Sequential versus Simultaneous Graphesthesia Tasks in 6- and 10-Year-Old Children

(pediatrics, sensory integration, sex differences, tactile processing)

Colleen M. Smith  Sharon A. Cermak  David L. Nelson

Reported in the statistics of the Southern California Graphesthesia Test are significant sex differences for certain young age groups, with females scoring higher than males. In contrast, another study has reported that adult males scored higher than females on the same test.

The purpose of this study was to examine the interaction between sex and age and to investigate a possible explanation for this interaction. Sixty-four normal children between the ages of 6.0 and 7.0 years, and 10.0 and 11.0 years were administered two graphesthesia tasks. One task was an adaptation of the Graphesthesia Test of the Southern California Sensory Integration Test (SCSIT). In this task, shapes were drawn sequentially on the palmar surface of the child’s hand. A second task was devised whereby each of the same shapes was presented in a simultaneous manner, that is, the entire outline of each shape was pressed onto the palmar surface of the child’s hand. Results indicated that for both tasks, younger boys performed relatively less ably than girls, but older boys equalled or surpassed the girls. At a level approaching significance, females scored relatively higher than males on the sequential task, and males scored relatively higher than females on the simultaneous task. However, this tendency toward an interaction between sex and the type of task does not fully explain the interaction between sex and age on graphesthesia tasks.

Sex differences have been found in the Graphesthesia Test of the Southern California Sensory Integration Test (SCSIT) for the 4.6 to 4.11-, 5.0 to 5.5-, and 6.0 to 6.5-year age groups, with females consistently scoring higher than males (1). Factor analytic studies have shown that graphesthesia correlates with visual-spatial skills, and other studies have shown that the right hemisphere is specialized in visual-spatial perception earlier in boys than in girls (2-6). Since boys perform better than girls on analysis of tactile spatial material, it is somewhat surprising that girls score significantly higher than boys on a test that heavily loads on a form and space factor (3, 6).

Colleen M. Smith, MS, OTR, is an occupational therapist at Children’s Hospital; Sharon A. Cermak, EdD, OTR, is Associate Professor of Occupational Therapy, Sargent College, Boston University, and a faculty member of the Center for the Study of Sensory Integrative Dysfunction; and David L. Nelson, PhD, OTR, is Assistant Professor of Occupational Therapy, Sargent College of Allied Health Professions, Boston University; all in Boston, MA 02115.
In contrast, in a study of adult tactile functioning using the SCSIT, men did better than women on the Graphesthesia Test (7). This was the only significant sex difference on the tactile tests. These results are the exact opposite of what is found with young children but are consistent with the research stating that adult males perform better on visual-spatial and tactile-spatial tasks than females (6).

One possible explanation for the female superiority in young children and the male superiority in adults is that girls mature earlier than boys in tactile functioning. However, there are no other significant differences between young boys and girls as measured by the remaining tactile tests of the SCSIT.

Another possible explanation for this sex difference with children in the Graphesthesia Test is that boys and girls use different strategies. If one considers the Graphesthesia Test of the SCSIT, the shape is sequentially drawn on the back of the child's hand, but the child must be able to use the information together mentally to form a holistic shape. Perhaps, for younger ages, the sequential demands of the task are greater than the spatial demands. Therefore, the superiority of young females on the graphesthesia task may be due to their ability to perceive sequential input (through the left hemisphere processing) more ably than males. This is consistent with the literature that suggests earlier left hemisphere specialization in females (8). Therefore, it is possible that, if the information on the Graphesthesia Test were presented in a simultaneous manner, which would require right hemisphere processing, boys would process the input relatively better than girls.

A third explanation of this apparent interaction between age and sex on the Graphesthesia Test may be that girls perform cross-modal (tactile-spatial) functions at an earlier age than boys, with boys catching up and surpassing the girls at a later age. A fourth explanation may be that the superior motor ability of young girls results in higher scores on the Graphesthesia Test, since it requires the subject to reproduce the shapes manually (1).

It is important to confirm whether there is an interaction between sex and age on graphesthesia tasks since the second previous studies that suggest such an interaction cannot be directly compared to each other. This study was designed to address the following questions:

1. Is there an interaction between sex and age on the sequential graphesthesia task, such that young girls score relatively higher than young boys, and older boys score relatively higher than older girls?
2. Is there an interaction between sex and the type of graphesthesia task, such that boys process simultaneously presented input relatively better than girls, but girls process sequentially presented input relatively better than boys?
3. Is there a triple interaction, such that the interaction between sex and age on the sequential graphesthesia task is greater than the interaction between sex and age on the simultaneous task?

Method
Subjects. Subjects were 64 normal children, with 32 subjects aged 6.0 to 7.0 years, and 32 subjects aged 10.0 to 11.0 years. There were 16 males and 16 females in each age group.

The subjects were randomly selected from a pool of subjects from six elementary schools in Ramsey, New Jersey, and Boston, Massachusetts. The following criteria were used in selecting the subjects:

1. parental right-hand preference as determined by a questionnaire;
2. child right-hand preference as defined by teacher and parent report;
3. at least 70 percent right-hand preference on the Lateral Consistency Test;
4. language quotient of 85 or above on the Peabody Picture Vocabulary Test-Revised (PPVT-R);
5. appropriate achievement in school as determined by teacher report.

Procedures. Initial screening of the child's and the parent's handedness was done through a questionnaire that was completed by the child's parents. If both the parents and the child were right-handed by report, then the child was tested individually in a distraction-free setting by the principal investigator in one session of approximately 20 minutes. The Lateral Consistency Test, adapted from Lyle, was administered initially, and, if the child was right-handed on at least 70 percent of the items, the PPVT-R was administered (9, 10). If the child scored 85 or above, the graphesthesia tasks were administered.

There were two graphesthesia tasks: the sequential graphesthesia task and the simultaneous graphesthesia task. The sequential graphesthesia task was adapted from the Graphesthesia Test of the SCSIT, with the only difference
being that the input was provided to the palmar surface of the hand rather than to the dorsal surface of the hand. This was done because of the nature of the simultaneous graphesthesia task, which requires a smooth, flat palmar surface versus the tendonous dorsal surface. In the sequential graphesthesia task, the examiner drew each of the shapes with the eraser of a pencil on the palmar surface of the child's hand. In the simultaneous graphesthesia task, the examiner pressed the same shape outlines onto the palmar surface of the child's hand for two seconds, with the same amount of pressure as in the Graphesthesia Test of the SCSIT. These shape outlines were made of Orthoplast, and the area of the shape outline that came in contact with the child's skin was covered with rubber washer material similar to the pencil eraser that was used in the sequential graphesthesia task. The shape outlines were 5 cm (2 inches) by 5 cm (2 inches) in size in order to approximate the size drawn on the child's hand in the sequential graphesthesia task. The input was similar to the first graphesthesia task except that the input was simultaneous rather than sequential. Both the graphesthesia tasks were administered by a therapist certified to administer the SCSIT and were scored in the manner described in the Graphesthesia Test of the SCSIT. Raw scores were used in all statistical analyses. Since the only difference in administration and scoring between the tasks was the difference in sequential and simultaneous presentation, the two types of tasks thus could be considered as conditions (levels) of the same independent variable and therefore could be compared to each other through analysis of variance. Both tasks were presented to all subjects in a counterbalanced order, with half the subjects randomly receiving the simultaneous task before the sequential task, and with the other half receiving the tasks in the opposite order.

Results
To investigate whether the order of presentation for the graphesthesia tasks was a significant variable, two simple analyses of variance were performed (one for the simultaneous graphesthesia task and one for the sequential graphesthesia task). There were no significant differences as a function of order; therefore, the use of the counterbalanced procedure was considered adequate, and order was not assessed further as a variable.

To test the hypotheses, a three-way analysis of variance was performed: sex (2) × age (2) × graphesthesia task (2), the last of which was a repeated measure since the subjects were tested on both tasks (see Table 1 for a summary of the analysis of variance).

The sex-by-age interaction was significant: F(1, 60) = 4.65, p < .05, and examination of group means indicates that young girls did relatively better than young boys, whereas older boys did relatively better than older girls (see Figure 1 for a graphic depiction of these results).

<table>
<thead>
<tr>
<th>Source</th>
<th>Between Subjects</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>3.445</td>
<td>1</td>
<td></td>
<td>3.445</td>
<td>0.26</td>
</tr>
<tr>
<td>Age</td>
<td>202.508</td>
<td>1</td>
<td></td>
<td>202.508</td>
<td>15.21*</td>
</tr>
<tr>
<td>Sex × age</td>
<td>61.883</td>
<td>1</td>
<td></td>
<td>61.883</td>
<td>4.65†</td>
</tr>
<tr>
<td>Error (between)</td>
<td>798.719</td>
<td>60</td>
<td></td>
<td>13.312</td>
<td></td>
</tr>
<tr>
<td>Task</td>
<td>1617.383</td>
<td>1</td>
<td></td>
<td>1617.383</td>
<td>201.98*</td>
</tr>
<tr>
<td>Sex × task</td>
<td>29.070</td>
<td>1</td>
<td></td>
<td>29.070</td>
<td>3.63</td>
</tr>
<tr>
<td>Age × task</td>
<td>164.256</td>
<td>1</td>
<td></td>
<td>164.256</td>
<td>20.51*</td>
</tr>
<tr>
<td>Sex × age × task</td>
<td>1.320</td>
<td>1</td>
<td></td>
<td>1.320</td>
<td>0.16</td>
</tr>
<tr>
<td>Error (within)</td>
<td>480.469</td>
<td>60</td>
<td></td>
<td>8.008</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3359.055</td>
<td>127</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .01
† = P < .05

The interaction between sex and task approached significance: F(1, 60) = 3.63, .05 < p < .10. This indicates that girls tended to score relatively higher than boys on the sequential task and that boys tended to score relatively higher on the simultaneous task (see Figure 2).

The triple interaction (sex × age × task) was not significant: F < 1. Thus the interaction between sex and age that had been previously reported in the literature on

![Figure 1](http://ajot.aota.org/unknown.png)

Sex × age interaction, in mean raw scores, with F = females and M = males

The American Journal of Occupational Therapy 379
Sex x task interaction in mean raw scores, with F = females and M = males, and with 1 = sequential task and 2 = simultaneous task.

The significant interaction between age and task, F(1, 60) = 20.51, p < .01, indicates that the sequential task was more sensitive to developmental change in both boys and girls than the simultaneous task (see Figure 3). Boys and girls scored considerably higher on the sequential task than on the simultaneous task, as indicated by the main effect of the type of task. Boys and girls were not different from each other across both ages and type of task, and older children were more skillful than younger ones across sex and type of task.

Discussion

These data have important implications for occupational therapists and others who evaluate tactile functioning in children. First, the sex by age interaction on graphesthesia tasks, which has been suggested in two previous studies, has been confirmed in a direct comparison between younger and older boys and girls. Therefore, in interpreting the Graphesthesia Test, the sex and age of a child should be considered. Since girls initially perform better than boys, young males with decreased Graphesthesia Test scores may not be significantly delayed, but the opposite would be true of females. This may explain a low graphesthesia score for young boys when all other tactile test scores are within age expectations. On the other hand, older boys should be expected to perform as well as or better than girls of the same age.

The sex by task interaction is consistent with the literature, which states that females process sequential input better and that males process simultaneous input better (8). In a sequential graphesthesia task, the child must be able to put the information together mentally to form a holistic shape. Due to their superiority in sequential processing, young girls would be expected to perform relatively more ably than boys on a sequential graphesthesia task, as found in this study and as found by Ayres (1). On the other hand, boys would be expected to perform relatively more ably on a simultaneous graphesthesia task because of boys' relative skill in simultaneous processing. Although many studies of tactile functioning in the literature suggest no sex differences, results of this study imply that sex interacts both with the nature of the tactile task and with age.

Although the sex by age and the sex by task interactions were confirmed, it has not been shown that the sex by age interaction is a function of the sequential nature of the task, since the triple interaction was not significant. However, it is important to note that triple interactions, or the lack thereof, are difficult to interpret because they depend on the interplay of three different independent variables. Further research is needed to help explain the cause of the interaction between age and sex. For example, the relatively poor ability of
young boys might be due to immature motor skill and might be explained in a study in which young boys and girls did the Graphesthesia Test both in the standardized way and in a way in which less fine motor skill is required (that is, pointing to a picture of the shape instead of drawing it).

Results of this study concur with other studies that show better performance in tactile functioning with an increase in age, especially for preschool to school-age children. However, this study did not concur with studies that suggest that tactile functioning is mature at age six, unless it is argued that the developmental differences are due to the spatial or motor components of the task rather than to the tactile component (1).

The sequential task in this study was more sensitive to developmental change than was the simultaneous. Little variance in test scores on the simultaneous test suggests problems in the design of the measuring tool, and further development of this tool is needed in order to decrease error and to record the level of function more sensitively. The results of this study also depend on the reliability of the observations. In future research a person who is unaware of the hypotheses should collect the data if possible.

Conclusion
The implications of this research relate both to the evaluation of tactile processing and to the treatment of children with tactile deficits. The process of identifying appropriate evaluation and treatment input is an ongoing one, and slight variations in the forms of sensory input could make the difference between a child's success and failure in responding. In terms of the understanding of normal development, this study suggests the need to consider the importance of sex differences in the processing of different forms of tactile input.

Acknowledgments
Appreciation is extended to the staff, children, and parents of the participating schools in Ramsey, New Jersey, and Boston, Massachusetts, for their cooperation and assistance, and to Dr. Capasso, Assistant Superintendent of Ramsey Public Schools, for his assistance. Research was conducted as partial fulfillment of the requirements for an Advanced Master's Degree in Occupational Therapy at Boston University. This article was supported in part by a grant from the United States Department of Education, which was administered through Sargent College of Allied Health Professions, Boston University, Boston, Massachusetts.

REFERENCES