Comparison of the Performance of Younger and Older Adults on Three Versions of a Puzzle Reproduction Task

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Key Words: age factors • evaluation process, occupational therapy • perception

Objectives. Because constructional ability is a crucial perceptual-motor skill that relates to daily functioning, it should be accurately assessed in clients with neurological dysfunction. This study examined three versions of the Puzzle Reproduction task (a constructional ability task) of the Loewenstein Occupational Therapy Cognitive Assessment (LOTCA) in order to determine whether a reduced-detail version of the task would be easier (i.e., require less time to complete) than the original version and whether a subplacement version would be more difficult to perform (i.e., require more time to complete) than the original version. In addition, the study examined whether older adult subjects would perform more slowly than younger adult subjects.

Method. Seventy-two right-handed adults with no disabilities were divided into two age groups: 18 to 30 years old (n = 36) and 58 to 70 years old (n = 36). Each subject was tested on one of three versions of the LOTCA Puzzle Reproduction task (i.e., original, subplacement, simplified).

Results. For the older subjects, the simplified version of the task required significantly less time than the original version, although there was not a significant time difference between the original and subplacement versions. For the younger subjects, the subplacement version required significantly more time than the original version, but there was no significant time difference between the original and simplified versions. Results also indicated that older subjects took significantly longer to perform all three versions of the task than did the younger subjects.

Conclusion. The findings support the use of the simplified version of the LOTCA Puzzle Reproduction task with older adults or with persons with major cognitive-perceptual difficulties. Further studies of the level of difficulty of the subplacement version are needed to examine whether this version is more sensitive to constructional deficits in a sample of persons with neurological impairments because even mild constructional deficits have been shown to relate to disabilities in daily functioning.

Constructional ability is the capacity to articulate parts into a single entity or object (Benton, 1993) and requires the integration of visual perception, motor planning, and motor execution (Strub & Black, 1977). Constructional activities, at any level, are the expressions of perceptual abilities and visuomotor organization and always have spatial components (Lezak, 1995). Nearly all adults with brain damage, including those with head injury, are expected to show some loss of constructional ability (Neistadt, 1989). Several studies have linked constructional deficits to poor activities of daily living (ADL) and instrumental activities of daily living (IADL) (Neistadt, 1989).
The American Journal of Occupational Therapy

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The concept of construction, according to Lezak (1995), embraces two large classes of activities: (a) drawing and (b) building and assembling. She emphasized the importance of evaluating these activities separately because a person’s level of performance on one of these classes of activities does not necessarily match his or her performance on the other. Many tests have been developed to assess constructional abilities in adults. Table 1 lists and categorizes examples of these tests under three major classes of activities: (a) copying, (b) drawing, and (c) building and assembling. Building and assembling abilities are further divided into two dimensional and three dimensional because they have been shown to be separable (Benton, 1993; Benton & Fogel, 1962; Lezak, 1995).

Some tests assess constructional abilities exclusively, whereas tests of cognitive ability include items that assess constructional abilities. For example, seven of the subtests of the Loewenstein Occupational Therapy Cognitive Assessment (LOTCA) (Itzkovich, Elazar, Averbuch, & Katz, 1990)—Copying, Geometric Forms, Reproduction of a Two-Dimensional Model, Pegboard Construction, Colored Block Design, Plain Block Design, Reproduction of a Puzzle, and Drawing a Clock—assess constructional abilities. The LOTCA was designed to assess cognitive skills in persons with traumatic brain injury, cerebrovascular accident (CVA), and other neurological disorders. The test and its measurement properties are described in several sources (Averbuch & Katz, 1991; Itzkovich et al., 1990; Katz, Itzkovich, Averbuch, & Elazar, 1989). Although the test was designed and standardized in Israel for use with adults, it is widely used for adults in the United States. Recent research has indicated no significant differences between American and Israeli subjects with CVA and healthy adults on most of the subtests; thus, the LOTCA’s psychometric properties apply to its use by occupational therapists in assessing American adults (Annes, Katz, & Cermak, 1996; Cermak et al., 1995).

In a recent study, Katz, Elazar, Itzkovich, Ring, and Soroker (1996) examined the relationship between performance on the LOTCA and daily function in 40 subjects with right CVA with and without neglect. The three daily function measures used were the Functional Independence Measure (FIM) (Granger, 1993), ADL checklist (Hartman-Maeir & Katz, 1995), and the drink and sandwich preparation tasks of the Rabideau Kitchen Evaluation-Revised (Neistadt, 1992b). Scores on four LOTCA areas—Orientation, Perception, Visuomotor Organization, Thinking—were correlated with the three daily function measures. For the neglect group, moderate to high correlations, $r = .48$ to $r = .80$, were found between the four LOTCA areas and the three daily function measures at discharge. The highest correlations were between the Visuomotor Organization and Thinking areas and the drink and sandwich preparation tasks, $r = .80$. Within the nonneglect group, correlations generally were moderate, $r = .36$ to $r = .62$, at discharge, with the highest correlation between the Visuomotor Organization area and the FIM total score, $r = .62$.

Six months after discharge, three LOTCA subtests from the Visuomotor Organization area were administered—Colored Block Design, Reproduction of a Puzzle, and Drawing a Clock (Katz et al., 1996). In the neglect group, moderate to high correlations, $r = .40$ to $r = .77$, were found between the three Visuomotor Organization subtests and the three daily function measures. Specifically, the Puzzle Reproduction subtest highly correlated with all daily function measures, $r = -.70$; the highest was with sandwich preparation, $r = .70$. These results suggest the importance of constructional abilities to functional performance in ADL and IADL tasks and, therefore, the importance of accurate and sensitive evaluation of these abilities and deficits.

The LOTCA Puzzle Reproduction subtest was designed to assess the visuomotor components of the building and assembling activity (a constructional ability). The puzzle is a colorful image of a butterfly divided into nine pieces (see Figures 1 and 2). The client is asked to place the nine puzzle pieces directly on top of the butterfly image in order to assemble the picture. Because of the symmetry of the image, a client’s directional problems are clearly expressed. Many clients with these problems can correctly construct the middle of the image (i.e., three vertical pieces) (see Figure 1) but have difficulty constructing its sides. An additional source of difficulty arises when a client incorrectly places one or more puzzle pieces. Because the pieces are placed directly on top of the image, the gestalt of the whole image may change, and the client then is unable to visualize the change and locate a replacement piece for the part or parts of the image he or she covered incorrectly.

Clinical experience with this test has indicated that older clients with cognitive-perceptual deficits often find the Puzzle Reproduction task too difficult. To better meet the needs of older clients, the authors of the LOTCA created a simplified version in which they reduced the surface details of the butterfly puzzle image (LOTCA-Geriatric [LOTCA-G]; see Figure 2) (Katz, Elazar, & Itzkovich, 1995). At the same time, the authors were interested in increasing the difficulty of the task in order to identify mild constructional deficits. Several other authors have
Table 1  
Classes of Visuomotor Organization Activities and Sample Tests

<table>
<thead>
<tr>
<th>Activity</th>
<th>Test Name</th>
<th>Task</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Rey-Osterriech Complex Figure</td>
<td>Copying and reproduction from memory</td>
<td>Lezak (1995)</td>
</tr>
<tr>
<td></td>
<td>• Developmental Test of Visual Motor Integration</td>
<td>Figure copying</td>
<td>Beery and Burenica (1989)</td>
</tr>
<tr>
<td></td>
<td>• Visual Motor Gestalt Test</td>
<td>Figure copying</td>
<td>Bender (1938)</td>
</tr>
<tr>
<td></td>
<td>• Lovewentstein Occupational Therapy Cognitive</td>
<td>One section involves testing constructional</td>
<td>Irkvovich, Elazar, Averbuch,</td>
</tr>
<tr>
<td></td>
<td>Assessment</td>
<td>abilities</td>
<td>and Katz (1990)</td>
</tr>
<tr>
<td></td>
<td>• Parietal Lobe Battery of the Boston</td>
<td>Figure copying</td>
<td>Goodglass and Kaplan (1983)</td>
</tr>
<tr>
<td></td>
<td>Diagnostic Aphasia Examination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drawing</td>
<td>• Rey-Osterriech Complex Figure</td>
<td>Drawing from memory</td>
<td>Lezak (1995)</td>
</tr>
<tr>
<td></td>
<td>• Parietal Lobe Battery of the Boston</td>
<td>Drawing to command</td>
<td>Goodglass and Kaplan (1983)</td>
</tr>
<tr>
<td>Building and</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Assembling</td>
<td>Two dimensional</td>
<td>Block building from pictures</td>
<td>Weschler (1981)</td>
</tr>
<tr>
<td></td>
<td>• Wechsler Adult Intelligence Scale-Revised Design</td>
<td></td>
<td>Arthur (1947)</td>
</tr>
<tr>
<td></td>
<td>• Koh’s Block Design</td>
<td>Block building from model</td>
<td>Goodglass and Kaplan (1983)</td>
</tr>
<tr>
<td></td>
<td>• Parietal Lobe Battery of the Boston</td>
<td>Matchstick design from model</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diagnostic Aphasia Examination</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Three dimensional</td>
<td>Block building from model</td>
<td>Benyon, Sivan, Hamscher, Varney,</td>
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<tr>
<td></td>
<td>• Test of Three-Dimensional Constructional Praxis</td>
<td></td>
<td>and Spren (1994)</td>
</tr>
<tr>
<td></td>
<td>• Parietal Lobe Battery of the Boston</td>
<td>Block building from model</td>
<td>Goodglass and Kaplan (1983)</td>
</tr>
<tr>
<td></td>
<td>Diagnostic Aphasia Examination</td>
<td>Block building and direct placement</td>
<td>Neistadt (1989a)</td>
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<tr>
<td></td>
<td>• Parquetry Block Test</td>
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</tbody>
</table>

suggested ways to modify a task in order to change its level of difficulty (Ben-Yishay, Diller, Mandelberg, Gordon, & Gerstman, 1974; Lezak, 1995; Neistadt, 1989a; Toglia, 1991). Toglia (1991) stated that as a task becomes more complex in its surface characteristics (i.e., its shape, number of pieces, color), it becomes more challenging for the person to select relevant stimuli; thus, planning the performance of the task is more difficult. Likewise, decreasing the complexity of these same parameters makes it more simple to perform.

The task’s level of difficulty is often assessed by evaluating the time it takes to complete it. When initial data on the LOTCA were collected for children, scores indicated that as age increased from 6 to 12 years, the length of time it took to perform the Visuomotor Organization subtests decreased (Averbuch & Katz, 1991). In another study that used a shorter and less complicated version of the LOTCA (Katz et al., 1995), time was found to be a major variable in older subjects. The results indicated that healthy older subjects (over 70 years of age) took more time to perform the test than middle-aged subjects (40–70 years of age). Additionally, older subjects with CVA (mean age = 77 years) took more time than did the healthy older subjects to perform the test. Longer performance time is presumably due to the fact that the slowing of cognitive functioning that occurs with aging is more pronounced when a CVA has occurred (Riley, 1994).

Considering the importance of constructional ablil-
ties to daily function as well as the importance of accurate and sensitive measures of these abilities, the purpose of this study was to compare performance on three versions of the LOTCA Puzzle Reproduction subtest: (a) the direct placement (original) version, (b) the subplacement version, and (c) the simplified version from the LOTCA-G. The rationale for the subplacement task follows well-known tests, such as the Block Design subtest of the Weschler Adult Intelligence Scale-Revised (Weschler, 1981), which measures constructional abilities by placing the blocks below the picture design. The change alters the task difficulty but maintains the original intent to measure constructional abilities. We wished to determine whether the simplified LOTCA-G version takes less time to perform than the original version and whether the subplacement version takes longer to perform than the original. Finally, we wanted to examine whether older subjects would require more time to complete each version of the Puzzle Reproduction subtest than would younger subjects.

Method

Subjects

The subjects were 72 right-handed adults from the greater Boston area who did not have a history of brain injury or perceptual or learning difficulties. They were divided into two age groups: (a) younger subjects, 18 to 30 years old ($n = 36$), and (b) older subjects, 58 to 70 years old ($n = 36$). The mean age of the younger group was 25.4 years ($SD = 5.1$), and the mean age of the older group was 65 years ($SD = 4.4$).

Procedure

The subjects were tested individually in quiet environments. Before testing, subjects completed an information sheet that surveyed age, gender, handedness, years of education, current job title, and history of an event or disorder that could impair their perception. The subjects in each age group were sequentially assigned to perform one of the three versions of the Puzzle Reproduction subtest: (a) the direct placement (original) version, (b) the subplacement version, or (c) the simplified version from the LOTCA-G. Twelve subjects in each age group (6 men, 6 women) participated in only one of the three versions of the subtest to avoid a practice and learning effect.

The LOTCA Puzzle Reproduction subtest consists of a picture of a colorful butterfly on a 10 in. by 7 in. card divided into nine squares with intersecting lines (see Figure 1) and nine corresponding puzzle pieces. After the puzzle pieces were scattered on the tabletop adjacent to the puzzle, subjects were asked to construct the puzzle by placing the pieces directly on top of the image of the butterfly. For the subplacement version, subjects were asked to construct the puzzle by placing the pieces below, rather than directly on top of, the image. In the LOTCA-G version, the details of the image of the butterfly and the corresponding puzzle pieces are reduced, and the subjects were required to place the nine pieces directly on top of the image (see Figure 2).

All subjects were told that they could take whatever amount of time they needed to correctly construct the puzzle and that their time would be recorded. Time scores and subjects’ comments during the task were recorded. Because subjects without disabilities tend to perform almost perfectly on the Puzzle Reproduction task (Averbuch & Katz, 1991; Cermak et al., 1995; Katz et al., 1989; ), accuracy score was not the variable of interest.

Results

Because previous studies showed no difference between scores of men and women on the LOTCA (Averbuch & Katz, 1991; Katz et al., 1995), Puzzle Reproduction subtest scores of both male and female subjects were combined. To examine whether there were differences in time scores as a function of age and subtest version, a two (Age) by three (Version) analysis of variance was conducted. Age was significant, $F(1, 66) = 61.41, p < .0001$; puzzle version was significant, $F(2, 66) = 9.47, p < .0002$; and age-by-version interaction was significant, $F(2, 66) = 4.75, p < .01$. The means and standard deviations for each age on each version are reported in Table 2 and shown in Figure 3.

Scheffé multiple comparisons indicated that the older subjects took significantly longer to perform each version than did the younger subjects. Within the younger group, there was no significant difference between the time scores on the original and LOTCA-G versions; however, the time score for the subplacement version was significantly longer than that for either of the other two versions. Within the older group, there was no significant difference between time scores on the original and subplacement versions; however, the time score for the LOTCA-G version was significantly shorter than that for the other two versions.

Discussion

As anticipated, there was a main effect for age as well as for task version, although the age-by-version interaction was unexpected. Katz et al. (1995) found that the LOTCA-G version required less time than the original version for older subjects to perform. Our results were similar. However, the time required by the younger group to complete the LOTCA-G was not significantly less than the time it took them to complete the original. This finding may be because the mean time required for younger adults to complete the original version (26 sec) is predominantly
used in the physical motion of placing the pieces onto the puzzle image. If this is the case, time cannot be significantly decreased in the LOTCA-G version for healthy young adults, even if it is less complicated to process for persons who have constructional deficits.

That the younger group’s time score for the subplacement version was significantly longer than that for the original indicates greater task difficulty of the subplacement version; however, this was not true for the older group. The amount of detail and spatial demands on the original and subplacement versions might have been more complex and difficult for the older subjects in that the placement of the puzzle pieces became a relatively less important factor. Another possible explanation is that if a piece of the butterfly image is covered incorrectly in the original (direct placement) version, the image is changed, adding further difficulty for the task. The change of image was not a problem for younger subjects because they made fewer initial errors, but it may have made the original version relatively more difficult for the older subjects.

The finding that older subjects took a longer time to perform all versions of the test than did the younger subjects may be partly related to the strategy used in the placement of the pieces. Many of the younger subjects placed the pieces directly on top of the correct spot, eliminating the need for a trial-and-error strategy. They either picked up all nine pieces at once and placed each onto its designated position, or they picked up each piece individually and placed it onto its correct position. The older subjects tended to use more of a trial-and-error approach. For instance, older subjects would incorrectly place a piece where they thought it belonged and later pick up the appropriate piece for that spot and take some time trying to discern its correct position. This approach added to the task’s difficulty because the correct spot was covered by an incorrect piece, hence distorting the puzzle image. Another type of trial-and-error approach the older subjects used consisted of physically manipulating a piece to a few spots rather than mentally discerning its position before placing it.

The major limitation of the study is its use of a convenience sample and the small number of subjects tested on each version of the Puzzle Reproduction subtest. To generalize the results beyond the Boston area, more subjects from different locations should be tested. Replication of the study would be beneficial.

Conclusions

Implications of our findings in conjunction with previous findings, which show high correlations of constructional abilities with daily function, suggest that intervention should include evaluation of constructional abilities with tests as well as through actual functional tasks. The strategies persons use to complete a constructional task can suggest approaches to be used in intervention.

As indicated in Table 1, there are different ways to assess constructional ability, with each tool providing different information about this complex skill. In this study, we focused on one method of assessment, namely a two-dimensional assembly of puzzle pieces into a picture. Further, we modified an existing puzzle task (a LOTCA subtest) in order to decrease and increase the task difficulty. Our results support the use of the LOTCA-G version of the subtest for evaluating older adults or persons with major cognitive-perceptual difficulties because we have found that decreasing the number of surface characteristics of the task is a valid way to simplify it.

Continued research is needed to examine the subplacement version of the LOTCA Puzzle Reproduction subtest in order to be confident that it is more difficult than the original version and that it is a valid way to assess mild constructional deficits. The subplacement version changed the spatial requirements of the task, and as such, required more complex constructional abilities. Therefore, it is a more sensitive tool as supported by our findings with the younger subject group. Further studies can be conducted to compare the subplacement version with other similar tests or to compare different diagnostic groups’

Table 2

<table>
<thead>
<tr>
<th>Subject Group</th>
<th>Test Version</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Original</td>
</tr>
<tr>
<td>Younger</td>
<td>26.3</td>
</tr>
<tr>
<td>Mean (sec)</td>
<td>7.8</td>
</tr>
<tr>
<td>Older</td>
<td>117.0</td>
</tr>
<tr>
<td>Mean (sec)</td>
<td>42.3</td>
</tr>
</tbody>
</table>

performance on this version. The substitution version is not yet included in the test battery because more work on reliability and validity must be completed.

However, both ways of changing task difficulties have implications for changing actual daily activities and can be used when adaptations are needed. Interpreting results can range from the need to reduce the number of components for a whole activity (e.g., preparing a meal that includes two courses compared with four for two or four persons, setting the table or having it set by somebody else, making a salad from only cucumbers and tomatoes instead of a variety of vegetables) to the need to provide an example or to start the task for the client (e.g., moving and arranging office supplies in a different location). However, these activities require more than constructional abilities. Deficits in these skills make it harder to function adequately in daily activities and to become independent. Moreover, the length of time needed to complete an activity is an important component in functional independence. Our results show that a similar task can take some persons five times longer to perform than others, a fact that may have crucial implications for function and for intervention. ▲

Acknowledgments

This study was completed by the second author in partial fulfillment of the requirements for the master of science degree, Department of Occupational Therapy, Sargent College of Health and Rehabilitation Sciences, Boston University.

References


