Objective. Both classification and deductive reasoning are essential cognitive components underlying any learning process and, therefore, are important to assess in children with developmental or learning disabilities. The aim of this study was to establish construct-related validity of the Toglia Category Assessment (TCA) and the Deductive Reasoning test, which were originally developed to evaluate adults with brain injury. This study represents the first step in validating and adapting the two tests for children who are typically developing.

Method. The study population consisted of 235 children without disabilities in 6 different age groups (from 5–11 years of age). Both the TCA and the Deductive Reasoning test were administered to all participants.

Results. The results of the study indicate significant differences in the average performance of children in several age groups on both the TCA and the Deductive Reasoning test, but they do not show differences among all the groups. Children could not predict their ability in either test, but most were able to estimate their ability after actual performance of the TCA. A significant correlation was found only for the 5-year-olds and 7-year-olds between the Deductive Reasoning test final score and the children's estimation of their performance.

Conclusion. The findings of this study support the suitability of the TCA and the Deductive Reasoning test for use with children who are typically developing. We recommend that both tools be studied further to amplify their validity.


Both classification and deductive reasoning are essential cognitive components underlying any learning process (Rosser, 1994). Children with developmental or learning disabilities frequently demonstrate cognitive disabilities that limit their occupational performance at school and home. Those children who demonstrate decreased performance are typically referred to occupational therapy for intervention (Polatajko et al., 1995). Notwithstanding the importance of cognitive skills in children, none of the standardized assessments developed and used by occupational therapists specifically assess or measure children’s classification and deductive reasoning abilities. Occupational therapists need appropriate cognitive assessments to evaluate these abilities in children.

The Toglia Category Assessment (TCA) and the Deductive Reasoning test are standardized assessments used with adults to evaluate their ability to establish categories, switch conceptual sets, and carry out deductive rea-
Categorization is defined as a method of creating concepts about the world by organizing stimuli and classifying them into groups possessing similar characteristics (Rosser, 1994). A dynamic assessment aims to establish the degree to which individual performance may be modified or changed. This concept is based on Vygotsky’s (1978) principle of the Zone of Proximal Development (ZPD), which is defined as the difference between unaided performance and performance achieved by guidance or cuing. Thus, the ZPD is an index of the difference between the child’s level of performance when functioning independently and the level of performance when interacting with a more knowledgeable partner. Vygotsky hypothesized that the ZPD reveals the child’s potential for learning and characterizes differences in ability not identified by static tests.

Dynamic assessment strategies have been applied successfully to standardized tools that measure school achievement and children’s learning potential (Campione & Brown, 1990). Both the TCA and the Deductive Reasoning test entail methods of dynamic assessment by which the evaluator intervenes to provide cues to the participant whenever needed. The information obtained from this approach can then be used to construct individualized treatment plans (Josman, 1999). The purpose of this study was to establish construct-related validity of the TCA and the Deductive Reasoning test for children who are typically developing.

Constructs Assessed in the TCA and Deductive Reasoning Test

Categorization

Categorization is defined as a method of creating concepts about the world by organizing stimuli and classifying them into groups possessing similar characteristics (Rosser, 1994). Categorization is the predominant term used in the neuropsychology literature, whereas classification is the term most commonly used in developmental psychology (e.g., Inhelder & Piaget, 1964). The two terms are often used interchangeably. Categorization is essentially a way of simplifying the world around us. The ability to assign a new object to an existing category makes it possible to change the unknown into the known insofar as we attribute to the new object all the information previously acquired about its category. Furthermore, this ability to organize the world influences the prediction and anticipation of similar events in the future (Rosser, 1994). These basic cognitive processes are involved in every thinking activity, such as identifying details, making comparisons, solving problems, and acquiring new knowledge. Categorization also requires the ability to perform a shift in a conceptual set. This ability to shift ideas and actions and to adopt different perspectives of a concept is termed cognitive flexibility (McCarthy & Warrington, 1990). The ability to create categories and store information in an organized manner reduces the load on memory and facilitates efficient processing of information (Markman, 1989).

Difficulty in executing categorization affects functional performance in daily life as well as learning processes. Through a series of studies, Scott and Greenfield (1991) were able to support their hypothesis that children with learning disabilities have a specific difficulty in categorical ability. Moreover, the evaluation of categorization ability in groups of children at high risk for learning disabilities was deemed to be both important and critical because it may provide a predictive tool for expected difficulties in school.

Deductive Reasoning

The two main types of inferences that exist in everyday life are called inductive and deductive. In inductive reasoning, the main interest is in prediction based on partial data. Thus, an element of uncertainty and probability is involved. In deductive reasoning, one of the subjects of this article, a new conclusion is based on the primary data at our disposal. This ability to make inferences and draw conclusions is critical for evaluating information, solving problems, and making decisions.

In the process of deductive reasoning, the person draws conclusions on the basis of available information, perceptual observations, memory, beliefs, and imagination. Conclusions may be based on each individual component or on all of them (Johnson-Laird & Byrne, 1991). Reasoning is a deliberate process of thought that enables a person to derive new information from old on the basis of a set of systematic principles establishing specific relations between premises and conclusions (Rosser, 1994). The correct conclusion is reached if one has rationally followed the initial hints provided and has confirmed or disproved assumptions formed in the process. Thus, at the end of the process, an option that seems to be correct is singled out.

The use of deductive reasoning processes can already be discerned in young children. In the early stages, deductions arrived at by the child may appear to be somewhat amusing to the adult observer, but an analysis of the child’s deductive reasoning will show that a correct logical process has transpired and that the eventual deduction is quite logical and sound. In recent years, didactic games requiring this type of reasoning, such as “Guess Who,”1 have been developed. Because deductive reasoning is central to the thinking processes of judgment, problem solving, and decision making, it is central to a child’s stages of development and influences the child’s learning ability in kindergarten.

and school. As such, it should be a prime area for evaluation and, when necessary, treatment.

Metacognition

Metacognition refers to a person’s knowledge of his or her own cognitive processes, the tasks to be accomplished, and the strategies to be used (Flavell, 1985). The term metacognition includes awareness and executive functions. Awareness refers to one’s consciousness of the existence of a problem and the ability to analyze his or her ability (or inability) to solve it. Executive functions are the activities that govern the person’s performance (Brown, 1987). The ability to initiate, set a goal, and plan and carry out behaviors directed toward that goal through the use of effective strategies and self-regulation are all considered to be executive functions (Katz & Hartman-Maier, 1998). Metacognition mediates cognitive abilities and provides the basis for generalization and the transfer of acquired abilities to daily functioning.

Many aspects of awareness can be observed either preceding, during, or immediately succeeding the completion of a certain activity (Toglia, 1998). The issue of awareness is of central importance in the treatment of children because the awareness of their own strengths and weaknesses influences learning and its generalization (Belmont, Butterfield, & Ferretti, 1982). None of the tests commonly used include an evaluation of self-awareness. The assessments used in the present study combine a metacognitive component with the cognitive examination. Awareness of one’s own capacities is assessed with each of the tools both before and after the performance of the test itself.

The purpose of this study is to examine the construct-related validity of both the TCA and the Deductive Reasoning test for a population of children who are typically developing. Two research questions were addressed:

1. Is there a difference in performance on each test among children of various age groups?
2. Is there a relationship between the children’s self-awareness of their competence in each test and their actual abilities?

Because cognitive abilities are typically expected to increase with age during childhood, a corresponding increase in test scores would be expected if the tests are indeed valid. Therefore, it was expected in the current study that differences in performance in both the TCA and Deductive Reasoning test would be found among children in various age groups, meaning that younger children would score lowest and that the scores would increase with age.

Method

Sample

The study population consisted of 235 children, 5 to 11 years of age (112 [47.7%] boys, 123 [52.3%] girls) who were typically developed, attending public schools in northern Israel, and receiving no form of treatment. The children were recruited from several schools, with a convenience sample used for data collection. The Ministry of Education granted approval for conducting the study, and the parents gave written permission to include their children in the study. The sample was divided into six age groups of varying sizes (see Table 1). The number of boys and girls in each age group differed; however, no significant differences in test scores between boys and girls were found in the t-test analysis.

Instruments

TCA. The TCA (Toglia, 1994) employs everyday objects to evaluate categorization abilities in persons who have experienced brain injury. Participants are asked to sort plastic food utensils into three groups: kinds of utensils (fork, spoon, knife), size (big, small), and color (green, yellow, red). The evaluation is dynamic-interactive, and the evaluator supplies cues as necessary. These cues are arranged in a hierarchical order, starting from (a) repeating the instructions, to (b) general feedback, to (c) specific feedback, to (d) demonstration, and finally to (e) reducing the number of objects. The range of scores for each categorization is 1 to 11, with each intervention used resulting in a lowering of the score. In addition, an overall score (3–33) is obtained from the sum of the scores attained on all three subtests (Toglia, 1994).

To test participants’ awareness of their own abilities, two awareness questions are posed before the assessment (prediction questions), and two additional awareness questions are asked after test completion (estimation questions). The participants are asked for their opinions regarding how they will perform or have performed on the assessment. In the second estimation question (after completion of test), participants were asked whether their performance had improved from the first categorization to second and from second to third. Information obtained from the awareness questions is then correlated with the assessment score itself. For the purpose of this study, another part was added to the test. After completion of the assessment, the evaluator noted whether performance improved on the second or third categorization compared with the first. This score is called “eval” and ranges from 1 = not improved to 4 = improved.

Table 1: Mean Scores and Standard Deviations of the Different Age Groups in Categorization and Deductive Reasoning

<table>
<thead>
<tr>
<th>Age Group (Years)</th>
<th>Categorization&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Deductive Reasoning&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n  M  SD</td>
<td>n  M  SD</td>
</tr>
<tr>
<td>5</td>
<td>22  7.485  .389</td>
<td>21  4.87  .211</td>
</tr>
<tr>
<td>6</td>
<td>71  8.319  .216</td>
<td>66  5.61  .119</td>
</tr>
<tr>
<td>7</td>
<td>46  8.514  .269</td>
<td>38  5.561  .157</td>
</tr>
<tr>
<td>8</td>
<td>37  9.396  .300</td>
<td>35  6.20  .163</td>
</tr>
<tr>
<td>9</td>
<td>30  10.089  .313</td>
<td>30  6.422  .177</td>
</tr>
</tbody>
</table>

<sup>a</sup>Possible score range is 1 to 11. <sup>b</sup>Possible score range is 1 to 7.
The findings of a previous study with adults (Josman, 1999) indicated that the TCA has an interrater reliability of $r = .87$, internal consistency ranging from .74 to .80 ($p < .001$), and a concurrent validity with the Riska Object Classification (Williams & Allen, 1985) of $r = .52$ ($p < .001$). No discriminant validity was obtained.

**Deductive reasoning.** The Deductive Reasoning test is essentially an extension of the categorization assessment, is administered after the TCA, and incorporates a game of questions using the food utensil set (Toglia, 1994). The evaluator informs the participant that he or she is thinking about an item from the set, and the participant is asked to discover which item is being thought about by asking questions to which the evaluator can answer only yes or no. The participant is instructed to use a minimum of questions and may not ask specific questions, such as, “Did you select the small red fork?”

The Deductive Reasoning test also is dynamic-interactive and includes cues that are hierarchically arranged (Toglia, 1994). The scores range from 1 to 7 (1 = unable to guess the chosen item, 7 = able to guess the chosen item with five questions or fewer); every needed incident of cuing lowers the score. The test involves three trials; after the participant correctly guesses the first item, the evaluator says, “Let’s try it again,” for a second and third trial. The final score is a sum of the scores obtained in the three trials. If the participant has obtained the highest mark of 7 twice, there is no need to continue, and the final score is 21. As in the TCA, awareness questions in this assessment are divided into prediction questions asked before starting the test and estimation questions asked on completion of the test. For the purpose of this study, another part was added to the test to compare objective progress in the test as observed by the evaluator with progress in the test as estimated by the participant. After completion of the assessment, the evaluator noted whether performance improved from the second to the third trial. This score is calculated by subtracting the score of the second trial (DR2) from the score of the third trial (DR3). Information obtained from the awareness questions is compared with the score obtained in the assessment itself. The Deductive Reasoning test is in use by clinicians treating persons experiencing head injuries, but no research has yet been carried out regarding its validity or reliability.

The questions and the cues included in both tests were translated into Hebrew and adapted to the participants’ language level before beginning the study. Demographic data about age, gender, locality of residence, and parents’ education (expressed as years of schooling) were obtained from the parents.

**Data Collection**

The first author collected data at each participating school with each child individually and without the presence of other persons. Administration of the TCA and Deductive Reasoning test lasted approximately 30 min for each child. Both tests were administered according to standard protocol (Toglia, 1994).

**Data Analysis**

**Categorization.** Following administration of the TCA, three scores were recorded for each participant, one each for color, type, and size. The possible scores for each parameter ranged from 1 to 11, and the positive overall score, which is the sum of the three parameters, ranged from 3 to 33.

For the statistical analysis, a three-way analysis of variance (ANOVA) with repeated measures was performed, using a 6 (age group) x 3 (parameter of categorization) design. Post hoc tests were then performed using Scheffé multiple comparison and simple contrast procedures to test for significant differences between the age groups and categorization parameters (Kirk, 1982; Rohlf & Sokal, 1981).

**Deductive reasoning.** Three scores, one for each of the three interventions, ranged from 1 to 7. The overall (final) score, which is the sum of the three interventions (i.e., three trials for guessing) ranged from 3 to 21.

For the statistical analysis, a three-way ANOVA with repeated measures was performed, using a 6 (age group) x 3 (intervention) design. To investigate the correlation between categorization and deductive reasoning, a Pearson product-moment correlation was conducted on the final scores of TCA and Deductive Reasoning test.

**Awareness.** The awareness questions in both the TCA and Deductive Reasoning test were divided into two components: (a) prediction questions before test performance and (b) estimation questions after test performance. To investigate self-awareness ratings, Pearson product-moment correlations between self-prediction and estimation to actual performance (final score) were conducted for both assessments. In addition, the improvement scores (eval, DR3–DR2) were correlated with the second estimation question on how the participants judged their improvement during the assessment. The level of significance was set at .05 for all statistical tests.

**Results**

**Categorization**

The results of the ANOVA indicated a significant main effect for the parameter of categorization, $F(2,458) = 28.038$, $p < .001$. The children performed more accurate categorizations according to color ($M = 9.39$, $SD = 2.6$) and type ($M = 9.51$, $SD = 2.49$) than according to size ($M = 7.88$, $SD = 3.09$) (see Figure 1).

A significant main effect for age was obtained for performance, $F(5,229) = 11.234$, $p < .001$. Performance of the three older age groups (8–11-year-olds) was more accurate than that of the youngest age group (5-year-olds), and the two older age groups (9–11-year-olds) performed more
accurately than the 6-year-olds and 7-year-olds (see Table 1). All differences in performance between the group ages were significant.

No significant interaction between the parameter of categorization and age group was obtained, $F(10,458) > 1$, implying that the same pattern of performance was evident in the three kinds of categorization in several age groups.

**Deductive Reasoning**

The results of the ANOVA indicated a significant main effect for trials of deductive reasoning, $F(2,426) = 59.24$, $p < .001$. The children improved significantly from the first trial to the second and then to the third (see Table 2).

A significant main effect for age was obtained from the performance, $F(5,213) = 12.35$, $p < .001$. Performance of the three older age groups (8–11-year-olds) was more accurate than performance of the youngest age group (5-year-olds), and the two older age groups (9–11-year-olds) performed more accurately than the 6-year-olds and 7-year-olds (see Table 1).

The interaction between trial of deductive reasoning and age group was significant, $F(10,426) = 2.00$, $p < .05$. Post hoc analyses indicated that the significant interaction is due to the difference among the age groups in their improvement from the first and second trials to the third (see Table 2). The 5-year-olds did not improve from the second trial to the third compared with the other age groups (see Figure 2). In addition, on the first trial, the three youngest age groups performed less accurately than the three older age groups. On the second trial, the two youngest age groups performed less accurately than the two older age groups, and the 7-year-olds performed less accurately than the oldest age group. On the last trial, all the children performed better than the 5-year-olds. A significant positive correlation between the overall TCA score and the overall Deductive Reasoning test score ($r = .46$, $p = .0001$) implied that high child performance on the TCA is concomitant with high performance on the Deductive Reasoning test, and alternately, poor performance on the TCA is coupled with similar poor performance on the Deductive Reasoning test.

**Awareness**

With regard to awareness, the following relationships were analyzed: (a) the relationship between participants’ levels of awareness of their performances before the assessment and outcome score, (b) correlation between TCA overall final scores and estimation scores, and (c) correlation between the actual improvement in performance and the child’s estimation of improvement.

**Categorization.** No significant correlation between the actual performance and the child’s prediction was obtained for any of the age groups. On the other hand, the results showed a significant correlation between the TCA final score and the children’s (except for the 7-year-olds) estimation of their performance. These correlations are stronger for 8 years of age and up (see Table 3).

### Table 2

**Mean and Standard Deviations in the Three Trials of Deductive Reasoning According to Age Groups**

<table>
<thead>
<tr>
<th>Age Group (Years)</th>
<th>$n$</th>
<th>Prediction 1</th>
<th>Prediction 2</th>
<th>Estimation 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>221</td>
<td>-.122</td>
<td>-.088</td>
<td>-.368***</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
<td>-.287</td>
<td>-.386</td>
<td>-.523*</td>
</tr>
<tr>
<td>6</td>
<td>71</td>
<td>-.22</td>
<td>-.197</td>
<td>-.241*</td>
</tr>
<tr>
<td>7</td>
<td>46</td>
<td>-.184</td>
<td>-.188</td>
<td>-.121</td>
</tr>
<tr>
<td>8</td>
<td>36</td>
<td>-.099</td>
<td>-.214</td>
<td>-.597***</td>
</tr>
<tr>
<td>9</td>
<td>30</td>
<td>.068</td>
<td>.341</td>
<td>-.589***</td>
</tr>
<tr>
<td>10–11</td>
<td>29</td>
<td>.051</td>
<td>-.197</td>
<td>-.715***</td>
</tr>
</tbody>
</table>

*p < .05. **p < .01. ***p < .001.
The correlation between the actual improvement in performance and the child’s estimation of improvement was significant only for the 10-year-olds to 11-year-olds but in the wrong direction \(r = -0.377, p < .05\). The better the child performed as measured on the TCA, the lower the accuracy of the child’s estimation of performance.

To sum up the relationship between awareness and performance of categorization, none of the children in the assessed age groups were capable of accurately predicting their categorization ability. From 8 years of age, however, children were moderately capable of estimating their performance on the classification tasks.

**Deductive reasoning.** The results showed that there was a significant correlation between the deductive reasoning final score and the children’s estimation of their performance only for the 5-year-olds \(r = -0.669, p < .01\) and 7-year-olds \(r = -0.325, p < .05\) and for all participants as a group \(r = -0.241, p < .001\). No significant correlation was found between the actual performance of deductive reasoning and the child’s prediction in any of the age groups. The correlation between the actual improvement in performance and the child’s estimation of improvement was significant only for the 5-year-olds \(r = -0.565, p < .05\).

To sum up the relationship between awareness and performance of deductive reasoning, none of children in the assessed age groups were capable of predicting their deductive reasoning ability. Only the 5-year-olds and 7-year-olds adequately estimated their performance on deductive reasoning.

**Discussion**

The findings of this study support the suitability of the TCA and the Deductive Reasoning test with children. The TCA evaluates categorization ability, which is fundamental and central to children’s everyday functioning. In every area of life, ranging from getting up in the morning and selecting suitable clothes to engaging in school activities, children must implement their classification skills. The Deductive Reasoning test evaluates deductive reasoning ability, which is also central to children’s everyday functioning, such as solving problems and, especially, strengthening learning abilities. Therefore, it is essential that occupational therapists evaluate and, if necessary, treat these cognitive components.

The tools in these assessments consist of plastic utensils of various colors and sizes. These are everyday objects that are familiar to children of all ages and from different cultures. In the course of the study, the children’s reactions to these objects were positive. No child refused to participate in the evaluation; indeed, most seemed to enjoy the classification test and even more so the deductive reasoning test. Some children requested to change roles with the evaluator, underlining the general belief that the tool neither poses a threat nor arouses anxiety. This conclusion is an important starting point for adapting a new tool for the evaluation of children.

Both instruments used in this study employed a dynamic assessment approach. In recent years, the field of dynamic assessment in general and in occupational therapy in particular has made great strides (Hadas-Lidor & Katz, 1998). One advantage to this approach is that in addition to the child’s final score, it is possible to point to the cues or evaluator interventions that mediated the child to succeed at the task. Although this type of mediation may reduce the child’s overall score, it enables him or her to uncover a new classification criterion and to demonstrate flexibility in thinking. In addition, the information thus obtained augments the evaluator’s information about the kinds of cues likely to help the participant.

The first research question addressed whether differences in performance on the TCA and Deductive Reasoning test would be found between children of different age groups. This question was only partially answered. Although differences emerged in the average scores, significant differences were found mainly between the youngest and the oldest age groups, not among all age groups. This finding strengthens the construct-related validity of the TCA and Deductive Reasoning test and provides the foundation for applying and implementing these assessments with children.

The fact that no significant differences were observed between age groups by year is not surprising. Theory pertaining to the development of categorization and deductive reasoning skills does not address single year differences, and stages of cognitive development, as described by Piaget (1970), are not manifested in 1-year segments. Notably, in a previous study concurrent validity for the TCA compared with the Riska Object Classification was supported for adults with head injuries and schizophrenia (Josman, 1999). To date, no systematic study has determined the validity and reliability of the Deductive Reasoning test. It is recommended that both assessments be studied further to amplify their validity. In addition, studies should investigate whether the tools discriminate between children with and without disabilities. Although a sample of convenience was used for data collection in the present study, we recommend that a random sample be sought to represent the child population more reliably. Additionally, large-scale studies are needed to establish scale norms on the basis of age.

The second research question addressed the nature of the relationship between children’s awareness of their capabilities and their actual performances, as assessed by correlating the prediction estimation questions and actual performance. Similar results were obtained for the TCA and the Deductive Reasoning test, showing no relationship between the children’s predictions of their abilities to categorize and their actual performances. However, a significant relationship was found between children’s estimations...
of their performances and their actual performances, except for the 7-year-olds, on the TCA (see Table 3); the same significant relationship was found for only the 5-year-olds and 7-year-olds on the Deductive Reasoning test.

Children's predictive abilities are based on their capacities to focus on and recall situations similar to that in which they are now being asked to perform and, on the basis of that knowledge, to predict how they will succeed on the test about to be tackled. The ability to estimate, on the other hand, is based on the activity just completed. Thus, it is feasible to hypothesize that estimation ability would be somewhat easier for children insofar as their awareness is enhanced once an activity is performed. Children who are aware of their strengths and weaknesses may be able to devote more effort to activities with which they have difficulty. Accordingly, they might more readily seek or accept strategies to assist in their attempts at overcoming their difficulties. In any case, it may be important for occupational therapists to aim to bolster children's awareness of both pretest and posttest performance. In addition, if therapists have knowledge of children's awareness already in the evaluation stage, then they will be better able to plan the course of treatment and appropriate interventions.

Conclusion
The results of this study contribute to the validity of the TCA and Deductive Reasoning test as used with a sample of children who are typically developing. We recommend that research with large-scale studies be conducted to establish score norms on the basis of age. We also recommend the establishment of discriminative validity for both assessments by conducting a comparative study with a clinical population, such as children with learning disabilities and controls, to investigate manifestations of significant performance differences. Once discriminative validity as well as test norms are established, the TCA and the Deductive Reasoning test may be recommended for use in evaluating children in occupational therapy. ▲

Acknowledgments
We thank all the children and their parents for participation in this study.

References


