Cognitive impairment is now widely recognized as a central feature of schizophrenia (Heinrichs, 2005). Difficulties with attention, working memory and higher order executive functioning are prominent in this population (Forbes, Carrick, McIntosh, & Lawrie, 2008; Johnson-Selfridge & Zalewski, 2001; Lee & Park, 2005; Reichenberg & Harvey, 2007) and deficits in processing speed are especially pronounced (Knowles, David, & Reichenberg, 2010). In fact, patients perform 1.5 to 2.0 standard deviations below healthy controls on many tests of cognitive functioning (Keefe & Fenton, 2007).

Cognitive impairments in schizophrenia are posited to reflect an underlying neurological vulnerability to the illness since they precede illness onset, are stable over time, persist when symptoms begin to remit, and are associated with frontal and medial temporal lobe dysfunction (Albus et al., 2006; Erlenmeyer-Kimling et al., 2000; Hughes et al., 2002; Joyce & Huddy, 2004; Rund, 1998). Research has also shown that cognitive functioning is more accurate than neurobiology in distinguishing schizophrenia patients from healthy comparison subjects (Davidson & Heinrichs, 2003; Heinrichs, 2005). Furthermore, difficulties in neurocognition have important clinical implications. Cognitive deficits have been linked to poor quality of life, social functioning, and community outcome (Green, Kern, & Heaton, 2004; Williams et al., 2008). Given the pervasive and integral nature of cognitive impairments in schizophrenia, the continued refinement of methods used to quantify and qualify these deficits is necessary to advance the field.

The Wechsler Adult Intelligence Scale (WAIS) has been used extensively to study impairment across a range of cognitive domains in schizophrenia. However, cognitive performance among those with the illness has yet to be examined using the newest edition of this measure. Hence, the current study aims first, to provide WAIS-IV normative data for Canadian individuals with schizophrenia of low average intelligence; second, to examine schizophrenia performance on all WAIS-IV subtest, index and general intelligence scores relative to healthy comparison subjects; and third, to revalidate the pattern of impairment identified in this clinical group using the WAIS-III, where processing speed (PS) was most affected, followed by working memory (WM), perceptual reasoning (PR) and verbal comprehension (VC). The WAIS-IV was administered to outpatients with schizophrenia and their performance compared with age, gender, and education matched controls. WAIS-IV schizophrenia performance data are provided. Analyses revealed significant impairment on several tasks, including the new Cancellation subtest and the VC supplemental subtest, Comprehension. At the index score level, group differences in PS were significantly larger than those observed in all other cognitive domains. Impairments were also observed in WM amid relatively preserved performance in VC, thereby confirming the pattern of impairment identified using the WAIS-III.

Keywords

schizophrenia, cognition, Wechsler Adult Intelligence Scale, processing speed, working memory, verbal comprehension, cancellation

The Wechsler Adult Intelligence Scale (WAIS) is a comprehensive test of general intellectual ability comprising subtests spanning four domains of cognitive functioning, namely, verbal comprehension, perceptual reasoning, working memory, and processing speed (Wechsler, 2008). For more than four decades, the WAIS has been used extensively to examine cognitive ability in schizophrenia, with patients impaired relative to comparison subjects on most tasks (Allen et al., 1998; Dickinson & Coursey, 2002;
Dickinson, Iannone, & Gold, 2002; Gold et al., 1995; Jortner, 1970; Revheim et al., 2006). However, to our knowledge, the cognitive impairments affecting individuals with the illness have yet to be assessed using the latest edition of the Wechsler Adult Intelligence Scale, the WAIS-IV (Wechsler, 2008).

A number of revisions were made to enhance the WAIS-IV relative to its predecessors (Frazier, 2011). First, whereas the WAIS-III (Wechsler, 1997) collapsed tasks involving verbal and working memory into the Verbal IQ score, and tasks involving processing speed and perceptual organization into the Performance IQ score, the WAIS-IV omits the summary Verbal IQ and Performance IQ scores and places greater emphasis on the four distinct index-based measures previously confirmed by factor analysis (Bowden, Saklofske, & Weiss, 2011a; Dickinson et al., 2002; Dickinson, Iannone, Wilk, & Gold, 2004). Second, three new subtests, namely, Visual Puzzles, Figure Weights, and Cancellation, were added; and two others, Picture Arrangement and Object Assembly were eliminated (Hartman, 2009). Subtests used to derive the Perceptual Reasoning Index (PRI) were also changed. Whereas the WAIS-III Perceptual Organization Index was derived from Block Design, Matrix Reasoning, and Picture Completion, the core subtests of the analogous index measure in the WAIS-IV include the new Visual Puzzles task and omit Picture Completion, now deemed a supplemental subtest. In addition, adjustments to individual items and subtests were made in an attempt to improve clarity, decrease fine motor demands, reduce cultural biases, and decrease administration time (Frazier, 2011; Hartman, 2009). Discontinue rules, for example, were shortened for 4 of the 15 subtests, item illustrations were simplified and subtests which made use of similar sounding letters or numbers (e.g., P and B) were revised. Subtest instructions were also simplified and demonstration and sample items added. Finally, the WAIS-IV standardization sample was updated to reflect our aging and increasingly diverse population (Frazier, 2011; Hartman, 2009; Wechsler, Coakley, & Raiford, 2008). This has the added advantage of correcting for inflation to intelligence scores which occurs when dated norms are used (Flynn, 2009). As a result of these changes, the WAIS-IV boasts substantial improvement over its predecessors.

At present, schizophrenia norms for the WAIS-IV subtest, index, and general intelligence scores have not been reported in the literature, nor have they been examined alongside a comparable group of healthy individuals. Likewise, group data for the three new subtests of the WAIS-IV are lacking. Moreover, studies using earlier versions of the WAIS have demonstrated a particular pattern of cognitive impairment, with tasks involving processing speed yielding the largest group differences, followed by working memory and perceptual organization, amid relatively well-preserved performance on subtests involving verbal knowledge (Allen et al., 1998; Chen & Yao, 2009; Dickinson & Coursey, 2002; Dickinson et al., 2002; Dickinson et al., 2004; Gold, Queen, Iannone, & Buchanan, 1999; Goldberg & Gold, 1995; G. Goldstein, Beers, & Shemansky, 1996; Lezak, 1995; Nestor, Kubicki, et al., 2010; Nestor, Niznikiewicz, & McCarley, 2010; Nuechterlein et al., 2004; Psychological Corporation, 1997). It is not yet known whether this pattern of cognitive impairment will be equally robust when performance is assessed using the WAIS-IV.

In addition, seldom have neuropsychological studies in schizophrenia simultaneously matched control and clinical groups on a number of key demographic variables known to affect cognition. Gender is one such factor. Sexual dimorphisms have been noted across cognitive domains in disordered and nondisordered populations alike, with women generally outperforming their male counterparts on tasks of language and memory, and men demonstrating an advantage on tasks that draw on spatial abilities (Beatty, Mold, & Gontkovsky, 2003; Feingold, 1993; J. M. Goldstein et al., 1998; Halari, Mehrrota, Sharma, Ng, & Kumari, 2006; Hoff, Riordan, O’Donnell, & DeLisi, 1991; Maylor et al., 2007; Sota & Heinrichs, 2003). Furthermore, some research suggests that relative to healthy comparison subjects, cognitive impairments are more pronounced among men with schizophrenia than among women, indicating that gender may also interact with group membership to affect cognition (Heinrichs & Zakzanis, 1998; Sota & Heinrichs, 2003). Educational achievement is yet another variable to consider (Stratta, Prosperini, Daneluzzo, Bustini, & Rossi, 2001), with years of education accounting for a significant proportion of the variance in neuropsychological test performance (G. Goldstein, Zubin, & Pogue-Geile, 1991; Gontkovsky, Mold, & Beatty, 2002). This relationship is especially important to be mindful of in schizophrenia, since most affected individuals achieve no more than a high school education (Heinrichs, 2005; Heinrichs & Zakzanis, 1998; Jones, Guth, Lewis, & Murray, 1994). Finally, age has also been associated with cognition (Jeste, Wolkowitz, & Palmer, 2011). These findings underscore the importance of closely matching, or otherwise controlling, for gender, education, and age when examining WAIS-IV cognitive performance in schizophrenia relative to controls. If not, observed between-group differences risk being an artifact of variations in group demographics rather than a reflection of true cognitive impairment in the clinical group.

Hence, in the current study, WAIS-IV cognitive performance was examined in a sample of outpatients with schizophrenia or schizoaffective disorder relative to healthy control participants individually matched for age, gender, and education. Study goals were threefold: first, to provide mean group performance data for a Canadian reference sample of individuals with schizophrenia on each of the 15
subtests, four index scores and two general intelligence measures of the WAIS-IV; second, to assess schizophrenia performance on these scales relative to healthy comparison subjects; and third, to obtain data on the pattern of performance across the four cognitive domains identified by the WAIS-IV in the clinical group relative to controls. Consistent with previous research using the WAIS (Allen et al., 1998; Dickinson & Coursey, 2002; Dickinson et al., 2004; Gold et al., 1999; Nestor, Kubicki, et al., 2010; Nestor, Niznikiewicz, & McCarley, 2010; Psychological Corporation, 1997), we hypothesized that individuals with schizophrenia will demonstrate a differential pattern of performance wherein the PRI is least impaired, followed by the Working Memory Index (WMI) and finally, the Processing Speed Index (PSI) where the greatest impairments are expected (i.e., PRI > WMI > PSI). Since verbal comprehension is generally stable over time and relatively resistant to clinical illness (G. Goldstein et al., 1996; Lezak, 1995; Nuechterlein et al., 2004), we expected patients to evoke preserved performance on verbal tasks relative to controls.

**Method**

**Participants**

Data for 37 outpatients with schizophrenia or schizoaffective disorder and 185 healthy controls were collected for this study. Patients were recruited from the Hamilton Program for Schizophrenia, a community-based, case management and psychiatric rehabilitation program in Ontario, Canada. Flyers describing the study were posted at the location and individuals interested in participating were asked to communicate their interest via their case-workers. All clients were assessed using the Structured Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders, fourth edition, text revision (DSM-IV-TR SCID-I; First, Spitzer, Gibbon, & Williams, 2002) and met DSM-IV-TR criteria (American Psychiatric Association, 2000) for schizophrenia or schizoaffective disorder. Participants who presented with Cushing’s disease, mental retardation, or a comorbid substance use disorder, learning disorder, developmental disability, neurological disorder, or a thyroid or endocrine problem were excluded. Participants were also required to have normal or corrected-to-normal vision and hearing, as well as English as a first language.

Data for healthy controls were extracted from Pearson Assessment’s American standardization sample, which includes 800 examinees ranging from 16 to 90 years of age. Given limitations in collecting additional data for our clinical group, we chose to consider a larger subset of controls so as to improve statistical power. Guided by Grimes and Schulz (2005), who note that increasing the number of controls to a ratio of 4:1 improves a study’s ability to detect existing differences, whereas increases beyond that ratio do little to improve power, we considered a control sample five times the size of our schizophrenia group. Each participant with schizophrenia was individually matched to five individuals from the standardization sample who were of the same gender, had attained the same level of education and who most closely approached the patient in age. This yielded a control sample of 185 participants. Information regarding exclusion criteria for the control sample can be found in the WAIS-IV Technical and Interpretive Manual (Wechsler et al., 2008). Table 1 provides the demographic characteristics of the study participants.

**Measures**

Structured Clinical Interview for DSM-IV-TR Axis I disorders—patient edition (SCID-I/P; First et al., 2002). The SCID is a semistructured interview that informs diagnostic decisions based on DSM-IV-TR criteria. The current study used the SCID-I/P, an adaptation of this measure designed specifically for use with individuals who have been identified as psychiatric patients.

Positive and Negative Syndrome Scale (Kay, Fiszbein, & Opler, 1987). The Positive and Negative Syndrome Scale is a widely used measure of symptom severity for patients with schizophrenia and other psychotic disorders. Following a semistructured interview, patients are rated on 30 symptom items which range in severity from 1 (absent) to 7 (extreme). Items can be categorized into three dimensions, namely positive symptoms, negative symptoms, and general symptoms.

Wechsler Adult Intelligence Scale—fourth edition (Wechsler, 2008). The WAIS-IV is a comprehensive test of intellectual functioning. It consists of 10 core and 5 supplemental subtests. Raw subtest scores are converted into scaled scores corrected for age group. Subtest scaled scores are standardized to a mean of 10, with one standard deviation reflected in three point increments.

Subtests measuring similar aspects of cognitive ability are combined to derive one of four index scores: Verbal Comprehension (VCI; Similarities, Vocabulary, and Information), Perceptual Reasoning (PRI; Block Design, Matrix Reasoning, and Visual Puzzles), Working Memory (WMI; Digit Span and Arithmetic), and Processing Speed (PSI; Symbol Search and Coding). Supplemental subtests associated with these indices are Comprehension (VCI), Figure Weights and Picture Completion (PRI), Letter–Number Sequencing (WMI), and Cancellation (PSI). These are meant to replace a core subtest when performance on the latter has been compromised because of factors unrelated to the participant or task in question. For example, a participant’s Arithmetic score may not be reflective of his or her true ability if during the administration of the test, he or she was distracted by loud noises (Lichtenberger & Kaufman,
Table 1. Demographic Characteristics.

<table>
<thead>
<tr>
<th></th>
<th>Schizophrenia</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>37</td>
<td>185</td>
</tr>
<tr>
<td>Sex male, n (%)</td>
<td>25 (67.6)</td>
<td>125 (67.6)</td>
</tr>
<tr>
<td>Age in years (mean ± SD)*</td>
<td>45.08 ± 7.83</td>
<td>44.49 ± 9.63</td>
</tr>
<tr>
<td>Education in years, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-11 (Did not graduate from high school)</td>
<td>9 (24.3)</td>
<td>45 (24.3)</td>
</tr>
<tr>
<td>12 (High school graduate or equivalent)</td>
<td>16 (43.2)</td>
<td>80 (43.2)</td>
</tr>
<tr>
<td>13-15 (Some postsecondary)</td>
<td>6 (16.2)</td>
<td>30 (16.2)</td>
</tr>
<tr>
<td>16 or More (completed postsecondary degree or more)</td>
<td>6 (16.2)</td>
<td>30 (16.2)</td>
</tr>
<tr>
<td>Ethnicity, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>34 (91.89)</td>
<td></td>
</tr>
<tr>
<td>Non-Caucasian</td>
<td>2 (5.41)</td>
<td></td>
</tr>
<tr>
<td>Undisclosed</td>
<td>1 (2.70)</td>
<td></td>
</tr>
<tr>
<td>Clinical diagnosis, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schizophrenia</td>
<td>33 (89.19)</td>
<td></td>
</tr>
<tr>
<td>Schizoaffective disorder</td>
<td>4 (10.81)</td>
<td></td>
</tr>
<tr>
<td>Age at onset of illness in years (mean ± SD)</td>
<td>20.31 ± 3.98</td>
<td></td>
</tr>
<tr>
<td>Duration of illness in years (mean ± SD)</td>
<td>24.71 ± 8.27</td>
<td></td>
</tr>
<tr>
<td>PANSS score$^b$ (mean ± SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>18.14 ± 5.11</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>15.92 ± 5.19</td>
<td></td>
</tr>
<tr>
<td>General</td>
<td>31.95 ± 7.35</td>
<td></td>
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<tr>
<td>Antipsychotics, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taking typical or first-generation antipsychotics</td>
<td>6 (16.2)</td>
<td></td>
</tr>
<tr>
<td>Taking atypical or second-generation antipsychotics</td>
<td>28 (75.68)</td>
<td></td>
</tr>
<tr>
<td>Taking a combination of typical and atypical antipsychotics</td>
<td>2 (5.41)</td>
<td></td>
</tr>
<tr>
<td>Not taking any antipsychotic medication</td>
<td>1 (2.70)</td>
<td></td>
</tr>
<tr>
<td>Dosage in mg/day$^c$ (mean ± SD)</td>
<td>14.16 ± 10.07</td>
<td></td>
</tr>
</tbody>
</table>

Note. PANSS = Positive and Negative Syndrome Scale.

2009). In this instance, the test administrator could use the Letter–Number Sequencing score instead of the Arithmetic score to calculate the WMI for this participant.

All core subtest scores contribute to the determination of the Full Scale IQ (FSIQ), whereas the General Ability Index (GAI) is composed of the six VCI and PRI core subtest scores alone. All four index scores, in addition to the FSIQ and GAI, are standardized to a mean of 100, with one standard deviation reflected in 15-point increments.

**Procedure**

This research protocol was approved by the Ethics Review Board and the Human Participants Review Sub-Committee at York University. It also conforms to the standards of the Canadian Tri-Council research ethics guidelines.

Prior to beginning the study, participants were thoroughly briefed on the research protocol and intent, and written informed consent was obtained. Participants in our clinical group were assessed on two occasions and were provided remuneration for their time. During the initial assessment, chart reviews and brief semistructured interviews were carried out to gather relevant demographic and clinical information. This included the participant’s age, date of birth, education level, ethnicity, formal diagnosis, age at onset of illness, and a list of his or her prescribed medications. Comorbid psychiatric condition(s) were also noted. The SCID-I/P was then administered to confirm a diagnosis of schizophrenia or schizoaffective disorder and participants’ symptoms were assessed using the Positive and Negative Syndrome Scale rating measure. During a second meeting, participants completed the core and supplemental subtests of the WAIS-IV.

**Data Analysis**

Scaled scores. Data for this study were collected as part of a larger examination of a new measure of social perception developed by Pearson Assessment, for which only American standardization information is presently available. This has two noteworthy and related implications for the current study. First, since funding was awarded for the express purpose of providing remuneration to patients, control data were extracted from the WAIS-IV American standardization sample and as such, our Canadian clinical group was compared with an American control population. Second, WAIS-IV cognitive raw scores for our schizophrenia sample were converted into subtest and index scaled scores using American norms so as to maintain consistency in the derivation of clinical and control group data used in our analyses. Note, scaled scores for the schizophrenia group were also derived using Canadian norms, and are provided as a reference in Table 2 since Canadian population norms for this clinical group have not yet been published in the literature.

Although using American norms to derive scaled scores for the schizophrenia group introduces a potential bias, findings generated in this manner are argued to be conservative. Research suggests that on average, Canadians score slightly higher on the WAIS-IV than Americans do (Bowden et al., 2011a, 2011b). For example, mean raw score
performance on the Block Design task is approximately 41 for Canadians and 34 for Americans. However, when developing standardization data for each population, mean subtest raw scores are independently set to a scaled score of 10 (i.e., in the example above, both raw scores would convert to a scaled score of 10 using the appropriate norms). Conversely, raw scores typically convert into higher scaled scores when Americans norms are used resulting in a slight overestimate in performance relative to a Canadian reference sample (see Table 2). Therefore, the chances of finding mean differences between the patient and control groups in this study are reduced, and any significant group differences which are observed are likely reflective of legitimate cognitive impairment in the schizophrenia group.

**WAIS-IV performance and group differences.** Mean group scaled scores were calculated for each of the 15 subtests, four index scores, and two general intelligence measures of the WAIS-IV. Scaled scores derived using American norms were used in the analyses that follow. The effect of group on the WAIS-IV subtest scores was examined using a multivariate analysis of variance (MANOVA). Post hoc univariate analyses of variance (ANOVAs) were then carried out to explicate between group differences on each of these scales. Group differences on the index and global cognitive scores were also assessed using univariate ANOVAs. Alpha levels were adjusted at each stage of the analysis using a Bonferroni correction. To evaluate the magnitude of the effect of group on each of the dependent variables, effect size calculations (Cohen’s $d$; Cohen, 1992) were undertaken by dividing the mean group difference by the pooled standard deviation for each of the scales.

To investigate the pattern of performance across groups on the VCI, PRI, WMI, and PSI, a multivariate approach to repeated measures analysis was used, followed by post hoc contrasts.

**Results**

**WAIS-IV Cognitive Profile in Schizophrenia**

WAIS-IV mean subtest, index, and general intelligence scaled scores derived using American and Canadian norms are presented in Table 2.
MANOVA was first used to assess whether schizophrenia group membership conferred an overall disadvantage on the 15 WAIS-IV subtests relative to mentally healthy controls. All assumptions were met and analyses revealed a main effect of group, $\Lambda = 0.72$, $F(15, 206) = 5.25$, $p < .001$. Results for the post hoc univariate ANOVAs are presented in Table 2 and illustrated in Figure 1. Mean differences for 5 of the 15 subtests were significant after adjusting the alpha level using a Bonferroni correction. The magnitudes of group differences on the Comprehension and Symbol Search subtests were in the medium range (Cohen’s $d = 0.56$ and 0.75, respectively). Large effect sizes were noted for the Picture Completion subtest (Cohen’s $d = 0.81$), as well as two of the three processing speed subtests: Cancellation and Coding (Cohen’s $d = 1.30$ and 0.88, respectively). Mean differences on the two new PRI subtests, Figure Weights, and Visual Puzzles, were not significant following a Bonferroni correction ($p = .029$ and $p = .035$, respectively). All scaled scores were normally distributed. However, the assumption of equality of variance was met for all but the Picture Completion variable. Hence, group differences on this subtest were further examined using post hoc independent samples $t$ tests (equal variances not assumed), as well as a Mann–Whitney nonparametric test. Results converged on both post hoc tests, demonstrating a significant between-group difference, $t(65.17) = 5.04$, $p < .001$; $U = 1998.50$, $z = -4.01$, $p < .001$.

Univariate ANOVAs were then carried out for each of the four index scores. All assumptions were met, and results were in keeping with our hypothesis. The schizophrenia group evinced a pattern of increasing impairment on the PRI, WMI, and PSI, with the PSI yielding large effect size differences across groups ($p < .001$, Cohen’s $d = 0.87$). Differences on the WMI were also significant ($p = .012$, Cohen’s $d = 0.42$), but the PRI only showed a trend toward impairment after adjusting for multiple comparisons ($p = .044$, Cohen’s $d = 0.36$). In contrast, patient performance on the VCI was comparable with controls ($p = .65$). Group differences on the WAIS-IV index scores are presented in Table 2 and depicted in Figure 2.

Between-group differences on the GAI and FSIQ were also assessed using univariate ANOVAs. Analyses revealed that schizophrenia group performance differed significantly from healthy comparisons on the FSIQ ($F = 7.42$, $p = .007$, Cohen’s $d = 0.47$) but not the GAI ($F = 1.99$, $p = .160$, Cohen’s $d = 0.24$).

**Pattern of Performance on the WAIS-IV Index Scores**

A multivariate approach to repeated measures analysis was used to investigate the pattern of performance across cognitive domains in the schizophrenia group relative to controls. All assumptions were met, and analyses revealed a significant group-by-domain interaction, $\Lambda = 0.91$, $F(3, 218) = 6.84$, $p < .001$. Follow-up post hoc contrasts revealed that relative to controls, the degree of impairment on the PSI in the schizophrenia group was significantly larger than that observed on the VCI, PRI, and WMI, $F(1, 220) = 19.31$, $p < .001$; $F(1, 220) = 7.17$, $p = .008$; and $F(1, 220) = 3.90$, $p = .050$, respectively. Individuals with schizophrenia also performed more poorly on the WMI than they

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**Figure 1.** Group performance on WAIS-IV cognitive subtest scaled scores.  
*Note. Error bars indicate 95% confidence intervals. WAIS-IV = Wechsler Adult Intelligence Scale–fourth edition.  
*p < .003.*
did on the VCI, $F(1, 220) = 7.06, p = .008$. In contrast, group differences on the PRI did not differ significantly from those observed on the VCI and WMI, $F(1, 220) = 3.74, p = .054$ and $F(1, 220) = 0.35, p = .557$, respectively.

**Discussion**

The present study is the first to examine cognitive performance in schizophrenia using the latest edition of the WAIS. Results demonstrate that the WAIS-IV is sensitive to schizophrenia, with patients performing below demographically matched control participants on most subtests and index scores. Statistically significant impairments were evident on the processing speed and working memory summary indices, as well as 5 of the 15 subtests after applying a Bonferroni correction. In addition, schizophrenia patients showed the expected pattern of differential impairment across the four cognitive domains, as previously identified using the WAIS-III.

The introduction of new WAIS subtests has the potential to uncover subtle but important differential sensitivities, to which the clinician needs to be alert in case work. Three new subtests were added to the WAIS-IV. Although results are suggestive of a trend toward impairment on Visual Puzzles and Figure Weights, patients demonstrated greatest difficulty on the PSI supplemental subtest, Cancellation, a search task where subjects are asked to identify target objects of a particular shape and color from a visual display (McCrae & Robinson, 2011). In fact, effect size analyses revealed that the mean group difference on Cancellation surpassed that observed on all other WAIS-IV subtests, including Coding. This finding is interesting in light of recent meta-analytic work by Dickinson, Ramsey, and Gold (2007) that shows that impairments on Digit Symbol Coding are more substantial than those observed on all other neuro-psychological measures in the review, and may therefore reflect the single largest cognitive deficit in schizophrenia. Future research should examine WAIS-IV performance on both the Coding and Cancellation subtests, so as to determine whether the latter task is in fact a more sensitive measure of processing speed impairment in this population. This is especially important given that the mean scatter of scores derived using Canadian and American norms differed in this study, and as a result, individual subtest discrepancies may be more or less evident when norms from one country are used over another.

Also noteworthy is the variability in performance across subtests of a given domain. For instance, although performance on the core subtests of the VCI was relatively intact in the patient group, individuals with schizophrenia evinced significant impairment on the supplemental subtest of this index, namely Comprehension. A similar pattern of results has been noted using the WAIS-IV in other clinical groups as well (Holdnack, Goldstein, & Drozdick, 2011). Several items in this subtest rely on abstract reasoning. Participants may be asked, for example, to explain metaphors or the meaning of less well-known proverbs (Lichtenberger & Kaufman, 2009). This may be especially challenging for individuals who engage in ‘unusual and idiosyncratic’ thinking, which is often the case in schizophrenia.

These findings call attention to the potential implications of substituting core subtest scores with supplemental subtest
scores when working with individuals affected by schizophrenia. The supplemental VCI subtest, Comprehension, appears to be more challenging than the core VCI subtests for this population. Therefore, performance on this subtest may not be comparable to performance on Vocabulary, Similarities, and Information. Should clinicians use Comprehension to replace a spoiled core subtest in calculating the VCI, they should be aware that this may result in a lower index level score than expected. A similar argument may be made for the Cancellation subtest of the PSI. Further research directly assessing the impact of supplemental subtest substitution in the WAIS-IV across clinical and nonclinical groups is warranted, particularly since substantial variability in performance across core and supplemental subtests has not been observed in nonschizophrenia normative samples (see control group data Table 2; see also Bowden et al., 2011a, 2011b; Ryan & Glass, 2011).

Results from analyses examining the differential pattern of impairment across the four cognitive domains were consistent with previous literature (Allen et al., 1998; Chen & Yao, 2009; Dickinson & Coursey, 2002; Dickinson et al., 2002; Dickinson et al., 2004; Gold et al., 1999; Goldberg & Gold, 1995; G. Goldstein et al., 1996; Lezak, 1995; Nestor, Kubicki, et al., 2010; Nestor, Niznikiewicz, & McCarley, 2010; Nuechterlein et al., 2004; Psychological Corporation, 1997) and in line with our predictions. Individuals with schizophrenia evinced most impairment on the PSI relative to age, education, and gender-matched controls. Impairments were also noted on the WMI and a trend toward impairment was noted on the PRI. In contrast, preserved performance was observed on the VCI.

In keeping with meta-analytic work by Knowles et al. (2010), group differences on the PSI were especially notable. Effect sizes were in the large range, and between-group differences were significantly larger than those observed on all other index measures. Likewise, schizophrenia performance on the PSI subtests (Symbol Search, Coding, and Cancellation) was also indicative of substantial impairment, with effect sizes in the medium to large range.

Impaired functioning in the schizophrenia group was also apparent on the WAIS-IV WMI, and group differences here were significantly larger than those observed on the VCI. This is consistent with research in the field, which has repeatedly found that the short-term maintenance and manipulation of information in memory is an area of difficulty for this population (Forbes et al., 2008; Gold, Carpenter, Randolph, Goldberg, & Weinberg, 1997; Lee & Park, 2005). Although, mean differences on tasks associated with the WMI were not significant on their own, core WMI subtests certainly showed a trend toward impairment. In fact, group differences on Digit Span would have reached significance ($p = .007$) were it not for the strict application of a Bonferroni correction to control for the family-wise error rate (alpha required for statistical significance = .003). Performance differences on Arithmetic were more mild ($p = .074$), however, demonstrating variability in task performance across WMI subtests.

Still, effect size differences on the WMI and its subtests were smaller than anticipated. Whereas previous research using the WAIS-III working memory subtests and similar measures has yielded effects sizes in the medium to large range (Dickinson et al., 2007; Forbes et al., 2008; Lee & Park, 2005), small to medium effect sizes were noted in the current study. We offer a few potential explanations for this discrepancy. To begin, the clinical sample in the present study consisted of a group of outpatients with schizophrenia. Conversely, meta-analytic studies identifying medium to large effect size differences in working memory have collapsed data across inpatient and outpatient samples (see Forbes et al., 2008; Lee & Park, 2005). In addition, as part of the changes made to the WAIS-IV, a number of WMI subtest items were revised. For instance, WAIS-III Letter–Number Sequencing and Digit Span items that were deemed confusing (e.g., items that included similar sounding digits or letters), were adjusted or removed to improve task clarity in the WAIS-IV (Hartman, 2009). The Arithmetic subtest was also altered to decrease the emphasis on mathematical skills and the English measurement system. Together, these changes may have resulted in a slight decrease in the measure’s sensitivity to impairments in schizophrenia than was previously the case. Future concurrent validity research comparing WAIS-III and WAIS-IV WMI scores with other measures of working memory should clarify this discrepancy.

WAIS-IV PRI clinical group performance was comparable to previous literature using the WAIS-III in this population (Dickinson et al., 2002; Nestor, Kubicki, et al., 2010; Nestor, Niznikiewicz, & McCarley, 2010). Relative to controls, individuals with schizophrenia expressed greater difficulty in perceptual reasoning with group differences showing a trend toward significance after adjusting for the family-wise error rate.

However, mean performance differences on the PRI were not significantly larger than those observed on the VCI, where preserved performance was found. Findings here are not surprising. Previous literature supports the notion that tasks relying on perceptual organization skills are generally more difficult than tasks assessing verbal abilities in schizophrenia (Allen et al., 1998; Dickinson et al., 2004; Nuechterlein et al., 2004), as was noted in the present study. However, findings regarding the degree of impairment on Perceptual Reasoning tasks is mixed (Dickinson et al., 2007; Forbes et al., 2008; Lee & Park, 2005). In contrast, preserved performance across core and supplemental subtests has not been observed in nonschizophrenia normative samples (see control group data Table 2; see also Bowden et al., 2011a, 2011b; Ryan & Glass, 2011).
difficult to predict whether the index score would be more or less sensitive to perceptual reasoning impairments in our clinical group, relative to studies examining similar deficits using previous versions of the WAIS. Results of the present study indicate that omitting Picture Completion in favor of Visual Puzzles as a core PRI subtest may result in an index score that is less sensitive to impairment in schizophrenia. Of all the PRI subtests, Picture Completion appears to be the most challenging for individuals with the illness, with effect sizes in the large range (p < .001, Cohen’s d = 0.81). In contrast, our clinical group was less impaired on Visual Puzzles, a subtest which is new to the WAIS. Future research may attempt to assess the relative sensitivity of these measures to impairments in perceptual organization in schizophrenia.

In contrast to all other index measures, performance on the VCI was not different between groups, reflecting preserved verbal ability in our outpatient sample relative to demographically matched controls. This finding was expected since a majority of VCI subtest items draw on crystallized verbal knowledge (Dawes, Jeste, & Palmer, 2011), which is known to be relatively resilient to clinical illness and stable over time (Dickinson et al., 2002; Gold et al., 1999; Goldberg & Gold, 1995; G. Goldstein et al., 1996; Groth-Marnat, 2009; Nuechterlein et al., 2004). Mean VCI performance in our group was also comparable to prior research using the WAIS-III to assess cognition in schizophrenia (Dickinson et al., 2002; Nestor, Niznikiewicz, & McCarley, 2010).

Nevertheless, the finding of preserved verbal task performance in schizophrenia is a controversial one, with other research finding impairment on the Vocabulary, Similarities, and Information subtests of the WAIS (Dickinson et al., 2007). Variations in the way control and clinical groups are matched may partially explain this difference. It is not always the case, for instance that groups are matched on demographic variables known to affect cognitive performance. This is problematic when between-group differences along these variables are apparent. As an example, in many studies control participants are on average slightly more educated than individuals affected by schizophrenia (Dickinson et al., 2007), thereby conferring a disadvantage to patient groups as compared with controls on cognitive measures. In other research, participants are matched on parental level of education. Parents of individuals with schizophrenia typically achieve higher levels of education than their children whose academic pursuits are often interrupted by illness onset. Hence, matching on parental, and not participant, level of education may similarly result in increased performance discrepancies between schizophrenia and control groups. Continued research examining performance on VCI subtests between patients and demographically matched controls is needed to determine if, in fact, these measures are intact in schizophrenia.

In summary, the overall pattern of impairment observed across WAIS-IV index scores was in keeping with our hypothesis, with patients expressing most impairment on tasks of processing speed, and least impairment on tasks relying on verbal knowledge. It is likely that this pattern broadly characterizes schizophrenia as a diagnostic group. Findings of the present study provide a reference against which clinicians and researchers may compare WAIS-IV impairment patterns among people with schizophrenia, and may serve to complement more comprehensive clinical and cognitive assessments. Schizophrenia group scaled score performance derived using Canadian norms may also prove useful in discriminating meaningful impairment when individual performance on a particular subtest or index score is of interest.

However, clinicians are cautioned against applying the pattern of performance observed herein as some kind of definitive schizophrenia rubric. Significant variability in performance across cognitive domains exists between participants. Not all individuals with schizophrenia show greatest impairment on the PSI, for instance, and some express difficulty on verbal tasks. Similarly, some individuals with the illness appear cognitively unimpaired relative to comparable healthy subjects, scoring in the high average range across subtests. Furthermore, our sample consisted of a relatively high-functioning group of Canadian outpatients, and differences in the degree of impairment across scores are also likely affected by other factors, such as the severity of illness and geographic location. Therefore, clinicians are encouraged instead to use the current study’s findings as general guidelines for the idiographic interpretation of neurocognitive assessments.

Study limitations include a relatively small schizophrenia sample size. Future research should endeavor to collect larger samples, as this would allow for a more detailed examination of WAIS-IV cognitive performance than was possible here. The effect of ethnicity and antipsychotic dosage, for instance, which have previously been found to influence cognitive performance in this population (Knowles et al., 2010; Walker, Batchelor, & Shores, 2009) may be assessed if larger samples are available. Also, random selection of study participants was not possible. Samples were instead selected based on availability, affecting the generalizability of these findings. Additionally, future studies should endeavor to examine patient and control samples of the same nationality. This will likely result in greater between-group performance discrepancies for some subtests and index scores. Studies examining clinical and control groups matched on other variables of interest, such as socioeconomic status and parental level of education, may also provide new insights on WAIS-IV cognitive performance in schizophrenia.

Conclusions

The present study was the first to examine cognitive performance in a group of individuals with schizophrenia using the WAIS-IV (Wechsler, 2008). Results indicate that
relative to age-, gender-, and education level–matched controls, patients express difficulty on several WAIS-IV subtests and domains. They further suggest that the pattern of cognitive impairment identified in schizophrenia using the WAIS-III is robust and remains when cognitive ability is assessed using the WAIS-IV. Patient and control group performance was comparable on tasks relying on crystallized verbal knowledge. In contrast, the schizophrenia group performed below controls on measures of perceptual reasoning, working memory, and processing speed, with impairments on the latter being significantly larger than those observed on all other index measures. Similar cognitive profiles have been observed in other clinical groups including individuals with traumatic brain injury and Alzheimer’s disease, and may reflect a common underlying neuropathology (Wechsler et al., 2008). Findings may have implications for predicting functional competence and community independence in schizophrenia (Heinrichs, Ammari, Miles, & McDermid Vaz, 2010).

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