A person’s ability to think practically and reason is determined by the cognitive processes that are referred to as executive functions (Goldman-Rakic, 1993). Executive functions include the ability to attend to specific stimuli and ignore others, depending upon what a person is focusing on. In complex tasks involving multiple kinds of mental activities, a person’s executive functions are used to plan the sequence of mental steps and make plans for the participation in different activities. Executive functions also enable the person to switch the focus of attention between activities as needed. Thus, executive functions are crucially involved in decision-making, allowing a person to choose between different courses of action based upon what is happening in the present, what is known about a situation, and what could happen if a different action took place in that particular situation (LeDoux, 2002).

The status of executive functions plays a critical role in social and vocational recovery among persons who have sustained brain injuries. Executive functions appear to be important for successful rehabilitation because these abilities include higher order cognitive skills such as problem solving, concept formation, cognitive flexibility, and self-regulation (Hanks, Rapport, Millis, & Deshpande, 1999). Hanks et al., for example, examined whether or not executive functions could predict rehabilitation outcome six months after acute brain rehabilitation. The authors examined...
90 participants ages 17 to 73 years who were admitted to traumatic brain injury, orthopedic and spinal cord treatment units, assessing four measures of executive functions (Wisconsin Card Sorting Test [Heaton, 1982], The Trail Making Test [Reitan & Wolfson, 1993], The Controlled Oral Word Association Test [Benton & Hamsher, 1989], and Letter Number Span [Gold, Carpenter, Randolph, Goldberg, & Weinberger, 1997]) and comparing performance on these measures to the Functional Independence Measure (FIM) (Uniform Data System for Medical Rehabilitation, 1993), as well as to three outcome measures including the Community Integration Questionnaire (CIQ) (Willer, Rosenthal, Kreutzer, Gordon, & Rempel, 1993). The authors found that executive functions, verbal memory, and estimated premorbid intelligence predicted functional independence after discharge from rehabilitation. These findings support the importance of executive functions in predicting functional and rehabilitation outcomes. While the measures used in the study were self-report measures and not performance-based, the results suggest that executive functions are related to successful outcomes not only for persons with brain injuries, but for other rehabilitation populations as well.

Deductive reasoning, the capacity to formulate and test hypotheses (Solso, 1998), is dependent on a person's executive function abilities (Kafer & Hunter, 1997; Lezak, 1995; Vilikki & Holst, 1991). Nickerson (1986) included deductive reasoning as one of the abilities that represents human intelligence, along with the ability to classify patterns, to modify behavior adaptively, to reason inductively, to develop and use conceptual models, and to comprehend. In the deductive reasoning process, an individual draws a conclusion based on a small amount of information garnered from perceptual observations, memories, beliefs, and imagination (Johnson-Laird & Byrne, 1991). Deductive reasoning depends on the ability to form and manipulate mental representations of relations between objects and events. Thus, deductive reasoning abilities have important implications in all areas of life.

The Deductive Reasoning test is one subtest in Toglia's Category Assessment (TCA) (Toglia, 1994) that is designed to assess the deductive reasoning ability of adults who have brain injuries or mental illness. TCA involves use of plastic utensils to be sorted according to size, color, and utensil type. In the Deductive Reasoning test the examinee is asked to determine which utensil the examiner is thinking about, with the least amount of guessing and the fewest possible number of questions. The examinee's ability to identify and remember details, make comparisons, shift from one category to another, think abstractly, and attend to the task are assessed. During each trial, the examinee must keep track of the information that was used in prior parts of the task, and must use this information to draw new conclusions and deductions.

Only one study was found that supported the validity of the Deductive Reasoning test. This study, by Josman and Jarus (2001), established initial construct-related validity of the Deductive Reasoning test for typically developing children. The authors examined the performance of 235 children without disabilities in six different age groups, ranging from 5 to 11 years of age. Results demonstrated a significant main effect for age, allowing the authors to identify the developmental trends of scores on the Deductive Reasoning test among children.

Goverover and Hinojosa (2002) examined the ability of a categorization (TCA) and Deductive Reasoning test (Toglia, 1994) to predict performance on instrumental activities of daily living (IADL) in adults with brain injuries. The authors found that both categorization and deductive reasoning accounted for a significant proportion of the variance in IADL performance scores. Thus, the authors concluded that deductive reasoning and categorization ability are fundamental for the performance of IADL.

Based on these findings, the current study was designed to examine the discriminant validity of the Deductive Reasoning test to validate its use as a quick measure of a person's deductive reasoning ability and functional abilities (i.e., everyday competence). The current study was also designed to examine the interrater reliability of the Deductive Reasoning test, since this psychometric characteristic of the test has not yet been established. These psychometric properties need to be established for the Deductive Reasoning test because the degree of reliability and validity of any assessment tool determine the appropriateness of that tool for practice and research. In the current study, interrater reliability was derived by having two trained observers watching the performance of the test independently and simultaneously recording the test scores. Discriminant validity was obtained by comparing the performance of persons with brain injuries and persons without disabilities. It was hypothesized that performance and learning patterns would be different for these two groups.

Method
Design
A between groups repeated measure design (Portney & Watkins, 2000) was used to examine performance differences between two groups (persons with brain injury and persons without disabilities) across three consecutive administrations of the Deductive Reasoning test. The dependent variables were the three separate Deductive Reasoning scores and a total Deductive Reasoning score derived by summing up each individual's three Deductive Reasoning scores. Groups membership and Deductive Reasoning trial served as the independent variables.

Participants
A total of 93 persons (47 males, 46 females) participated in this study including 42 persons with brain injury and 51 without disabilities ranging in age from 18 to 84 ($M = 44.15$, $SD = 17.601$). Participants with brain injuries included 25 men and 17 women ranging in age from 21 to 84 ($M = 52.381$, $SD = 16.947$) with a mean 12.3 years of education ($SD = 2.9$). The group without disabilities was considerably younger ($M = 37$ years versus $M = 52$ years) and better educated ($M = 16.7$ years versus 12.3 years) than the group with disabilities. The participants with brain injuries had been hospitalized in a neurosurgery acute ward following diagnoses of aneurysms ($n = 11$), cardiovascular accident (CVA) ($n = 3$), traumatic brain injury (TBI) ($n = 6$), brain
tumors \((n=20)\), and normal pressure hydrocephalus \((n=2)\). Participants without disabilities (22 males, 29 females) ranged in age from 18 to 70 \((M=37.372, SD=15.19)\) with 16.67 mean years of education \((SD=2.43)\). Participants without disabilities were recruited from the general public in the New York City area by flyers and personal contact. All recruitment and intervention procedures were approved by the university committee on activities involving human subjects and by the research board at the institution where the data collection was completed.

**Instruments**

The Deductive Reasoning test (Toglia, 1994) consists of 18 plastic utensils including three different colored forks, spoons, and knives of two sizes. The test incorporates a question game to evaluate a person’s ability to formulate and test different hypotheses. The examiner begins the test by asking the participant to examine all the utensils from the set. The participant is told that the examiner has “selected” one utensil and that he or she is to ask yes and no questions to determine which item the examiner has selected. The participant is told to ask the smallest number of “yes” or “no” questions to determine which utensil the evaluator has selected. In actuality, the evaluator does not think of an item and answers “no” to all the questions until there is only one utensil. By answering “no,” the examiner challenges the participant to create more hypotheses and to shift from one concept to another.

The test is considered dynamic-interactive because the evaluator has a standard sequence of prompts to allow the participant to solve the problem with five questions. Modification of the test includes increasing and reducing the number of utensils in order to make the test more or less difficult. Scores for this test range from 1 (cannot obtain the right answer with maximum cues and task modification) to 7 (able to get the correct answer with five questions) for every trial. When a participant asks about a specific utensil, rather than a category that includes few utensils, the examiner prompts the participant with a question such as, “Can you think of a question that will narrow down your choice better?” Every prompt lowers the score by one point. The test involves three trials and the final score is the sum of the scores obtained in the three trials (maximum score = 21).

**Procedure**

Data for participants with brain injuries were collected by the first author as part of a larger study (see Goverover, 2002). These participants were oriented to their environment, were able to follow two-step instructions, and could attend to a task for at least 30 minutes. Each participant was tested individually in an environment free from distractions that could influence his or her performance. Participants without disabilities were students, family members, and friends who volunteered after being given a flyer about the study. Each participant signed a consent form before individual appointments were scheduled. Testing of participants without disabilities was done individually in a quiet room or university faculty office. The total time for each examination was no more than 15 minutes for all three trials. Two raters, who were professional-level occupational therapy graduate students, rated performance of 31 of the participants without disabilities during the time they were available to help with the study. These student raters were trained by the first author to administer the test in a standardized manner. The rating was done independently by each of the raters.

**Analysis**

Data analysis was completed in three stages. First, descriptive analysis was performed on the Deductive Reasoning test total and trials scores. Second, an interclass correlation coefficient (ICC) reliability test (McGraw & Wong, 1996) was performed with the Deductive Reasoning scores obtained for the 31 participants without disabilities during the time they were available to help with the study. These student raters were trained by the first author to administer the test in a standardized manner. The rating was done independently by each of the raters.

Results indicated significant main effect for group membership, \(F(1, 91) = 52.68, p < .001\). Between groups repeated measures analyses was performed to compare participants’ performance across trials and between groups. Results indicated significant main effect for group membership, \(F(1, 91) = 52.68, p < .001\). Performance of participants with brain injuries \((M=14.67, SD=4.88)\) was significantly lower than participants without disabilities \((M=20.00, SD=1.697)\). In order to ensure appropriate use of the analysis, the Mauchly’s Test of Sphericity was performed. Results showed that the assumption of sphericity was violated \((p < .001)\), thus the Greenhouse-Geisser test was used to test differences in Deductive Reasoning performance between the two participant groups (Tabachnick & Fidell, 2001). Results indicated a significant increase in all participants’ scores across trials, \(F(1.63, 148.67) = 35.094, p < .001\) (See Table 1).

A repeated contrast analysis was performed to examine the source of group deductive reasoning performance differences within the three trials. Results indicated that overall there was a significant

**Table 1. Deductive Reasoning Scores Across Testing Trials and Groups**

<table>
<thead>
<tr>
<th>Group</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Brain Injuries</td>
<td>4.38 (SD = 1.69)</td>
<td>4.88 (SD = 1.9)</td>
<td>5.5 (SD = 1.62)</td>
</tr>
<tr>
<td>Without Disabilities</td>
<td>6.1 (SD = 1.26)</td>
<td>6.84 (SD = .543)</td>
<td>6.96 (SD = 1.96)</td>
</tr>
<tr>
<td>Total</td>
<td>5.37 (1.72)</td>
<td>5.96 (SD = 1.65)</td>
<td>6.3 (SD = 1.31)</td>
</tr>
</tbody>
</table>
increase in the Deductive Reasoning test scores from the first to the second trial, \( F(1, 91) = 23.34, p < .01 \), and from the second to the third trial, \( F(1, 91) = 19.21, p < .01 \). A repeated contrast analysis performed to examine the source of group Deductive Reasoning performance differences within the three trials and between groups revealed that the increase in Deductive Reasoning scores from the first to the second trial was similar for both participant groups, \( F(1, 91) = 0.38, p = .537 \). When scores on the second trial were compared to the third trial, however, a significant difference between groups was revealed, \( F(1, 91) = 8.9, p = .004 \). Deductive Reasoning trial scores increased significantly for participants with brain injuries from the second to the third trial, but did not increase significantly for participants without disabilities. This pattern of results is presented in Figure 1.

**Discussion**

The results of the current study raise a number of important issues related to the Deductive Reasoning test, in particular, the issues of discriminant validity and interrater reliability. The first issue of concern is in regard to the difference in Deductive Reasoning performance between individuals with brain injuries and individuals without disabilities. As expected, persons with brain injuries scored lower on the Deductive Reasoning task than persons without disabilities. Consistent with this result, other studies have demonstrated that people with brain injuries exhibit diminished capacity to carry out daily tasks (Josman, Berney, & Jarus, 2000; Neistadt, 1993; Vilkki & Holst, 1991). The findings of the current study provide additional support for the discriminant validity of the Deductive Reasoning test as the participants’ scores distinguish between participants with brain injury and participants without disabilities. Thus, findings suggest that occupational therapist should consider using this test to evaluate a patient’s deductive reasoning skills as Goverover and Hinojosa (2002) reported a strong association between scores on this test and the performance of daily tasks.

The current study confirms the high interrater reliability of the Deductive Reasoning test. The practical significance of this finding is that it suggests that therapists can use the Deductive Reasoning test as a reassessment tool. Furthermore, it gives more information on the fact that the Deductive Reasoning test is rated in a consistent and reliable way by examiners. Although the findings of the current study support the discriminant validity of the Deductive Reasoning test, more research is needed to establish its validity. For example, studies should compare participants’ performance on the Deductive Reasoning test with other tests that measure the same constructs (e.g., Twenty Questions Test [Mosher & Hornsby, 1966]).

A very important aspect of the Deductive Reasoning test is the dynamic approach to assessment included in the test design. While a person completes the tasks, a therapist examines the person’s ability to learn from the task and feedback. In the current study, there was a significant increase in the participants’ performance scores over three Deductive Reasoning trials. The dynamic approach of the Deductive Reasoning test was demonstrated by the finding that participants with brain injuries improved significantly in their performance across all three trials while participants without disabilities improved significantly only from the first to the second trials. This finding suggests that participants without disabilities benefited most from cues that were given while they performed the first trial, and were able to generalize their learning to the second and third trials, while participants with brain injuries needed more cues while they performed the second trial, and their performance continued to improve on the third trial. Thus, a patient’s performance on the Deductive Reasoning test may provide valuable information about his or her potential for change or learning. Such information can help the therapist choose an appropriate treatment approach for intervention (i.e., functional or remedial approach) in order to subsequently design activities that meet the abilities of the individual (Toglia, 1998).

The results of the current study are promising. The current study does, however, have some limitations. First, participants without disabilities reported that they did not have any kind of disability; however, this information was self-reported, and there is no other indication that these participants do not have cognitive or emotional problems. Second, the sample of individuals with brain injuries was heterogeneous (i.e., age, type of injury), something that could create more variability in the results. Third, age and education were not the same for both groups with the group without disabilities younger and better educated. Since it is known that age and education can affect cognitive abilities, differences in scores could have been influenced. Finally, the interrater reliability data were collected...
from participants without disabilities and it would be appropriate to replicate this inter-rater reliability analysis with persons with brain injuries.

**Conclusion**

The current study investigated differences in deductive reasoning performance between persons with brain injury and persons without disabilities. Significant differences in performance were found; persons with brain injuries scored significantly lower on the Deductive Reasoning test than persons without disabilities. Additionally, a high level of interrater reliability was established for the Deductive Reasoning test. The current results support that the Deductive Reasoning test may be appropriate for clinical practice. While the current study has several limitations, its findings are important as a first step in establishing the psychometric integrity of the Deductive Reasoning test.

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**References**


