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A Comparison of Remediation Techniques on the Wisconsin Card Sorting Test in Schizophrenia

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Abstract

A wealth of evidence has revealed that deficits on a commonly used measure of executive-function, the Wisconsin Card Sorting Test (WCST), can be improved through a variety of methods of instruction in patients with schizophrenia. Relatively little is known however, which of these remediation methods produce strongest and most durable effects and whether these effects generalize to other, untrained executive-function measures. Two of the most commonly studied methods for remediation on the WCST, step-by-step didactic instruction on the task and utilization of self-monitoring strategies, have both been shown to improve WCST performance, yet have never been directly compared. Thirty-four participants with schizophrenia were randomly assigned to one of three experimental conditions: Condition A consisted of didactic training which incorporated a detailed account of changing sorting principles throughout the test; Condition B consisted of a self-monitoring strategy that required that participants verbalize their strategies out loud after each card sort; Condition C was a non-trained control group that received the same outcome assessments as the two training groups at identical time intervals without intervening training. Patients were assessed with the WCST and two other executive-function tests immediately prior to training, immediately after training and at a 1-month follow-up. Results revealed: (1) participants assigned to the didactic and self-monitoring conditions made significant gains on the WCST relative to a no-intervention control condition; (2) the effects of self-monitoring, but not didactic training, were evident at a one-month follow-up; and (3) only participants assigned to the self-monitoring condition showed generalization to a second, non-trained measure of executive-function. The significance of these results for implementation of strategies for comprehensive and sustained programs of remediation are discussed.

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Conflict of Interest

Dr. Choi has received grant/research support from Eli Lilly and Company.

Contributors

Both Drs. Choi and Kurtz designed the study, contributed to writing the grant and protocol, supervised research assistants in collecting the data, and then contributed to conducting the statistical analysis and writing up the manuscript. Both authors approved the final manuscript.

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Keywords

Schizophrenia; cognition; neuropsychology; cognitive remediation; Wisconsin Card Sorting Test

1. Introduction

A majority of individuals with schizophrenia demonstrate neuropsychological deficits which are resistant to the benefits of psychotropic medication and are significantly correlated with psychosocial status (Green et al., 2004; Harvey & Keefe, 2001). In light of these findings, researchers have begun to investigate whether neurocognitive impairments are amenable to cognitive remediation strategies (Bell et al., 2001; Fiszdon et al., 2004; Medalia et al., 2005; Twamley et al., 2003). Interventions designed to improve performance on the Wisconsin Card Sorting Test (WCST), a reliable and well-established measure of abstraction and conceptual flexibility for use in neuropsychiatry (Berg, 1948; Heaton et al., 1993) have been some of the most well-studied strategies in this research domain (e.g., Kurtz et al., 2001). The remediation of impaired executive functioning is considered particularly important to overall rehabilitation since these skills play a significant role in the patient's capacity to function in the community, obtain employment, and maintain independent living (Green, 1996; Jaeger & Douglas, 1992; Lysaker et al., 1995; McGurk et al., 2004; Wexler & Bell, 2005).

After an initial report suggesting that deficits on the WCST could not be ameliorated with enhanced instruction (Goldberg et al., 1987), a variety of studies within the last two decades have shown that significant improvements can be achieved on various measures of the WCST using different instructional techniques and monetary reinforcement (e.g., Bellack et al., 1990, 1996, 2001; Green et al., 1992; Kern et al., 1996; Hellman et al., 1998; Young & Freyslinger, 1995; Young et al., 2002). To date, the didactic method of remediation introduced by Goldberg and Weinberger (1994) and expanded by Bellack and his colleagues (1996, 2001) has provided the most convincing evidence for modifiability of performance on the WCST. The technique consists of expanded instruction which incorporates a detailed account of sorting principles as well as an explanation of the changes that occur in sorting throughout the test using learning principles of modeling and corrective feedback. A variety of studies have found that such training resulted in substantial improvements on the WCST with some evidence of generalization to non-trained tests of executive functioning (Bellack et al., 2001; but see Bellack et al., 1996).

However, some investigators have argued that Bellack's technique reduces the difficulty level of the WCST and changes the nature of the test since abstraction, flexibility, and concept formation are no longer measured in such a modified task (Perry et al., 2001). To address this issue, Stratta et al. (1994) introduced training that enhanced strategy formation by having participants verbalize their strategies so as to augment working memory for the test. They found significant improvements in performance on the WCST, provided that the participants continued to verbalize their sorting strategies. Perry et al. (2001) studied this simple training method on 73 subjects with schizophrenia. Utilizing a self-monitoring strategy similar to Stratta et al., the participants were simply asked to verbalize the reasons behind the card placement after each sort ("Why did you put that there?"). Results revealed that participants who were exposed to this training made fewer perseverative responses and achieved more categories on the WCST than those who received only the standard instruction. Thus, remediation strategies designed to augment working memory also seem to improve executive functioning and do so without necessarily modifying the nature and difficulty level of the WCST.

To date, only a few studies have compared relative effectiveness of different approaches to WCST remediation, and no study has compared the durability and generalization of these

remediation methods to non-trained measures of executive-function (Koren et al., 2006). The purpose of the present study was to conduct a head-to-head comparison of two alternative approaches to remediation of performance on the WCST, didactic training and self-monitoring, that have both shown efficacy but that differ markedly in remediation strategy utilized. We hypothesized that: (a) Participants with schizophrenia treated with the didactic or self-monitoring remediation training will show significantly improved performance on WCST relative to participants in a no-intervention control condition; (b) Improved performance on WCST will generalize to performance on non-trained tests of executive functioning and will persist at a one-month follow-up in both training conditions, and (c) self-monitoring instruction will produce larger and more persistent generalization effects.

2. Method

2.1 Participants

Participants in the study were 34 outpatients (ages 18 to 64) from the Schizophrenia Rehabilitation Program at The Institute of Living, Hartford, CT, and the Schizophrenia Research Program and Adult Outpatient Psychiatry Department at Montefiore Medical Center, Bronx, NY. Only participants who were impaired on the WCST at baseline (fewer than 4 categories) were included in the protocol. Prior to participation in study, participants had to be psychiatrically stable for at least 2 weeks on their psychotropic medication. All participants were diagnosed with schizophrenia or schizoaffective by their respective treating clinician. Diagnosis was confirmed by the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-IV; First et al., 1997). Any participants with significant auditory/visual impairment, lack of fluency in English or medical illnesses known to impair brain function, other than schizophrenia, were excluded. Participants who met criteria for current substance abuse/dependence were also excluded, including those with active substance abuse 30 days prior to intake.

2.2 Measures

Wisconsin Card Sorting Test (Berg, 1948; Heaton et al., 1993)—The WCST is a 128-item measure of conceptual flexibility and problem-solving that is hypothesized to tap into skills mediated by prefrontal cortical structures (Berg, 1948; Heaton et al., 1993). The test requires participants to match a series of cards beneath four reference cards according to shape, color, and number of geometric shapes and must infer the sorting rule from feedback to their responses. The full 128-card paper-and-pencil version of the test was used. Categories achieved and age, education and sex-corrected total error T-scores were selected as dependent measures.

Booklet Category Test: 2nd Edition (BCT; DeFilippis and McCampbell, 1997)—The BCT is a variation of the Category Test first developed as part of the Halstead-Reitan Neuropsychological Battery (Reitan & Wolfson, 1985). The BCT is a modified test of executive ability that consists of 7 subtests and 208 items measuring abstraction and concept formation. It requires patient to identify a strategy for categorizing geometric shapes and symbols, and select the correct match from among a set of four choices. Age, education and sex-corrected total error T-scores were selected as a dependent measure.

Penn Conditional Exclusion Test (PCET; Kurtz et al., 2004)—The Penn Conditional Exclusion Test is a novel measure of executive functioning with four alternate forms for repeat administration. The PCET has been validated with the WCST and other neuropsychological measures (Kurtz, Wexler, & Bell, 2004; Kurtz et al., 2004), and the alternate forms have been shown to be related to one another. The test requires the participant to select one of the four figures that does not belong in the group using different sorting principles which are inferred through feedback to their responses.

2.3 Procedure

A description of the study was given to all participants and written informed consent approved by each respective hospital Institutional Review Board. Following consent, participants were randomly assigned to one of three conditions: (Control) participants only received the standard instructions on WCST; (Self-Monitoring) participants were asked to verbalize reasons behind card placement after each sort on WCST; (Didactic Training) participants were shown the correct response strategy at onset of WCST and provided corrective feedback as they attempted to learn correct problem-solving strategies. All eligible participants were initially given the standard WCST and non-trained tests to assess baseline performance. Following a 15-minute break, participants in training conditions (Self-Monitoring, Didactic) received the respective training on the WCST while participants in the control condition were re-administered the standard WCST during this stage to control for practice effects. In the immediate post-training phase, all participants were retested on all measures using standard instructions. All participants were re-tested once again on measures following a 1-month interval. In order to control for effects due to presentation order, the order of test administration during each assessment phase was counterbalanced across groups. In addition, to ensure objectivity of test administration and scoring, both stages of post-treatment assessment were conducted by evaluator who was blind to conditions. All participants were administered the 128-card version of the WCST while results were scored using the WCST: Computer Version 3 Research Edition (WCST: CV3; Heaton, 1999).

2.31 WCST Administration

Self-Monitoring Training Instructions (Perry, Potterat, & Braff, 2001)—In addition to standard WCST instructions, in this condition the examiner instructed participants in the following manner, “This time in addition to telling you whether you are right or wrong after each sort, I will ask you to tell me the reason you put the card where you did. The question that I will ask is, “Why did you put that there?” I will ask you the question after each card sort. There is no time limit on the test. Are you ready? Let’s begin.”

Didactic Training Instructions (Bellack et al., 1990)—In this condition, the examiner lays out the cards as specified in the manual and trained the participant in the following manner:

There are 3 ways you can match up the cards: color, shape, and number. If you match by color, you would put a red card under the red pile, a green card under the green pile, a yellow card under the yellow pile, and a blue card under the blue pile. If you match by shape, you would put a triangle under the triangle, a star under the stars, a cross under the crosses, and a circle under the circles. Finally, if you match by number, you would put a card with one form on it under the card with one form, a card with two forms on it under the card with two forms, a card with three forms under the card with three forms, and a card with four forms under the card with four forms. Each time you choose you should try to decide which will be correct: color, shape or number. That category will be correct until you get it right several times in a row. After you get several correct in a row, I will change the category that is correct.

The training is conducted on cards 1 to 5 and repeated for cards 32 to 37 adjusting for the correct sorting rule, so participants received 2 sets of training per 64-card deck. If the participant did not understand the concept even after training, the examiner was allowed to provide the following corrective steps: (a) explain the concept of number, (b) rephrase by explaining that only one principle is correct at a time, (c) explain that choosing the correct category again would be correct, and (d) explain that if the response is “Wrong”, it is probably true that it will continue to be wrong and he/she should try either shape or number. However, if after two sets of training (cards 1 to 5 and 32 to 37) the participant was still unable to correctly respond, the test was discontinued.

2.4 Data Analysis

The distribution of scores for each variable in each group was inspected for normality and compared to relevant comparison groups for homogeneity of variance. With the exception of categories solved from the WCST, in no case was there evidence that variables selected for the study violated the assumptions underlying the use of parametric statistical procedures. We substituted non-parametric tests to assess Categories from the WCST. In no instances did the results of parametric measures differ from those of non-parametric tests, thus the results from parametric tests for all measure are reported.

To ensure that the three experimental groups were similar on baseline neurocognitive tests scores, we compared each of these scores across the three groups via one-way analyses of variance (ANOVA). To assess the impact of WCST training on WCST performance we computed change scores from pre- to post-training for each participant on categories solved and total error T-scores on the WCST. We then entered these change scores into two one-way ANOVAs, one for each WCST variable, with experimental condition as a between-subjects variable. To assess the durability of change in WCST performance as a function of training, we computed a second set of change scores between test performance at intervention termination and performance at the one-month follow-up for each participant on each WCST measure. Again, these change scores were entered into one-way ANOVAs with training condition as a between-subjects variable. Of not, the change in total errors for the WCST was recorded in T-score and not raw number of errors, so an increase in errors reflects a *decrease* in total errors T-score.

To assess generalization, we calculated change scores from pre- to post-intervention on the PCET and BCT and then entered these change scores into two one-way between-group ANOVAs. To assess durability of any observed generalization effects we also calculated change scores from the termination of the intervention to a one-month follow-up on the BCT and PCET and entered these values into between-group, one-way ANOVAs. While data on the WCST from every study participant was included in our analyses, consistent with previous studies in this research area (e.g., Bellack et al., 2001), we employed an operational criterion of 10% improvement on the WCST in the two training groups as sufficient evidence of learning to warrant investigation of generalization effects for this part of the analysis. Thus, only those participants showing 10% improvement on the WCST after training were included in the ANOVAs assessing generalization and durability of learning to untrained measures of executive-function (PCET and BCT). Since this analysis was limited to improvers, the sample used for this calculation was slightly reduced to 11 participants in the self monitoring group and 6 in the didactic condition. When significant effects were evident in ANOVA, Tukey's HSD test was selected for pair-wise comparisons. All statistical tests were two-tailed and alpha was set at .05.

3. Results

No significant differences were evident between the two WCST training or control conditions on demographic or clinical variables (see Table 1). There were also no significant between-group differences on any of the four measures of problem-solving at baseline (all $p > .339$). As shown in Figure 1, the one-way ANOVA for change in categories solved on the WCST from pre- to post-training revealed a main effect of group ($F [2, 31] = 15.39, p < .001$) with didactic and self-monitoring conditions both producing improvement relative to non-trained control participants ($p < .001$), with no significant differences between the two training methods used. As can be seen in Figure 2, T-score change in errors from pre to post-training revealed an effect of group that approached significance ($p = .067$). To assess durability of training effects, change scores from immediately after training to the one month follow-up were assessed. As can be seen in Figure 1, change in categories solved on the WCST during the follow-up interval

revealed a significant group effect ($F [2, 31] = 21.87, p < .001$) with the didactic condition showing a significant reduction in categories solved on the WCST over the follow-up interval relative to the self-monitoring and non-trained control conditions ($p < .001$). Similarly, as can be seen in Figure 2, change in the T-score for errors on the WCST across the 1-month follow-up interval showed a significant group effect ($F [2, 31] = 5.09, p = .012$) with a decrease in T-scores in the didactic condition relative to the self-monitoring ($p = .014$) and non-trained control condition ($p = .038$). No differences in change scores were evident between the self-monitoring and non-trained control conditions at a 1-month follow-up ($p = .908$).

To assess generalization, only data from participants showing a 10% improvement on the WCST in the two intervention conditions were included. This produced a loss of two participants in the self-monitoring condition and three in the didactic condition. Results from change scores on the BCT from pre- to post-training revealed a significant group effect $F (F [2, 26] = 3.85, p = .034)$. As can be seen in Table 2, pair-wise comparisons showed that participants in the self-monitoring condition showed improved performance on the BCT ($p = .030$), relative to the participants randomly assigned to the didactic and untrained control conditions, who did not differ from one another ($p = .272$). There were no group differences in change scores for the PCET from pre- to post-training testing, and no differences in change scores between groups on either measure (BCT or PCET) from termination of the intervention to the 1-month follow-up (all $p > .077$).

4. Discussion

Our results revealed three important findings. First, both types of expanded instruction on the WCST selected for this study, explanation of the task, followed by rehearsal and feedback via didactic training and a self-monitoring intervention requiring participants to describe their sorting rule, produced similar improvements in categories solved and total errors on the WCST in patients with schizophrenia assessed immediately after the intervention, relative to an untrained control group with similar exposure to the test materials. Large effect-size improvement ($d = 1.78$ for categories; $d = .97$ for errors) on the WCST were evident as a function of two modest and very different training procedures that are well beyond those associated with simple task practice and are consistent with a variety of other findings in the literature (e.g., Bellack et al., 1990, 1996, 2001; Kurtz et al., 2001; Perry et al., 2001; Stratta et al., 1994). Second, results from the one-month follow-up revealed differences in the durability of these two forms of training over time. Only patients randomly assigned to the didactic learning condition showed a significant decrement in performance on the WCST between the immediate test and follow-up. In contrast, gains on the WCST evident in patients in the self-monitoring condition were still present at a one-month follow-up. The failure to see a persistent effect of training on the WCST in the didactic condition is consistent with some studies (e.g., Hellman et al., 1998) but not others (e.g., Metz et al., 1994). Lastly, generalization of improved WCST performance to another, untrained measure of executive-function, that used different test stimuli and sorting rules (the BCT), was evident in the self-monitoring condition, relative to untrained control participants with similar exposure to the WCST and BCT. There was no evidence of generalization in the didactic condition. Taken together, these latter findings are the first, to our knowledge, to show differential durability and generalization of alternative approaches to enhanced task instruction on the WCST, and thus provide clues regarding which approaches to remediation of cognitive deficits in schizophrenia could potentially produce more sustained and generalized effects.

The findings of improved performance on the WCST in the self-monitoring condition are important in that they address the concern that early studies of remediation on the WCST that utilized enhanced instruction, rehearsal and feedback changed the nature of the WCST, reducing the difficulty of the task and raising the possibility that observed improvements on

the WCST could be an epiphenomenon linked to recall of learning strategies, rather than a reflection of improved rule-learning and cognitive flexibility (e.g., Goldberg and Weinberger, 1994). Self-monitoring procedures in which patients are simply asked to describe their sorting principle were introduced as a method for enhancing performance while minimally violating the integrity of the WCST (e.g., Stratta et al., 1994; Perry et al., 2001). Self-monitoring stands in distinct contrast to didactic-type instructions, which provides the precise steps for correct sorting. In addition, self-monitoring seems to enhance task engagement by encouraging patients to consider the demands and actions of the task, and thereby recruit and allocate limited attention/working memory resources toward more relevant aspects of the task. Thus, the current results suggest that marked improvement on the WCST can be produced by strategies that minimally affect the nature of the cognitive skills required by the task and by presumably encouraging more efficient resource allocation of attention and/or working memory.

These are the first findings, to our knowledge, to show generalization of effects of self-monitoring to an untrained measure of executive-function in the context of performance of the WCST. Our results, however, do bear some similarity to those of Meichenbaum and Cameron (1973). In that study, a more comprehensive program of self-instruction and monitoring produced generalization to both speeded psychomotor and divided attention tasks, as well as increased coherent discourse in structured interviews and proverb interpretation. Their study was one of the first to investigate techniques of cognitive intervention in schizophrenia, including duration of treatment effects and the application to functional rather than cognitive outcomes. Their findings on utilizing aloud and covert self-talk serve as the basis of understanding self-monitoring and metacognitive strategies in use today in various cognitive remediation models. The clinical application of self-guidance instruction has been incorporated into modern scaffolded teaching methods to modify behavior in schizophrenia (Young et al., 2003), and into metacognitive verbalization methods used in conjunction with cognitive behavioral therapy to target social biases and social attribution errors (Moritz & Woodward, 2007).

These findings provide preliminary support on how self-monitoring techniques can improve problem-solving ability in schizophrenia. As cognitive remediation programs become more widely available at the community level, it is important to identify efficacious components which enhance remediation, and provide the clinician with therapeutic tools that are time-efficient and straightforward to implement. Importantly, as the ultimate goal of remediation is to generalize progress on training tasks to functional outcome, current results inform how a simple instructional technique can facilitate enduring generalization of improvement on neuropsychological test performance to non-trained domain tasks.

Several caveats to the current findings should be mentioned. First, it remains unclear the degree to which improved performance on the WCST in this study reflects changes in error variance associated with the test such as motivation and effort, rather than the skills in concept formation and cognitive flexibility that the test is presumed to tap. We note however that the balance of studies have shown that enhancing motivation and effort through monetary reinforcement, in the absence of instruction modification, have produced modest or no change in performance on the WCST (e.g., Bellack et al., 1990; Hellman et al., 1998; but see Summerfelt et al., 1991). Such differences may be attributed to several mitigating factors such as the number of card administrations (128-card versus 64-card), frequency of feedback (didactic provides feedback only on the first 5 cards per deck while self-monitoring probes the participant at every card sort), and computer versus card administration. Follow-up studies should be targeted at dissociating these alternative interpretations of obtained findings. Second, the clinical implications of the individual remediation techniques described in this paper remain most likely limited when utilized as a stand-alone intervention. Nonetheless, we emphasize that the results of this type of analog study are designed to provide guidance on the types of remediation

strategies that, when employed as part of more extended remediation procedures, may be most likely to promote durable change in elementary neurocognitive function and associated functional outcome. Third, sample size in the current study was small and even smaller for the assessment of generalization, where only participants with a 10% improvement on the WCST after training were included in each comparison. This may have impeded our ability to detect even medium-large effect-size changes on measures of generalization in the didactic condition, resulting in possible Type II error. Finally, we note that we did not explicitly train generalization in the didactic condition as has been done in previous work (Bellack et al., 2001) and this fact may account for study discrepancies.

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Figure 1.
Number of categories achieved on the WCST at baseline, post-testing, and 1-month follow up.

Figure 2.
Total errors on the WCST (T-score) at baseline, post-testing, and 1-month follow up.

Table 1
Demographic and clinical characteristics of the three experimental groups.

	Control <i>n</i> =12 <i>M</i> (<i>SD</i>)	Self-Monitoring <i>n</i> =13 <i>M</i> (<i>SD</i>)	Didactic <i>n</i> =9 <i>M</i> (<i>SD</i>)	F-Value	Significance
Age (years)	35.75 (8.97)	37.00 (6.31)	40.11 (12.23)	.61	n.s.
Education (years)	11.33 (1.96)	11.31 (2.35)	10.89 (1.96)	.13	n.s.
Gender, male (percentage)	75	69	78	Chi-sq = .22	n.s.
Duration of Illness (years)	12.27 (9.92)	11.58 (9.27)	10.83 (8.03)	.04	n.s.

Table 2
Generalization of improvement on WCST to Booklet Category Test (BCT) and Penn Conditional Exclusion Task (PCET).

	Control <i>M (SD)</i>	Self-Monitoring <i>M (SD)</i>	Didactic <i>M (SD)</i>
PCET Total Errors (Raw score)			
Pre-testing	45.65 (20.19)	52.46 (11.53)	63.00 (16.16)
Post-testing	51.50 (26.96)	69.85 (9.23)	67.00 (18.22)
BCT Total Errors (T score)			
Pre-testing	26.59 (7.86)	29.23 (6.48)	26.50 (3.69)
Post-testing	26.47 (9.85)	34.46 (10.03) *	30.75 (9.28)

* Mean Difference (Post Hoc: Tukey HSD multiple comparison) is significant at .05.