Using the Wisconsin Card Sorting Test to assess learning potential in normal IQ schizophrenia: Does it have potential?

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Background: Learning potential, a dynamic multi-administration approach to assessment, is claimed to predict functional outcome in schizophrenia better than traditional single-administration neuropsychological tests. Aims: This study investigates the relation between learning potential and clinical and demographic variables, social functioning and neuropsychological abilities in a sample of 30 participants with schizophrenia with a mean IQ score within the normal range (mean Wechsler Abbreviated Scale of Intelligence (WASI) IQ = 106). Methods: Two Wisconsin Card Sorting Test (WCST) based methods for assessing learning potential are compared. Results: The dimensional approach (calculation of gain scores following training) identified one aspect of executive functioning (set shifting) to be related to learning potential. Associations with other neuropsychological tests and social functioning were however limited. The categorical approach (separating high-achievers from learners and non-learners) was not sensitive within this normal IQ sample. Conclusions: Although there seems to be a relation between learning potential and some aspects of executive functioning, the two existing WCST methods should be used with caution when assessing learning potential in individuals with schizophrenia who have IQ scores within the normal range.

Learning potential, Neurocognition, Schizophrenia, Social functioning.

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Neurocognitive performance is an important predictor of functional outcome in schizophrenia (1–3). However, the ability to live independently, engage in work and function adequately in interpersonal relationships also requires other skills. It has been hypothesized that learning potential—or the ability to learn from feedback and instruction—mediates the relationship between basic neuropsychological and functional outcome (2). Learning potential in schizophrenia may have important implications for the choice of treatment. Because it is reasonable to believe that persons with limited learning potential will benefit from rehabilitation to a lesser extent (4), learning potential assessment could be used in a clinical setting to differentiate individuals who are to receive cognitive remediation from those who should be offered other treatments, such as for example cognitive adaptation (5).

In contrast to traditional neuropsychological testing with a single (static) administration, learning potential assessments are dynamic and measure the ability to learn by integrating interventions in the regular test administration. The Wisconsin Card Sorting Test (WCST; 6) has been used to investigate a number of different phenomena in schizophrenia research, such as for instance motivation or test effort (7). It has also been the preferred method to assess learning potential through a 64-card test–train-test version. The test is administered three times. The first (T1) and third (T3) trials are administered according to standard procedure. During the training administration (T2), the subject is given continuous feedback and instructions on how to perform the task. Learning potential corresponds to the difference between T1 and T3 performance. Persons with schizophrenia have been shown to differ in their ability to...
learn the principles behind the WCST (8). Whereas some understand the solution to the test during T1, others differ in their improvement from T1 to T3, reflecting different degrees of learning potential. An algorithm described in detail by Wiedl (8) has been the preferred method to classify individuals with schizophrenia based on WCST performance. In this algorithm, a T3 score for each individual is hypothesized and a confidence interval is calculated. If the actual T3 score falls above this confidence interval, true change (learning) is said to have taken place. Cut-offs have been defined as follows: a person who sorts at least 43 cards correctly on T1 (and T3) is a “high-achiever”. A person sorting less than 43 cards correctly on T1, but who ameliorates the score with at least 15 correctly sorted cards from T1 to T3, is considered a “learner”. Any individual not fitting either category is considered a “non-learner”.

As an alternative to this categorical approach, Sergi et al. (9) proposed a dimensional method of calculating gain scores by dividing actual gain from T1 to T3 by potential gain. Thus, instead of forcing subjects into one of three actuarially defined learning potential groups, each subject receives a score reflecting the actual improvement in performance following training.

Learning potential has been shown to predict the ability to learn problem-solving skills (8), the acquisition of work skills (9), vocational integration (10) and readiness for psychosocial rehabilitation (4). Woonings et al. (11) reported that change in WCST performance was related to baseline social functioning, but not to change in social functioning after a rehabilitation program. Participants with schizophrenia differing in learning potential status have also been shown to have distinct neurocognitive profiles with high-scorers and learners having better attention (12, 13) and verbal learning (12) than non-learners, high-scorers having better executive function, working memory, and fine motor speed scores than learners and non-learners (12), and learners outperforming non-learners on measures of verbal and working memory (14). Also, it has been reported that high-scorers have higher IQ than the other two groups (4, 12, 13). A recent study found learning potential in schizophrenia to be related to the neuronal integrity of the anterior cingulate cortex (15). Stuss et al. (16) have demonstrated that the use of similar verbal instructions to the ones used in learning potential research in schizophrenic improve the WCST performance of people with focal brain damage.

Although the number of studies on learning potential in schizophrenia is growing steadily, the methods used to measure the concept are not fully validated. Also, the utility of the concept is still uncertain. The potential of the WCST as the preferred method for assessing learning potential in normal IQ schizophrenia has not been investigated, and which of the two existing WCST methods best estimates learning potential remains to be seen.

Research seems to indicate that 20–40% of people with schizophrenia show no evidence of cognitive impairment when compared with normative data (17, 18). On the other hand, several studies have shown that when impairment classification is done ideographically, participants with schizophrenia who have normal IQ are not so “neuropsychologically normal” after all. Landro et al. (19) reported working memory deficits and impaired verbal and non-verbal performance in individuals with schizophrenia who had normal IQ and intact WCST scores. Allen et al. (20) showed that a normal IQ schizophrenia sample had deficits on specific neuropsychological tests when compared with normal IQ participants with milder psychiatric diagnoses or a medical condition not involving the central nervous system. Wilk et al. (21) found that a similar schizophrenia sample achieved a normal IQ through high scores on verbal comprehension and perceptual organization, and lower scores on tests loading on working memory or speeded processing. A disease-related fall from a higher-than-normal premorbid IQ-level can be hypothesized to have taken place.

Learning potential has not been investigated in participants with schizophrenia who have minor cognitive impairment or normal IQ. While such a sample can be expected to perform better than other samples, variability in learning potential is still expected since their neurocognition probably is impaired compared with premorbid level. The question then is whether the methods used so far are able to delineate the learning potential in individuals with normal IQ schizophrenia, or whether other, more sensitive methods should be searched for.

Aims of the study

The present study aims to examine how WCST learning potential relates to clinical and demographic background variables; to neurocognition; and to social functioning in a schizophrenia sample with IQ in the normal range; and secondly, to compare the two existing WCST learning potential assessment methods (categorical vs. dimensional).

Materials and methods

Participants

Thirty Caucasian subjects (20 males and 10 females) with a DSM-IV (22) diagnosis of schizophrenia were included in the study. All are participants in the Norwegian TOP (Thematic Organized Psychosis Research) study and were recruited to the current substudy on learning potential from psychiatric departments at Ullevål University Hospital in Oslo. Informed consent was signed by all participants, and the Regional Committee for Medical
Research Ethics and the Norwegian Data Inspectorate approved the study. The schizophrenia diagnosis was confirmed by the Structured Clinical Interview for DSM-IV Axis I disorders (23), which was administered by trained and reliable psychiatrists (kappa = 0.77). Exclusion criteria were traumatic brain injury or neurological disease, IQ below 70 and age below 18 or above 55. The reader is referred to Table 1 for information on the sample's demographic and clinical characteristics. All participants were using antipsychotic medication. One person received only first-generation antipsychotic medication, whereas two persons used a combination of first- and second-generation antipsychotic medication. Three individuals were using clonazepam in addition to second-generation antipsychotic medication. Of the whole sample, 29 used second-generation antipsychotic medication, whereas two persons used a combination of first- and second-generation antipsychotic medication. Of the whole sample, 29 used second-generation antipsychotic medication. Three individuals were using clonazepam in addition to second-generation antipsychotic medication. Approximately one third were using antidepressants.

Table 1. Demographic, clinical and neuropsychological characteristics and social functioning in participants with schizophrenia (n = 30).

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>31.5 (9.6)</td>
<td>20–55</td>
</tr>
<tr>
<td>Education</td>
<td>12.6 (2.3)</td>
<td>9–20</td>
</tr>
<tr>
<td>Gender (m/f)</td>
<td>20/10</td>
<td></td>
</tr>
<tr>
<td>WASI IQ</td>
<td>106.0 (11.5)</td>
<td>87–132</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clinical characteristics</th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of illness</td>
<td>6.3 (5.0)</td>
<td>1–24</td>
</tr>
<tr>
<td>PANSS positive</td>
<td>12.0 (3.8)</td>
<td>7–21</td>
</tr>
<tr>
<td>PANSS negative</td>
<td>15.3 (5.6)</td>
<td>7–28</td>
</tr>
<tr>
<td>PANSS total</td>
<td>55.3 (11.1)</td>
<td>30–76</td>
</tr>
<tr>
<td>GAF-s</td>
<td>48.2 (10.5)</td>
<td>24–67</td>
</tr>
<tr>
<td>GAF-f</td>
<td>46.4 (11.2)</td>
<td>28–78</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Neuropsychological tests raw scores</th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logical Memory*</td>
<td>18.2 (6.2)</td>
<td>6–31</td>
</tr>
<tr>
<td>Digit Span forwards</td>
<td>6.1 (1.1)</td>
<td>4–9</td>
</tr>
<tr>
<td>Digit Span backwards</td>
<td>4.7 (1.1)</td>
<td>3–8</td>
</tr>
<tr>
<td>Digit symbol</td>
<td>59.6 (14.6)</td>
<td>36–101</td>
</tr>
<tr>
<td>“Stroop”†</td>
<td>62.2 (18.1)</td>
<td>34–118</td>
</tr>
<tr>
<td>Category Fluency†</td>
<td>39.8 (11.3)</td>
<td>22–65</td>
</tr>
<tr>
<td>Category Switching†</td>
<td>11.8 (2.5)</td>
<td>7–16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Social functioning (SFS)</th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Withdrawal/so.c. engagement</td>
<td>105.9 (10.8)</td>
<td>84–124.5</td>
</tr>
<tr>
<td>Interpersonal communication</td>
<td>114.8 (19.6)</td>
<td>55–145</td>
</tr>
<tr>
<td>Independence-performance</td>
<td>107.4 (10.0)</td>
<td>79–127</td>
</tr>
<tr>
<td>Independence-competence</td>
<td>114.9 (12.7)</td>
<td>64–131</td>
</tr>
<tr>
<td>Recreation</td>
<td>112.0 (13.3)</td>
<td>84–140</td>
</tr>
<tr>
<td>Prosocial</td>
<td>112.4 (15.6)</td>
<td>65–133</td>
</tr>
<tr>
<td>Employment/occupation</td>
<td>107.0 (11.8)</td>
<td>81.5–122.5</td>
</tr>
</tbody>
</table>

s, standard deviation; WASI, Wechsler Abbreviated Scale of Intelligence; PANSS, Positive and Negative Syndrome Scale; GAF-f, Global Assessment of Functioning Function score; GAF-s, Global Assessment of Functioning Symptom score; SFS, Social Functioning Scale. *Delayed recall. †From the Delis–Kaplan Executive Function System.

Assessments

MEASURE OF LEARNING POTENTIAL

Learning potential was assessed with a manually administered 64-card test–train–test version of the WCST (6). T1 and T3 follow standard administration procedures. T2 is the training administration and follows the instructions described by Green et al. (24). The test administrator tells the subject about the sorting rules (“There are three ways to match the cards: you can match the card by color, by the number of objects on the card, or by shape”). After each correct answer, the person is told why it was right (“That’s right, we are matching to color”), and after each wrong answer the alternatives (“That was wrong, so we are not matching to the number of objects, we must be matching to color or shape”). After 10 consecutively correctly sorted cards, the subject is informed of the rule change (“After you get 10 correct in a row, the rule changes; you are no longer matching to color, you must be matching to the number of objects or to the shape”). Number of categories correctly sorted, number of correct responses and number of perseverative responses on the WCST are reported. The difference between T1 and T3 is the measure of learning potential.

INTELLECTUAL MEASURE

IQ was assessed with the Wechsler Abbreviated Scale of Intelligence (WASI; 25). Mean current IQ was 106.0 (range: 87–132; standard deviation, s = 11.5). Although this is a broad range, the group as a whole can still be considered a normal IQ sample because their average score is within the normal range. Elsewhere we have reported on the current sample’s minor cognitive (26) and social cognitive impairment (27).

NEUROPSYCHOLOGICAL TEST BATTERY

We chose tests from the domains that have been shown to be central to schizophrenia (28). As a measure of verbal memory Logical Memory from the Wechsler Memory Scale (WMS-III; 29) was included. The number of story units correctly recalled after the 30-min delay is the score reported. Attention was assessed with the Digit Span Forwards and working memory with Digit Span Backwards from the Wechsler Adult Intelligence Scale (WAIS-III; 30). Psychomotor speed was measured with the Digit Symbol from the WAIS-III. As measures of executive functioning, tests from the Delis–Kaplan Executive Function System (D-KEFS; 31) were administered. From the Color-Word Inhibition test, we used the “Stroop” condition, i.e. the third subtest where the person is instructed to name the color of the ink of color words that are written in ink of a different color. From the Verbal Fluency test we report scores for Category Fluency (Animals and Boys’ Names), and for Category Switching where the person is instructed to shift between...
naming as many items of fruits and furniture as possible within 60 s. By choosing these three tests different aspects of the executive domain is covered: inhibition of behavior (the “Stroop” task), initiation of behavior (Category Fluency) and set shifting (Category Switching).

In order to be able to compare the neuropsychological test scores on the same scale, they were converted to z-scores using the distribution of the current sample. Thereafter, they were collapsed into one neuropsychological variable.

**Measure of Social Functioning**

To assess social functioning we chose the Social Functioning Scale (SFS; 32), a self-rating instrument of everyday functioning developed for individuals with schizophrenia. It consists of seven subscales (mean = 100, s = 15). The scale was translated to Norwegian by the first and second author and has been accepted as the official Norwegian version of the SFS (www.qolid.org). This specific measure of social functioning was chosen because of its extensive use within the research field. A composite, average score for all seven scales was computed.

The scores for the whole sample on all measures are presented in Table 1. Because of the challenges in applying US norms on a Norwegian sample, raw scores are reported for neuropsychological tests.

**Statistical analyses**

The Statistical Package for the Social Sciences (SPSS for Windows, version 14.0; SPSS Inc., Chicago, IL) was used for statistical analyses. Improvement in WCST performance from T1 to T3 was analyzed with paired samples t-tests.

First, we calculated gain scores by dividing actual gain from T1 to T3 by potential gain, using the following formula: Gain score = (T3−T1)/(T1−T2). Sorting 58 cards correctly was considered perfect performance, since six errors are expected because of the maximum six rule-changes that can occur on a 64-card WCST version. In four separate standard regression analyses, the following associations were examined: 1) the impact of demographic (age, education, IQ) variables (entered together in a single block as independent variables) on learning potential (WCST gain score entered as the dependent variable); 2) the impact of clinical (GAF, PANSS, duration of illness) variables (entered together in a single block as independent variables) on learning potential; 3) the impact of neurocognition (the composite neuropsychological score entered as the independent variable) on learning potential; and 4) the impact of learning potential (independent variable) on social functioning (the composite SFS score entered as the dependent variable). Thus, four different and separate regression models were tested. Models that revealed significant associations were explored further through bivariate correlations (Pearson’s r) investigating the relationship between each of the variables from the significant model and learning potential (WCST gain score). This approach, examining overall models before moving on to more detailed models, was chosen in order to limit the number of comparisons; thus reducing the risk of producing Type I errors. The direction of the four original regression models is based on a theoretical understanding of the interrelations between the phenomena in question. This line of research assumes that learning potential is a mediator between neurocognition and functional outcome (2) with clinical variables considered background variables along with demographic information. This is the reason why learning potential was considered an independent variable only in the regression analysis that investigated the association with social functioning.

Second, in accordance with the algorithm described by Wiedl (8), persons were classified as high-achievers, learners or non-learners.

**Results**

Scores on the three WCST trials are presented in Table 2. The sample’s performance improved significantly from T1 to T3 on all three measures. In all, 22 individuals improved their performance from T1 to T3.

**Dimensional approach**

The group’s mean gain score was 0.4 (s = 1.11), ranging from −0.3 to 2.5 (range = 5.5) with a median of 0.7. Neither the three demographic (r = 0.29, adjusted $R^2 = −0.03$, $P = 0.523$) nor the four clinical ($r = 0.18$, adjusted $R^2 = −0.17$, $P = 0.972$) background variables had

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**Table 2.** Performance on the Wisconsin Card Sorting Test in participants with schizophrenia (n = 30).

<table>
<thead>
<tr>
<th></th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T1−T3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (s)</td>
<td>M (s)</td>
<td>M (s)</td>
<td>t (df =29)</td>
</tr>
<tr>
<td>Categories</td>
<td>3.5 (1.4)</td>
<td>5.3 (0.8)</td>
<td>4.4 (0.9)</td>
<td>3.32</td>
</tr>
<tr>
<td>Correct responses</td>
<td>48.3 (8.0)</td>
<td>59.7 (2.9)</td>
<td>54.4 (5.8)</td>
<td>3.73</td>
</tr>
<tr>
<td>Perseverative responses</td>
<td>8.5 (4.8)</td>
<td>1.1 (2.0)</td>
<td>4.5 (3.1)</td>
<td>4.16</td>
</tr>
</tbody>
</table>

s, standard deviation.
substantial impact on the sample’s learning potential. The composite score for the seven neuropsychological tests ($r = 0.37$, adjusted $R^2 = 0.10$, $P = 0.047$) demonstrated a substantial impact on learning potential. Therefore, this was studied further by way of bivariate correlations between each neuropsychological test score and learning potential (Table 3). Only Category Switching was significantly associated with learning potential ($r = 0.47$, $P = 0.008$), explaining about 20% of the variance. Learning potential had no impact on social functioning in the sample ($r = 0.13$, adjusted $R^2 = -0.02$, $P = 0.496$).

**Categorical approach**

In line with the algorithm, two subjects were classified as non-learners, five as learners, and the remaining 23 individuals as high-achievers. Because of the small number of non-learners and learners, no statistical analyses for group differences were conducted. The scores, however, indicated that the non-learners probably belong to a different subgroup with poorer neurocognitive performance.

**Discussion**

This study compared the categorical and the dimensional methods of assessing learning potential with the WCST in a schizophrenia group with normal IQ. We found the dimensional method using gain scores to be more sensitive than the categorical approach. The sensitivity of the dimensional method is implied since executive functioning significantly predicted WCST gain scores. In this sample, however, the categorical WCST algorithm yielded only two non-learners (6.7%). This is in stark contrast to other studies that have used the same algorithm, where this group has consisted of 17.5–68% of the sample (4, 8, 11, 13). Our study had 16.7% learners (20–82.5% in previous studies) and 76.7% high-achievers (0–38% in the other studies). This indicates that the categorical approach using the existing algorithm has limited sensitivity in a normal IQ sample.

### Table 3. Follow-up bivariate correlations between neuropsychological test scores and Wisconsin Card Sorting Test (WCST) learning potential (gain score).

<table>
<thead>
<tr>
<th>Neuropsychological test</th>
<th>WCST learning potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logical Memory*</td>
<td>$0.25$</td>
</tr>
<tr>
<td>Digit Span forwards</td>
<td>$0.26$</td>
</tr>
<tr>
<td>Digit Span backwards</td>
<td>$0.08$</td>
</tr>
<tr>
<td>Digit symbol</td>
<td>$0.21$</td>
</tr>
<tr>
<td>&quot;Stroop&quot;†</td>
<td>$-0.14$</td>
</tr>
<tr>
<td>Category Fluency†</td>
<td>$0.29$</td>
</tr>
<tr>
<td>Category Switching†</td>
<td>$0.47$</td>
</tr>
</tbody>
</table>

*Delayed recall.
†From the Delis–Kaplan Executive Function System.

Whether another algorithm would be more useful remains uncertain and is beyond the scope of this paper.

Our study group is different from other learning potential samples in the research literature. Many of the previous studies have been conducted in state hospitals and within the VA system in the USA, which possibly treat a more severely ill sub-sample of individuals with schizophrenia than we do. In addition to having a higher IQ compared with other learning potential studies (4, 12), our sample has a lower psychotic symptom load (4), a shorter duration of illness (9, 11–13), and receive less support from mental health services than other samples. However, our sample of schizophrenia subjects closely matches the population of individuals with schizophrenia referred for treatment in Norway (33). Thus, the demographic and clinical characteristics of our Norwegian sample are believed to account for the preponderance of high-achievers and low number of non-learners.

By forcing subjects into categories on what is really a continuous measure, important information is lost. Variability in learning potential may still exist as a characteristic of the individual’s way of functioning, but a different assessment technique may be required to capture it, and indeed, the dimensional gain score showed more sensitivity than the categorical approach, as it was significantly associated with executive functioning among the neuropsychological test scores. Perhaps not surprisingly, the test in question was the set shifting measure (Category Switching), one of the aspects that are assessed in the regular administration of the WCST. Thus, our study gave some support to the notion that learning potential assessed with the WCST is associated with neurocognition, and more so than with clinical and demographic information. On the other hand, learning potential was not found to be associated with social functioning. This would have constituted support for the clinical utility of this method in normal IQ schizophrenia. Our measure of social functioning is based on self-report, and we cannot rule out that this has compromised the validity of the scores. Utilizing objective measures of functional level would bypass this problem. However, in spite of this, and because the associations between WCST learning potential and the studied variables are limited, even with neurocognition, we encourage the search for other and more sensitive methods to assess learning potential in normal IQ schizophrenia. In another study (34), we have presented preliminary results indicating that the California Verbal Learning Test (35) could be one such alternative approach.

One obvious limitation of the study is the small number of subjects, and a possible argument for the few significant associations is an underpowered study. However, the scores on the initial trial of the WCST are within normal limits, thus limiting how large the gain
score could be. This is confirmed by the low gain score in our sample. Consequently, a ceiling effect for the gain score is expected. Therefore, it is not surprising that the associations with clinical and demographic background variables, neurocognition and social functioning were limited.

Based on our findings, we believe that both WCST methods described may be too easy to estimate learning potential in a normal IQ schizophrenia sample. Although the WCST is sensitive to frontal brain damage (36), as a measure of executive functioning it has been criticized for loading heavily on general intelligence (37). This could be one explanation for why the WCST does not differentiate learning potential well in participants with normal IQ. Future studies should search for alternative, more sensitive learning potential assessment methods that to a lesser extent load on general IQ.

To conclude, although there seems to be a relation between learning potential and some aspects of executive functioning, the two existing WCST methods should be used with caution when assessing learning potential in individuals with schizophrenia who have IQ scores within the normal range.

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