close his or her eyes, and one object was taken away. The other objects were rearranged, and the subject was asked which object had been removed. Any subject unable to identify the missing object was asked to name the objects aloud. When this was not sufficient, the subject was asked to categorize the objects into classes and to rehearse aloud—for example, three iron objects, one red object, and three small objects.

Inductive reasoning. Training in emotion perception (Brenner et al. 1980) was based primarily on principles of inductive reasoning and was carried out over a series of perceptual processing stages. Training began with more basic processes that required the subject to identify and describe sensory information, then proceeded hierarchically over a series of more complex processing stages that concluded with training exercises on the processing of interpersonal relationships as well as the thoughts and motives of others. The aim was to increase the processing of meaningful social stimuli and to prevent the drawing of premature conclusions based on processing of partial information.

Compensatory strategies. Procedures for training in emotion recognition were based largely on the work of Ekman and Friesen (1975) and consisted of instructing patients on how to identify emotions in the facial expressions of others. For instance, anxiety is the only emotion in which the white of the eye above the iris appears. Anxiety and anger are difficult to tell apart, but this single distinction can do the job. Conscious inspection of this feature can compensate for a failing preconscious Gestalt perception. Subjects were provided information about various types of facial expressions and the physical mannerisms that typically accompany them. In addition, subjects practiced making different facial expressions that depicted certain emotions (e.g., happiness) and practiced displaying these different emotions through role-play exercises. The aim was to facilitate active processing of facial movements involved in emotion perception.

The cognitive retraining program was conducted in 45 exercises over a total of 22 sessions. Each patient was trained individually in 20-minute sessions held two times per week over approximately 3 months. Between-session homework assignments were given so that subjects could practice the training exercises outside of the laboratory setting. Training began with two sessions on visual perception, two on tactile perception, and two on auditory perception. The next ten sessions focused on perceptual processing, working memory load, and integration of different sensory modalities. Social perception training was introduced at this point, with an early emphasis on elementary listening skills. Emotion recognition was covered in the last six training sessions, each session focusing on a different emotion. The training procedures for each session were described in an instruction manual (see table 1).

Subjects in both the experimental and the control groups were maintained on their initial type and dose of antipsychotic medication throughout the study. Both experimental and control groups received identical treatment regimens on the unit, with the exception of the cognitive training program for the experimental group. To equate both groups on the amount of time devoted to training, the control group was engaged in leisure activities for the same amount of time that the experimental group spent in training sessions. The two instructors that were involved in training the experimental group also participated in the leisure activities with the control group. To control for the amount of interpersonal contact in the leisure activities, the instructors limited their conversation with subjects to brief remarks. The types of leisure activities for the control group typically included playing board games and other similar activities. Both instructors were trained for 8 hours by the first author before beginning the study and had previously established skills in behavior management. A session-by-session training manual can be obtained from the first author.

Dependent Variables. A brief neuropsychological battery was administered to the experimental and control groups immediately before and after the training period. The mean interval between test administrations was 3.5 months (range = 3–4.5 months). The test battery included measures from four neurocognitive domains: perception, attention, memory, and executive functioning. The effect of training on perception was the primary focus, and the effects on the other areas of neurocognitive functioning were examined for generalization effects.

Perception. Two tests were used to assess perceptual processing abilities.

(1) Emotion Matching Test (van der Gaag and Haenen 1990). This test, which was developed for this study, measures emotion perception. The Cronbach alpha was 0.79 (n = 42). The test included 60 pairs of photographs, each depicting one of six emotions. The subject was instructed to indicate whether the emotions were the same or different. The dependent measure was the total number correct.

(2) Emotion Labeling Test (van der Gaag and Haenen 1990). This test, which was developed for this study, assesses the ability to verbally label an emotional expression. The Cronbach alpha was 0.78 (n = 42). Twenty-four still photographs of faces depicting one of six emotional expressions were presented to the subject. The subject was instructed to identify which of the six emotions best fit the emotion depicted in the photograph. The dependent measure was the total number correct.

Attention. Four tests were used to assess attention.

(1) A computerized (3–7) Continuous Performance Test (CPT; Rosvold et al. 1956). This test was used to measure visual vigilance and was developed in accor-

Table 1. Overview of target cognitive functions trained in the 22-session cognitive retraining program

Session	Target function	Exercises
1–2	Visual perception	Describing colors, objects, and body postures as well as memorizing.
3–4	Tactile perception	Describing objects' qualities, such as hard, soft, warm, cold, flexible, light, ticklish, humid, etc.; arranging objects (e.g., from smooth to rough).
5–6	Auditory perception	Identifying everyday sounds from a tape and musical instruments in orchestral music.
7–9	Compound visual perception	Writing in the air and reading; copying figures by verbal instruction; finding the seven differences in two "identical" pictures; describing and interpreting photographs with social scenes.
10–12	Tactile perception and proprioception	Making mirror movements; describing and copying expressive body postures.
13–16	Language perception, verbal dialogues, and emotion expression	Reading aloud and rehearsing sentences with emotional content; constructing sentences and questions with target words in them; retelling short stories; practicing expressions of emotion.
17–22	Recognition and expression of basic emotions: anger, sadness, surprise, fear, happiness, and disgust	Doing four exercises in each session: performing facial gymnastics in which all facial muscles are strained and relaxed; describing a portrait photograph displaying an emotion; learning the discrete features of the expression; and role-playing a recent experience with the target emotion.

dance with specifications described by Nuechterlein and colleagues (1986). The dependent measure was a sensitivity index d'.

(2) A computerized forced-choice Span of Apprehension task (SPAN; Estes and Taylor 1964). This test was used to measure early visual processing and iconic readout and emphasizes visual scanning abilities. This measure was designed according to specifications described by Nuechterlein and colleagues (1986) and Asarnow and MacCrimmon (1978, 1981). The dependent measure was the proportion correct for the ten-letter array.

(3) Trail Making A and B (Halstead 1947). This test was used to measure cognitive flexibility. The dependent measure was time to completion (in seconds).

(4) Stroop Color-Word Test (Stroop 1935). This test was used to measure cognitive interference on a divided attention task. The dependent measure was an interference score—time to complete card 3 (color interference) minus time to complete card 2 (color name reading).

Memory. Four measures from three tests were used to assess memory functioning.

(1) Rey Auditory Verbal Learning Test (RAVLT; Rey 1964). This test is a measure of secondary memory. The dependent measures of interest were a learning score (total number of items recalled over the five learning trials) and a retention score (number correct on trial 5 minus number correct on delayed recall).

(2) Rey-Osterreith Complex Figure Test—immediate recall (Rey 1964). This test is a measure of nonverbal visuoconstructive memory. The dependent measure was a retention score derived by subtracting the total score for the recall administration from the total score for the direct copy.

(3) Wechsler Adult Intelligence Scale (WAIS), Digit Symbol Substitution Test (Wechsler 1958). This is a rapid problem-solving test sensitive to impairments in working memory. The dependent measure was the total number correct.

Executive functioning. Executive functioning was assessed using four measures from three tests.

(1) Wechsler Intelligence Scale for Children, Mazes (de Bruyn et al. 1986). This is a measure of planning ability. We selected five mazes from the total number used in the full administration. Two outcome scores were selected as dependent measures: total time to complete all five mazes and total number of errors.

(2) Word Fluency (Luteijn and Ploeg 1983). This is a measure of the ability to generate categorically related items. The dependent measure was the total number of items generated for two semantic categories (animal names, professions) over 2 minutes (1 minute per category).

(3) WAIS Picture Arrangement (Wechsler 1958). This is a test of social understanding that requires the subject to arrange a series of pictures in their logical sequential order. The dependent measure was the total number correct.

Results

Initially, the two groups were compared on demographic and clinical variables. As presented in table 2, the two groups were comparable in age, level of education, gender ratio, duration of illness, and antipsychotic medication dose (in haloperidol equivalents).

Some measures from the neurocognitive data yielded skewed score distributions; therefore, a log10 transformation was conducted to normalize the distributions. Between-group contrasts were then performed to see if there were any differences in neurocognitive functioning at baseline. The two groups did not differ on any of the neurocognitive measures at baseline.

The data were analyzed using a one-way multiple analysis of covariance (MANCOVA) for each of the domains of neurocognitive functioning (i.e., perception, attention, memory, executive functioning). Baseline neu-

Table 2. Demographic, chronicity, and clinical measures for the experimental and control groups: means, standard deviations, and 95% confidence intervals

	Experimental Group (n = 21)			Control Group (n = 21)		
	Mean	SD	CI	Mean	SD	CI
Age (yrs.)	30.4	8.1	26.7–34.1	31.7	7.9	28.0–35.4
Education (range 1–7)	4.3	1.7	3.5–5.1	4.7	1.5	4.0–5.4
Duration of illness (yrs.)	9.9	5.8	7.3–12.6	9.6	8.1	5.8–13.3
Neuroleptic dose (haloperidol equivalents)	13.3	12.2	7.7–18.8	11.8	8.0	8.2–15.5
Gender ratio (male:female)	13:8			14:7		

Note.—CI = confidence interval; SD = standard deviation.

rocognitive scores were entered as covariates. The independent variable was group assignment (experimental vs. control), and the dependent variables were the multiple measures selected to assess each of the respective neurocognitive domains.

The results indicated a beneficial effect of training on measures of perception, but the gains did not generalize to improvements in attention, memory, or executive functioning, although there is a trend in memory (see table 3). Followup contrasts between groups on the measures of perception revealed that the experimental group improved significantly more than the control group on both the Emotion Matching and Emotion Labeling Tests of facial emotion.

The baseline and posttraining performance scores of the training and control groups are displayed in table 4 along with the tests for the between-group contrasts on each measure and within-group paired *t* tests. Medium effects of about 1 standard deviation (SD) can be detected with the current number of subjects per group. Small effect sizes of about 0.25 to 0.5 SD go undetected. To explore the smaller effects, we included paired *t* tests to detect within-group changes. With these additional, primarily exploratory, analyses, we found no evidence for generalized effects in attention: CPT and SPAN showed no effects, Trails A improved in the controls, Trails B improved in the training group, and the Stroop improved in both groups. For memory, both groups improved in RAVLT learning and Rey Complex Figure retention scores. The differential effects were small, however, and do not justify the conclusion that training had a substantial effect on memory. For executive functioning, some evidence can be found to support generalization effects. Performance on the Mazes test time score, Word Fluency, and Picture Arrangement all improved in the training group but not in the control group.

Discussion

In this study, we examined the efficacy of a 3-month training program aimed at remediating neurocognitive deficits in social and emotion perception. The results showed that training was effective, resulting in a 23 percent reduction of errors in emotion matching and a 49 percent reduction of errors in emotion labeling from baseline levels of performance. These improvements approximate the performance levels of normals, who, on average, make 35 percent to 55 percent fewer errors than people with schizophrenia do. When we examined generalization effects, we found some support for improvement on measures of executive functioning but not on other domains included in this study. It is important to emphasize that social and emotion perception were the primary targets for intervention and that training procedures were developed principally for remediation of those deficits and not other neurocognitive processes. Hence, any benefits to other neurocognitive processes were through the indirect effects of training on perception. This may explain why we failed to attain stronger effects on attention, memory, and executive functioning.

Table 3. Multivariate tests over the posttreatment data with the baseline data as covariates

Cognitive domain	F	*df*	*p*
Perception	4.40	2,37	< 0.05
Attention	1.08	5,31	*ns*
Memory	2.63	4,33	< 0.10
Executive functioning	1.40	4,33	*ns*

Note.—ns = nonsignificant.

The approach of this study emphasized the use of self-instruction, memory enhancement, inductive reasoning, and compensatory strategies for improving function—methods that have been found successful for improving other areas of functioning in this population (Kern et al. 1996). As these procedures were not pitted against one another, we cannot say which one accounted for the greatest variance in determining outcome. Future studies may wish to compare these training interventions directly to find out which is superior. At this time, we can only speculate as to which of these interventions played the most critical role in determining posttraining outcome.

Early visual processing may be important to emotion recognition (Kee et al. 1998), and to some extent our training procedures for improving emotion perception began by targeting relatively early stages of visual processes. Vigilance, memory, and to some extent executive functions have also been found to be related to emotion recognition (Bryson et al. 1997), and our study included procedures to account for these processing difficulties as well. It is also possible that certain nonplanned, idiosyncratic aspects of training (e.g., the role-playing of autobiographical incidents) may have directly affected performance outcome on the emotion perception measures. The effects may also have been partially due to our assessment methods. There was some overlap between the outcome measures used to assess emotion perception and the materials used during training. The photographs in the emotion matching and labeling tests and the six photographs in the training sequence were from the same photo series that was published by Ekman and Friesen (1975). Although the training photographs were not in the tests, the photographs used some of the same people.

Historically, neuropsychologists have focused on impairments as targets of treatment, typically inferring improvement in psychosocial functioning when improvement in neuropsychological test scores is shown, even

Table 4. Raw data of baseline and posttreatment results; the confidence interval of the multivariate contrast over the posttreatment data with the baseline data as covariates and paired *t* test

	Group	Baseline		Posttreatment		CI, between groups	Paired *t* test, within groups
		Mean	SD	Mean	SD		
Perception							
Emotion Matching Test	Training	45.3	6.3	48.7	5.2	–5.6, –0.1*	3.66**
	Control	44.4	6.2	45.3	6.1		0.74
Emotion Labeling Test[1]	Training	18.0	4.9	21.0	3.4	–0.4, –0.1*	3.55**
	Control	18.8	3.3	19.6	3.8		1.67
Attention							
Continuous Performance Test	Training	2.7	1.1	2.86	1.2	–0.4, 0.5	1.06
	Control	3.1	1.0	3.1	1.1		0.02
Span of Apprehension ten-letter array	Training	0.67	0.15	0.72	0.10	–0.1, 0.1	1.64
	Control	0.67	0.13	0.68	0.11		0.24
Trail making A	Training	49.7	27.6	40.8	14.1	–7.4, 7.5	–1.87
	Control	47.1	17.5	40.0	14.3		–2.12 *
Trail making B[1]	Training	143.4	77.0	102.9	58.0	–0.2, 0.1	–3.37 **
	Control	133.6	100.6	121.0	110.2		–1.05
Stroop interference test[1]	Training	73.8	51.8	59.4	37.6	–0.1, 0.1	–2.74*
	Control	68.1	52.7	49.8	27.5		–3.15 **
Memory							
RAVLT retention score	Training	1.1	1.6	0.7	1.7	–1.5, 1.1	–0.70
	Control	1.1	2.9	1.2	2.5		–0.88
RAVLT learning score	Training	36.8	14.8	45.3	12.5	1.6, 9.5*	4.73***
	Control	33.5	11.9	38.7	11.4		3.14**
Rey Complex Figure Test	Training	17.3	6.5	12.0	7.1	–6.9, 0.8	–3.83***
	Control	18.5	6.0	15.4	7.8		–2.31*
WAIS Digit Symbol Substitution Test	Training	36.1	10.0	39.1	12.2	–7.5, 5.5	1.94
	Control	38.1	10.2	42.8	16.3		1.85
Executive functions							
Mazes time score[1]	Training	92.2	46.6	71.0	27.8	–0.2, 0.1	–2.73*
	Control	90.5	59.6	105.1	131.8		0.64
Mazes error score[1]	Training	2.5	2.6	1.9	1.4	–0.3, 0.1	0.58
	Control	2.4	2.4	4.0	4.9		–1.69
Word Fluency	Training	26.3	8.5	28.8	8.6	–1.4, 5.1	2.22*
	Control	27.9	8.8	28.4	9.2		0.34
WAIS Picture Arrangement	Training	9.9	5.1	12.4	4.8	–0.5, 4.0	3.33**
	Control	11.1	4.3	11.5	4.5		0.44

Note.—CI = confidence interval; RAVLT = Rey Auditory Verbal Learning Test; WAIS = Wechsler Adult Intelligence Scale.

[1] A log10 transformation normalized the skewed distribution before testing.

* $p < 0.05$; ** $p < 0.005$; *** $p < 0.001$

though there is little evidence for such a relationship (Wilson 1991). More recently, however, certain investigators have proposed a key conceptual switch—namely, that rehabilitative efforts need to move away from attempts at remediating neurocognitive impairments (i.e., improving test scores) and toward developing strategies to ameliorate disabilities associated with neurocognitive impairment (Wilson 1997) or teaching individuals to cope with their disabilities (Bellack et al. 1999). Such changes have led to the proposed use and development of compensatory strategies to help neurocognitively impaired individuals function more independently.

The findings from the present study should be interpreted with an awareness of some of the more salient methodological limitations. The sample size was modest, providing enough power to detect medium to large effect sizes but possibly not enough power to detect small group differences in performance. For this reason, we included within-subject *t* tests in the analyses to allow a more explorative examination of the data. The findings from the present study lend some modest support for generalization to executive functioning, but we cannot rule out the possibility that generalization effects are due to type I error.

A second concern is the relatively short duration of training. Training took place in a total of approximately 8 hours of instruction (two 20-minute sessions each week over 3 months) plus another 8 hours of homework assignments. It is possible that stronger generalization effects would have emerged had training been intensified and some bridging mechanisms inserted into the training exercises to facilitate generalization. Just as in psychotherapy, we assumed that patients would get involved in the treatment process, and to some extent they did (e.g., nursing reports indicated that a few patients repeatedly practiced their homework assignments on the ward).

A third concern is the lack of data on symptoms. At the time we were developing the study we favored a more comprehensive cognitive assessment, primarily because our hypotheses were tied to changes in social perception, with generalized effects to other neurocognitive domains. Because past studies have shown little relationship between psychotic symptoms and neurocognitive functioning, we did not expect remediation training to be affected to a significant degree by changes in symptoms. However, because we did not include symptom measures in the study, we cannot make any claims about the relative independence of training effects apart from improvements in symptoms.

Another limitation of the present study is related to the potential influence of the instructors on outcome. One of the instructors was employed by the first author, and both instructors acknowledged their belief that the experimental procedures were more effective than participation in leisure activities. However, it should be noted that no data were collected by these instructors, and in addition, the outcome measures of interest were objective ones. Nevertheless, we cannot rule out the possibility that the instructors inadvertently influenced performance outcome by virtue of their enthusiasm for one approach rather than the other.

Cognitive deficits are difficult to remediate, but they appear to have prognostic value. The functional outcome of individuals with schizophrenia has always been difficult to predict on the basis of clinical symptoms. On the other hand, more recent evidence has indicated that neurocognitive performance may be a particularly strong predictor of functional outcome in such areas as community functioning, social problem-solving ability, and psychosocial skill acquisition (Green 1996; Green et al. 2000). Lysaker et al. (1993) reported that patients with executive deficits attained poorer vocational outcome. Wykes (1994) found that successful versus unsuccessful community outcome was best predicted by selected neurocognitive deficits. So improving cognitive function in schizophrenia is of major importance in improving outcome in these patients.

If research in cognitive remediation is to flourish, investigators will need to agree on a model of cognitive rehabilitation, develop empirically tested and theoretically based interventions, and integrate these methods with the ongoing advances in psychopharmacology that have revealed some promise in this regard. Finally, the litmus test for cognitive rehabilitation will be when interventions, born in the laboratory, can be shown to reliably impact the social and occupational functioning, and quality of life, of people with schizophrenia.

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