Published in final edited form as:
Am J Psychiatr Rehabil. 2008 April ; 11(2): 144–163. doi:10.1080/15487760801963678.

Development and Pilot Testing of a Novel Compensatory Cognitive Training Intervention for People with Psychosis

Elizabeth W. Twamley[1], **Gauri N. Savla**[1], **Cynthia H. Zurhellen**[1], **Robert K. Heaton**[1], and **Dilip V. Jeste**[1,2]

1*University of California, San Diego*

2*VA San Diego Healthcare System*

Abstract

The cognitive deficits of schizophrenia have a profound impact on everyday functioning and level of community integration for affected individuals. Cognitive training (CT) interventions may help improve these impairments. We developed and pilot tested a 12-week, group based CT intervention that focused on compensatory strategies and habit learning. Participants were randomly assigned to CT plus standard pharmacotherapy or standard pharmacotherapy (SP) alone and were assessed at baseline, three months (i.e., post-intervention), and at six months. Effect sizes were calculated comparing change in the CT group with change in the SP group. CT had medium to large positive effects on attention, learning, memory, executive functioning, functional capacity, negative symptoms, and subjective quality of life. Most effects became stronger at follow-up, but the effect on negative symptoms was not maintained. Immediately post-treatment, compared with SP subjects, CT participants reported fewer cognitive problems and greater use of cognitive strategies; many of these effects were maintained, but were generally weaker, at six-month follow-up. The initial effect sizes for this compensatory CT intervention suggest that it holds promise for improving cognitive performance, functional capacity, negative symptoms, and quality of life. It is proposed that CT emphasizing habit learning may result in long term changes in ability to function independently in the community.

There is little doubt regarding the importance of cognitive impairment in psychotic disorders such as schizophrenia. The disease has previously been conceptualized as a psychiatric disorder with concomitant cognitive deficits, but is now being recognized as a neurodevelopmental, biobehavioral cognitive disorder that causes psychiatric symptoms (Gur et al., 1997; Heaton et al., 2001; Heinrichs, 2005; Kurtz, 2005). The increasing awareness of the association between cognition and everyday functioning in psychosis (Bellack et al., 1994; Bellack et al., 1999; Green, 1996; Green & Nuechterlein, 1999; McGurk & Meltzer, 2000; Twamley et al., 2002) has resulted in growing interest in treatments to improve cognition (Marder & Fenton, 2004). Thus far, the success of pharmacologic agents in improving cognition has been limited, leading many researchers and clinicians to focus on cognitive training (CT) as a means for improving cognitive functioning.

Studies of cognition in schizophrenia have identified neuropsychological deficits in almost every domain, including preattentive abilities, attention, working memory, learning, memory, conceptualization, organization, planning, self-monitoring, and flexibility of thinking (Heaton et al., 2001, Saykin et al., 1991). The meta-analysis of Green and colleagues (2000) found that

Corresponding Author: Elizabeth W. Twamley, PhD, Department of Psychiatry, University of California, San Diego, 140 Arbor Drive, San Diego, CA 92103, Tel: 619-497-6684, Fax: 619-497-6686, email: etwamley@ucsd.edu.

verbal learning and memory, immediate verbal memory, vigilance (i.e., sustained attention), and executive functioning were especially important predictors of functional outcomes.

Can the cognitive impairments of psychosis be improved by training? CT has been used for many years in the field of acquired brain injury (Cope, 1995; Goldstein, 1942; NIH Consensus Conference, 1999; Wilson, 2002), so it makes sense that similar techniques could be applied to the brain disorder of schizophrenia. The traumatic brain injury literature uses three classifications for CT approaches – compensatory, restorative, and environmental – and these have been applied to CT for schizophrenia as well (see Bellack et al., 1999; Spaulding et al., 1998; Twamley et al., 2003). The compensatory approach aims to teach strategies that allow clients to work around their cognitive deficits; restorative approaches aim to correct the deficits; and environmental approaches aim to modify the environment to reduce cognitive demands. Each approach has its pros and cons. Compensatory strategies can become lifelong habits to help a person bypass his/her deficits, but the strategies must be initiated in the real world when they are needed, and this does not always happen. The restorative approach may result in improvements in cerebral functioning, but the extent to which these changes are possible and lasting is not known. No studies have shown that the cognitive impairments of schizophrenia can be eliminated by any available treatment, although some studies have shown normalization and even superior performance on trained tasks (Fiszdon, Cardenas, Bryson, & Bell, 2005). Environmental approaches appear to have very large effects (e.g., Velligan, et al., 2000), but therapist involvement is extensive and may require long-term follow-up by the therapist (although the environmental modifications may be maintainable by relatives, case managers, or supervisors).

Both the goals of CT and the types of outcomes measured have changed in the last decade. Research on CT for schizophrenia initially examined effects of treatment on cognitive tests only (e.g., the Wisconsin Card Sorting Test; see review by Kurtz et al., 2001), but it is now moving in the direction of seeking effects on broader outcomes, such as symptoms, community and social functioning, and quality of life (Twamley et al., 2003). It is now generally agreed that improving cognition is not enough; the improvements in cognition must be shown to generalize to these more distal outcomes for an intervention to be considered effective. Particularly ambitious are the CT interventions geared toward improving functional outcomes such as employment (Bell et al., 2001, 2003; Fiszdon et al., 2004; McGurk et al., 2005; Vauth et al., 2005).

Our CT intervention focuses on compensatory strategies with some consumer-driven environmental modifications, with the goal of making these strategies and modifications habits in the real world. Habit learning, which relies on neostriatal pathways and does not require declarative memory systems (Bayley et al., 2005; Knowlton et al., 1996), has been shown to be intact in people with schizophrenia (Clare et al., 1993; Keri et al., 2005). Furthermore, habits are particularly resistant to forgetting (Bayley et al., 2005). Our goal was to capitalize on the strength of habit learning in schizophrenia to help clients form new habits in thinking, learning, and problem-solving as a potential route to improving everyday functioning and, ultimately, quality of life. Some of the strategies we teach are cognitively-mediated skills that many people with psychotic disorders never developed when they were younger (e.g., using a calendar). Thus, our goal was to make these skills habitual in order to increase autonomy and mastery. There is a Chinese proverb that says, “Give a man a fish and you feed him for a day. Teach a man to fish and you feed him for a lifetime.” Analogous to this idea in the CT intervention was the belief that consumers could decrease their reliance on others (e.g., the family member who calls to remind the person of every doctor’s appointment) and increase their independence (e.g., by remembering to check the calendar every day for appointments or other events).

Our intervention focuses on four cognitive domains, in the following order: Prospective Memory (i.e., remembering to remember); Attention and Vigilance; Learning and Memory; and Executive Functioning (problem solving and cognitive flexibility). These domains were selected based on their documented impairment in schizophrenia (Braff et al., 1991; Elvevag et al., 2003; Gold et al., 1992; Gold et al., 2000; Goldberg et al., 1990; Heaton et al., 1994; Kondel, 2002; Nuechterlein et al., 2004; Paulsen et al., 1995; Saykin et al., 1991; Shum et al., 2004; Woods et al., 2007), their relevance for everyday functioning (Butters et al., 1998; Green et al., 2000), and their potential modifiability. Stakeholders from various groups (e.g., consumers, caregivers, treating clinicians, and experts in cognitive training for schizophrenia and brain injury) provided input regarding cognitive problems experienced in everyday life and provided feedback during the development of the CT manual. For example, clients wanted assistance with remembering people's names, so a section on name learning was developed. Table 1 presents examples of the everyday importance of each of the four domains and lists strategies and habits addressed in CT.

The CT Intervention

The CT intervention emphasizes teaching and practicing compensatory and environmental strategies. The compensatory strategies trained are both internal (e.g., learning and remembering information by using acronyms or visual imagery) and external (e.g., learning and remembering information by writing it down in a place where it will be seen). Our CT intervention is a 12 week, 2 hour per week, manualized group treatment. A short break divides each session to reduce fatigue. The CT intervention was designed to be practical, portable, low-tech, and engaging to clients. It is presented in an interactive, game-like format as much as possible to maintain interest and attention. Homework assignments are designed to encourage additional practice outside treatment sessions and generalization of strategies to the home environment, but are not so complex as to be overwhelming to the subjects. The goal of CT classes and homework assignments was to help clients develop new habits that would help them with real-world cognitive functioning. CT was delivered in the clinic in a group format, and all sessions were facilitated by two co-facilitators with groups of 4-6 participants.

In this article, we present an initial examination of the effect sizes from this ongoing trial. The small sample size and the interim nature of the data precluded presentation of inferential statistics.

Method

Participants

Our randomized controlled trial compared CT plus standard pharmacotherapy with standard pharmacotherapy alone. Thirty-eight participants completed a baseline assessment and at least one follow-up evaluation. Four participants dropped out after their baseline assessment but before randomization, 3 dropped out of the SP group, and 11 dropped out of the CT group. Of the CT drop-outs, 7 dropped out after randomization but before the group started, and four attended one or two CT sessions but did not return. One found the group setting too anxiety-provoking, one felt he had no cognitive problems, one relapsed on alcohol and stopped coming to the clinic entirely, and one discontinued his antipsychotic medication and had a symptom exacerbation. The 18 drop-outs did not differ statistically from the 38 completers on age, gender, ethnicity, diagnosis, duration of illness, antipsychotic dose, positive and negative symptom severity, or premorbid IQ, but drop-outs had significantly fewer years of formal education (11.9) than did completers (13.2; t=2.73, df=54, p=.009).

The 38 participants were diagnosed with schizophrenia (47.4%), schizoaffective disorder (47.4%), or another primary psychotic disorder (psychosis NOS or depression with psychotic

features, 5.2%). Most were male (65.8%) and Caucasian (65.8%); the mean age was 48, and the education level was 13. The participants were chronically ill (mean duration of illness was 25 years), and most were taking atypical antipsychotic medications only (76.3%), while 7.9% were taking both atypical and typical antipsychotic medications, 7.9% were taking typicals only, and 7.9% took no antipsychotic medication. A substantial proportion of the participants were members of ethnic minority groups (13.2% Black; 13.2% Latino/Hispanic; 5.3% Asian; 2.6% mixed/other). Fourteen participants were randomly assigned to CT, and 24 participants were assigned to SP. The CT and SP groups did not differ significantly at baseline on age, education, gender, diagnosis, illness duration, antipsychotic dose, symptom severity, or premorbid IQ; however, Caucasians were overrepresented in the CT group and underrepresented in the SP group (see Table 2).

Measures

The American National Adult Reading Test (ANART; Grober & Sliwinski, 1991) was administered at baseline as an estimate of premorbid IQ. All other measures were administered at baseline (0 months), immediately following CT (3 months), and three months following the end of treatment (6 months). Participants were administered neuropsychological tests in the following cognitive domains targeted by the CT intervention:

1. Prospective Memory (Memory for Intentions Screening Test [MIST; Raskin, unpublished]);
2. Attention (Digit Span Forward from the Wechsler Adult Intelligence Scale-Third Edition [WAIS-III; Wechsler, 1997]);
3. Verbal Learning (Hopkins Verbal Learning Test-Revised [HVLT-R; Benedict et al., 1998] initial total recall);
4. Verbal Memory (HVLT-R [Benedict et al., 1998] percent retained); and
5. Executive Functioning (Wisconsin Card Sorting Test-64 card version [WCST-64; Kongs et al., 2000]).

Participants were also administered neuropsychological tests in the following domains, which were not targeted in the CT intervention:

1. Processing Speed (Digit Symbol subtest of the WAIS-III; Wechsler, 1997);
2. Working Memory (Letter Number Sequencing subtest of the WAIS-III; Wechsler, 1997);
3. Language (Category Fluency [Benton & Hamsher, 1989]);
4. Visual Learning (Brief Visuospatial Memory Test-Revised [BVMT-R; Benedict, 1997] initial total recall); and
5. Visual Memory (BVMT-R [Benedict, 1997] percent retained).

Participants were also administered the University of California, San Diego Performance-Based Skills Assessment (UPSA; Patterson et al., 2001), a performance-based measure that uses role-play scenarios to evaluate everyday functioning in five areas: Household Chores, Communication, Finance, Transportation, and Planning Recreational Activities. This measure predicts distal functional outcomes, such as level of independence in living situation (Mausbach et al., 2007; Twamley et al., 2002). The Positive and Negative Syndrome Scale (PANSS; Kay et al., 1987) assessed severity of positive and negative symptoms. The Quality of Life Interview (QOLI; Lehman, 1988) was administered to measure subjective quality of life. Participants also completed the Cognitive Problems and Strategies Assessment, an unpublished self-report measure of perceived cognitive difficulties and use of cognitive

strategies. At the post-treatment assessment, a standardized questionnaire was used to elicit participant ratings of satisfaction with the CT intervention. Examiners were trained to a high level of interrater reliability (ICC > .90) and were blind to group assignment.

Analyses

Below, we present data on participant ratings of satisfaction with CT. We also calculated Cohen's *d* effect sizes (Cohen, 1988) to provide preliminary estimates of the magnitude of effects in this ongoing trial. All effect sizes reported below compare the CT and SP participants on 0-3 month change scores and 0-6 month change scores. Positive effect sizes indicate positive effects of CT compared to SP. Below, we discuss only those effects in the medium range or above (i.e., ≥.50; Cohen, 1988). Finally, we examined the percentage of participants who were initially impaired in the targeted cognitive domains and in functional capacity who improved to normal levels (i.e., within one standard deviation of the mean for healthy individuals) following CT.

Results

Initial analyses regarding satisfaction with the CT intervention show that it was well-received by those who participated. CT completers (n=14) attended 81.3% of the sessions and rated the intervention highly in terms of overall satisfaction (8.8 on a 1-10 scale), quality of instruction (9.5), likelihood of recommending the class to others (9.0), and feeling personally helped by the class as a whole (8.4) and within the four modules (8.8 for Prospective Memory and Executive Functioning, 8.6 for Attention and Vigilance, and 8.1 for Learning and Memory).

Effects of CT on Targeted Cognitive Domains

When examining the effects of the CT intervention on the targeted cognitive domains at 3 months, CT showed a medium effect only on verbal memory (HVLT-R percent retained; see Table 3). This effect was not maintained at 6 months, but new improvements were noted at 6 months among CT participants on several of the targeted domains. There was a medium effect of CT on verbal learning (HVLT-R recall total) and executive functioning (WCST-64 total correct). A large effect size was noted for attention (Digit Span forward). Of the CT participants who were impaired at baseline on any of these domains, 50% or greater improved their performance to normal levels within the domains of attention, verbal learning, verbal memory, and executive functioning.

Effects of CT on Non-targeted Cognitive Domains

Among the non-targeted cognitive domains, CT showed a large effect on visual memory (BVMT-R percent retained), but this effect was not maintained at the 6 month follow-up evaluation (see Table 3).

Effects of CT on Functional Capacity

The effect of CT on the measure of functional capacity (UPSA total and subscales) was variable. CT had moderate effects on the UPSA total, as well as the Household Chores subscale, both of which increased to a large effect at 6 months. A medium effect of CT on the Communication subscale emerged at 6 months (see Table 3). At least 50% of CT participants who were impaired on the UPSA subscales at baseline improved to normal levels following CT on UPSA Communication, Finance, Transportation, and Planning Recreational Activities.

Effects of CT on Positive and Negative Symptom Severity and Quality of Life

There was no effect of CT on positive symptoms, but CT had a large effect on negative symptoms at 3 months, which was not maintained at 6 months. The medium effect of CT on subjective quality of life at 3 months became a large effect at 6 months (see Table 3).

Effects of CT on Self-Reported Cognitive Problems and Strategy Use

At 3 months, CT had medium effects on self-reported difficulties with general cognitive functioning (see Table 3), including memory (*d*=.51), learning (*d*=.60), and a large effect on perseveration (*d*=.92). At 6 months, the effects on perseveration (*d*=.59) and learning (*d*=.82) were maintained, and a medium effect on self-reported memory retrieval problems emerged (*d*=.55). CT had multiple positive effects on participants' self-reported use of strategies to compensate for cognitive difficulties (see Table 3). Specifically, at the 3-month evaluation, CT showed medium effects on several strategies, including writing things down (*d*=.71), using mental imagery (*d*=.69), categorization (*d*=.50), paraphrasing (*d*=.52), hypothesis testing (*d*=.59), and set switching (*d*=.65). There were large effects on additional strategies, including using a calendar (*d*=1.59), making lists (*d*=1.01), overlearning (*d*=.94), making eye contact (*d*=.97), asking questions (*d*=.1.06), using a daily schedule (*d*=1.14), and keeping things in the same place so they will be found later ("a place for everything, and everything in its place"; *d*=.87). Large effects were maintained at 6 months on calendar use (*d*=1.19), making eye contact (*d*=.85), creating a place for everything (*d*=.87), and set switching (*d*=.90). Additionally, medium effects were maintained for using mental imagery (*d*=.55), asking questions (*d*=.76), brainstorming (*d*=.62), and self-monitoring (*d*=.62). A medium effect also emerged at 6 months for using a problem-solving method (*d*=.50).

The following quotes from clients help illustrate how they applied the CT strategies in their daily lives:

- "My calendar helps me to mark off my morning pills – I can check to see that I took them."
- "[The calendar] gives me peace of mind. I make notes to myself about ordering prescriptions and household duties."
- "I went from not checking my sugars daily (maybe every other day or I would skip a few days) to checking every day or twice a day. I write my sugar levels down in my calendar."
- "Paraphrasing makes my conversations more interesting. Normally I would just say, 'Is that right?' but now I'm a more active participant."
- "I love the overlearning strategy to remember names. I made flashcards for each new person I met at my AA meetings. On the back of the card, I'll write down their phone number and personal details. I'm meeting more people and socializing with them. I'm having a social life outside of my addiction for the first time in two and a half years."
- "Self talk is a learning tool. It's not like talking back to voices. If you do it for instructions or a task, it's normal."

Discussion

The goal of this study was to assess whether a compensatory CT intervention, focusing on strategy and habit learning, could help participants with psychosis improve their cognitive and functional performance. We examined the effects of CT on the participants' neurocognitive test performance in both targeted and non-targeted domains, and functional capacity measures immediately following the intervention (3 months after baseline) and three months following

the end of the intervention (6 months after baseline). Additionally, we examined participants' clinical symptoms, subjective ratings of their quality of life, their self-perceived cognitive difficulties, and the compensatory strategies they reported using. The intervention was feasible to deliver and was well-attended and well-received by participants who completed it.

Not surprisingly, the effects of CT on the targeted cognitive domains were greater than those on non-targeted cognitive domains. The positive effects of CT extended beyond cognition, however; functional capacity, as measured by the UPSA, and subjective quality of life also improved and were maintained at follow-up. CT-associated improvements in cognition, functional capacity, and quality of life generally increased during the follow-up period, indicating that CT participants showed increasing benefit over time. A substantial proportion of initially impaired participants were able to improve their cognitive or UPSA scores to within normal levels of performance following the intervention. Although CT targeted specific cognitive domains (i.e., prospective memory, attention, verbal learning and memory, and executive functioning), none of the cognitive tests used as outcome measures, nor the UPSA, is used during the intervention (i.e., the intervention does not train to the test). Therefore, the positive effects of CT are reflecting a generalization of training. However, it is not known if the benefits of CT can be sustained longer than three months following the intervention.

CT showed an impressive effect on negative symptom severity immediately following the intervention, but not at follow-up. The CT sessions provided an opportunity for participants to have social interaction and group support, and the lack of sessions during the follow-up could have contributed to the attenuated effect on negative symptom severity.

Compared with SP participants, CT participants also reported decreases in cognitive problems and increases in cognitive strategy use following the intervention. In contrast with the effects on cognition, functional capacity, and quality of life, the effects on self-reported cognitive problems and strategy use were generally stronger immediately post-treatment. This pattern suggests that some consumers may not develop new cognitive habits easily or may need more continual prompting to use their strategies. As Ritch et al. (2007) point out, we should not always expect psychosocial treatment gains to last beyond treatment for all clients; continued treatment may be necessary, just as continued pharmacological treatment is necessary. Although the treatment effects were somewhat attenuated at follow-up, many strategies were maintained during the follow-up period, even without booster sessions. It is our hope that these strategies became long-term habits.

It is difficult to know whether the effects of CT represent the attenuation of deficits or increased ability to compensate for them. However, because our CT intervention does not use any drills, we believe it unlikely that the intervention is correcting underlying cognitive deficits. Compensatory strategies may generalize better to real-world situations because they become part of a person's way of interacting with the world. Velligan's group investigated a medication adherence intervention using compensatory and environmental strategies, and found that medication adherence gains were maintained during a six-month, no-contact follow-up (Ritch et al., 2007). These types of results show that compensatory and environmental strategies can effect long-term change in cognitively-mediated behaviors.

Although the current study demonstrated some exciting findings, it is not without limitations. The sample size was small, with a high drop out rate among the CT participants and overrepresentation of Caucasians among CT completers, all of which limit the generalizability of our findings. Furthermore, this is an ongoing study, so inferential statistics were not computed. However, the positive effect sizes we found encourage us to continue investigating this CT intervention. If these and similar results hold with larger samples, they will support

the idea that habit learning can result in long term changes in instrumental activities of daily living that are necessary for independence in living and community integration.

References

Bayley PJ, Frascino JC, Squire LR. Robust habit learning in the absence of awareness and independent of the medial temporal lobe. Nature 2005;436(7050):550–3. [PubMed: 16049487]

Bell M, Bryson G, Greig T, Corcoran C, Wexler BE. Neurocognitive enhancement therapy with work therapy: Effects on neuropsychological test performance. Archives of General Psychiatry 2001;58(8): 763–768. [PubMed: 11483142]

Bell M, Bryson G, Wexler BE. Cognitive remediation of working memory deficits: Durability of training effects in severely impaired and less severely impaired schizophrenia. Acta Psychiatrica Scandinavica 2003;108(2):101–109. [PubMed: 12823166]

Bellack AS, Gold JM, Buchanan RW. Cognitive rehabilitation for schizophrenia: Problems, prospects, and strategies. Schizophrenia Bulletin 1999;25(2):257–274. [PubMed: 10416730]

Bellack AS, Sayers M, Mueser KT, Bennett M. Evaluation of social problem solving in schizophrenia. Journal of Abnormal Psychology 1994;103(2):371–8. [PubMed: 8040506]

Benedict, RHB. Brief Visual-Spatial Memory Test - revised Professional Manual. Odessa, FL: Psychological Assessment Resources; 1997.

Benedict RHB, Schretlen D, Groninger L, Brandt J. Hopkins Verbal Learning Test -revised: Normative data and analysis of inter-form and test-retest reliability. The Clinical Neuropsychologist 1998;12(1): 43–55.

Benton, AL.; Hamsher, KS. Multilingual aphasia examination. Iowa City, IA: AJA Associated; 1989.

Braff DL, Heaton R, Kuck J, Cullum M, Moranville J, Grant I, Zisook S. The generalized pattern of neuropsychological deficits in outpatients with chronic schizophrenia with heterogeneous Wisconsin Card Sorting Test Results. Archives of General Psychiatry 1991;48(10):891–98. [PubMed: 1929758]

Butters, MA.; Soety, EM.; Glisky, EL. Memory rehabilitation. In: Snyder, PJ.; Nussbaum, PD., editors. Clinical Neuropsychology. Washington, DC: American Psychological Association; 1998. p. 450-466.

Clare L, McKenna PJ, Mortimer AM, Baddeley AD. Memory in schizophrenia: What is impaired and what is preserved? Neuropsychologia 1993;31(11):1225–41. [PubMed: 8107983]

Cohen, J. Statistical power analysis for the behavioral sciences. Vol. 2. Hillsdale, NJ: Erlbaum; 1988.

Cope DN. The effectiveness of traumatic brain injury rehabilitation: A review. Brain Injury 1995;9(7): 649–670. [PubMed: 8680395]

Elvevag B, Maylor EA, Gilbert AL. Habitual prospective memory in schizophrenia. BMC Psychiatry 2003;3:9. [PubMed: 12890293]

Fiszdon JM, Bryson GJ, Wexler BE, Bell MD. Durability of cognitive remediation training in schizophrenia: performance on two memory tasks at 6-month and 12-month follow-up. Psychiatry Research 2004;125(1):1–7. [PubMed: 14967547]

Fiszdon JM, Cardenas AS, Bryson GJ, Bell MD. Predictors of remediation success on a trained memory task. Journal of Nervous and Mental Disease 2005;193(9):602–608. [PubMed: 16131943]

Gold JM, Randolph C, Carpenter CJ, Goldberg TE, Weinberger DR. Forms of memory failure in schizophrenia. Journal of Abnormal Psychology 1992;101(3):487–94. [PubMed: 1500605]

Gold JM, Rehkemper G, Binks SW, Carpenter CJ, Fleming K, Goldberg TE, Weinberger DR. Learning and forgetting in schizophrenia. Journal Abnormal Psychology 2000;109(3):534–8.

Goldberg TE, Saint-Cyr JA, Weinberger DR. Assessment of procedural learning and problem solving in schizophrenic patients by Tower of Hanoi type tasks. J Neuropsychiatry Clin Neurosci 1990;2(2): 165–73. [PubMed: 2136071]

Goldstein, K. Aftereffects of brain injuries in war: Their evaluation and treatment The Application of Psychologic Methods in the Clinic. New York: Grune & Stratton; 1942.

Green MF, Kern RS, Braff DL, Mintz J. Neurocognitive deficits and functional outcome in schizophrenia: Are we measuring the “right stuff”? Schizophrenia Bulletin 2000;26(1):119–36. [PubMed: 10755673]

Green MF, Nuechterlein KH. Should schizophrenia be treated as a neurocognitive disorder? Schizophrenia Bulletin 1999;25(2):309–18. [PubMed: 10416733]

Green MF. What are the functional consequences of neurocognitive deficits in schizophrenia? American Journal of Psychiatry 1996;153(3):321–30. [PubMed: 8610818]

Grober E, Sliwinski M. Development and validation of a model for estimating premorbid verbal intelligence in the elderly. Journal of Clinical and Experimental Neuropsychology 1991;13(6):933–49. [PubMed: 1779032]

Gur RC, Ragland JD, Gur RE. Cognitive changes in schizophrenia - a critical look. International Review of Psychiatry 1997;9(4):449–457.

Heaton R, Paulsen J, McAdams LA, Kuck J, Zisook S, Braff D, Harris J, Jeste DV. Neuropsychological deficits in schizophrenics: Relationship to age, chronicity and dementia. Archives of General Psychiatry 1994;51(6):469–76. [PubMed: 8192549]

Heaton RK, Gladsjo JA, Palmer B, Kuck J, Marcotte TD, Jeste DV. The stability and course of neuropsychological deficits in schizophrenia. Archives of General Psychiatry 2001;58(1):24–32. [PubMed: 11146755]

Heinrichs RW. The primacy of cognition in schizophrenia. American Psychologist 2005;60(3):229–242. [PubMed: 15796677]

Kay, SR.; Opler, LA.; Fiszbein, A. Positive and Negative Syndrome Scale (PANSS) Rating Manual. San Rafael, CA: Social and Behavioral Sciences Documents; 1987.

Keri, Juhasz, Rimanoczy, et al. Habit learning and the genetics of the dopamine D3 receptor: evidence from patients with schizophrenia and healthy controls. Behavioral Neuroscience 2005;119(3):687–93. [PubMed: 15998189]

Knowlton, Mangels, Squire. A neostriatal habit learning system in humans. Science 1996;273(5280):1399–402. [PubMed: 8703077]

Kondel TK. Prospective memory and executive function in schizophrenia. Brain and Cognition 2002;48(23):405–10. [PubMed: 12030477]

Kongs, SK.; Thompson, LL.; Iverson, GL.; Heaton, RK. Wisconsin Card Sorting Test–64 card version (WCST-64). Odessa, FL: Psychological Assessment Resources; 2000.

Kurtz MM. Neurocognitive impairment across the lifespan in schizophrenia: an update. Schizophrenia Research 2005;74(1):15–26. [PubMed: 15694750]

Kurtz MM, Moberg PJ, Gur RC, Gur RE. Approaches to cognitive remediation of neuropsychological deficits in schizophrenia: a review and meta-analysis. Neuropsychol Rev 2001;11(4):197–210. [PubMed: 11883669]

Lehman AF. A quality of life interview for the chronically mentally ill. Evaluation and Program Planning 1988;11(1):51–62.

Marder SR, Fenton W. Measurement and treatment research to improve cognition in schizophrenia: NIMH MATRICS initiative to support the development of agents for improving cognition in schizophrenia. Schizophrenia Research 2004;72(1):5–9. [PubMed: 15531402]

Mausbach BT, Bowie CR, Harvey PD, Twamley EW, Goldman SR, Jeste DV, Patterson TL. Usefulness of the UCSD performance-based skills assessment (UPSA) for predicting residential independence in patients with chronic schizophrenia. Journal of Psychiatric Research. 2007epub ahead of print

McGurk SR, Meltzer HY. The role of cognition in vocational functioning in schizophrenia. Schizophrenia Research 2000;45(3):175–84. [PubMed: 11042435]

McGurk SR, Mueser KT, Pascaris A. Cognitive training and supported employment for persons with severe mental illness: One year results from a randomized controlled trial. Schizophrenia Bulletin 2005;31(4):898–909. [PubMed: 16079391]

National Institutes of Health and National Institute of Mental Health. Bridging science and service: A report by the National Advisory Mental Health Council's Clinical Treatment and Services Research Work Group. 1999. Retrieved from http://www.nimh.nih.gov/research/bridge.htm

Nuechterlein KH, Barch DM, Gold JM, Goldberg TE, Green MF, Heaton RK. Identification of separable cognitive factors in schizophrenia. Schizophrenia Research 2004;72(1):29–39. [PubMed: 15531405]

Patterson TL, Moscona S, McKibbin CL, Hughs T, Jeste DV. UCSD performance-based skills assessment (UPSA): Development of a new measure of everyday functioning for severely mentally ill adults. Schizophrenia Bulletin 2001;27(2):235–245. [PubMed: 11354591]

Paulsen JS, Heaton RK, Sadek JR, Perry W, Delis DC, Braff D, Kuck J, Zisook S, Jeste DV. The nature of learning and memory impairments in schizophrenia. Journal of the International Neuropsychological Society 1995;1(1):88–99. [PubMed: 9375213]

Ritch JL, Diamond P, Zeber J, Vontur M, Lam FY, Ereshefsky L, Miller AL, Velligan DI. Do the effects of environmental supports last once home visits are withdrawn? Schizophrenia Bulletin 2007;33(2): 603.

Saykin AJ, Gur RC, Gur RE, Mozley PD, Mozley LH, Resnik SM, Kester DB, Stafiniak P. Neuropsychological function in schizophrenia: Selective impairment in memory and learning. Archives of General Psychiatry 1991;48(7):618–24. [PubMed: 2069492]

Shum D, Ungvari GS, Tang WK, Leung JP. Performance of schizophrenia patients on time-, event-, and activity-based prospective memory tasks. Schizophrenia Bulletin 2004;30(4):693–701. [PubMed: 15954184]

Spaulding, W.; Reed, D.; Storzbach, D.; Sullivan, M.; Weiler, M.; Richardson, C. The effects of a remediational approach to cognitive therapy for schizophrenia. In: Wykes, T.; Tarrier, N.; Lewis, S., editors. Outcome and innovation in psychological treatment of schizophrenia. London: John Wiley & Sons Ltd; 1998. p. 145-160.

Twamley EW, Doshi RR, Nayak GV, Palmer BW, Golshan S, Heaton RK, Patterson TL, Jeste DV. Generalized cognitive impairments, ability to perform everyday tasks, and level of independence in community living situations of older patients with psychosis. American Journal of Psychiatry 2002;159(12):2013–2020. [PubMed: 12450950]

Twamley EW, Jeste DV, Bellack AS. A review of cognitive training in schizophrenia. Schizophrenia Bulletin 2003;29(2):359–382. [PubMed: 14552510]

Vauth R, Corrigan PW, Clauss M, Dietl M, Dreher-Rudolph M, Stieglitz R, Vater R. Cognitive strategies versus self-management skills as adjunct to vocational rehabilitation. Schizophrenia Bulletin 2005;31 (1):55–66. [PubMed: 15888425]

Velligan DI, Bow-Thomas CC, Huntzinger C, Ritch J, Ledbetter N, Prihoda TJ, Miller AL. Randomized controlled trial of the use of compensatory strategies to enhance adaptive functioning in outpatients with schizophrenia. American Journal of Psychiatry 2000;157(8):1317–1323. [PubMed: 10910797]

Wechsler, D. Wechsler Adult Intelligence Scale - Third Edition (WAIS-III). San Antonio, TX: The Psychological Corporation; 1997.

Wilson BA. Cognitive rehabilitation in the 21st century. Neurorehabilitation and Neural Repair 2002;16 (2):207–210. [PubMed: 15151117]

Woods SP, Twamley EW, Dawson MS, Narvaez JM, Jeste DV. Deficits in cue detection and intention retrieval underlie prospective memory impairment in schizophrenia. Schizophrenia Research 2007;90(13):344–350. [PubMed: 17175138]

Table 1

Cognitive Impairments in Schizophrenia, Functional Outcomes, and Cognitive Training Strategies

Targeted Domain	Importance for Everyday Functioning (Work, School, Independent Living)	Specific Compensatory Strategies and Habits in Cognitive Training
Prospective Memory	• Remembering to go to work or school • Remembering to take medications • Remembering to turn in school assignments • Remembering to do assigned tasks at work in response to cues	**1** Daily calendar use **2** To-do lists and prioritizing tasks **3** Linking tasks or using “can’t miss reminders” to remember tasks
Attention and Vigilance	• Paying attention to communications from supervisors and coworkers • Maintaining attention in class or while studying • Maintaining attention to work tasks or household projects without getting distracted	**1** Conversational vigilance skills (reduce distractions, eye contact, paraphrasing, and asking questions) **2** Task vigilance skills (paraphrase instructions, use self-talk during tasks to maintain focus)
Learning and Memory	• Learning and remembering work tasks • Learning novel information in school or vocational training • Learning and remembering names of supervisors and coworkers	**1** Encoding strategies (write things down, paraphrasing/repetition, association, chunking, categorizing, acronyms, rhymes, visual imagery, name-learning strategies) **2** Retrieval strategies (systematic searching) and organizational strategies for general learning and memory
Executive Functioning (Problem Solving and Cognitive Flexibility)	• Problem solving and coping with unexpected situations on the job or in vocational training, or at home • Being able to balance demands of work/ school with home/family needs • Thinking flexibly and self-monitoring performance at work	**1** 6-step problem solving method (define problem, brainstorm solutions, evaluate solutions systematically, select a solution, try it, evaluate how it worked) **2** Self-talk while solving problems **3** Hypothesis testing **4** Self-monitoring

Table 2

Participant Characteristics within the CT and SP groups

	CT (n=14)	SP (n=24)	t	χ^2	*df*	*p*
Demographic Variables						
Mean age (SD)	44.9 (10.1)	50.2 (8.0)	1.794		36	.081
Mean years of education (SD)	13.3 (1.7)	13.2 (1.5)	.146		36	.884
% Male	64.3	66.7		.022	1	.881
% Caucasian	85.7	54.2		3.91	1	.048
Disease Burden Variables						
Diagnosis				5.29	3	.152
n, Schizophrenia	4	14				
n, Schizoaffective Disorder	9	9				
n, Other primary psychotic d/o	1	1				
Mean duration of illness (SD)	19.6 (14.2)	27.5 (10.4)	1.933		35	.061
Mean antipsychotic dose, CPZE (SD)	396.9 (298.3)	267.5 (260.8)	1.332		32	.192
Mean PANSS positive symptoms (SD)	17.9 (7.3)	17.0 (6.5)	.394		36	.696
Mean PANSS negative symptoms (SD)	14.1 (6.6)	14.3 (5.3)	.113		36	.911
Mean premorbid IQ (SD)	105.2 (10.7)	108.7 (9.6)	1.034		36	.308

Table 3

Effects of Cognitive Training on Outcome Measures

Measure	Cohen's *d* at 3 months	Cohen's *d* at 6 months	Percent normalized
Targeted Cognitive Domains			
Prospective memory (MIST summary score)	.22	.47	29%
Attention/Vigilance (Digit Span forward)	.49	1.00	100%
Verbal learning (HVLT-R recall total)	.38	.67	67%
Verbal memory (HVLT-R percent retained)	.61	.04	50%
Executive functioning (WCST-64 total correct)	.47	.79	83%
Non-targeted Cognitive Domains			
Processing speed (Digit Symbol)	-.16	-.41	--
Working memory (Letter Number Sequencing)	-.16	-.31	--
Language (AFV total correct)	.15	-.01	--
Visual learning (BVMT-R learning)	-.86	-.23	--
Visual memory (BVMT-R percent retained)	.97	.25	--
Functional Capacity			
UPSA Household Chores	.62	.94	49%
UPSA Communication	.48	.57	63%
UPSA Finance	.03	-.04	75%
UPSA Transportation	.09	.21	50%
UPSA Planning Recreational Activities	-.18	-.18	89%
UPSA Total score	.67	.89	33%
Symptoms			
PANSS positive symptoms	-.04	.12	--
PANSS negative symptoms	.93	.17	--
Quality of Life			
QOLI global satisfaction	.52	.84	--
Cognitive Problems and Strategies Assessment			
Mean, cognitive problems	.67	.40	--
Mean, cognitive strategies	1.27	1.06	--