Demographic Analyses between Normative and Clinical Samples

Analyses of the demographic characteristics of the two groups indicated that the clinical group was older ($t = -2.691$, $df = 239$, $p < 0.008$) and less well educated ($t = 4.615$, $df = 235$, $p < 0.001$) than the normative group (Table 5.1). There were no significant group differences with respect to male/female ratios or handedness ($\chi^2 = 2.54$, $df = 1$, $p > 0.05$ and $\chi^2 = 2.77$, $df = 1$, $p > 0.05$ respectively). T-tests for gender differences in combined CANA and MMSE total scores revealed no significant findings for the CANA total score, but showed that female participants outperformed male participants on the MMSE total score ($t = -2.345$, $df = 154$, $p < 0.02$). When gender differences in total scores were further analyzed by group, only the normative group showed significantly better performance by female participants compared to male participants with respect to the MMSE total score ($t = -2.066$, $df = 35.55$, $p < 0.046$).

Pearson correlations between the CANA and MMSE total scores and age and education level are shown in Table 1. For the normative group, participants' age and education level correlate significantly with the total scores for the CANA and for the MMSE. In contrast, the CANA and MMSE total scores for the clinical group correlate significantly, but less strongly, with participants' age. Interestingly, there are no significant correlations with the clinical group's educational level.

Table 1 - Pearson Correlations between the CANA and MMSE Total Scores, Age and Education of Subjects

Groups	CANA	MMSE
Normative[a,b]		
score vs. age	-0.771	-0.535
score vs. education	0.614	0.563
Clinical[c,d,e,f]		
score vs. age	-0.357	-0.230
score vs. education	0.124	-0.050
Combined[g,h,i]		
score vs. age	-0.437	-0.329
score vs. education	0.397	0.187

[a]CANA $p < 0.001$, $n = 148$, [b]MMSE $p < 0.001$, $n = 70$, [c]CANA $p < 0.001$, $n = 93$, [d]CANA $p < 0.237$, $n = 93$
[e]MMSE $p < 0.0033$, $n = 86$, [f]MMSE $p < 0.648$, $n = 86$, [g]CANA $p < 0.001$, $n = 241$, [h]MMSE $p < 0.001$, $n = 156$, [i]MMSE $p < 0.02$, $n = 156$

Sensitivity and Specificity

Given the significant correlations between total score for the CANA Test or the MMSE and normative participants' age and education level, it was decided to conduct a regression analysis with total score (CANA or MMSE) as the dependent variable and age and education level as the independent variables using only the data for the normative group. Age and education adjusted standardized residual scores were obtained for both the normative and clinical groups using the regression equation computed from the normative group data. Indices for the CANA Test and MMSE total scores were used to compute sensitivity and specificity of the age and education adjusted standardized scores. A cut-off score of –1 standard deviation units (i.e., a T-score less than 40) was used to determine if a participant's score fell in the normative group or the clinical group (Heaton, Grant, & Matthews, 1991).

Table 2 shows indices for sensitivity and specificity for the CANA Test using age and education corrected standardized residual scores and selecting a cut-off score of –1 standard deviation units. Sensitivity is in the excellent range and specificity is in the very good range (Tape, 2001).

Table 2 – Sensitivity and Specificity of the CANA Test after Correcting for Age and Education Effects

Total Score	Patients	Controls	Totals
< -1 Standard Deviation	88 (a)	18 (b)	106
-1 Standard Deviation	5 (c)	130 (d)	135
Totals	93	148	241

Note: Sensitivity a/(a + c) = 88/93 = 94.62%
Specificity d/(b + d) = 130/148 = 87.84%

A Receiver Operating Characteristic (ROC) curve analysis offers a means of comparing the sensitivity/specificity of two tests applied to the same population. The areas under the ROC curves resulting from comparing the specificity and sensitivity of the CANA with the MMSE using the age and education adjusted total scores were 0.963 (standard error = 0.0152, $p<0.001$) and 0.758 (standard error = 0.0412, $p<0.001$) for the CANA and the MMSE respectively. Therefore, each test was significantly better than chance with respect to specificity and sensitivity. In addition, the ROC curve analysis indicates that the difference in sensitivity/specificity between the CANA and the MMSE is statistically significant (difference = 0.205, $p < 0.001$). Further, the ROC curve analyses provide the optimum cut-off score for the best combination of specificity and sensitivity for a given test.

Therefore, for the CANA Test, the cut-off score to optimize sensitivity/specificity is –1.22 (i.e., a T-score of 38), which yields a sensitivity of 94.2% and a specificity of 91.4%. Both indices are in the excellent range (Tape, 2001). The optimum cut-off score for the MMSE participants is –0.33 (i.e., a T-score of 47), yielding a sensitivity of 74.4% and a specificity of 78.6%. Likewise, the optimum cut-off score for the CANA using the data from both clinical and normative subjects was –1.40 (i.e., a T-score of 36), yielding a sensitivity of 93.2% and a specificity of 93.5%.

Reliability Coefficients

For the CANA Test, test-retest was not a viable option; therefore, the split-half analysis was performed. There were 49 individual test items that were divided into two half-tests using the odd/even method. This provided two nearly parallel forms with approximately equal variances. Then Spearman Brown Split-halves Reliability coefficient formulas were used in the analysis. Table 3 provides the reliability coefficients for the total normative sample (N = 148) and for each age group category.

Table 3 – Reliability Coefficients for the CANA Test by Age Group

Category	Reliability Coefficient
18 – 32 (N = 51)	.43
33 – 55 (N = 52)	.57
56 – 96 (N = 45)	.60
Total (N = 148)	.77

The strongest reliability coefficient was observed when all respondents were used ($r = .77$). This is an acceptable level of reliability (Pedhazur & Schmelkin, 1991). The low value in the 18 – 32 age group most likely was related to a significantly high level of no variance on certain test items. The conclusion is that the CANA Test is approaching reliable internal consistency.

Interscorer Reliability

Of the 49 test items in the CANA Test, all but five are scored in a straightforward and objective manner. That is, there are either right or wrong answers. The score is either 1 for correct or 0 for not correct. Thus, for these items, an interscorer reliability of 1.0 is assumed. The exceptions to this objectivity are Items 33, 34, & 35 in the Visuospatial Subscale and Items 36 and 37 in the Verbal Reasoning Subscale. These are the only items that require subjective analysis. For these items, interscorer reliability was further assessed.

There were a total of 90 cases (60 normative subjects and 30 clinical subjects) for each item. Reliability coefficients were obtained using Cronbach's coefficient alpha, which measures "internal consistency of items in a scale" Garson (1999) from which it can be seen that alpha measures true variance over total variance. According to J.C. Nunnelly (1978), the alpha of a scale should be greater than .70 for items to be considered reliable. Table 4 represents the interscorer reliability for normative, clinical, and combined subjects.

Table 4 – Interscorer Reliability Coefficients

Visuospatial Subscale	Normative (N = 60)	Clinical (N = 30)	Combined (N = 90)
Item 33 - Score Figure 10	.60	.93	.84
Item 34 - Score Figure 11	.77	.84	.86
Item 35 - Score Figure 12	.70	.62	.72

Verbal Reasoning Subscale	Normative (N = 60)	Clinical (N = 30)	Combined (N = 90)
Item 36 - Dog & Horse	.99	.97	.97
Item 37 - Insect & Plant	.96	.92	.95

Criterion Validity

The CANA Test has been correlated with the Mini-Mental State Exam (MMSE, Folstein, Folstein, & McHugh, 1975), the Barrow Neurological Institute's Screen for Higher Cerebral Function (BNIS, Prigatano, 1991), and VIQ, PIQ, and FSIQ from the Wechsler Adult Intelligence Test- Revised (WAIS-R, Wechsler, 1981). A portion (N = 70) of the normative sample group was administered both the CANA Test and the MMSE in alternating sequence. The following table summarizes the results of correlation studies between specific subscales of the CANA Test with the MMSE Total Score for normative subjects using the Pearson formula.

Table 5 – Correlation Coefficients between the CANA Test and the MMSE for Normative Sample (N=70)

CANA Test Subscale	MMSE Total Score
Language Subscale	.45**
Immediate Verbal Memory Subscale	.67**
Immediate Visual Memory Subscale	.58**
Orientation Subscale	.21
Attention Subscale	.46**
Visuospatial Subscale	.47**
Verbal Reasoning Subscale	.11
Visual Reasoning Subscale	.33**
Delayed Verbal Memory Subscale	.36**
Delayed Visual Memory Subscale	.31**
Verbal Quotient	.61**
Performance Quotient	.56**
Problem Solving Quotient	.51**
Total Cognitive Quotient	.66**

**Correlation is significant at the 0.01 level (2-tailed)

The next table summarizes the correlation coefficients between the CANA Test and the MMSE when evaluating a clinical sample of patients (N = 84). It should be noted that the overall correlation coefficients are very close to those for the normative sample.

Table 6 – Correlation Coefficients between the CANA Test and the MMSE for Clinical Sample (N=84)

CANA Test Subscale	MMSE Total Score
Language Subscale	.42**
Immediate Verbal Memory Subscale	.23*
Immediate Visual Memory Subscale	.52**
Orientation Subscale	.67**
Attention Subscale	.33**
Visuospatial Subscale	.42**
Verbal Reasoning Subscale	.16
Visual Reasoning Subscale	.33**
Delayed Verbal Memory Subscale	.48**
Delayed Visual Memory Subscale	.43**
Verbal Quotient	.64**
Performance Quotient	.52**
Problem Solving Quotient	.40**
Total Cognitive Quotient	.67**

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

The following table summarizes the results of correlation studies using Pearson's formula between the CANA Test subscale scores and Total Scores for the Barrows Neurological Institute Screen for Higher Cerebral Function (BNIS).

Table 7 – Correlation Coefficients between the CANA Test and the BNIS for Clinical Sample (N=43)

CANA Test Subscale	BNIS Total Score
Language Subscale	.30
Immediate Verbal Memory Subscale	.19
Immediate Visual Memory Subscale	.29
Orientation Subscale	.25
Attention Subscale	.53**
Visuospatial Subscale	.40**
Verbal Reasoning Subscale	-.16
Visual Reasoning Subscale	.31*
Delayed Verbal Memory Subscale	.46**
Delayed Visual Memory Subscale	.20
Verbal Quotient	.52**
Performance Quotient	.42**
Problem Solving Quotient	.39**
Total Cognitive Quotient	.53**

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

The following table summarizes the results of correlation studies using Pearson's formula between the CANA Test subscale scores and Verbal, Performance, and Full Scale Quotients for the Wechsler Adult Intelligence Scale – Revised (WAIS-R).

Table 8 – Correlation Coefficients between the CANA Test and the WAIS-R for Clinical Sample (N=17)

CANA Test Subscale	VIQ	PIQ	FSIQ
Language Subscale	.54*	.15	.42
Immediate Verbal Memory Subscale	.05	.08	.10
Immediate Visual Memory Subscale	.22	.06	.19
Orientation Subscale	-.13	.44	.13
Attention Subscale	.28	.39	.39
Visuospatial Subscale	.21	.61**	.44
Verbal Reasoning Subscale	.20	.14	.20
Visual Reasoning Subscale	-.06	.48	.22
Delayed Verbal Memory Subscale	.10	.07	.11
Delayed Visual Memory Subscale	.03	.31	.19
Verbal Quotient	.42	.46	.51*
Performance Quotient	.07	.62**	.37
Problem Solving Quotient	.21	.43	.37
Total Cognitive Quotient	.26	.60**	.48**

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).