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Differential Performance of Traumatic Brain Injury Subjects and Non-Brain-Injured Peers on Cognitive Tasks

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The *Scales of Cognitive Ability for Traumatic Brain Injury* (SCATBI) (Adamovich & Henderson, 1992) is a test designed to assess cognitive-linguistic status after closed head injury (CHI) and to describe the extent of changes during and following rehabilitation. This test measures performance on five scales, each representing a general area of ability that may be impaired after CHI and is necessary to function in day-to-day life. The five scales are (1) Perception and Discrimination, (2) Orientation, (3) Organization, (4) Recall, and (5) Reasoning. Each scale is made up of a series of small tests, or "testlets" (Thissen, Steinberg, & Mooney, 1989). Testlets are collections of similar items designed to measure a common trait or subdomain. The testlets for each scale are summarized in Table 1.

In general, items within each testlet progress from easier to more difficult. The item scores are summed to produce a testlet score, and the testlet scores are summed to produce a total score for each of the five scales. The total raw score for each of the scales can be converted to normed scores (percentile ranks or standard scores). A severity score can be computed from the total composite score. The standardization form of the test was administered to 322 subjects over a period of approximately 1 year. The subjects included 244 CHI and 78 non-brain-injured individuals drawn from 26 sites in the United States and Canada. The scores of the non-brain-injured subjects were used to estimate the average difficulty of the test as a kind of upper bound of expectations for head-injured subjects.

The SCATBI standardization sample is reported by age intervals in Table 2. Approximately half of the head-injured patients were between 15

Table 1. Five SCATBI Scales and Their Associated 41 Testlets

I. Perception and Discrimination
1. Sound recognition
2. Shape recognition
3. Word recognition (no distraction)
4. Word recognition (with distraction)
5. Color discrimination
6. Shape discrimination
7. Size discrimination
8. Discrimination of color, shape, size
9. Discrimination of pictured objects
10. Auditory discrimination (real words)
11. Auditory discrimination (nonsense)

II. Orientation
1. Premorbid questions
2. Postmorbid questions

III. Organization
1. Identifying pictured categories
2. Identifying pictured category members
3. Word associations (word categories)
4. Sequencing objects (size)
5. Sequencing words (alphabetical)
6. Sequencing events (time of year)
7. Sequencing events (pictured task steps)
8. Sequencing events (recall task steps)

IV. Recall
1. Memory for graphic elements
2. Naming pictures (word retrieval)
3. Immediate recall of word strings
4. Delayed recall of word strings
5. Cued recall of words
6. Cued recall of words in discourse
7. Word generation
8. Immediate recall of oral directions
9. Recall of oral paragraphs

V. Reasoning
1. Figural reasoning: matrix analogies
2. Convergent thinking: central theme
3. Deductive reasoning: elimination
4. Inductive reasoning: opposites
5. Inductive reasoning: analogies
6. Divergent thinking: homographs
7. Divergent thinking: idioms
8. Divergent thinking: proverbs
9. Divergent thinking: verbal absurdities
10. Multiprocess reasoning: task insight
11. Multiprocess reasoning: analysis

and 30 years of age, and the median age was 30. The sample contained more than twice as many males as females, a proportion typical of the head-injured population. As indicated in Table 3, approximately two-thirds of the patients in the sample were tested between 30 days and 1 year post injury, and the percentage tested within 30 days post injury was nearly equal to the percentage tested more than one year post injury. The groups were similar with regard to years of education, years of employment, and primary language.

Table 2. SCATBI Standardization Sample by Age

Age Range (Years)	Brain-Injured n	Brain-Injured %	Non-Brain-Injured n	Non-Brain-Injured %
15–19	26	13.3	7	10.0
20–29	67	34.2	26	37.1
30–39	46	23.5	23	32.9
40–49	25	12.8	8	11.4
50–59	14	7.1	2	2.9
< 59	18	9.2	4	5.7
Total reporting	196	100.1	70	100.0
Not reporting	48		8	

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Table 3. SCATBI Standardization Sample (Brain-Injured Only) by Time Post Injury

Time Post Injury	n	%
< 30 days	32	18.2
31–60 days	26	14.8
61–90 days	19	10.8
91–120 days	12	6.8
121–180 days	23	13.1
181–365 days	34	19.3
12–18 months	26	14.8
> 18 months	4	2.3
Total reporting	176	100.1
Not reporting	68	

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Pearson product moment correlations were computed between each of the raw scores on the five SCATBI scales and the level scores on *Rancho Los Amigos Levels of Cognitive Functioning* (Malkmus, Booth, & Kodimer, 1980). As shown in Table 4, the correlations for 125 selected subjects were moderate, ranging from a low of .50 (Perception and Discrimination) to a high of .60 (Reasoning). This moderate agreement between the two instruments supports the validity of each as a measure of cognitive functioning, but it also suggests that they are complementary measures rather than substitutes for each other. The internal consistency reliability of the SCATBI was assessed using Cronbach's alpha. The alphas for the SCATBI,

Table 4. Correlations Between Scores for Five SCATBI Scales and Rancho Severity Level, Standardization Sample (n = 125)

	*Rancho Level with SCATBI Raw Scores**	*Rancho Level with SCATBI Standard Scores**
Perception/discrimination	.50	.40
Orientation	.58	.50
Organization	.51	.46
Recall	.59	.57
Reasoning	.60	.57

Note:
*$p < .001$.

Table 5. SCATBI Scale Raw Score Means, Standard Deviations, Interitem Consistency Reliability Coefficients (alphas), and Standard Errors of Measurement, Standardization Sample (n = 164)

	M	SD	r	*SEM*
Perception/discrimination	49.2	10.9	.95	2.4
Orientation	16.6	5.1	.90	1.6
Organization	22.4	7.2	.92	2.0
Recall	32.1	10.8	.90	3.4
Reasoning	31.9	13.8	.93	3.7

Note:

reported in Table 5, reflect high interitem consistency for the raw scores on the five scales.

Perhaps the most important question for users of test instruments such as the one under study is how effectively the scores differentiate between head-injured and non-brain-injured subjects. The CHI subjects in the standardization sample evidenced a wide range of ability and impairment, whereas the non-brain-injured subjects exhibited a somewhat narrower range of abilities. A discriminant analysis of the standard scores of the five scales classified 96% of the non-brain-injured subjects as non-brain-injured and 79% of brain-injured subjects as brain-injured. These relatively high levels of agreement with the previously made classifications positively support the predictive validity of the SCATBI (see Table 6).

The purpose of this investigation was to examine the differences among three groups for each of the 41 individual testlets that make up the SCATBI's five scales.

Table 6. Classification of Brain-Injured Patients and Matched Samples of Non-Brain-Injured Peers Using Standard Scores of Five SCATBI Scales

	Non-Brain-Injured Accurately Classified		*Brain-Injured Accurately Classified*	
Match variables	n	%	n	%
Site, Age	55	84.6	93	86.9
Site, Age, Sex	46	88.5	56	84.9
Site, Age, Sex, Education	33	91.7	33	86.8
Site, Age, Sex, Education, Years Worked	22	95.7	19	79.2

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METHOD

Three groups were studied: 78 non-brain-injured subjects who had been selected from peer groups of head-injured patients in each standardization site; 80 CHI subjects who had obtained a composite score below the mean for the total CHI group (low CHI); and 84 CHI subjects who had obtained a composite score at or above the mean for the CHI group (high CHI). These were subjects from the previously described standardization sample. Mean scores were computed for each group on each of the 41 testlets and five scales. An effect size (Cohen, 1988) was obtained to determine the magnitude of the differences between means of the three experimental groups.

RESULTS

The means and standard deviations for each scale for each group, reported in Table 7, show a consistent pattern of higher scores for non-brain-injured subjects across all five scales; in most cases, mean scores of non-brain-injured subjects were within a few points of the maximum possible score. The low CHI group exhibited greater variability, as reflected in the larger standard deviations, than did the non-brain-injured subjects. The high CHI group had higher mean scores than the low CHI group, and both head-injured groups had lower mean scores than the non-brain-injured group. Because a simple difference between each pair of means for each

Table 7. Mean Testlet Scores and Standard Deviations for Selected Subgroups of Closed-Head-Injured (CHI) Subjects and Non-Brain-Injured Peers

	CHI High[a]		*CHI Low*[b]		*Noninjured*[c]		*Total Possible*
Scale Totals	*Mean*	SD	*Mean*	SD	*Mean*	SD	*Points*
Perception and discrimination	54.4	3.0	43.9	13.3	55.7	3.9	58
Orientation	19.3	1.3	13.7	6.0	19.8	0.7	20
Organization	26.2	1.2	18.6	8.1	26.3	2.5	30
Recall	39.4	4.3	24.4	10.3	44.7	6.4	52
Reasoning	41.0	6.5	22.3	12.9	47.2	7.9	55

[a]*N* = 84. [b]*N* = 80. [c]*N* = 78.

of the three groups would not reflect the difference variances of the three groups, an effect size was computed for each difference. An effect size represents the difference between two means divided by the average standard deviation (that is, the square root of the sum of the squared standard deviations for the two groups). Not only does effect size reflect the variances of the groups, but there are also conventional guidelines for judging the meaningfulness of its various magnitudes. Cohen (1988) has suggested a three-level classification—small, medium, and large, corresponding to effect sizes of .2, .5, and .8, respectively. Cohen gives the following examples: "A small effect size is not visible to the naked eye. A medium effect size is conceived as one large enough to be visible to the naked eye. That is, in the course of normal experience, one would become aware of an average difference in IQ between clerical and semi-skilled workers or between members of professional and managerial occupational groups" (1988, p. 27). A difference with a large effect size "is represented by the mean IQ difference estimated by the difference between holders of the Ph.D. degree and typical college freshmen" (Cohen, 1988, p. 27).

Table 8 reports effect sizes for the differences between scale means of three groups: high CHI minus low CHI, non-brain-injured minus high CHI, and non-brain-injured minus low CHI. Effect sizes greater than .5 are indicated by an asterisk, and those greater than .8 are indicated by two asterisks. The data in Table 8 reflect the substantial differences observed between non-brain-injured subjects and subjects with closed-head-injury. The effect size for each testlet within each of the five scales was also computed. In a comparison of CHI subjects below the mean with CHI subjects above the mean, 38 of 41 testlets yielded medium or large effect sizes. In the comparison of CHI subjects below the mean with non-brain-

Table 8. Effect Sizes of Differences Between Mean Testlet Scores for Selected Subgroups of Closed-Head-Injured (CHI) Subjects and Noninjured Peers

Scale Totals	*CHI High/ CHI Low*	*Non-Brain-Injured/ CHI High*	*Non-Brain-Injured/ CHI Low*
Perception and discrimination	1.09**	0.40	1.21**
Orientation	1.30**	0.51*	1.44**
Organization	1.31**	0.09	1.30**
Recall	1.90**	0.99**	2.37**
Reasoning	1.83**	0.85**	2.33**

*Effect size > .5. **Effect size > .8.

injured subjects, 37 of 41 testlets yielded medium or large effect sizes. The comparison between non-brain-injured subjects and CHI subjects above the mean produced medium or large effect sizes for 10 of 41 testlets.

DISCUSSION

Significant differences were observed between non-brain-injured subjects, CHI subjects scoring above the mean, and CHI subjects scoring below the mean. Significant differences were also observed between high CHI subjects and low CHI subjects.

The comparison of the high CHI group and the low CHI group yielded large effect sizes (> .8) for all five scales. The comparison of the non-brain-injured group and the high CHI group yielded a medium effect size (> .5) for the Orientation scale and a large effect size (> .8) for the Recall and Reasoning scales. The comparison of the non-brain-injured group and the low CHI group yielded large effect sizes for all five scales.

The non-brain-injured subjects and high CHI subjects produced mean or large effect sizes for only 10 of 41 testlets. The fact that the majority of these differences were in the Recall and Reasoning testlets and scales suggests that tasks from those domains are the most critical in differentiating higher functioning CHI subjects from their non-brain-injured counterparts. These differences have important implications for both assessment and treatment. Although this study grouped patients above and below the SCATBI mean, there are pervasive deficits even at the mild level of head injury, and these deficits are reflected over a wide variety of tasks. However, mildly injured persons often do not receive treatment, even though they report significant changes in all aspects of their life, including divorce and loss of employment. Years after their injury they are frequently obsessed with their inability to process and remember information, only to be told by their physician and others that what they need is a good psychiatrist. It is to be hoped that this test will provide information regarding the specific deficits of mildly impaired patients, as well as the moderate and severe deficits seen in more seriously impaired patients. In any event, the results warrent further investigation of the SCATBI performance of patients with minor head injury, as defined by conventional criteria (e.g., initial Glasgow Coma scale scores above 12).

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