Performance of Normal Older Adults on Tests Designed to Measure Parietal Lobe Functions
(constructional apraxia, Gerstmann's syndrome, visuospatial organization)

Phyllis Fleming Farver, Thomas B. Farver

Symptoms referable to the parietal lobes, such as difficulty with dressing, unilateral neglect, or manual apraxia, are a frequent rehabilitation problem among stroke patients. Occupational therapists need an evaluation tool for parietal lobe functions and performance expectations for adults 40 years and older. A battery of tests designed to measure functions of the parietal lobes was given to 68 normal adults from 40 to 88 years of age. The test battery included drawings, stick designs, finger identifications, right-left identifications, arithmetic, clock settings, map localizations, block constructions, visual organization tasks, and visual discrimination tasks. Statistical analysis of the data revealed significant age-related changes on the constructional tasks, finger identifications, clock settings, visual organization tasks, and visual discrimination tasks. No significant age effect was found on right-left identifications, map localizations, or arithmetic. Implications for the evaluation and treatment of older adults in occupational therapy are discussed.

Disturbance of sensory integration as well as other symptoms referable to the parietal lobes have been found to be important factors affecting the recovery of hemiplegic patients (1, 2). Functional implications of the symptoms include difficulties in orienting one's clothing to one's body (3); ignoring one side of the body in bathing, dressing, and walking (4); or making apparently bizarre movements because of distorted spatial judgments (4). Occupational therapists need an

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evaluation tool to help them anticipate patient difficulties in activities of daily living and define the more basic disabilities contributing to these functional problems. Certain sensory disabilities, motor disabilities, and intellectual deficits are attributed to dysfunction in the parietal lobes (5). The sensory disabilities that may occur with parietal region damage are impaired joint-position sense in the fingers, loss or impairment of 2-point discrimination, defective tactile localization of stimuli, sensory neglect or “inattention,” and astereognosis (5). Motor disabilities may include some degree of uncoordination, diminished muscular resistance to passive stretching, muscular wasting, poverty of voluntary movements, and manual apraxia (5). The intellectual defects in parietal disorders may include anosognosia, visuospatial disorientation, simultanagnosia, constructional apraxia, picture agnosia, disturbances of the body image or schema, and Gerstmann’s syndrome, which includes finger agnosia, agraphia, acalculia, and right-left disorientation (5).

Taylor developed a battery of tests including the evaluation of kinesthesia, proprioception, eye pursuit, visual perception of form and position in space, visual form constancy, visual discrimination, visual perception of the vertical position, drawing, 2-point tactile discrimination, manual perception of form, right-left discrimination, body visualization, coin identification, arithmetic, weight perception, fine motor planning, and block constructions (6). Another battery, the Parietal Lobe Tests (PLT) of the Boston Diagnostic Aphasia Examination (7), has been developed that similarly measures the sensory, visuospatial, and cognitive tasks of the Taylor battery. It complements and supplements the Taylor tests by including tests not included in the Taylor; also, it is more difficult and, therefore, more discriminative. This test has been used to evaluate brain-damaged patients, but normative data are not yet available. The present study was designed to gather preliminary normative data for the PLT and two supplementary visuospatial tests for persons more than 40 years of age, the years of the highest incidence of cerebrovascular accident (8, 9), and to determine whether there are age-related changes in performance that should be examined in a larger study.

Older adults have been found to be poorer performers than younger adults on various tests similar to those used in the PLT. On the Wechsler Adult Intelligence Scale, the expectation for the verbal subtests is slightly less for older adults than for younger adults, and the expectation for the performance subtests is markedly less for older adults (10). Also, older adults were found to be poorer performers than younger adults on the Bender Visual-Motor Gestalt Test (11), on the Thurstone Embedded Figures Test (12), on the Draw-a-Person Test (13), on arithmetic computation tests (14), and on spatial tests (15). Taylor likewise found decreased accuracy among normal older subjects on tests of visual figure-ground discrimination, gross upper-extremity proprioception, perception of joint motion in the right upper extremity, eye pursuit, and combined measures in body visualization (6).

If age significantly affects performance on tests designed to measure function of the parietal lobes, certain implications are presented for occupational therapists. In the evaluation of elderly stroke patients on tests designed to measure functions of the parietal lobes, age must be taken into account. Defective performance may reflect problems caused by the aging process in addition to problems of the recent cerebrovascular accident.

The question addressed in this study was: Do normal older adults show age-related changes in performance on the Parietal Lobe Tests of the Boston Diagnostic Aphasia Examination, the Hooper Visual Organization Test, and the Popplereuter Superimposed Figures Test? It was hypothesized that age-related changes would be seen.

**Methods**

**Subjects.** Thirty-four male and 34 female subjects between the ages of 40 and 88 years participated in this study. They were divided into five age groups (40-49 years, 50-59 years, 60-69 years, 70-79 years, and 80-89 years). Numbers of subjects in each group, mean age for each age group, and mean educational level for each age group are given in Table 1. An attempt was made to exclude from the study persons with a history of any of the following conditions: cerebrovascular accident; loss of consciousness, head injury for which medical treatment was received; tumors of the nervous system; clumsiness of one hand; difficulty speaking; cardiac arrest, seizure disorder, or any other neurological disorder involving the head or neck region; treatment for acute or chronic conditions resulting from the use of drugs or alcohol; hospitalization for psychiatric illness; and hypertension for which medication was required. There were 15 subjects who were exceptions to the criteria, mostly by reason of taking medication for hypertension or having a head injury, but with no known neurological sequelae. Exceptions were evenly distrib-
The tests were as follows:

1. **Drawing**—Two- and three-dimensional objects drawn from verbal command and copied.
2. **Construction**—Block and stick designs constructed from memory, photographs, or an actual model.
3. **Finger gnosis**—Verbal comprehension, verbal naming, visual and tactile identification of fingers.
4. **Right-left orientation**—Right and left identification on self, another person, and on drawings of hands and feet.
5. **Arithmetic ability**—Calculations and clock settings on clock faces drawn with and without numbers.
6. **Topographical orientation**—Identification of geographic items on a United States map.
7. **Hooper Visual Organization Test**—Identification of objects drawn with parts disorganized; selected items that have been demonstrated to elicit isolated responses in patients with right hemisphere disease.
8. **Poppelreuter Superimposed Figures Test**—Identification of individual figures drawn superimposed one upon the other, a type of figure-ground task; selected items that have been demonstrated to elicit isolated responses in patients with right hemisphere disease.

Reliability of the test instrument was evaluated by test-retest of four subjects including one male and three females 56 to 63 years of age. To minimize a learning effect, those tasks that involved redoing missed items in a simpler form were omitted throughout the age groups. All but five subjects were living independently. Three were temporarily hospitalized for surgical reasons, one was the resident of a senior citizens' home, and one was a convalescent living in the home of a friend.

All subjects used the right hand for writing and several other tasks of daily living.

**The Test Instrument.** The test battery used in this study consisted of the six Parietal Lobe Tests of the Boston Diagnostic Aphasia Examination (7), the Hooper Visual Organization Test (16), and the Poppelreuter Superimposed Figures Test (17, 18)—the latter two were used in a supplementary manner because they required verbal responses rather than constructional responses. The tests were as follows:

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**Table 1**

<table>
<thead>
<tr>
<th>Subject Group</th>
<th>No. Subjects</th>
<th>Mean Age (S D)</th>
<th>Mean Educational Level (S D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-49 Years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>5</td>
<td>43.6 (2.4)</td>
<td>12.4 (2.6)</td>
</tr>
<tr>
<td>Females</td>
<td>8</td>
<td>44.4 (3.0)</td>
<td>13.4 (1.5)</td>
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<tr>
<td>Total</td>
<td>16</td>
<td>44.0 (2.7)</td>
<td>12.9 (2.1)</td>
</tr>
<tr>
<td>50-59 Years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>8</td>
<td>56.3 (1.0)</td>
<td>12.9 (3.3)</td>
</tr>
<tr>
<td>Females</td>
<td>8</td>
<td>54.3 (2.9)</td>
<td>12.6 (1.1)</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>55.3 (2.4)</td>
<td>12.7 (2.4)</td>
</tr>
<tr>
<td>60-69 Years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>8</td>
<td>62.0 (1.4)</td>
<td>12.2 (2.1)</td>
</tr>
<tr>
<td>Females</td>
<td>8</td>
<td>63.3 (2.0)</td>
<td>13.4 (1.0)</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>62.8 (1.8)</td>
<td>12.9 (1.7)</td>
</tr>
<tr>
<td>70-79 Years</td>
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<td></td>
</tr>
<tr>
<td>Males</td>
<td>6</td>
<td>75.7 (3.2)</td>
<td>10.2 (3.9)</td>
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<tr>
<td>Females</td>
<td>6</td>
<td>73.5 (2.9)</td>
<td>11.5 (2.8)</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>74.6 (3.1)</td>
<td>10.8 (3.3)</td>
</tr>
<tr>
<td>80-89 Years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>4</td>
<td>83.8 (2.5)</td>
<td>11.2 (1.5)</td>
</tr>
<tr>
<td>Females</td>
<td>4</td>
<td>84.0 (2.7)</td>
<td>10.2 (2.1)</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>83.9 (2.4)</td>
<td>10.8 (1.8)</td>
</tr>
</tbody>
</table>
ted. Although four subjects were too small for statistical analysis, a comparison of test-retest scores indicated acceptable reliability. Of the 56 test-retest scores, only 9 of the retest scores differed by more than one point from the corresponding initial test score.

Procedure. Subjects were tested in an office, at home, or at bedside. The test battery was given in one session. The Parietal Lobe Tests of the Boston Diagnostic Aphasia Examination were administered in the manner described by Goodglass and Kaplan (7). The instruction for the Hooper Visual Organization Test was, "If you put these pieces together what would they be a picture of?" The instruction for the Poppelreuter Superimposed Figures Test was, "Name all the objects you see in this picture." In scoring, full credit, half credit, and no credit responses were established. For example, one item of the Hooper Visual Organization Test was a picture of a hand separated into four parts. A full credit response was "hand," half credit was "glove," no credit was "fingers." On the Poppelreuter Superimposed Figures Test, one item was musical instruments superimposed upon one another. One instrument was a guitar. Violin, banjo, or mandolin were also considered acceptable for full credit.

Results
An analysis of covariance for a 2-factor model with replication and Duncan's New Multiple Range Test for pairwise comparisons of means were used to analyze the data. When the data of a particular variable did not satisfy the assumptions implicit in the analysis of covariance, the data were transformed using the rankit transformation (19).

The two factors for the analysis of covariance were age (consisting of the five decade groups) and sex; the covariate was educational level. The ten test scores analyzed were: drawings to command, stick constructions to memory, the total of the finger gnosis scores, the total of the right-left orientation scores, arithmetic, clock settings, map orientation, block constructions copied from photographs, the Hooper Visual Organization Test, and the Poppelreuter Superimposed Figures Test.

Table 2 summarizes the data, giving the means (adjusted for educational level) of each age group and pairwise multiple comparisons of the means. For all the variables no statistically significant sex effect or sex by age interaction effect was found. The latter finding suggesting that the results obtained for each age group were consistent over the two sexes. In addition, three variables—right-left orientation, arithmetic, and map orientation—had
no statistically significant age effect. For all the remaining seven variables—drawings to command, stick constructions to memory, finger gnosis, clock settings, block constructions to photographs, the Hooper Visual Organization Test, and the Poppelreuter Superimposed Figures Test—a statistically significant age effect was noted ($p < 0.05$). The results for clock settings, block constructions to photographs, and the Hooper Visual Organization Test were highly significant ($p < 0.005$). The scores for block constructions to photographs were able to distinguish among the three oldest age groups. The scores for the Hooper Visual Organization Test were able to distinguish between the 70-79 and 80-89 age groups. The scores for these two oldest age groups were also significantly lower than those of the two youngest age groups studied. The 60-69 age group had an intermediate test score to that of the two oldest and two youngest age groups studied that differed significantly (being higher) only from the score for the 80-89 age group. The clock setting score for the 80-89 age group was significantly lower than the corresponding scores for the three youngest age groups studied. The clock setting score for the 70-79 age group was intermediate and not significantly different from the scores for the other age groups.

The total of the finger gnosis scores for a given subject was calculated by summing the scores of the four component tests—verbal comprehension, verbal naming, visual matching, and visual tactile identification. An analysis of the scores of each component test showed the following: The scores for verbal comprehension and verbal naming had no variability with virtually all subjects scoring the maximum number of points possible. For the tactile finger identification component no statistically significant age, sex, or age by sex interaction effect was observed. Thus, the variability observed in the total of the finger gnosis scores is a reflection of the variability observed in the third component, the visual matching score. The statistical analysis of the visual matching scores parallels that described above for the total of the finger gnosis scores.

Likewise, the total of the right-left orientation scores for a given subject was calculated by summing the two component scores—verbal right-left orientation or pointing to right or left on command, and visual right-left orientation or naming right or left from drawings. An analysis of the two component scores showed that the verbal right-left orientation test had low variability with no age, sex, or age by sex interaction effects observed. Thus, the variability observed in the right-left orientation scores is a reflection of the variability observed in the second component, the visual right-left orientation score. The statistical analysis of the visual right-left orientation scores parallels that described for the total of the right-left orientation scores.

**Discussion**

On the drawings from command, stick constructions from memory, block constructions from photographs, finger gnosis, clock settings, the Poppelreuter Superimposed Figures Test, and the Hooper Visual Organization Test, significant age-related changes were observed. On map locations, arithmetic, and right-left orientation tasks, no significant age-related changes were seen. On the finger gnosis subtest only the visual matching section showed significant age-related changes, and thus it is seen that the older subjects had more difficulty than the younger subjects on those subtests with a strong visuospatial component. The exception to this is map locations for which errors may be attributed to lack of knowledge as well as topographical disorientation.

The subtests that tested for disabilities of the Gerstmann's syndrome, right-left orientation, arithmetic, and three of the four sections of the finger gnosis tasks showed no significant age-related changes. A possible interpretation of this finding is that the right parietal lobe functions significantly decline with age, whereas the left parietal lobe functions do not. Detailed analyses of the test used, style of performance of the subjects, and the results of performance would be necessary to test such an interpretation.

Although it was not the purpose of this study to analyze in detail the performance process of each subject or to do item analysis of the various subtests, certain observations concerning the qualities of errors were made. In the drawings there were examples reduced or enlarged in size, poor reproductions of angles, loss of perspective, rotations, errors of spatial relations, overscoring, and poorer left halves of drawings than right halves. On stick construction there were examples of rotations, shape disorganization, and perseveration. Errors in visuospatial relationships appeared on block constructions. On clock settings some subjects drew hands pointing toward the center of the clock, drew hands that had no reference to the center of the clock, incorrectly designated the long and short hands, or drew hands of equal length. Frequent errors on the Hooper Visual Organization Test were isolated responses, responses...
based upon only one part of the drawing. These errors have been discussed in the literature (7, 20-24) as characteristic of brain-damaged patients.

The results of this study have implications for occupational therapists. One is that in testing the brain-damaged patient more than 70 years of age, errors that might be considered to reflect parietal lobe damage in a younger patient may reflect "normal performance" for this age. Second, patients more than 70 years of age cannot be expected to function independently. One is that in testing the older adults showing defective performance on constructional tasks. This changing treatment for an older patient involves teaching a new constructional skill. Third, if normal older adults showing defective performance on certain tasks of a battery of tests designed to measure functions of the parietal lobes are able to function independently, one may expect that younger brain-damaged adults with the same level of defect to function independently. However, there might be an adjustment or compensation made over the years enabling older adults to continue to function independently.

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Summary
This study was designed to test the performance of normal older adults on a battery of tests designed to measure functions of the parietal lobes. Review of the literature led to the hypothesis that age-related changes may be expected on some subtests of the battery of tests designed to measure functions of the parietal lobes. The subjects were 68 normal adults from 40 to 88 years of age. The following subtests showed significant age-related decline in performance: The Hooper Visual Organization Test, block constructions to photographs, drawings from command, stick constructions from memory, clock settings, finger gnosis, and the Poppelreuter Superimposed Figures Test. No significant age-related decline was seen on the subtests of right-left orientation, arithmetic, or map locations. On many of the subtests qualitative differences in performance were seen between better performers and poorer performers who usually corresponded to younger and older subjects, respectively. Age-related changes on certain subtests and qualities of the errors were discussed. The implications for evaluation and treatment of patients in occupational therapy were also discussed.

REFERENCES