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It's all in the cards: effect of stimulus manipulation on WCST performance in schizophrenia

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Abstract

Patients with schizophrenia can be taught the Wisconsin Card Sorting Test (WCST) sorting rules based upon expanded feedback. However, few task manipulations have been reported that differentially improve patient performance without altering the nature of feedback provided. The present study tests the hypothesis that deficits in WCST performance in schizophrenia reflect, in part, impaired ability to manipulate abstract stimulus features, rather than impaired ability to utilize feedback. We developed a modified stimulus set – the Rockland Face Sorting Test (RFST) – in which abstract shapes were replaced with faces, which we hypothesized would be more tractable to sorting by patients. Task rules and feedback remained unchanged. Relative RFST and WCST performance was examined in 19 patients as well as 15 normative controls. A comparison group of 15 patients received only repeated WCST administrations. Patients performed significantly better on the RFST vs. the WCST in categories completed, total correct responses and conceptual level responses, whereas no improvement was seen in either the normative or repeated WCST comparison groups. Furthermore, progressive improvement was seen following repeated RFST administration. These findings demonstrate that stimulus characteristics, as well as executive deficits, contribute to impaired WCST performance in schizophrenia.

Keywords

Wisconsin Card Sorting Test (WCST); cognitive remediation; executive functioning; schizophrenia

1. Introduction

Schizophrenia is a debilitating neuropsychiatric disorder, associated with substantial functional and cognitive impairment. There is an increasing focus on remediation of these impairments as a means for improving functional outcome (Kurtz et al., 2001; Greig et al., 2007; McGurk et al., 2007). Although second generation antipsychotics have a limited impact on psychosocial

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functioning (Swartz et al., 2007), ongoing research is exploring non-pharmacological interventions.

The Wisconsin Card Sorting Test (Berg, 1948), 64-card version (WCST) (Kongs et al., 2000) is a test that is widely used to demonstrate neurocognitive dysfunction in schizophrenia (Van der Does, 1992; Laws, 1999). Subjects are provided with a set of cards that they must sort according to abstract rules corresponding to specific stimulus attributes (i.e. color, form, number). After 10 sequential correct trials, the rule switches and subjects, based upon correct/incorrect feedback, must switch to sorting according to a different stimulus characteristic and abstract rule. The task is scored according to the number of categories in which the criterion of 10 correct sequential responses was achieved (“categories completed”). “Conceptual level” responding refers to the ability to maintain set for 3 consecutive responses, irrespective of the final criterion of 10 correct is ultimately achieved. Perseverative responses refer to the tendency to continue applying old rules even after “incorrect” feedback is obtained.

In schizophrenia, performance on the WCST is markedly impaired on several measures including categories completed, total correct responses and perseverative errors (Kongs et al., 2000). Although increased perseverative responding has sometimes been considered characteristic of schizophrenia (Van der Does, 1992), other studies (Laws, 1999) show no differential increase in perseverative vs. non-perseverative errors. Performance has been correlated with overall psychosocial function (Kurtz and Wexler, 2006) and work function (Lysaker et al., 2005; Greig et al., 2007). The cognitive dysfunction measured by WCST performance in patients with schizophrenia is stable over time, with minimal practice effects (Laws, 1999; Harvey et al., 2005). The factors underlying WCST performance – including abstract thinking, self monitoring, set switching (Burgess and Shallice, 1996; Miyake et al., 2000) - are generally grouped under the constructs of executive functioning or working memory. Anatomically, impaired WCST performance has been most closely linked to prefrontal dysfunction, based upon both fMRI evidence (Riehemann et al., 2001) and correlation with regional grey (Rüsch et al., 2007) and white (Kubicki et al., 2003; Leitman et al., 2007) matter alterations.

Most efforts to remediate WCST deficits to date have focused on improving learning, by offering explicit training, or on improving motivation using manipulations such as the offering of monetary rewards (Kurtz et al., 2001). The most successful remediation efforts have required extensive modifications to verbal stimuli of the test instructions, *i.e.*, specifically informing patients about the nature of the sorting categories and sorting principles or offering step-by-step instruction. Collectively, these various modifications of the verbal stimuli produce impressive short term improvement, with a large mean weighted effect size of 1.08 (Kurtz et al., 2001). Improvements persist in an attenuated form up to six weeks later. In contrast, manipulations to the form of the stimuli have generally not led to improved WCST performance. For example, as part of a larger study, Rossell and David (1997) made two modifications to the form of the stimuli. In one, the stimuli were changed to words printed in grey (i.e. “four blue circles”) in place of symbols, while in the other; the shapes were made more abstract using non-namable random shapes. Neither of these changes improved performance, although only three patients were tested in each group.

For the present study, stimuli were altered by using faces instead of abstract shapes. The nature of feedback, however, was not altered. Patients with schizophrenia have increasingly well documented deficits in ability to process visual stimuli, including impaired dorsal stream activation by simple visual stimuli (Spencer et al., 2003; Butler et al., 2007) and impaired ability to close fragmented stimuli (Doniger et al., 2002). Although patients can obviously name the symbols used in the WCST, they may nevertheless be less able than controls to utilize abstract symbols for complex cognitive operations. For the present study, the abstract shapes

on the WCST were replaced by cartoon faces depicting, respectively a man, woman, boy or girl. Furthermore, abstract symbol color was depicted instead as hair color (Figure 1). Since categorization by identity occurs frequently during everyday interaction (*i.e.*, we routinely remember individuals based upon their age, sex and hair color but infrequently based upon the pattern of their clothing), it was hypothesized that patients would find this task more tractable, and thus would show improved performance relative to the traditional versions. As in the traditional version, subjects were not explicitly told which stimulus characteristics were relevant to the task at hand, but had to infer these based upon feedback.

Because the RFST is a new test, the following study proceeded in 3 stages. First, in order to evaluate whether patients might perform differentially on the RFST vs. WCST, we tested a group of 19 subjects, first on the WCST and then immediately followed by the RFST. This was done to permit within group comparison, and also based upon our experience that patients show minimal learning effect following standard WCST administration so that sequential administration would not be a confound. In addition, we employed two comparison groups: first, a group of 15 patients who received two consecutive WCST administrations to verify absence of practice effects during sequential WCST administration, and, second, a group of 15 normative control subjects who received the WCST followed by RFST to evaluate the degree to which controls benefit from stimulus modification. All 3 groups received an additional WCST administration following the second test to examine potential carryover effects from RFST to subsequent WCST administration, leading to either WFW or WWW sequences. Statistical analyses were conducted both within and across subject groups.

Following completion of the first phase and initial signs of effectiveness of the RFST, several individuals who participated in the first phase of the study were invited back to receive the complementary sequence. This was done both to increase sample size and also to ensure that between-test differences were not to be between-subject factors. 16 patients (8 per group) participated in cross-over administration.

Finally, in order to evaluate potential benefits from repeated test administration, an additional cohort of 10 subjects received 5 administrations of the RFST over 3 days, bookended by 2 administrations of the WCST. For this subgroup, differential performance was assessed both on the RFST relative to the WCST, and on final WCST compared to baseline performance. A characteristic of the WCST in normal volunteers is their tendency to improve during repeat administration of the task, as they gradually infer the sorting rules based upon feedback. In the present study, we hypothesized that not only would patients benefit from increased tractability of faces vs. abstract shapes, leading to superior performance on the RFST relative to the WCST, but that their improved performance on individual task administrations would also permit them to show gradual improvement during repeated administration analogously to controls.

2. Methods

2.1 Subjects

Subjects consisted of a convenience sample of 47 patients recruited from inpatient and outpatient sites associated with the Nathan Kline Institute. Diagnosis was obtained either through a SCID (First et al., 1996) screening or from chart diagnosis, and all patients met DSM-IV-TR criteria for either Schizophrenia or Schizoaffective Disorder. 15 controls were recruited from the healthy volunteer pool at the Nathan Kline Institute. All controls went through a SCID screening to rule out any psychopathology. Unavailable data included level of education and IQ for one WRW patient and for one Repeat RFST patient, the BPRS/SANS for one WWW patient and the Only R patients, and IQ for one control patient. As expected, controls had completed more years of education ($t=6.99$, $df=1$, 46, $P<0.01$) and had higher IQ scores than patients ($t=4.72$, $df=1$, 45, $P<0.01$).

2.2 Materials

The WCST-64 (Kongs et al., 2000) involves 64 response cards, which differ in color (red, green, blue and yellow), shape (circle, square, cross and star) and number (one, two, three and four). The subject is instructed to consecutively sort each card under one of the 4 stimulus cards (Figure 1 top row), according to which they consider correct. After each sort, they are informed whether they are correct or incorrect. The first sorting category is color. After 10 consecutive correct sorts, the category changes, without forewarning, first to form and then to number. Subjects are given no other instruction, specifically no information on the nature of the sorting categories or scheduled switches in sorting principles is provided.

We modified the 64-card version of the task by replacing the shapes with four faces (Figure 1 bottom row: Rockland Face Sorting Test—RFST). Other than these differences in form, and a change of the color to closer conform to natural hair, the RFST (number, instructions, card order, number of ambiguous cards, procedure and scoring) is identical to the WCST-64.

2.3 Procedure

All patients were interviewed using semi-structured clinical interviews, [Brief Psychiatric Rating Scale (BPRS) (Overall and Gorham, 1962) and Schedule for Negative Symptoms (SANS) (Andreasen, 1982)], and subsequently underwent three series (series=1 deck of 64 cards) of card sorting tests in one sitting. Patients were offered, but not required to take a break in between series. The 3 series took approximately 45 minutes to administer. Patients were assigned to groups by a non-random sample of convenience as per the ongoing scheduled appointments made for other research tasks at our institute.

19 patients, as well as the 15 normative controls, received the tests in the following order: WCST, RFST and WCST (WRW patient group and WRW control group). The remaining 15 patients received three successive rounds of the WCST (WWW patient group).

For both the WCST and the RFST, the card (non-computer) version was given, using the standard procedure and instructions (Kongs et al., 2000). No special instructions about the nature of the task or the sorting principles were given.

A non-random subset, based on availability for a follow-up visit, of both the WRW and WWW patient groups completed an exploratory cross-over, *i.e.*, patients originally assigned to the WRW patient group completed three series of the WCST on a subsequent visit, and vice versa. Finally, to address potential issues regarding order/priming effects related to the initial presentation of the WCST, we administered the RFST to a group of five additional patients (Only R group).

2.4 Statistical analyses

Demographics (age, sex, level of education, hospital status, mean quick IQ (Ammons and Ammons, 1962) and baseline psychopathology (SANS and BPRS) for the two patient groups were compared by Fisher's exact test for categorical values and by student's tests for continuous values. Demographic comparisons were made with 3×2 chi square tests and ANOVA, for categorical and continuous values respectfully.

Total correct, perseverative errors, conceptual level responses, and categories completed were calculated for each series as per standard scoring rules (Kongs et al., 2000). To test the hypothesis that exposure to the RFST would carryover to the WCST itself, the group by time interaction performance between series 1 to 2 and 1 to 3 was compared by a repeat measures ANOVA. Additionally, the first/second and first/third series were compared within group by a student's t-test for the WWW patient, WRW patient and WRW control groups. Effect sizes

between series 1 and 2 were calculated for the WWW patient and WRW patient groups. Data from cross-over patients was analyzed using both within subject measures to ensure that differential WRW vs. WWW effects were not due to patient characteristics. Additionally, a pooled analysis combining the results of the two visits is presented. All values in text are (mean $\pm$ standard deviation). Two-tailed statistics are used throughout.

2.5 Extension study

Following completion of the above study, an additional sample of 10 subjects, including 2 patients from the WRW group, was recruited to both confirm and extend the preliminary findings. Patient characteristics were similar to those who participated in the initial study. For the extension study, patients performed an initial WCST, followed by 5 repetitions of the RFST over 3 consecutive days, followed by a final WCST administration on Day 4. Comparison was made both between RFST and WCST performance, and between WCST performance prior to, and following, repeated exposure to the RFST. As in the original study, administration rules for the RFST were identical to those for the WCST, with subjects being told only whether their responses were correct or incorrect.

3. Results

3.1 Description of sample

Patients assigned to the WRW, WWW, Repeat RFST or Only R groups did not differ significantly from each other in age, gender distribution, education, hospitalization status, IQ or clinical ratings (Table 1). As expected, controls performed better than the patients in all performance variables for all three series ($P < 0.01$ for all comparisons).

3.2 Between series comparisons (WCST vs. RFST)

3.2.1 Phase I: Comparison of WCST and RFST performance—To test the hypothesis that patients would perform better on the RFST, a repeat-measures MANOVA was performed. With a within group factor of test number (test 1 vs. test 2) and between-subject factor of sequence (WRW vs. WWW), we showed a significant test number X sequence interaction for categories completed ($F = 6.12$, $df = 1, 32$, $P < 0.02$), indicating superiority of performance on the RFST vs. WCST.

Moreover, we compared WCST series 1 with the RFST for the WRW group with a student's paired t-test (Table 2A). Patients completed significantly more categories when doing the RFST than they had completed in the immediately preceding WCST ($t = 3.08$, $df = 1, 18$, $P < 0.01$). Mean difference in performance was 0.63 ± 0.9 categories (Figure 2A), corresponding to an effect size of 0.66. Significantly better scores were obtained as well on total correct responses ($t = 2.06$, $df = 1, 18$, $P = 0.05$) and conceptual level responses ($t = 2.76$, $df = 1, 18$, $P = 0.01$). Conversely, there was no significant difference in the number of perseverative errors (Table 2A). To rule out practice effects, we made the same comparison for the WWW group. WWW patients showed no significant improvement during the first 2 repeats of the WCST (Figure 2B). Further, a group of 5 subjects (Only R) administered the RFST at first administration (i.e. without preceding WCST), showed RFST scores (mean 2.6 categories completed) that were similar or higher than those of patients who received the RFST only after a trial of the WCST, suggesting that improved RFST, relative to WCST performance, was not due to a priming or order effect.

As opposed to patients, controls showed no superior performance on the RFST vs. WCST for categories completed ($t = 0.32$, $df = 1, 14$, $P = 0.8$), nor for the other performance measures (Table 2C). A repeated measures MANOVA comparing patients receiving the WRW sequence vs. controls receiving the same sequence showed a nearly significant group X test interaction for

categories completed ($F=3.67$, $df=1, 32$, $P=0.07$), demonstrating greater benefit for patients from the alternate version of the task than for controls (Figure 2B). Moreover, when the Only R group was included in a univariate ANOVA, significant differences in relative performance between patients and controls on RFST vs. WCST were further enhanced ($F=3.9$, $df=1, 106$, $P=0.05$). No significant group X test number interaction was noted for other measures.

3.2.2 Phase I: Carryover effects—To test the hypothesis that exposure to the RFST would lead to immediate improvement on a subsequent administration of the WCST, we compared the results of the WCST for series 1 and 3 for the three groups (Figure 2B). Patients in the WWW group showed no significant improvement in performance from test 1 to test 2 to test 3, confirming absence of a learning effect in the traditional version of the task. Patients in the WRW group showed a trend towards more total correct in test 3 of the sequence than test 1, suggesting some carryover effect although the degree of difference did not reach statistical significance ($F=3.22$, $df=1, 18$, $P=0.08$). As expected, controls showed significant improvement between test 1 and test 3 in the WRW sequence in total correct responses ($t=2.75$, $df=1, 14$, $P=0.01$) and categories completed ($t=2.09$, $df=1, 14$, $P=0.05$), consistent with significant learning effect in a normative population on this task.

3.3 Phase II: Cross-over group—In order to evaluate potential carryover effects, 16 patients completed a cross-over second visit: eight originally assigned to the WRW patient group and eight originally assigned to the WWW patient group. The WRW patient group completed the second visit an average of 95 days later (range of 36 to 155 days), and the WWW patient group returned an average of 29 days later (range of 0 to 77 days). Despite an average of over two months longer between sessions, the original WRW patient group completed significantly more categories on initial WCST retest, 2.25 ± 2.1 categories, on the first series of their second visit, compared to only 1.38 ± 1.2 categories for the initial WWW patient group ($F=5.29$, $df=1, 14$, $P=0.03$).

Patients exposed to WRW following crossover (who had been in the WWW group in phase I) showed a difference of 0.75 ± 1.0 categories between RFST and WCST performance, similar to the level of improvement seen in the WRW group in phase I. In contrast, patients exposed to the WWW sequences during crossover performed 0.10 ± 1.6 categories less well on second, than first, WCST administration. When the initial and cross-over groups were pooled on a repeat measures MANOVA, mean difference in performance in RFST vs. WCST in WRW sequences was significantly greater than the difference seen during two successive WCST administrations in the WWW sequence ($F=8.127$, $df=1, 48$, $P<0.01$). The difference in performance in RFST vs. WCST across the original and cross-over groups, 0.67 ± 0.9 categories, corresponding to a moderate-large effect size ($d=0.72$ sd units).

3.4 Phase III: Repeated RFST administrations—In order to assess potential additive beneficial effects of repeated RFST administrations, an additional cohort of 10 schizophrenia patients received 1 administration of the WCST, followed by 5 successive administrations of the RFST, followed by a final WCST administration over a 4-day period. Comparisons were made between mean RFST vs. initial WCST performance, as well between WCST performance following vs. preceding the RFST for categories completed (Figure 3), as well as additional WCST parameters (Table 3).

The comparison between the Day 1 WCST and the mean RFST performance was significant for categories completed ($t=2.87$, $df=1, 9$, $P=0.02$), with a trend noted for conceptual level responses ($t=2.11$, $df=1, 9$, $P=0.06$). When performance was compared between WCST following vs. preceding RFST administration, significant improvement was seen in categories completed (0.80 ± 0.9 categories, $t=2.75$, $df=1, 9$, $P=0.02$), total correct ($t=2.90$, $df=1, 9$, $P=0.02$)

and conceptual level responses ($t=2.24$, $df=1, 9$, $P=0.05$). The improvement in categories corresponds to a large effect size ($d=0.87$ sd units).

4. Discussion

Impaired WCST performance is one of the most consistent findings in schizophrenia (Laws, 1999; Harvey et al., 2005). Many studies have explored the consequences of manipulation of feedback on subsequent task performance, with general good effect. The principal finding of the present study is that patients with schizophrenia can also perform significantly better on an adaptation of the task, the RFST, in which the nature of the stimuli is modified but the form of the task and the nature of the feedback is left unchanged. In this study, we modified the WCST by using stimuli (faces) that we felt would be more familiar and tractable for patients than the abstract shapes used in the base version. In a sample of patients receiving consecutive administrations of the WCST and our modified version (the RFST), we demonstrated an improvement of 0.63 ± 0.9 categories ($d=0.66$), as well as significant increases in total correct and conceptual level responses. In contrast, patients receiving sequential administrations of the WCST did not show improvement, suggesting that better performance on the RFST vs. WCST was not due to repetition effects. In addition to showing significantly better performance on the RFST vs. WCST during first-time exposure, patients also showed significant cumulative gains during repeat exposure, suggesting possible approaches for stimulus-based remediation.

The present study differs from prior WCST modification studies in that alterations were made to the stimuli, rather than the feedback rules. Thus, as in the base WCST the only feedback that patients received was “correct” or “incorrect,” and they had to infer sorting rules and categorical shifts based upon this feedback. Our modification was intended to decrease the level of abstraction of the stimuli used in the test. Although it is unknown why our patients performed better on the RFST than the WCST, we propose that a change in abstraction was the key factor driving improvement.

Our theory is that the familiarity issue is most important to explain differential effects of our task manipulation – i.e. people routinely and (almost) automatically characterize people by age, gender and hair color, so that using stimuli that tap into this well rehearsed ability allows patients to comprehend the formal aspects of the task (i.e. extract rule from feedback, switch rule following change in feedback). Patients appear to have an easier time making use of the sorting rules when the potential alternative sorting operations are more familiar to them and thus were better able to conceptualize the task in the RFST condition than WCST condition. By conceptualize the task, we mean that patients were better able to say to themselves “I understand that there are 3 possible critical features on each card – Man/woman/boy/girl, yellow/red/brown/black hair, 1/2/3/4 stimuli - and my job, based upon feedback, is to figure out which is the correct dimension. Further, I understand that from time-to-time the rules change and that I must then determine which the new critical feature is.” Additionally, the salience of the facial stimuli may have increased interest and intrinsic motivation, which may have affected working memory throughout the task and improved performance, although extrinsic motivation, such as monetary reward, appears to minimally impact performance on the WCST (Bellack et al., 1990; Green et al., 1992; Hellman et al., 1998).

We also hypothesized that exposure to the RFST, since it was easier for patients than the WCST but included similar rules, might lead to subsequent improvement on the WCST itself, as previous efforts at remediation have (Kurtz et al., 2001). We tested this hypothesis by administering the RFST repeatedly (5 times) over 4 days between two administrations of the WCST. Patients showed significant incremental improvement during the RFST administrations, and also much improved performance on WCST following 4 administrations of the RFST compared to prior (0.80 ± 0.9 categories, $d=0.87$). Although these levels of

improvement are somewhat smaller than generated by explicit instruction (e.g., $d=1.08$, (Kurtz et al., 2001)), nevertheless they are noteworthy in that the overall form of the test remained unchanged.

As compared to the difference in RFST vs. WCST performance in patients, controls showed no significant difference in performance on the two tasks, leading to a significant group X test type interaction ($P=0.05$) when data were combined across first RFST and WCST administrations. This finding suggests that the change in visual stimuli was particularly helpful to patients, and that reduced ability to process the abstract nature of the visual stimuli may be rate limiting in terms of performance on this test. The significant immediate improvement that the controls demonstrated on a subsequent administration of the WCST is consistent with a documented ability of control subjects to benefit from repetition on the WCST (Basso et al., 2001). Whereas patients did not show improvement during 3 consecutive WCST administrations, they did show improvement during repeated RFST administrations. Furthermore, the degree of improvement in patients during repeated RFST administrations was similar to that observed in controls during the WRW sequence. Thus, although patients typically do not show improvement during repeated WCST administrations, the present study shows that plasticity might be possible given appropriate stimuli.

Because this was an initial, pilot study with this new task, many issues still need to be addressed. For example, it is unknown whether other types of stimulus modifications might have had led to even further beneficial effect. Our use of faces was based upon the concept that people, during everyday interaction, routinely characterize other individuals as to identity (i.e. whether they are men, women, girls or boys), and also according to common characteristics such as hair color (e.g. blond, brunette, redhead). However, patients with schizophrenia have a well-documented difficulty with at least some aspects of face recognition (Onitsuka et al., 2006; Silver et al., 2006), so that faces may not have been ideal. On the other hand, in the present study, which used stylized face cartoons rather than actual faces, patients appeared to have no difficulty in grasping the differences between faces. We also note that our slight modification in color to better conform to natural hair colors may have contributed to the differential in performance. In general, patients are not thought to show difficulty in color processing, although control studies to eliminate this possibility might be warranted.

A study (Mohlman, 2004) of non-psychotic patients with arachnophobia showed an impaired WCST performance by modifying the test to include spider pictures, suggesting that emotional aspects (e.g. fact that all subjects are smiling) might have contributed to the differential performance. If so, the need to engage individuals emotionally during task performance is also worth noting.

In the present study, repeated administration of the RFST led to progressive improvement in performance and carryover to a subsequent administration of the WCST. The choice of the number of repeats (5X) was based upon practical considerations and might, or might not, have led to maximal performance gains. Further, there was no control condition for this portion of the study. Future studies utilizing more repeats, and random assignment to experimental vs. control (e.g. repeat WCST) groups appears warranted. In some published WCST studies (Greig et al., 2007), interventions are applied repeatedly over weeks or months. It remains to be determined how performance would change over repeated intervention. Also in the present study, no objective indices of brain activity were obtained, that might have been informative regarding underlying locus of response. Finally, a recent study showed improvement on the WCST after a general cognitive training program. In the present study, no additional measures were obtained, so that generalizability of improvement, if present, will need to be evaluated in future studies.

In the present study, we did not find any significant difference in the number of perseverative errors in the RFST vs. WCST (phase I of study), or significant reduction in perseverative error rate following repeated RFST administration (phase II). It is unclear why this would be the case, as most studies (Kurtz et al., 2001) showing improvement in categories, also show improvement on perseverative errors. We speculate that the change in stimuli only led to an improved ability to infer the three categories, but did not correct deficits in cognitive flexibility that are also intrinsic to schizophrenia. If true, the present study suggests that substrates of impaired cognitive flexibility may be differentiable from substrates of impaired perceptual processing and that multilevel intervention may be preferable to intervention at either the cognitive or perceptual levels alone. Alternatively, other reviews (Laws, 1999) have suggested that the proportion of perseverative errors is minimal in comparison to deficits in categories completed and mean IQ. In the present study, although patients showed worse performance than controls across all measures, differences in perseverative error rate were less statistically robust than differences on other aspects of WCST performance.

In our study, all patients were receiving antipsychotic medication, which may have contributed to their impaired performance on the WCST. However, in general, medication effects on the WCST are small. Further, it is unclear why medication would favor performance on the RFST vs. performance on the WCST, or permit improvement during repeat RFST administration in the absence of improvement on repeat WCST administration.

In summary, level of functional disability is important in schizophrenia, and poor performance on the WCST has been associated with poor vocational function (Kurtz and Wexler, 2006). This study is suggestive that even abstract stimulus features (e.g. shape) add a greater level of complexity for patients than controls, and an important reminder to simplify visual, as well as verbal stimuli, when working with patients with schizophrenia. A concern in using WCST in persistently ill schizophrenia populations is that many subjects perform near or at floor (0–1 categories). In addition to suggesting potential remediation approaches, our initial data suggest also that the RFST may provide a version of the WCST that is more psychometrically appropriate for administration to chronic patients than the base version of the WCST itself. The present study is the first to demonstrate that alterations in the stimuli used in the WCST may lead to significant, differential between group performance increases, and progressive, large effect size performance improvements in schizophrenia. As such, it suggests that further studies investigating the neural bases and functional consequences of these improvements are warranted.

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Figure 1.
A comparison of the stimulus cards used. The top row shows the standard Wisconsin Card Sorting Test, and the bottom row shows the Rockland Face Sorting Test.

Figure 2. Change in Categories Completed Between Series

This figure denotes the change in categories completed between series 1 and 2 (A) and 1 and 3 (B). From left to right, the bars show the WRW patient group, the WWW patient group and the normative control WRW group. Error bars refer to standard error of the mean. In A, significant improvement (*) is noted between the WRW patient group and both the normative control and WWW groups. In B, significant improvement (*) is noted between the normative control group and the WWW group only.

Figure 3. Repeat RFST Performance

This figure denotes the change in categories completed between Day 1 (WCST) and the Mean RFST scores on Day 2, 3 and the final WCST on Day 4. Error bars refer to standard error of the mean. An upward trend with repeated exposure to the RFST is noted.

Table 1**Phase 1: Subject demographics**

	WRW (n=19)	WWW (n=15)	Controls (n=15)	Repeat RFST (n=10)^f	Only R (n=5)
Age	40.7±8.4	38.7±11.5	33.2±11.4	38.4±10	35.7±11.2
Male%	89%	87%	73%	100%	100%
Education	10.9±2.3	11.3±2.3	15.9±1.6	11.9±2.6	12.8±1.1
Inpatient%	53%	66%	N/A	40%	60%
IQ	95.3±11.7	93.2±13.8	111.5±8.2	95.8±8.4	97.2±6.7
BPRS total	35.8±10.5	35.1±7.9	N/A	39±9.6	N/A
SANS total	35.9±16.2	31.9±9.4	N/A	33.3±12.2	N/A

^f Including two patients from the WRW group.

Table 2

Table 2A: WCST performance for the WRW patient group.			
	WCST 1	RFST 1	WCST 2
Categories Completed	1.2±1.4	1.8±1.6 ^I	1.5±1.7
Total Correct	32.4±12	35.2±11.7	34.1±14.9
Conceptual Level Responses	21.5±15.3	25.6±15.6	24.9±19
Perseverative Errors	17.4±9.2	16.7±10.2	17.0±10.8

Table 2B: WCST performance for the WWW patient group^I			
	WCST 1	WCST 2	WCST 3
Categories Completed	1.2±1.1	1.1±1.4	1.1±1.4
Total Correct	32.1±11.1	32.5±11.7	30.2±10.5
Conceptual Level Responses	21±13.9	21.6±14.9	20.4±14
Perseverative Errors	18.2±11.2	20.1±11.9	21.7±14.5

Table 2C: WCST performance for the normative control group			
	WCST 1	RFST 1	WCST 2
Categories Completed	3.9±1.3	4.0±1.3	4.5±1.3 ^I
Total Correct	49.5±9.4	49.3±10	53.3±9
Conceptual Level Responses	45.9±12.9	46.3±13.4	49.8±12.6
Perseverative Errors	8.8±9.2	9.7±10	7.3±9.4

^I Significantly higher than WCST Series 1.

^I No significant differences during three repeats.

^I $P < 0.05$ vs. WCST 1

Table 3

Effect of repeat RFST administration on subsequent WCST performance

	Day 1 WCST	Mean RFST	Day 4 WCST ²
Categories Completed	2.1±1.5	2.9±1.5 ¹	2.7±1.3 ¹
Total Correct	39.9±11.3	44.5±6.3 ¹	44.9±10.0 ¹
Conceptual Level Responses	31.8±15.6	39.4±9.2 ¹	37.8±14.8 ¹
Perseverative Errors	14.4±11.2	10.8±3.8	10.9±6.3

¹ $P < 0.05$ vs. Day 1 WCST.² No significant differences with Mean RFST performance.