The purpose of this study was to determine the reliability and validity of the Loewenstein Occupational Therapy Cognitive Assessment (LOTCA) battery for brain-injured patients. The battery provides an initial profile of the cognitive abilities of the brain-injured patient that can be used as a starting point for occupational therapy intervention and as a screening test for further assessment. The LOTCA consists of 20 subtests and is divided into four areas: orientation, visual and spatial perception, visuomotor organization, and thinking operations. The battery takes 30 to 45 minutes to administer. Subjects in the study consisted of two patient groups (20 traumatic head injury patients and 28 cerebrovascular accident patients) and one control group (55 non-brain-injured adults). Results showed interrater reliability coefficients of .82 to .97 for the various subtests and an alpha coefficient of .85 and above for the internal consistency of the areas of perception, visuomotor organization, and thinking operations. The Wilcoxon two-sample test showed that all subtests differentiated at the .0001 level of significance between the patient groups and the control group. This supported the LOTCA's validity. Furthermore, factor analysis provided initial construct validation for three areas of the battery: perception, visuomotor organization, and thinking operations.

Traumatic head injuries are a main cause of death for young persons in the United States and elsewhere, and cause major and persisting disabilities that require long periods of treatment and rehabilitation (Adamovich, Henderson, & Auerbach, 1985). The high incidence and severity of head injuries warrant the attention of health professionals such as occupational therapists (Zoltan & Ryckman Meeder, 1985).

Adults who have had cerebrovascular accidents (CVAs) make up one of the largest hospitalized populations, and they require long rehabilitation periods. This population represents the largest incidence of a single diagnosis evaluated and treated by occupational therapists (Allen, 1985; Ottenbacher, 1980; Siev, Freishtat, & Zoltan, 1986; Trombly, 1983).
In both of these populations, perceptual cognitive deficits are the major determinants of confusion and a lack of rehabilitation progress even in patients whose motor skills have returned (Siev et al., 1986). Cerebral dysfunctions caused by brain lesions produce intellectual and/or behavioral changes that affect the person's capacity to carry out daily tasks (Najenson, Rahmani, Elaser, & Averbuch, 1984; Rahmani, 1982). Therefore, the effort to restore functional capacity must include an assessment of cognitive abilities.

Neuropsychological test batteries have been developed for various purposes in an attempt to relate behavioral deficits to underlying brain dysfunction. According to Goldstein and Ruthven (1983), the history of psychological assessment is characterized by controversy and rapid change, and has gone full circle from clinical examination and interview, through refined quantitative and qualitative evaluation, back to more clinical methods that focus on processes as well as end results (Lezak, 1983). This pattern is exemplified by Luria's 1973 neuropsychological tests, which were integrated into a set of tests by Christensen (1975) and further developed into the Luria-Nebraska Neuropsychological Battery (LNNB) (Golden, 1984; Golden, Hammerse, & Purisch, 1980).

Burnell (1985) and Barret (1986) suggested that the LNNB is an appropriate assessment tool in occupational therapy. However, the full battery is too extensive and too detailed to be practical for an initial evaluation in occupational therapy, which typically focuses on basic deficits related to dysfunction in the performance of daily tasks (Najenson et al., 1984). Moreover, the LNNB focuses mainly on diagnostic categories and the localization of lesions (Askenasy & Rahmani, 1988). The goal of the shortened screening version of the LNNB is only to predict whether giving the full battery is indicated (Golden, 1987). Therefore, the LNNB screening test should not be used for occupational therapy treatment planning related to activities of daily living.

**Literature Review**

Despite the prevalence of brain-injured patients in occupational therapy and the major role perceptual cognitive abilities play in their dysfunctions, current occupational therapy theories or frames of reference have not been developed. Allen's 1985 cognitive disability theory was developed primarily for use with the mentally ill. It was assumed that the theory applied to all patients with central nervous system deficits, but attempts to apply it to the head trauma population have been made only recently (Katz, 1988).

Abreu and Toglia (1987) presented a model of cognitive rehabilitation for brain-injured patients based on Luria's neuropsychological approach, information processing theories, and acquisition of reference. They identified six areas worthy of evaluation: orientation, attention, visual processing, motor planning, cognition, and occupational behavior. These areas were assumed to be in hierarchical order according to the capacity to process information and, therefore, to guide the assessment sequence. Conditions that facilitated or deteriorated performance, as well as strategies used by the patient, were considered.

Abreu (1987) designed a manual with theoretical and practical guidelines for the rehabilitation of perceptual-cognitive dysfunction based on four approaches: cognitive retraining, neurodevelopmental principles, biomechanical principles, and motor learning. The manual includes suggestions for various assessment instruments and techniques for process testing each area looking at qualitative and quantitative performance. However, as emphasized by the author, the techniques have not been tested for validity and reliability.

An important contribution to occupational therapy literature is Siev et al.'s 1986 book, which provides information on standardized and nonstandardized procedures for assessing the perceptual and cognitive abilities of adult stroke patients. As the authors stated, however, most evaluations are nonstandardized, and research is only in its early stages. Some of the book's authors also contributed to the Perceptual Motor Evaluation battery, which was developed for head-injured and other neurologically impaired adults (Jabri, Ryckman, Panikoff, & Zoltan, 1987). This evaluation was designed to comprehensively screen perceptual motor skills, but standardization has not been completed and only interrater reliability coefficients have been provided. Except for three subtest scores from the gross/visual skill area, which are between .60 and .70, all are above .82. To date, occupational therapy research studies related to the brain-injured population have concentrated primarily on stroke victims; only a few have addressed the problems of people with traumatic head injuries (Baum & Hall, 1981; Giles, 1988; Meeder, 1982; Schwartz, Shipkin, & Cermak, 1979). Most studies have attempted to describe relationships between various cognitive disorders and functional performance (e.g., between visual perception and activities of daily living) (Carter, Howard, & O'Neil, 1983; Carter, Oliveira, Dupont, & Lynch, 1988; Kaplan & Hier, 1982; Kowalski Lundi & Mitcham, 1984; Mitcham, 1982). Others have combined factors of constructional apraxia and body scheme. For example, MacDonald (1966) and Warren (1981) found that body scheme was a better predictor of dressing performance than praxis function as examined by a copying test, and Bradley (1982) found a difference in the
effectiveness of three-dimensional praxis tests (as compared to two-dimensional) in predicting upper extremity dressing skills.

Other researchers have employed more comprehensive batteries consisting of subtests assessing visual perception, praxis, and body scheme (Meeder, 1982; Taylor, 1968; Van Deusen Fox & Harlowe, 1984). Of these, only Taylor used subtests for conceptual and operational thinking, although these areas represent major problems for the stroke population. Moreover, few studies included non-brain-injured subjects (Concha, 1986; Kaplan & Hier, 1982; Schwartz et al., 1979; Taylor, 1968).

This review revealed that occupational therapists use an array of instruments and methods to evaluate perceptual and cognitive abilities, and that only a few tests were developed in occupational therapy and studied for their measurement properties. The most systematic attempt to determine instrument validity has been the studies of the St. Marys CVA Evaluation (Harlowe & Van Deusen, 1984; Van Deusen & Harlowe, 1986, 1987). This evaluation was designed for use in an acute care setting and includes self-care activities, motor strength, arm and hand strength, bilateral awareness, and perception (including stereognosis and body scheme). The studies of the St. Marys battery focused on the construct validity of the battery as a whole and of each of its parts. However, no control group was compared with the acute CVA group, and no reliability studies were reported.

More recently, Boys, Fisher, Holzberg, & Reid (1988) reported that the Ontario Society of Occupational Therapy (OSOT) Perceptual Evaluation (which comprises six areas: sensory function, scanning function, apraxia, body awareness, spatial relations, and visual agnosia) has high internal correlations and differentiates between neurologically impaired and non-neurologically impaired people. These findings indicate the battery's reliability and validity. However, patients with aphasia or traumatic head injury were excluded from the study for unexplained reasons, and as in previous batteries, thinking operations and problem solving were not evaluated.

The LOTCA battery is based on clinical experience as well as on Luria's neuropsychological and Piaget's developmental theories and evaluation procedures (Golden, 1984; Inhelder & Piaget, 1964). The battery is composed of 20 subtests including the Risks Object Classification (ROC) (Williams Riska & Allen, 1985), which was added to enhance the evaluation of categorization abilities with attributes such as shape, color, or number, in addition to tangible object categorization. This made it analogous to the sequence of the battery, which has both a tangible pictorial subtest and a geometrical subtest. At the time the study was conducted, however, the battery consisted of 19 subtests. (Orientation initially had only one subtest.)

Children's performances on the LOTCA were assessed recently to determine the age norms of the various subtests and to verify the hierarchical order of acquisition of the various cognitive competencies included in the battery. Results suggested a progression with age from 6 to 12 years in both level and speed of performance (Averbuch, 1988).

The LOTCA is divided into four areas: orientation, perception, visuomotor organization, and thinking operations. Procedures for assessing aphasic patients have been incorporated into the tests. The battery takes a total of 30 to 45 minutes, and can be administered in 2 or 3 short sessions if necessary. A 4- or 5-point rating scale is used for scoring each subtest. A profile of the battery is given in Figure 1.

The purpose of this study was to investigate the reliability and validity of the LOTCA's measurement properties.

Method

Subjects

The sample consisted of three groups. Two groups comprised brain-injured adults: 20 patients diagnosed with craniocerebral injury (CCI) and 28 patients diagnosed with CVA. A third group, the control, consisted of 55 non-brain-injured adults who were selected according to age (between 20 and 70 years), sex, and social position class. Social position is a measure determined by a person's years of education and type of occupation. For each of the five social position classes, the scale lists the type of occupations included and the range of years of education. An equation that combines both variables is used to determine a person's social position class (Hollingshead & Redlich, 1958; Williams Riska & Allen, 1985, p. 329, provides the scale).
As can be seen in Table 1, which summarizes the demographic characteristics of the subjects, the distribution of social position classes was not equal. The table shows also that the CCI group contained more male subjects and younger subjects than the CVA group. This is typical for the type of injury. Mean years of education were similar in each group, but CVA patients were generally lower in social position.

### Table 1
**Subjects’ Demographic Characteristics**

<table>
<thead>
<tr>
<th>Variable</th>
<th>CCI Group (n = 20)</th>
<th>CVA Group (n = 28)</th>
<th>Control Group (n = 55)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Male</td>
<td>Female</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>5</td>
<td>26</td>
</tr>
<tr>
<td>Age (SD)</td>
<td>25.4 (9.3)</td>
<td>57.5 (7.3)</td>
<td>42.6 (12.6)</td>
</tr>
<tr>
<td>Years of education</td>
<td>9.6 (3.0)</td>
<td>9.2 (4.0)</td>
<td>13.3 (4.4)</td>
</tr>
<tr>
<td>Social position class</td>
<td>1 0 2 10</td>
<td>11 0 0 15</td>
<td>II 2 3 13</td>
</tr>
<tr>
<td>IV</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>V</td>
<td>4</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td>Soldiers</td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. CCI = craniocerebral injury. CVA = cerebrovascular accident.
the recording and scored it. The therapists reached 100% agreement for 14 subtests, 86% for 4 subtests, and 72% for 1 subtest. This last subtest was changed, and thereafter the therapists reached 86% agreement. These levels of agreement and the correlation coefficients above .80 were considered acceptable, and enabled systematic data collection.

**Data Analysis**

Descriptive statistics and nonparametric statistical procedures were used because the data were measured on an ordinal scale, the sample sizes were moderate, and no assumption of an underlying normal distribution could be made for a group of brain-injured patients.

**Results**

**Demographic Variables**

The chi-square analysis of the relationships between demographic variables and performance on the battery revealed that, in the control group, age was non-significant, years of education was significant for all 19 subtests at the .0001 level, and social position was significant only for the areas of visuomotor organization and thinking operations at the .02 level. This indicated that, among the normal subjects, years of education was the main variable related to perceptual cognitive performance. In the patient samples, none of the variables was significantly related to performance, which indicated the predominance of the brain damage over other preexisting conditions.

**Description of Performance**

Table 2 shows means and standard deviations for all subtests of the two patient groups at each of the two testing times, and for the control group. The control group performed almost perfectly on all subtests except categorization, geometrical sequence, and classification. It seemed that, although the differences were small, variability increased with the complexity of the tests.

In the CCI group, the scores on the first assessment ranged from a low mean of 2.1 (range 1 to 5) on categorization to a high of 3.6 on visual identification of objects. In the CVA group, scores ranged from a low

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Means and Standard Deviations of the LOTCA Subtests for Three Populations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subtests</td>
<td>CCI Group Assessments</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Orientation</strong></td>
<td></td>
</tr>
<tr>
<td>Time and place</td>
<td>2.4 (1.4)</td>
</tr>
<tr>
<td><strong>Perception</strong></td>
<td></td>
</tr>
<tr>
<td>Object identification</td>
<td>3.6 (3.9)</td>
</tr>
<tr>
<td>Shape identification</td>
<td>3.1 (.7)</td>
</tr>
<tr>
<td>Overlapping figures</td>
<td>3.0 (.12)</td>
</tr>
<tr>
<td>Object constancy</td>
<td>2.9 (.14)</td>
</tr>
<tr>
<td>Spatial perception</td>
<td>2.9 (.14)</td>
</tr>
<tr>
<td>Praxis</td>
<td>2.9 (.14)</td>
</tr>
<tr>
<td><strong>Visuomotor Organization</strong></td>
<td></td>
</tr>
<tr>
<td>Copying geometric forms</td>
<td>2.5 (1.3)</td>
</tr>
<tr>
<td>Reproducing a two-dimensional model</td>
<td>2.7 (1.4)</td>
</tr>
<tr>
<td>Constructing a pegboard design</td>
<td>2.4 (1.3)</td>
</tr>
<tr>
<td>Constructing a colored block design</td>
<td>2.6 (1.4)</td>
</tr>
<tr>
<td>Constructing a plain block design</td>
<td>2.4 (1.2)</td>
</tr>
<tr>
<td>Reproducing a puzzle</td>
<td>2.4 (1.3)</td>
</tr>
<tr>
<td>Drawing a clock</td>
<td>2.3 (1.3)</td>
</tr>
<tr>
<td><strong>Thinking Operations</strong></td>
<td></td>
</tr>
<tr>
<td>Categorization (1-5)</td>
<td>2.11 (1.4)</td>
</tr>
<tr>
<td>ROC: Unstructured (1-5)</td>
<td>2.3 (1.5)</td>
</tr>
<tr>
<td>Structured (1-5)</td>
<td>2.7 (1.7)</td>
</tr>
<tr>
<td>Pictorial sequence</td>
<td>2.6 (1.4)</td>
</tr>
<tr>
<td>Geometrical sequence</td>
<td>2.2 (1.2)</td>
</tr>
</tbody>
</table>

*Note.* Wilcoxon test differentiated at .0001 level of significance between controls and both patients groups on all subtests (except object identification) during Assessment 1, and above the .02 level of significance during Assessment 2. CCI = craniofacial injury. CVA = cerebrovascular accident.
of 1.6 on geometrical sequence to a high of 3.9 on identification of objects. In the first assessment, both CCI and CVA patients showed impairment on almost all subtests, with greater variability among them. By the second assessment, 2 months later, some improvement on the average was seen, more so in the CCI group than in the CVA group.

**Internal Consistency Reliability**

Alpha coefficients were calculated for three areas included in the battery. An alpha coefficient of .87 was found for perception, which consisted of 5 subtests (object identification, shape identification, overlapping figures, object constancy, and spatial perception). An alpha coefficient of .95 was found for visuomotor organization, which consisted of 7 subtests (copying geometric forms; reproducing a 2-dimensional model, constructing a pegboard design, constructing a colored block design, constructing a plain block design, reproducing a puzzle, and drawing a clock). The third area, thinking operations, which consisted of 5 subtests (categorization, ROC unstructured and ROC structured, pictorial sequence, and geometrical sequence), had an alpha coefficient of .85.

These high reliability coefficients support the structure of the battery. On the other hand, correlation coefficients ranging from .40 to .80 among the subtests suggest that they are not all equivalent, and therefore, that all parts of the battery should be retained.

**Validity**

To evaluate the battery’s ability to differentiate between known groups, the Wilcoxon two-sample test was used to compare each patient group with the control group. Results showed that all subtests except identification of objects differentiated at the .0001 level of significance between the control group and each of the patient groups at the first assessment (z scores ranged from 2.0 to 6.2), and above the .02 level for the second assessment (z scores ranged from 2.5 to 4.5). The Kruskal-Wallis test was administered among the three groups and showed the same level of significance at both assessment times. This finding supported the battery’s validity in assessing perceptual cognitive impairment and in differentiating between known groups.

Criterion validity was examined within the CCI group for the visuomotor organization area with the Block Design subtest of the Wechsler Adult Intelligence Scale (WAIS) (Wechsler, 1981). A correlation coefficient of $r = .68$ was found between the score on the Block Design subtest and the mean score on the Visuomotor Organization subtests. To examine the process of performance and evaluate the speed factor, which was not measured on the LOTCA, the standard procedure of the Block Design subtest was varied, and patients were given an unlimited amount of time to complete the designs, although the patients were unaware of this (Lezak, 1983). Thus, two scores were given, one for performance in the standard time and a second if the patient’s score increased in the unlimited time situation. This procedure resulted in a second score for some of the patients. In these cases, a stronger correlation was found ($r = .77$). Interestingly, when the same procedure was used with a group of 20 chronic schizophrenic adult inpatients ($r = .69$ and $r = .78$, respectively), almost identical results were found (Katz, 1988). This procedure, which was first employed by Katz (1985) with a sample of depressive patients to study the effects of slowness on performance, appears useful for patient evaluation.

**Construct Validity**

Principal component factor analysis with orthogonal varimax rotation was performed to determine the construct validity of the battery. This validation procedure determined whether the subtests measure what they were intended to measure and cluster into the three assumed underlying areas of perception, visuomotor organization, and thinking operations. The analysis included 18 subtests (orientation was excluded because it had only 1 subtest) and was performed separately for the patient groups and for the control group. For the patient groups, the results of both assessments were included ($n = 96$). Table 3 presents the results of the analyses for the patient and control groups on three factors.

Factor 1 in the patient groups, the Visuomotor Organization and Sequence subtests, explained 44% of the variance. All 7 of the Visuomotor Organization subtests loaded above .63. Praxis loaded on Factor 2, together with spatial perception, object identification, and overlapping figures. Shape identification loaded on Factor 3 with categorization and classification. Object constancy was the only subtest that loaded lower (.53) and equally on both Factors 1 and 2.

These results within the patient groups may be explained by the fact that, in all of the Perception subtests as well as in the Praxis subtest, subjects were required to identify, comprehend, point to given objects, or imitate movements, but in the Visuomotor Organization and Thinking Operations subtests they were asked to perform a task, manipulate objects, or copy and build things involving motor, spatial, and logical knowledge. These latter requirements are more complex, and integrate the higher mental processes of problem solving, planning, and motor orga...
nizational abilities (Najenson et al., 1984). A very similar factor structure can be seen in the factor analysis of items measuring perceptual functions that was performed by Eriksson, Bernspang, and Fugl-Meyer, (1988). In their analysis, visuomotor organization items (termed high-order perception) loaded on Factor 1, and visual and spatial perception items (termed low-order perception) loaded on Factor 2, which explained 49% and 16.3% of the variance, respectively, for a group of 109 stroke patients. (Some of their items were adapted from an earlier version of the LOTCA). In the control group, the results were different. Three Perception subtests loaded highly (above .89) on Factor 1, along with Praxis and pictorial sequence, which explained 49% and 16.3% of the variance, respectively, for a group of 109 stroke patients. (Some of their items were adapted from an earlier version of the LOTCA).

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uted less to the variance explained. However, in both groups the total amount explained is above 60%, which is substantial.

Discussion

The measurement properties of the LOTCA were found to be reliable for all subtests in the agreement between raters and in the internal consistency of the three major areas: perception, visuomotor organization, and thinking operations. The LOTCA was also found to be valid in differentiating between healthy adult persons and brain-injured patients. This finding, along with the results of a previous study in which the performance profiles of psychiatric patients were shown to differ from those of CCI patients (Averbuch & Katz, 1988), suggests that the LOTCA differentiates level of performance as well, as some localization patterns related to brain lesions emerge. In addition, the beginning work on the determination of construct validity with factor analysis demonstrated a three-factor solution in accordance with the assumed underlying areas, even though the solution differed in the strength of its explanation of the variance in performance between patients and controls.

The LOTCA battery is used also as a measure of the patient's status over time. In those cases in which difficulties are present at initial assessment, the LOTCA can be employed as an objective measure for following up on patient progress. It is recommended that the assessment be repeated after an interval of at least 2 months to avoid simple memory carryover. However, learning as a possible explanation for higher scores must always be considered because many similar tasks are practiced during treatment. Nevertheless, it is precisely this learning, if generalized, that is the purpose of treatment, so it should not be regarded as a threat to validity as defined in measurement theory.

As a result of the data analysis, some changes were made on the score sheet (see Figure 1). The Object Identification subtest seemed to be very easy for all three subject groups, and thus may be retained only as a start-up task. The Shape Identification subtest, as discussed earlier, seems to contain two levels of difficulty (four easy items and four harder ones), in which the second set of shapes probably requires more formal knowledge. Therefore, a score of 4 will be given if the subject identifies all shapes either by naming, understanding, or matching. Orientation was divided into time and place, and each will be scored separately. A scoring key for rating attention and concentration was added to allow analysis of these areas. Attention and concentration are not tested with a specific subtest but should be evaluated by observing the patients during performance of the LOTCA. Thus, the final battery consists of 20 subtests and an observation-based score for attention and concentration. Length of time and number of sessions are also recorded on the scoring sheet.

The next step in the validation process of the LOTCA battery includes continued data collection at the LRH and in other countries to enlarge the database on the adult brain-injured population and on stroke patients. Regarding construct validation with the factor analysis procedure, additional studies with larger patient populations and control groups are necessary to provide further support for the structure of the battery based on the four underlying areas of orientation, perception, visuomotor organization, and thinking operations. The relationship between the LOTCA scores and functional evaluation and activities of daily living rating scales also need to be studied, as do changes in performance related to the rehabilitative process.

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