Categorization and Deductive Reasoning: Predictors of Instrumental Activities of Daily Living Performance in Adults With Brain Injury

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KEY WORDS
• cognition
• Deductive Reasoning test
• Toglia’s Category Assessment

OBJECTIVE. The purpose of this study was to examine the predictive relationship of categorization and deductive reasoning abilities to performance of instrumental activities of daily living (IADL) among adults with brain injury.

METHOD. A correlational research design was used to examine the performance of 19 patients from a neurosurgery acute care unit on Toglia’s Category Assessment (TCA), the Deductive Reasoning test (DR), and the Observed Tasks of Daily Living—Revised.

RESULTS. Multiple regression analysis indicated that categorization and deductive reasoning accounted for a significant proportion of the variance in IADL performance scores, with deductive reasoning making the greater contribution. Demographic characteristics such as age and education reduced the power of the previous variables, especially of the categorization.

CONCLUSION. The results of this study indicate that assessments of categorization and deductive reasoning abilities of persons with brain injury may be good predictors of IADL functional performance. Results support the use of the TCA and DR as quick measures of a person’s cognitive and functional abilities. Furthermore, this study provides preliminary results to support that categorization and deductive reasoning abilities are fundamental for the performance of IADL skills.


Cognitive and perceptual impairments are common sequelae for persons with brain injury (Katz, 1998). Cognition is a person’s capacity to acquire and use information to adapt to environmental demands (Lidz, 1987). Categorization and deductive reasoning are two cognitive abilities used during almost all intellectual and daily life tasks (Josman & Katz, 1998; Katz & Hartman-Maeir, 1998; Lezak, 1995). Together these two cognitive abilities provide the basic components for a person to initiate, plan appropriately, and monitor the performance of any task (Katz & Hartman-Maeir, 1998). Thus, categorization and deductive reasoning deficits have important implications in all areas of life, especially in the performance of activities of daily living (ADL).

Categorization is the ability to classify, categorize, or sort sensory input into groups in order to simplify the environment, reduce memory load, and help store and retrieve information efficiently (Markman, 1989). Categorization is used in almost all intellectual and daily activities (Josman, Berney, & Jarus, 2000; Josman & Jarus, 2001; Josman & Katz, 1998). Deductive reasoning is the ability to formulate and test hypotheses based on information available. When engaged in deductive reasoning, a person develops hypotheses, makes inferences, and rationalizes a conclusion. Deductive reasoning requires evaluating information, solving problems, and making decisions (Johnson-Laird & Byrne, 1991; Waltz et al., 1999). For these reasons, deductive reasoning plays a pervasive role in a person’s daily life (Nickerson, 1986).
When a person sustains a brain injury, he or she will likely exhibit categorization and deductive reasoning deficits (Giovagnoli, 2001; Lezak, 1995). Categorization and deductive reasoning are two cognitive processes included in executive functions (Katz & Hartman-Maeir, 1998; Lezak, 1995). Executive functions are cognitive processes that include the ability to plan, manipulate information, initiate and terminate activities, and recognize errors. These cognitive processes are fundamental to carrying out everyday activities (Unsworth, 1999).

A person’s ability to perform everyday life tasks and tasks that simulate situations of everyday life is considered to have predictive and external validity regarding intellectual functioning (Morrill, Park, & Poon, 1990). Salthouse (1990) asserted that there is a discrepancy exists between levels of intellectual functioning of older adults as assessed on laboratory-type measures and the older adults’ functioning in everyday situations. An assessment of adults’ performance with regard to practical or everyday activities or tasks has become a major focus of cognitive research (Diehl, Willis, & Schaei, 1995).

Some research has established an association between deficits in cognition and perception and a decrease in occupational performance (Cahn-Weiner, Malloy, Boyle, Marien, & Salloway, 2000; Katz, Hartman-Maeir, Ring, & Soroker, 1999, 2000; Neistadt, 1993). Neistadt (1993) examined constructional skill impairment and its influence on performance of meal preparation tasks by 54 men with head injury 18 to 52 years of age in a rehabilitation program. The results supported a significant statistical association between constructional abilities and meal preparation skills. Katz et al. (1999, 2000) investigated the influence of unilateral spatial neglect and cognitive deficits on the rehabilitation outcomes and long-term functioning in ADL of 40 right-handed persons with right-hemispheric damage. The authors determined that neglect was associated with lower performance on measures of impairment (i.e., sensorimotor, cognitive), and ADL and instrumental activities of daily living (IADL). They concluded that unilateral spatial neglect is a major predictor of rehabilitation outcomes. The findings of Katz et al. are not surprising because persons with unilateral neglect have sensorimotor, cognitive, and perceptual difficulties. The authors, however, did not describe the levels of severity of the neglect, which may affect performance variably.

Cahn-Weiner et al. (2000) examined cognitive abilities (e.g., executive function, language, attention, memory, spatial skills) of 27 community-dwelling older adults to ascertain whether the adults’ performances on cognitive tests could predict their functional status. They also examined the contribution of the participants’ emotional status and concluded that both executive function and severity of depression made significant contributions to IADL functional status. The authors further concluded that executive function deficits made the greatest contribution and that the scores on none of the other tests contributed significantly to the prediction of IADL function. The results of Cahn-Weiner et al.’s study suggest that executive function deficits in adults may be the best predictors of functional decline.

Kibby, Schmitter-Edgecombe, and Long (1998) examined the relationship among categorization, memory ability, and work functioning of 28 adults with severe head injury 1 year or more postinjury. They found that memory was the best predictor of on-the-job performance. Furthermore, memory and categorization equally predicted the positions held by the participants. Thus, memory and categorization appear to be good predictors of work-related skills.

The previously described studies demonstrated that persons with brain injury have difficulty with categorization. As a group, these studies have two main limitations. First, the participants in the studies were limited to patients in rehabilitation settings or elderly individuals. Second, participants tended to be limited to particular injuries (e.g., cerebrovascular accident, frontal lesions). Categorization, however, is not a localized function; thus, researchers need to examine the relationship of categorization ability and IADL performance among persons who have a variety of brain injuries. In the present study, the primary concern was to examine the evaluation of categorization and deductive reasoning and their relationship to function in IADL with patients on an acute neurosurgery ward who are not limited to a certain diagnosis.

Of the five studies found that used Toglia’s Category Assessment (TCA) and the Deductive Reasoning test (DR), only two included adult participants. Josman’s (1999) study compared performance on the TCA and the Riska Object Classification (Riska et al., 1985) of persons with brain injury and chronic schizophrenia. An earlier study by Josman and Katz (1998) investigated the performance of participants with and without stroke on categorization tests, one of which was the TCA, and everyday tasks. They explicitly examined the relationship between the results of these tests and performance on everyday tasks that require categorization abilities. Josman and Katz concluded that persons who have had a stroke have more difficulties with categorization than persons who had not. Three studies involved children as participants (Josman et al., 2000; Josman & Goffer, 1998; Josman & Jarus, 2001). Josman and Goffer (1998) adapted the TCA and DR for use on healthy children in Israel, and Josman et al. (2000)
demonstrated the importance of assessing categorization abilities and metacognitive components in children with brain injury. Most recently, Josman and Jarus (2001) reported on their efforts to establish the validity of the tests and on how they had adapted the tests for healthy children. No studies were found that examined the relationship between performance on the TCA or DR and IADL performance.

Based on this literature review, the following hypothesis and research questions were formulated. The hypothesis is that a patient's performance on the TCA and DR would be significantly related to performance on the Observed Tasks of Daily Living–Revised (OTDL-R; Diehl, Marsiske, Horgas, & Saczynski, 1998), which assesses IADL performance in adults. The research questions were as follows:
1. Are the performances of a person with brain injury on the TCA and DR valid predictors of performance on the OTDL-R?
2. Are the TCA and DR appropriate initial assessments for measuring IADL functioning of persons with brain injury?
3. Can the TCA and DR serve as appropriate assessments for measuring IADL functioning of persons with brain injury in an acute care setting? If so, these two assessments would be useful to therapists working in acute care because they are easy to administer, require less time to administer, and provide valuable information about potential treatment approaches. Unlike the currently popular executive function tests (e.g., the Wisconsin Card Sorting Test [Heaton, Chelune, Talley, Kay, & Curtiss, 1993]) and IADL tests (e.g., Assessment of Motor and Process Skills [Fisher, 1993]) that are lengthy and too complicated to administer in acute care wards, it takes about 10 to 25 minutes to complete the TCA and DR when administered together. The TCA has the additional benefits of standardization and clearly established norms (Josman, 1999; Toglia, 1998). Further, the TCA and DR provide dynamic information about the patient's learning capacities and can, therefore, facilitate the choice of treatment approach.

Method

Design

A correlational research design study was used to examine the proposed relationships without any attempt to control or manipulate the situation (Burns & Grove, 1997). The TCA, DR, and the OTDL-R were administered to patients with brain injury, and the associations among them were examined. The dependent variable was the OTDL-R score. The TCA and DR scores served as independent variables.

Participants

The participants (10 men, 9 women) were patients on an acute neurosurgery unit in Israel who had brain injury secondary to aneurysm (n = 7), cerebrovascular accident (n = 3), brain tumor (n = 7), normal pressure hydrocephalus (n = 1), and traumatic brain injury (n = 3). Participants’ ages ranged from 25 to 75 years (M = 51.63 years, SD = 17.62). Educational level ranged from 8 to 17 years (M = 12.09 years, SD = 3.14). Based on a screening by the treating physician, participants did not have aphasia, severe visual problems, or disorientation, as these disorders characteristically manifest varying sorts of cognitive and physical disorders. All participants were able to attend to a task for at least 30 min and had functional mobility within the testing environment.

Each participant was part of a convenience sample selected according to the previously described criteria. The participants were adult volunteers who regularly attended the rehabilitation program. The study was approved by the New York University Office of Sponsored Programs—University Committee on Activities Involving Human Subjects and by the research board at the institution where the data collection was completed.

Instruments

The TCA (Toglia, 1994) examines the ability of adults with brain injury or psychiatric illness to establish categories and switch conceptual sets. The TCA consists of plastic utensils that can be sorted according to size, color, and type. Scores range from 1 (unable to sort after reduction of amount) to 11 (independent sort—no cues given). A separate score is assigned for each sort (i.e., size, color, type), and a total score combines all three scores (maximum score = 33). Administration takes approximately 25 min. A patient's awareness is assessed on the TCA through the use of standard questions. Scores are obtained before the patient attempts the task and again after he or she completes each
task. Josman (1999) reported TCA interrater reliability (.87), internal consistency ranging from .74 to .80 \((p < .001)\), and concurrent validity \((r = .52, p < .001)\).

The DR (Toglia, 1994) uses the utensils from the TCA. Scores are based on a question game that evaluates the patient’s ability to formulate and test hypotheses. The patient determines which utensil the examiner is thinking about with the least amount of guessing and the fewest possible number of questions. The examiner gives a standard sequence of prompts when the patient is unable to solve the problem within four questions. Modifications of the test include increasing and reducing the number of utensils to make the test more or less difficult. Scores for this test range from 0 (cannot obtain the right answer with maximum cues and task modification) to 7 (is able to get the correct answer with five questions) (maximum score = 21). At the time of the study, Josman and Jarus (2001) had established construct-related validity of the DR. A significant main effect for age was obtained for performance both on the TCA, \(F(5, 229) = 11.234, p < .001\), and the DR, \(F(5, 213) = 12.35, p < .001\).

The OTDL-R (Diehl et al., 1998) is a behavioral measure of everyday competence that requires a patient to perform a number of observable actions in response to a question by the tester. The OTDL-R includes tasks from three IADL domains: medication use, telephone use, and financial management. For each domain, three problem scenarios and real-life materials are presented. For each task, materials are accompanied by a question presented on a card, and the patient is asked to perform the necessary steps to find the correct answer. For example, a patient is asked to interpret information on a medicine bottle label, dial the phone number for a hospital pharmacy, and pay a utility bill by check. Scores are recorded in a correct/incorrect format. Scores range from 0 (cannot obtain the correct answer with cues) to 26 (able to answer correctly all of the questions presented and demonstrate good everyday competency). The test has interrater reliability (.71), internal consistency (.80), concurrent validity, and construct validity \((\chi^2 = 16.37)\) (Diehl et al., 1995).

**Procedure**

The first author administered all three tests to each participant over a 48-hr time frame to minimize poor performance related to fatigue. The order of the tests (TCA, DR, OTDL-R) was evenly alternated across participants to eliminate bias resulting from prior tests influencing later ones. (The DR always immediately followed the TCA because the former is built on the latter.) Each participant was tested individually in an environment free from distractions that could influence his or her performance.

**Data Analysis**

Data analysis was completed in three stages: (a) descriptive analysis, (b) Pearson product-moment correlations between the OTDL-R and the two variables (DR, TCA) to identify significant correlations between the variables, and (3) linear regression--ordinary least square (OLS; Cohen & Cohen, 1983) to investigate the predictive relationship between the TCA and DR scores (predictors) and the OTDL-R scores (criterion). Age and education were included in the regression equation because levels of education and age have been demonstrated to be associated with cognitive performance (Cahn-Weiner et al., 2000; Kemper, 1984).

**Results**

The three main variables are categorization score (as measured by the TCA), deductive reasoning score (as measured by the DR), and IADL score (as measured by the OTDL-R). The TCA scores ranged from 12 to 33 \((M = 25.631, SD = 7.04)\); DR scores ranged from 5 to 21 \((M = 14.263, SD = 4.82)\); and OTDL-R scores ranged from 1 to 24 \((M = 14.473, SD = 5.984)\).

Pearson product-moment correlations were calculated for all tests, for age, and for education. Significant correlations were found between the score obtained on the OTDL-R and education \((r = .716, p < .01)\), age \((r = -.602, p < .01)\), and scores on the TCA \((r = .506, p < .05)\) and DR \((r = .796, p < .01)\) (see Table 1). The DR scores were sig-

### Table 1. Correlations of Scores on the OTDL-R, TCA, and DR and Age and Education

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<tr>
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<th>OTDL-R</th>
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<th>DR</th>
<th>Education</th>
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<tr>
<td>OTDL-R</td>
<td>.506*</td>
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<tr>
<td>TCA</td>
<td>.796**</td>
<td>.293</td>
<td></td>
<td>.670**</td>
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<tr>
<td>DR</td>
<td>.716**</td>
<td>.202</td>
<td>.661**</td>
<td>.463*</td>
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<tr>
<td>Education</td>
<td>- .502</td>
<td>-.390</td>
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*Note. \(N = 19\). OTDL-R = Observed Tasks of Daily Living–Revised; TCA = Toglia’s Category Assessment; DR = the Deductive Reasoning test.

\(* p < .05. ** p < .01.\)
Significantly correlated to education \( (r = .670, p < .01) \) and age \( (r = -.661, p < .01) \).

The next step was to choose the best model to explain the OTDL-R score by OLS (see Table 2). Regression analysis was performed with OTDL-R scores as the dependent variable and with various combinations of independent variables. In the first regression equation (Model 1), only DR and TCA scores were included. The TCA and DR together accounted for 71.4% of the variance in OTDL-R, with an adjusted \( R^2 \) of .6779, \( F(2, 18) = 19.94, p < .0001 \). The DR scores were a significant contributor to the model \( (B = .877, p = .0001) \). The TCA scores were also a significant contributor but less than the DR scores \( (B = .253, p = .0488) \). On the basis of this model, DR and TCA scores explained a significant portion of the OTDL-R. The DR scores, however, were stronger contributors than the TCA scores in this model to explain the OTDL-R scores.

In the second regression equation (Model 2), education and age were included in addition to DR and TCA scores. The percentage of the variance of OTDL-R explained by the four variables increased to 77.4%, with an adjusted \( R^2 \) of .70, \( F(4, 18) = 11.96, p < .0002 \). A test performed with the coefficients on both education and age equal to 0 resulted in an expanded model where the null hypothesis (of equality to 0) was not rejected, \( F(2, 14) = 1.86, p = .1927 \). In contrast, a test with both DR and TCA coefficients equal to 0 demonstrated that the null hypothesis was rejected, \( F(2, 14) = 5.20, p = .205 \). Thus, although knowing the education and age levels may be important to explain the OTDL-R scores, these variables cannot be substituted for the DR and TCA scores.

In the third regression equation (Model 3), the OTDL-R score was explained by TCA scores, education, and age. This equation showed that percentage of variance (68.5%) explained by the model was the lowest of the three models, with an adjusted \( R^2 \) of .6221, \( F(3, 18) = 10.88, p = .0005 \). It was noted that the TCA coefficient was very similar to those obtained in the prior two regression equations, and was statistically different from 0 at a significance level of .07. Thus, although TCA scores seem to capture an independent dimension of the OTDL-R not accounted for by the DR scores, education, or age, its overall contribution to the explanation of OTDL-R seems to be lower than that of the DR scores.

Finally, in the fourth regression equation (Model 4), DR scores, education, and age were included. DR \( (B = .612, p < .05) \) was the only significant coefficient, indicating that it captured a dimension of OTDL-R that was not captured by either education or age. The \( R^2 \) of .702 was higher than that obtained in Model 3, where the TCA scores were included along with education and age. This finding indicates again the potential superiority of DR scores over TCA scores in predicting the OTDL-R score.

**Discussion**

This study analyzed the association among categorization, deductive reasoning, and performances in IADL among patients with brain injury on an acute neurosurgery ward. The results provide support for the hypothesis that categorization and deductive reasoning are significantly related to (important predictors of) IADL performance in persons with brain injury. Categorization and deductive reasoning accounted for the greatest proportion of the variance in the OTDL-R scores, above and beyond the variance accounted for by other variables, such as age and education. Deductive reasoning and categorization scores accounted for 71.4% of the variance \( (p < .001) \). Although the second model (Table 2) explains that the level of education and the age of the participants may be important to help to explain the

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<th>Table 2. Summary of Regression Analysis for Variables Explaining Scores on OTDL-R With Coefficient Estimates and Significance Levels</th>
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<tr>
<td>Intercept</td>
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<td>DR 0.877*</td>
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*Note. N = 19. OTDL-R = Observed Tasks of Daily Living–Revised; TCA = Toglia’s Category Assessment; DR = the Deductive Reasoning test. *\( p < .05 \).
OTDL-R scores, the DR and TCA scores were more important to predict performance in the OTDL-R.

The results are consistent with other studies that have examined the associations between the cognitive component and the performance of daily living skills (Cahn-Weiner et al., 2000; Diehl et al., 1995; Josman & Katz, 1998; Kibby et al., 1998). These studies support the position that performance of everyday life activities requires the activation and application of multiple cognitive abilities and processes for their solution and performance. The present study further supports the view that categorization (as measured by the TCA) and deductive reasoning (as measured by the DR) abilities have a significant effect on the performance of IADL (as measured by the OTDL-R).

Deductive reasoning ability was found to be a better predictor of OTDL-R performance than categorization (TCA). Although TCA seems to measure an independent dimension of the OTDL-R not captured by the DR, education, or age, its overall contribution to the explanation of OTDL-R was lower than that of DR as demonstrated by Models 1 and 2 (Table 2). As mentioned previously, DR results accounted for the greatest proportion of variance in the OTDL-R, although it is not clear why this is the case. In a similar study, Greve, Bianchini, Hartley, and Adams (1999) assessed the performance of persons with brain injury on the Wisconsin Card Sorting Test (categorization) and functional tasks to examine the relationship to functional ability. They found a small, but significant relationship between scores on the Wisconsin Card Sorting Test and the participants’ functional abilities. Because the Wisconsin Card Sorting Test measures categorization ability, like the TCA, Greve et al.’s results are comparable to the findings in this study.

In the present study, the DR score made a unique contribution to the prediction of IADL, one that was greater than any other variable examined. There are several possible explanations for this finding. First, the specific nature of the functions sampled by the OTDL-R may contribute to the strong relationship with the DR. It is likely that the higher level cognitive processes measured by the DR are correlated more strongly to the OTDL-R, which is related to everyday cognitive competence, than the TCA, which may be less sensitive to these functions. The TCA might be less sensitive because to categorize, a person should be able to identify details, make comparisons, shift from one category to another, think abstractly, attend to the task, and remember the task details. Performance of the DR requires the same abilities but at a higher level of abstraction because the individual needs to make conclusions based on primary data. Furthermore, Josman and Jarus (2001) stated that the ability to make inferences and arrive at conclusions is critical for evaluating information, solving problems, and making decisions, components that are part of the IADL assessment. This reasoning may explain the stronger association between the DR and OTDL-R scores. Willis (1996) claimed that assessments of functional competence address what the individual can do, not what he or she actually does. Competence focuses on the individual’s mental and physical ability to make critical decisions regarding the care of self and the management of property. Thus, it is a function of higher order cognition, and multiple components may be involved in decision making. The TCA may not capture deficits in planning, organizing, and initiating as well as the DR does, which might explain the TCA’s lower correlation with OTDL-R scores.

Categorization and deductive reasoning abilities as measured by the TCA and DR also proved to be better predictors of functional impairment than demographic features, such as age and level of education. The results indicated that participants’ age and education affected their performance on the observational tasks both directly and indirectly but not significantly. These findings are somewhat similar to Diehl et al.’s (1995) study, which performed path analysis and reported that participants’ age affected their performance on the observational tasks. Furthermore, they found that age had a significant effect on participants’ everyday problem solving even after its indirect effects, though cognitive abilities had been taken into account. In the current study, age did not have a significant effect on the participants’ OTDL-R performance; however, it had a significant negative correlation with OTDL performance.

In this study, both the OTDL-R and the DR were significantly positively correlated to education and negatively correlated to age. Thus as a person becomes older, his or her performance on these tests declines; however, as a person has more years of education, his or her performance becomes better. Diehl et al. (1995) found that scores on the OTDL-R were positively correlated with intelligence. Thus, a successful performance on the OTDL-R relies on basic principles of problem solving, which are a function of intelligence. The sample for the present study comprised persons of a variety of ages and levels of education. In this sample, it was evident that the cognitive abilities of older adults were not as strong as those of younger adults. It was also apparent that the younger participants were more educated. These factors may explain the associations described. In the present study, more education may be the reason for the better performance of the younger adults.

Is the performance of a person with brain injury on the TCA and DR a valid predictor of his or her performance on
the OTDL-R. Overall, the TCA and DR were significantly correlated with the IADL functions as measured by the OTDL-R. Together, the TCA and DR accounted for more than 70% of the OTDL-R variation. These findings are interesting because they support the view that the TCA and DR scores can indicate the level of a person’s abilities to perform an IADL test. These results indicate that categorization and deductive reasoning as measured by the TCA and DR may be predictive of cognitively complex tasks of daily living considered essential for living on one’s own. Data from the TCA or (especially) DR can be useful for evaluation of IADL functions of persons with brain injury before discharge from an acute inpatient ward. In addition, these results give some support to the hypothesis that categorization and deductive reasoning are major components of daily functioning.

The second research question asked whether the TCA and DR can serve as appropriate initial assessments for persons with brain injury. The findings from this study support the view that either the TCA or (especially) the DR could be useful to gain information about the patient’s IADL and cognitive functions.

It is important to note several cautions that may limit the generalizability of the findings. First, the sample size (N = 19) was small and very heterogeneous in terms of age and education level. Heterogeneity is an advantage when the sample size is larger, but it may have been a problem in this study because the within-subjects difference was too big. More research with a larger sample is needed to be able to generalize from these results. Second, the IADL assessment represents only one possible aspect of everyday tasks drawn from the domain of medication intake, telephone use, and money management. Other tasks or other aspects of the same tasks need to be examined in relation to the two cognitive components explored here. Third, the DR does not yet have established validity and reliability with adult populations, and the OTDL-R was used for the first time with persons with brain injury. Thus, more research is needed to examine whether the model suggested in this study can be confirmed with a larger sample and with a greater variety of persons with brain injury. Finally, the psychometric characteristics of these tests need further examination.

Conclusion

This study shows that the TCA and DR can serve as useful measures of categorization, deductive reasoning, and everyday competence for persons with brain injury and can capture performance in domains that are associated with IADL and problem solving. We believe that these assessments can assist the therapist to gain information about patients’ potential performance in IADL while on an acute neurosurgery ward.

Acknowledgment

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