Twelve college-age students who had either a low grade point average or visual perceptual problems were provided a program of sensory integration activities to determine whether sensory integration therapy would affect their academic performance. Selected reading tests were administered to establish a pre-test baseline. The students were then given a sequenced program of sensory integration activities designed to stimulate the vestibular system. After a 14-week period, reading tests were again administered.

Test results indicate a statistically significant improvement in reading skills and support the use of sensory integration therapy for individuals with difficulty learning at the college level.

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The sensory integration (SI) approach as a means of treating children with learning disorders has gained wide acceptance in the field of occupational therapy (1). However, the use of the principles of SI are not limited solely to such children. Sensory integration has also been effective in the rehabilitation of the blind (2, 3) and those with psychiatric disorders (4, 5).

Sensory integration has been used extensively in helping children with learning disabilities learn how to learn, a necessary first step toward academic achievement. Most of the studies cited to support the use of SI have been with children or with older subjects having a diagnosis other than learning disability. The persons that have not been thoroughly studied are adolescents or young adults who are underachievers in school as a result of SI dysfunction. A question remains unanswered: Can young adults with
limited academic success respond to SI therapy, thereby improving their ability to learn and increasing their opportunity to enter a profession? The faculty of the School of Occupational Therapy at Texas Woman's University (TWU) recently considered this question.

Among TWU students interested in occupational therapy as a major course of study, two groups were of particular concern to the faculty. One group was composed of freshmen who had not achieved adequate scores on Scholastic Achievement Test (SAT) or Aptitude College Test (ACT) examinations to permit them to begin a major in occupational therapy; these students were classified as General Majors and admitted to the program only after the grade point average was sufficiently high. The second consisted of occupational therapy majors having difficulty achieving the grade point average of 2.8 for entrance to the senior level; faculty members observed that errors in performance tasks of some of these students appeared to be the result of learning disabilities.

The purpose of this study was to determine whether college students who had poor reading skills or observed difficulties with performance tasks would improve in reading skills after a program of SI therapy.

Review of the Literature
There is increasing evidence that movement and motor ability are of great significance in the development of visual-perceptual skills (6-8). Movement relies on input from three sources: vestibular, tactile-propricceptive, and visual. These three systems form a total composite of information that is transmitted to higher levels of the central nervous system for integration (9).

Sensorimotor development relies on neurological organization, hypothesized to begin through stimulation of the vestibular apparatus by the earth's gravitational pull. The force of gravity stimulates the vestibular system, which relays the input to the brain stem, the reticular formation, and the cerebellum. Within the brain stem, the vestibular nuclei relay impulses to the vestibulospinal tract, which influences extensor muscle tone and the medial longitudinal fasciculus, which in turn innervates cranial nerves III, IV, and VI that in turn stimulate the extrinsic muscles of the eye (10). The cerebellum, vestibular nuclei, and reticular formation are central to the control of muscular activity (11). Motion, or vestibular stimulation, is particularly significant in the control of saccadic and conjugate eye movement, which is essential for visual fixation and scanning movements of the eyes. Fixation and smooth scanning are necessary for reading.

Sensory information received from visual, tactile, and proprioceptive receptors is integrated to form an internal awareness of size, shape, weight, and direction of movement (12). Such awareness makes it possible to distinguish between a square and a circle, a doll and a dog, or a "p" and a "q."

This internal sense is highly developed in human beings (13). When these systems—vestibular, tactile-propricceptive and visual—are not integrated or one or more is in a state of dysfunction, poor or inadequate information may be transmitted to the nervous system for neurological integration. Hebb (14) and Ayres (6) agree that when the neural impulses are decreased in one or more of these three systems, a decreased ability to manipulate objects in a purposeful manner may result. Ability to explore objects purposefully is necessary for learning and for developing an internal awareness about their attributes such as size, shape, weight, placement, and spatial relationships, space between objects.

Reading skills are partially based on the ability to correctly perceive objects and their spatial orientation. Research by Ayres (6) indicates that therapy emphasizing correct...
interpretation of the environment resulted in academic success. Kephart (15) and Sund (16) also concluded that sensorimotor experiences are essential to learning. Sensorimotor difficulties have also been noted in children older than those in the previous studies but no suggestions for remediation were made (17).

Method
Subjects. Subjects in the study were 12 female students enrolled in TWU. Their ages ranged from 18 through 23 years and the mean age was 19.8 years. Seven of the students were applying for admission to the occupational therapy curriculum and the other five had been admitted and were attempting to maintain a grade point average of 2.8 so as to remain in the program. Subjects were either freshmen with ACT scores below 15 or SAT scores below 650, transfer students whose previous academic records were below a 2.5 grade point average on a 4.0 scale, or students who were identified in media courses as having difficulty with academic or motor skills. Subjects were not enrolled in remedial or speed-reading courses because it could have affected the post-test reading scores.

Procedure. Individual assessments included the visual perceptual tests and clinical observations from the Southern California Sensory Integration Tests (SCSIT) (18). Reading skills of the subjects were evaluated by using the Nelson-Denny Reading Test (19) and the Wide Range Achievement Test (WRAT) (20). On the Nelson-Denny vocabulary test the subject was required in 10 minutes to select the correct definition from a list of four for a given word. The Nelson-Denny comprehension test required the subject to read a section of material in 20 minutes, and answer questions concerning the material. The Level II reading section of the WRAT was used, where the subject pronounces 74 words. The two tests are standardized for this age group.

The WRAT and SCSIT were administered individually; the Nelson-Denny test, in a group. The procedures for administration and scoring of each test as outlined in the appropriate manuals were strictly followed. Pre-testing was done within the first 2 weeks of the study; post-testing, after the 12th week.

SI Program. The subjects participated in SI activities for sessions of approximately 50 minutes three times a week in a group situation and in 30-minute sessions twice a week on an individual basis. The 10-week SI program followed a 3-level developmental sequence: the first level concentrated on activities with the body primarily in apedal; the second, in quadrupedal; and the third, in a bipedal position.

In the apedal level the body was positioned close to the earth. Activities included using the body as a whole or using arms and legs bilaterally. The activities presented were perceived to promote bilateral postural integration: for example, riding prone or supine on a scooter board, rocking prone or supine on an equilibrium board, or rolling up in a chenille bedspread.

The second or quadrupedal level included the all-fours position as well as sitting and was introduced approximately one third of the way through the study. Most of the subjects had integrated the adaptive responses needed for the apedal level and were ready to try activities that placed the body in a quadrupedal posture. Students who preferred apedal to quadrupedal activities were encouraged to stay with the lower level until they felt confident to try other functions. This preference for the apedal level was perceived as a sign that the subject's central nervous system was not yet ready to move on to activities in which an adaptive response was needed to maintain balance. Examples of activities at the quadrupedal level include, in the all-fours position, going down a ramp on a scooter board or rocking on an equilibrium board.

The sitting aspect of the quadrupedal level required more postural adjustments than the apedal position, but the body remained close to the earth. Postural and equilibrium reactions required in the seated position differed from those necessary while horizontal on the moving inflatable or equilibrium boards. In addition to those promoting postural adjustments, activities were used at this level designed to encourage eye-hand coordination and use of bilateral arm and leg.

The third level, bipedal activities, was introduced about two-thirds of the way through the study. The activities for this level required that the body be either in kneeling or standing position and also that the subject practice motor planning, for example, walking on stilts, or playing catch while kneeling or standing on an equilibrium board.

The three activity levels had no time limits, students were free to continue at one level until they had integrated the adaptive response for that level and were ready to move on to the next.

During the study the subjects were told very little about SI but that these activities might help them improve their academic performance. Other types of activities used included games, competitive activities, and relays. Some activities were individual in nature and some re-
Table 1
Summary of Test Results

<table>
<thead>
<tr>
<th>Tests</th>
<th>Norm</th>
<th>Mean Pre test</th>
<th>Mean Post test</th>
<th>Standard Deviation Norm Pre test</th>
<th>Standard Deviation Norm Post test</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nelson-Denny Vocabulary</td>
<td>38</td>
<td>26</td>
<td>28</td>
<td>15.54</td>
<td>10.52</td>
<td>10.60</td>
</tr>
<tr>
<td>Nelson-Denny Comprehension</td>
<td>41</td>
<td>28</td>
<td>35</td>
<td>13.94</td>
<td>10.63</td>
<td>12.81</td>
</tr>
<tr>
<td>WRAT: Reading</td>
<td>58</td>
<td>42</td>
<td>47</td>
<td>13.79</td>
<td>12.06</td>
<td>10.02</td>
</tr>
</tbody>
</table>

n.s. = not significant

required group involvement. After the subjects were familiar with several different types of games and activities, occasionally they had a chance to choose their activity for the day on an individual basis and as a group decision.

Results

Initially, the study comprised 13 women but one student did not participate after the third week. The results were based on the remaining 12 students who participated in the entire study.

The SCSIT scores have not been reported here because they are not standardized for the age group used in this study. However, they were low compared with a normative sample taken at TWU. Table 1 shows the mean and the standard deviation for each of the three tests that were administered and standardized for this age group. The table also shows the level of significance for each test.

The t-test score (21) values for the Nelson-Denny vocabulary were not significant at either the .05 or .01 levels; however, the Nelson-Denny comprehension and WRAT values were significant at .05 and .01 levels.

Discussion

This study was undertaken to assess the use of a sensory-integrative approach to improve the academic performance of low-achieving college students. The results indicated that reading was significantly improved after students participated in a program of SI activities. These findings support earlier research by Ayres (1) that showed a relationship between academic skills and sensory integration treatment in elementary school children. In this study the relationship was demonstrated in college-level students.

One factor that was not formally evaluated but greatly influenced the study was motivation. Students' motivation appeared to vary throughout the study. Subjective observations of the students' verbal responses, body language, and attendance were made throughout the study and were considered indicators of motivation. The clinician and an observer rated the subjects independently and noted a similar ranking. Using the indicators, the students were divided into two groups, "well motivated" and "poorly motivated."

Table 2 presents the subjects divided into the two groups. The term increase, as used in this table, was designated as any amount of increase in the post-test scores. Among the well-motivated subjects there were four decreases in the post-test scores; among the poorly motivated subjects there were two decreases in post-test scores. Motivation did not play as significant a role in the improvement of post-test scores as expected; however, an objective measure of motivation would have made determining its effect more reliable.

Two individuals were of particular interest. Subject 3 showed lower post-test scores in all three areas, but was placed in the highly motivated group. Half-way through the semester, the student had a recurrence of a psychological problem that apparently affected the post-test scores, inaccurately reflecting her ability. Subject 1 had been previously identified in a media course as having a problem in perceptual-motor per-
The results indicate a need for further research in the area of SI for improvement of the academic performance of the older adolescent. Findings from this study suggest that the following be taken into consideration for future research: 1. lengthen the therapy program time from weeks to months to determine if overall reading improvement continues to increase over a longer time period; 2. determine if significant gains are also made in the area of visual perception; 3. monitor the effect of motivation on the subjects under study, by using an objective test to measure motivational levels; 4. increase the number of subjects under study in order to improve the statistical reliability; 5. develop a plan for long-term follow-up studies on individual subjects in terms of grade point average and academic and career success; and 6. use of a control group, for example, freshmen students matched for experimental variables, such as college entrance examination scores and reading levels.

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REFERENCES

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Table 2

Comparison of Motivation and Students' Test Performance

<table>
<thead>
<tr>
<th>Tests</th>
<th>Well Motivated</th>
<th>Poorly Motivated</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 5 6</td>
<td>7 8 9 10 11 12</td>
</tr>
<tr>
<td>N-D vocabulary</td>
<td>+ + - + + -</td>
<td>+ + - + + +</td>
</tr>
<tr>
<td>N-D compre-</td>
<td>+ + - + + +</td>
<td>+ + + + + + +</td>
</tr>
<tr>
<td>hension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WRAT</td>
<td>+ + - + + +</td>
<td>+ + + + + + +</td>
</tr>
</tbody>
</table>

+ = increase; 0 = no change; - = decrease.

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