The purposes of this study were to obtain a preliminary description of the sensory integrative and praxis abilities of 114 non-delinquent-prone adolescents aged 12 through 18 years and to compare their performances with those of 12 delinquent-prone adolescents with learning problems. Ten of the 17 subtests of the Sensory Integration and Praxis Tests (SIPT) (Ayres, 1989) as well as the Finger Posture Imitation Test (Drucker, 1980) and the MacQuarrie Test for Mechanical Ability (MacQuarrie, 1925/1953) were administered to both groups. It was hypothesized that performance on some tests would correlate with age in the non-delinquent-prone adolescents. It was also hypothesized that some delinquent-prone adolescents with learning problems would perform significantly worse on the tests of sensory integrative and praxis abilities than would the non-delinquent-prone adolescents. A data analysis indicated that performance on the praxis tests, Manual Form Perception, Graphesthesia, and Bilateral Motor Coordination showed a significant age correlation. The results of this study indicated a difference between the two groups, and it was concluded that the delinquent-prone group performed more poorly on all of the praxis-related tests and on the absolute values of the tests of Postrotary Nystagmus, Standing and Walking Balance, and Bilateral Motor Coordination. Some of the vestibular and praxis-related tests, therefore, may still provide useful information on children older than 8 years of age.

Conflicts with the law are disproportionate among adolescents, and the rate of delinquency continues to grow (Hodgkinson, 1985; Jensen & Rojek, 1980; Siegel & Siegel, 1981). Of the several theories regarding the etiology of juvenile delinquency, one of particular interest to occupational therapists is the neuropsychological theory that links learning disabilities with juvenile delinquency.

The learning and behavioral problems that a child with a learning disability may experience as a student do not necessarily disappear as he or she progresses through the grades. The label of classroom troublemaker at the elementary school level may be replaced by the label of delinquent at the high school level. Jacobson (1974) proposed that “learning disabilities greatly increase the probability of the child’s failure and frustration and therefore bring the child into conflict with the teachers in a way that generates delinquency” (p. 207).

The purposes of this study were to describe the performance of the non-delinquent-prone sample on tests of sensory integration and praxis and to compare their performance with that of the delinquent-prone sample.
Literature Review

Jacobson (1974) defined delinquent as "a juvenile whose action deviates from social norms and is labeled as 'delinquent.' He is so labeled when he is detected and then encounters court and law enforcement authorities" (p. 193). Theories regarding the etiology of juvenile delinquency are diverse. Most researchers believe juvenile delinquency can be attributed to a combination of factors (Bartol, 1980; Jensen & Rojek, 1980; Lewis & Pincus, 1988), such as psychosocial influences on human behavior. One important contributing factor may be the biological–neuropsychological component.

Numerous studies support the notion of a possible biological basis for criminal behavior (Gabrielli, 1981; Mednick, 1977; Mednick & Volavka, 1980; Raine & Venables, 1984; Walsh & Beyer, 1987). For example, research has shown a high incidence of central nervous system and autonomic nervous system abnormalities in the juvenile delinquent population. A 1979 prospective, longitudinal study found that electroencephalograph slowing is characteristic of delinquents and is present years before criminality (Mednick, Volavka, Gabrielli, & Itil, 1979). Studies have also shown that groups of delinquents appear to exhibit abnormal autonomic nervous system responsiveness as indicated by low scores on electrodermal testing (Borkovec, 1970; Mednick & Finello, 1983; Siddle, Nicol, & Foggitt, 1973). Nervous system abnormalities, therefore, appear to be common among those groups of delinquents previously studied.

Gaddes (1985), Cruickshank (1979), and Ayres (1972) proposed that one cause of learning disabilities may be organic. Studies have shown an association between learning disabilities and juvenile delinquency (Berman, 1974; Broder, Dunivant, Smith, & Sutton, 1981; Grande, 1988; Mauser, 1974; Murlay, 1976). Meltzer, Levine, Karriski, Palfrey, and Clarke (1984) conducted a study with 53 delinquent adolescents and found them to have multiple processing deficiencies. Berman (1975) conducted a neuropsychological study and concluded that the use of indicators of neuropsychological functioning to classify delinquents supports the assumption that learning or skill deficiencies are a basic element in a significantly large number of delinquents. Hurwitz, Bibace, Wolff, and Rowbotham (1972) found delinquent boys to perform consistently more poorly than a control group on tasks of sensorimotor and symbolic sequencing. In Karriski, Levine, Clarke, Palfrey, and Meltzer's (1982) study of 54 delinquent adolescents and 51 control subjects, the greatest discriminators were visual processing and auditory-language function. Zakoński (1949) presented data on the MacQuarrie Test for Mechanical Ability (MacQuarrie, 1925/1953), which showed differences in the scores of 50 delinquent and 50 nondelinquent adolescent males. Other studies have found similar results with the use of tests of motor performance and visual-perceptual-motor processing (Berman, 1978; Silver, 1961; Tarnopol, 1970; Watson, Ottenbacher, Workman, Short, & Dickman, 1982).

Hyperactivity is an additional factor mentioned in the literature linking nervous system irregularity, learning disabilities, and juvenile delinquency. Lambert and Sandoval (1980) stated that approximately 50% of hyperactive children are also learning disabled. In a study by Delamater and Lahey (1983), hyperactive, learning-disabled children with high conduct problems (i.e., children rated as high by their teachers on conduct-problem factors) were found to exhibit significantly lower skin conductance levels than were children with low conduct problems. It has also been found that hyperactive, aggressive children are predisposed to later delinquency (Loney, Kramer, & Milich, 1981; Loney, Whaley-Klahn, Koster, & Conboy, 1983). The interrelationship of conduct problems, hyperactivity, and learning disabilities is not fully understood at this time (Delamater & Lahey, 1983).

Based on the previous research, we hypothesized a relation between sensory integrative processing and juvenile delinquency. Sensory integrative dysfunction may interfere directly with the learning process or may lead to behavioral problems that interfere with school performance (Ayres, 1979).

Difficulties with learning may contribute to social problems and may lead to subsequent delinquency. Ayres (1979) stated that "many juvenile delinquents were children with sensory integrative disorders that interfered with their success in school" (p. 58). In the present study, we did not assume that all children with sensory integrative disorders or learning disabilities would become juvenile delinquents; some children are learning disabled, others are juvenile delinquents, and still others have sensory integrative dysfunction. Some children probably have a combination of these problems. Sensory integrative dysfunction may make learning and the performance of daily tasks difficult. If these difficulties are not resolved, the child may become frustrated and angry and act out behaviors that lead him or her to be labeled juvenile delinquent.

Method

Subjects

The subjects were 12 delinquent-prone (mean age = 14.05 years) and 114 non-delinquent-prone (mean age = 14.60 years) adolescents. Most of the subjects within each group were Caucasian and right-handed.
No significant differences were found between the two groups in mean age, age distribution, sex, race, or handedness.

The subjects in the delinquent-prone sample, 8 males and 4 females, had been referred by a psychologist from the California Law Enforcement Agency, who had labeled them as delinquent-prone and as having difficulty with learning. Consent was obtained prior to testing.

The subjects in the non-delinquent-prone sample came from one middle school and one high school in Southern California. A sequential, stratified (by age) randomization procedure was used to select the subjects in this group. The recruiting procedure continued until a sufficient and comparable number in each age category was obtained. One adolescent with an identified hearing loss as a result of head trauma was excluded. The sample was therefore considered to be a limited normative sample comprising 114 subjects—51 males and 63 females.

Instrument

Ten of the 17 subtests of the Sensory Integration and Praxis Tests (SIPT) (Ayres, 1989) as well as the Finger Posture Imitation Test (Druker, 1980) and the MacQuarrie Test for Mechanical Ability (MacQuarrie, 1925/1953) were administered to the subjects. These tests were selected because they measure vestibular, somatosensory, and praxis functions. These categories, however, are not mutually exclusive. For example, the Bilateral Motor Coordination Test, classified as a vestibular-related test, also includes a praxis element. Three SIPT subtests were classified as vestibular-related tests: Postrotary Nystagmus, Standing and Walking Balance, and Bilateral Motor Coordination. The SIPT subtests of Finger Identification, Manual Form Perception, Graphesthesia, Localization of Tactile Stimuli, and Kinesthesia constituted the category of somatosensory-related tests. The praxis-related tests were the SIPT subtests of Sequencing Praxis and Oral Praxis as well as the Finger Posture Imitation Test and the MacQuarrie test.

Procedure

An instructor from Sensory Integration international in Torrance, California, trained the five examiners. The delinquent-prone subjects were all tested by the same examiner. One of the five examiners tested each non-delinquent-prone subject at his or her school during three 1-hr physical education periods per student.

Data Analysis

Western Psychological Services in Los Angeles provided z scores for the SIPT tests, using normative data from children aged 8 years 11 months, the oldest age group of the SIPT data, as the standard for which norms were available. By special arrangement with Western Psychological Services, z scores beyond 3 standard deviations (the usual limit) were provided, so as to reflect the true variability of scores.

To accomplish the first purpose of the study, that is, to describe the performance of the non-delinquent-prone subjects on sensory integrative measures, descriptive statistics for the test scores of each group were computed. In addition, the association between age and test performance was computed for the non-delinquent-prone group with the Kendall's tau B correlation coefficients (Zar, 1984) because many of these subjects were expected to have high tied scores. Significant correlation coefficients would indicate that the performances of the non-delinquent-prone adolescents were linearly related to age. Correlation coefficients were not computed for the delinquent-prone group because of the small sample size.

The second purpose of the study was to compare the performances of the two groups; it was predicted that the delinquent-prone adolescents would perform more poorly than the non-delinquent-prone group. Because the scores of the subjects, as expected, were not normally distributed and because of the unbalanced sample sizes (12 delinquent-prone and 114 non-delinquent-prone subjects), a nonparametric approach with conditional logistic regression (Breslow & Day, 1980) was used. The matched (conditioned) variables were age, sex, and race. A likelihood ratio statistic was used and compared to a chi-square statistic.

Results

Descriptive results of the performance of the non-delinquent-prone group are shown in Table 1. The means of all of the SIPT subtests used in this study were significantly different from those of the 8-year-olds' norms, according to the independent sample t test. In the category of somatosensory-related tests, the SIPT subtests of Localization of Tactile Stimuli and Kinesthesia had relatively high means but small standard deviations. These two subtests showed little variation of performance within the non-delinquent-prone group. Moreover, Standing and Walking Balance: Eyes Open also had a high mean as well as a large standard deviation. The wide range of the first quartile and third quartile scores on this test also suggested a high degree of variability in the non-delinquent-prone group. A comparison to published norms for the MacQuarrie test indicated that the non-delinquent-prone subjects performed better than the average 14½-year-old.
Table 1
Descriptive Statistics in z Scores of the Performance of Non-Delinquent-Prone Adolescents (n = 114)

<table>
<thead>
<tr>
<th>Test</th>
<th>Quartile 1</th>
<th>Quartile 2</th>
<th>Quartile 3</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>VESTIBULAR-RELATED TESTS*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postrotary Nystagmus</td>
<td>0.35</td>
<td>0.92</td>
<td>1.80</td>
<td>1.10</td>
<td>0.97</td>
</tr>
<tr>
<td>Standing and Walking Balance</td>
<td>0.30</td>
<td>1.00</td>
<td>2.50</td>
<td>1.34</td>
<td>1.46</td>
</tr>
<tr>
<td>Eyes Open</td>
<td>-0.20</td>
<td>0.70</td>
<td>3.00</td>
<td>1.49</td>
<td>2.01</td>
</tr>
<tr>
<td>Eyes Closed</td>
<td>0.40</td>
<td>1.00</td>
<td>1.40</td>
<td>0.87</td>
<td>0.75</td>
</tr>
<tr>
<td>Bilateral Motor Coordination</td>
<td>0.70</td>
<td>1.20</td>
<td>1.40</td>
<td>1.04</td>
<td>0.63</td>
</tr>
<tr>
<td>Arms</td>
<td>0.60</td>
<td>1.10</td>
<td>1.20</td>
<td>0.91</td>
<td>0.72</td>
</tr>
<tr>
<td>Feet</td>
<td>0.80</td>
<td>1.20</td>
<td>1.20</td>
<td>0.98</td>
<td>0.62</td>
</tr>
<tr>
<td>SOMATOSENSORY-RELATED TESTS*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finger Identification</td>
<td>0.00</td>
<td>0.80</td>
<td>1.30</td>
<td>0.66</td>
<td>0.76</td>
</tr>
<tr>
<td>Manual Form Perception</td>
<td>0.20</td>
<td>0.60</td>
<td>1.50</td>
<td>0.66</td>
<td>0.72</td>
</tr>
<tr>
<td>Graphesthesia</td>
<td>0.80</td>
<td>1.30</td>
<td>1.50</td>
<td>1.12</td>
<td>0.62</td>
</tr>
<tr>
<td>Localization of Tactile Stimuli</td>
<td>3.00</td>
<td>3.10</td>
<td>3.20</td>
<td>3.10</td>
<td>0.11</td>
</tr>
<tr>
<td>Kinesthesia</td>
<td>3.40</td>
<td>3.40</td>
<td>3.50</td>
<td>3.41</td>
<td>0.09</td>
</tr>
<tr>
<td>PRAXIS-RELATED TESTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequencing Praxis*</td>
<td>1.10</td>
<td>1.40</td>
<td>1.75</td>
<td>1.35</td>
<td>0.45</td>
</tr>
<tr>
<td>Hand</td>
<td>1.00</td>
<td>1.20</td>
<td>1.50</td>
<td>1.19</td>
<td>0.33</td>
</tr>
<tr>
<td>Finger</td>
<td>0.75</td>
<td>1.30</td>
<td>1.70</td>
<td>1.20</td>
<td>0.58</td>
</tr>
<tr>
<td>Oral Praxis*</td>
<td>0.40</td>
<td>1.00</td>
<td>1.40</td>
<td>0.77</td>
<td>0.82</td>
</tr>
<tr>
<td>Finger Posture Imitation Testb</td>
<td>38.00</td>
<td>42.00</td>
<td>47.50</td>
<td>42.28</td>
<td>7.67</td>
</tr>
<tr>
<td>MacQuarrie Test for Mechanical Abilityc</td>
<td>52.67</td>
<td>65.00</td>
<td>72.33</td>
<td>62.34</td>
<td>13.60</td>
</tr>
<tr>
<td>Tracing</td>
<td>34.00</td>
<td>41.00</td>
<td>48.00</td>
<td>40.34</td>
<td>9.75</td>
</tr>
<tr>
<td>Tapping</td>
<td>33.00</td>
<td>38.00</td>
<td>42.00</td>
<td>37.55</td>
<td>7.01</td>
</tr>
<tr>
<td>Dotting</td>
<td>17.00</td>
<td>19.00</td>
<td>21.00</td>
<td>18.98</td>
<td>3.28</td>
</tr>
<tr>
<td>Copying</td>
<td>21.25</td>
<td>35.00</td>
<td>45.00</td>
<td>34.38</td>
<td>16.30</td>
</tr>
<tr>
<td>Location</td>
<td>16.00</td>
<td>23.00</td>
<td>31.00</td>
<td>23.15</td>
<td>9.49</td>
</tr>
<tr>
<td>Blocks</td>
<td>6.00</td>
<td>12.00</td>
<td>16.00</td>
<td>11.38</td>
<td>5.97</td>
</tr>
<tr>
<td>Pursuit</td>
<td>16.00</td>
<td>21.00</td>
<td>26.00</td>
<td>21.01</td>
<td>6.26</td>
</tr>
</tbody>
</table>

Note. All the means of the Sensory Integration and Praxis Tests (Ayres, 1989) are significantly larger than 0, which is the mean of the normative sample of 8-year-olds. The combined alpha level is fixed at .05.


Table 2 shows the descriptive data of the delinquent-prone subjects. The means and standard deviations of the Localization of Tactile Stimuli and Kinesthesia subtests in the delinquent-prone group were similar to those in the non-delinquent-prone group. The delinquent-prone subjects also had a large standard deviation on Standing and Walking Balance: Eyes Open as compared with the standard deviations on other portions of the SIPT. Few subtests of the SIPT had significantly higher mean scores than the normative data of the 8-year-olds.

Kendall's tau B correlation coefficients between age and test scores are shown in Figure 1. A linear trend with age was found to be significant for Bilateral Motor Coordination, Manual Form Perception, Graphesthesia, and all of the praxis-related tests. The praxis-related tests showed the strongest age trend.

A comparison of the performances of the two groups of subjects on the SIPT subtest scores is summarized in Figure 2. Standing and Walking Balance and Bilateral Motor Coordination had the largest differences between the two groups; Localization of Tactile Stimuli and Kinesthesia, the smallest.

Table 3 shows the findings addressing our hypothesis that the test scores of the non-delinquent-prone subjects would be significantly lower than those of the delinquent-prone subjects. The delinquent-prone sample performed significantly worse on the vestibular- and praxis-related tests. None of the somatosensory-related tests were significant. These findings were consistent with the results described earlier.

Because either very high or very low Postrotary Nystagmus scores may reflect dysfunction (Ayres, 1989), the absolute values of the Postrotary Nystagmus scores were used to discriminate between the two groups. We found that the absolute scores on Postrotary Nystagmus ($p < .025$) as well as the scores on Standing and Walking Balance ($p < .05$) and Bilateral Motor Coordination ($p < .0005$) were the most significant discriminators between the two groups. Generally, all of the praxis-related tests, particularly the MacQuarrie test ($p < .0005$), were the better discriminators between the two groups than the vestibular- and somatosensory-related tests (see Table 3).

The analysis was extended to determine if the
Table 2
Descriptive Statistics in z Scores of the Performance of Delinquent-Prone Adolescents (n = 12)

<table>
<thead>
<tr>
<th>Test</th>
<th>Median</th>
<th>Quartile 1</th>
<th>Quartile 2</th>
<th>Quartile 3</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VESTIBULAR-RELATED TESTS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postrotary Nystagmus</td>
<td>-0.05</td>
<td>0.75</td>
<td>1.56</td>
<td>0.87</td>
<td>1.13</td>
<td>1.13</td>
</tr>
<tr>
<td>Standing and Walking Balance</td>
<td>-0.23</td>
<td>-0.15</td>
<td>1.53</td>
<td>0.52</td>
<td>1.14</td>
<td>1.14</td>
</tr>
<tr>
<td>Eyes Open</td>
<td>-0.43</td>
<td>0.05</td>
<td>1.00</td>
<td>0.54</td>
<td>1.47</td>
<td>1.47</td>
</tr>
<tr>
<td>Eyes Closed</td>
<td>-0.50</td>
<td>0.30</td>
<td>0.85</td>
<td>0.41</td>
<td>1.09</td>
<td>1.09</td>
</tr>
<tr>
<td>Bilateral Motor Coordination</td>
<td>-1.38</td>
<td>-0.65</td>
<td>0.03</td>
<td>-0.68</td>
<td>1.16</td>
<td>1.16</td>
</tr>
<tr>
<td>Arms</td>
<td>-1.66</td>
<td>-0.85</td>
<td>0.28</td>
<td>-0.79</td>
<td>1.26</td>
<td>1.26</td>
</tr>
<tr>
<td>Feet</td>
<td>-1.10</td>
<td>-0.70</td>
<td>0.85</td>
<td>-0.36</td>
<td>1.12</td>
<td>1.12</td>
</tr>
<tr>
<td><strong>SOMATOSENSORY-RELATED TESTS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finger Identification</td>
<td>-0.30</td>
<td>0.60</td>
<td>0.80</td>
<td>0.24</td>
<td>0.89</td>
<td>0.89</td>
</tr>
<tr>
<td>Manual Form Perception</td>
<td>0.20</td>
<td>0.60</td>
<td>0.90</td>
<td>0.44</td>
<td>0.84</td>
<td>0.84</td>
</tr>
<tr>
<td>Graphesthesia</td>
<td>-0.28</td>
<td>0.85</td>
<td>1.73</td>
<td>0.63</td>
<td>1.15</td>
<td>1.15</td>
</tr>
<tr>
<td>Localization of Tactile Stimuli</td>
<td>2.90</td>
<td>3.10</td>
<td>3.10</td>
<td>3.03</td>
<td>0.13</td>
<td>0.13</td>
</tr>
<tr>
<td>Kinesesthesia</td>
<td>3.36</td>
<td>3.40</td>
<td>3.50</td>
<td>3.39</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td><strong>PRAXIS-RELATED TESTS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequencing Praxis</td>
<td>0.33</td>
<td>1.35</td>
<td>1.68</td>
<td>0.95</td>
<td>0.92</td>
<td>0.92</td>
</tr>
<tr>
<td>Hand</td>
<td>0.70</td>
<td>1.05</td>
<td>1.20</td>
<td>0.73</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>Finger</td>
<td>0.03</td>
<td>1.15</td>
<td>1.70</td>
<td>0.90</td>
<td>0.94</td>
<td>0.94</td>
</tr>
<tr>
<td>Oral Praxis</td>
<td>-0.08</td>
<td>0.55</td>
<td>0.78</td>
<td>0.38</td>
<td>0.77</td>
<td>0.77</td>
</tr>
<tr>
<td>Finger Posture Imitation Test</td>
<td>29.90</td>
<td>42.00</td>
<td>44.00</td>
<td>37.45</td>
<td>8.39</td>
<td>8.39</td>
</tr>
<tr>
<td>MacQuarrie Test for Mechanical Ability</td>
<td>36.35</td>
<td>68.00</td>
<td>49.67</td>
<td>45.06</td>
<td>8.91</td>
<td>8.91</td>
</tr>
<tr>
<td>Tracing</td>
<td>18.00</td>
<td>22.00</td>
<td>28.00</td>
<td>22.64</td>
<td>7.39</td>
<td>7.39</td>
</tr>
<tr>
<td>Tapping</td>
<td>23.00</td>
<td>30.00</td>
<td>40.00</td>
<td>30.91</td>
<td>8.97</td>
<td>8.97</td>
</tr>
<tr>
<td>Dotting</td>
<td>14.00</td>
<td>15.00</td>
<td>17.90</td>
<td>14.55</td>
<td>2.88</td>
<td>2.88</td>
</tr>
<tr>
<td>Copying</td>
<td>17.00</td>
<td>24.00</td>
<td>35.08</td>
<td>24.73</td>
<td>10.78</td>
<td>10.78</td>
</tr>
<tr>
<td>Location</td>
<td>13.00</td>
<td>20.00</td>
<td>24.00</td>
<td>20.00</td>
<td>8.93</td>
<td>8.93</td>
</tr>
<tr>
<td>Blocks</td>
<td>5.00</td>
<td>8.00</td>
<td>10.00</td>
<td>8.18</td>
<td>4.75</td>
<td>4.75</td>
</tr>
<tr>
<td>Pursuit</td>
<td>11.00</td>
<td>14.00</td>
<td>20.00</td>
<td>14.39</td>
<td>5.17</td>
<td>5.17</td>
</tr>
</tbody>
</table>

Note. The combined alpha level is fixed at .05.

* Subtest (D) of the Sensory Integration and Praxis Tests. †Indicates the means of the Sensory Integration and Praxis Tests (Ayres, 1989) are not significantly larger than 0, the mean of the 8-year-old normative sample. ‡(Drake, 1980). ‡(MacQuarrie, 1925/1953).

The large standard deviation in the scores of the non-delinquent-prone group suggests that the 11- through 18-year-old adolescents exhibit a wide range of variability in performance on Standing and Walking Balance: Eyes Open (see Table 1), thereby possibly suggesting that maturation, development, or learning occurs during this age span. A small standard deviation and a high mean score in the scores of the non-delinquent-prone group, however, do not necessarily imply that their sensory integrative abilities have reached maturation. Instead, it may suggest that the test reaches its ceiling (e.g., the Localization of Tactile Stimuli and Kinesesthesia subtests [see Figure 2]) and is no longer sensitive to the domain that it supposedly measures. Localization of Tactile Stimuli and Kinesesthesia, therefore, did not discriminate well between the delinquent- and non-delinquent-prone subjects.

The delinquent-prone subjects in this study appeared to have difficulty with bilateral motor coordination, because Bilateral Motor Coordination was the only test with a mean score less than zero. Thus, the delinquent-prone subjects performed worse than the 8-year-olds, according to the normative data, on Bilateral Motor Coordination. Past studies have shown...
similar problems to be present in subjects with learning disabilities (Ayres, 1972b, 1979; Stilwell, 1981, 1987). The failure to coordinate functions of the two sides of the body has been hypothesized to be related to vestibular dysfunction and is thought to be due to a deficit in interhemispheric integration. Difficulties in interhemispheric integration may contribute to disturbances in laterality, ocular jerk at midline, poorly established hand dominance, and low right–left ratio on dichotic listening (Ayres, 1969, 1971, 1972a, 1977). It would be interesting from a theoretical perspective to determine if similar problems exist in some delinquent-prone adolescents.

Using the absolute value of Postrotary Nystagmus, we found the difference between the two samples on this measure. Similar findings are reported in the literature, with Postrotary Nystagmus scores in the extreme ranges being more typical of children with learning or other problems (Ayres, 1978, 1979). Ayres (1975) proposed that depressed postrotatory nystagmus may result from overinhibition of the vestibular nuclei, whereas prolonged nystagmus was thought to result from inefficient inhibition from higher cortical centers acting on the vestibular nuclei. It seems reasonable, therefore, to conclude that the preponderance of postrotary nystagmus scores in the extreme range in either direction of the mean in the delinquent-prone group seemed to signify dysfunction.

The mean scores of Standing and Walking Balance: Eyes Open in both groups were higher than those of Standing and Walking Balance: Eyes Closed. The results of these data may imply that vestibular processing with visual compensation can be facilitated through learning or practice, even after the age of 8 years. This could explain the wide standard deviation band for Standing and Walking Balance: Eyes Open. Further research is needed, however, to support this notion. In addition, vestibular processing without the influence of vision is not likely to change dramatically in adolescents aged 11 through 18 years. That the gaps of mean and standard deviation be-

---

**Figure 1.** Association between age and test results with Kendall's tau B coefficient in non-delinquent-prone adolescents. 
*Note.* The length of the horizontal dotted lines indicate the strength of the correlation. PRN = Postrotary Nystagmus; SWB = Standing and Walking Balance; BMC = Bilateral Motor Coordination; FI = Finger Identification; MFP = Manual Form Perception; GRA = Graphesthesiia; LTS = Localization of Tactile Stimuli; KIN = Kinesthesia; SPR = Sequencing Praxis; OPR = Oral Praxis; FIPIT = Finger Posture Imitation Test (Druker, 1980); MacQ = MacQuarrie Test for Mechanical Ability (MacQuarrie, 1925/1953). *Subtest of the Sensory Integration and Praxis Tests (Ayres, 1989). *p < .05; **p < .01; ***p < .001.

**Figure 2.** Comparison of mean scores on the Sensory Integration and Praxis Tests (SIPT) (Ayres, 1989) between the delinquent-prone and non-delinquent-prone adolescents. 
*Note.* The mean scores of all portions of the SIPT from both the delinquent-prone and non-delinquent-prone subjects are listed. The dotted lines represent the differences between the two groups. PRN = Postrotary Nystagmus; SWB = Standing and Walking Balance; BMC = Bilateral Motor Coordination; FI = Finger Identification; MFP = Manual Form Perception; GRA = Graphesthesiia; LTS = Localization of Tactile Stimuli; KIN = Kinesthesia; SPR = Sequencing Praxis; OPR = Oral Praxis.


Table 3

Comparison Between Non-Delinquent-Prone Adolescents (n = 114) and Delinquent-Prone Adolescents (n = 12)

| Test                                      | Likelihood Ratio | P  
|-------------------------------------------|-----------------|-----
| **VESTIBULAR-RELATED TESTS**              |                 |     
| Postrotary Nystagmus*                     | 0.161           | ns  
| Absolute Value of Postrotary Nystagmus    | 4.082           | <.05 
| Standing and Walking Balance*             |                 |     
| Total                                     | 2.978           | .05 
| Open                                      | 1.853           | ns  
| Closed                                    | 2.936           | ns  
| Bilateral Motor Coordination*             |                 |     
| Total                                     | 26.730          | <.0005 
| Arms                                      | 20.228          | <.0005 
| Feet                                      | 28.745          | <.0005 
| **PRAXIS-RELATED TESTS**                  |                 |     
| Sequencing Praxis*                        | 3.959           | .025 
| Hand                                      | 7.070           | .008 
| Finger                                    | 1.311           | ns  
| Oral Praxis*                              | 4.744           | <.05 
| Finger Posture Imitation Test*            | 2.922           | <.05 
| MacQuarrie Test for Mechanical Ability*   | 22.380          | <.0005 
| Tracing                                   | 25.698          | <.0005 
| Tapping                                   | 7.862           | <.001 
| Dotting                                   | 20.767          | <.0005 
| Copying                                   | 5.539           | .01  
| Location                                  | 3.671           | <.05 
| Blocks                                    | 4.009           | <.05 
| Pursuit                                   | 12.806          | <.0005 

* Subtest of the Sensory Integration and Praxis Tests (Ayres, 1989).

Note. For matching on age, sex, and race, a conditional logistic regression was used. ns = not significant.

Performance on the praxis-related tests, especially the MacQuarrie test, revealed the greatest differences between the non-delinquent-prone and delinquent-prone groups (see Table 3). These findings are indirectly supported by the literature, which reports that the praxis tests of the SIPT are primary predictors for achievement and significant discriminators between learning-disabled and non-learning-disabled children (Parham, 1989). We therefore suggest that a link between the learning-disabled and the delinquent-prone groups is demonstrated by their performance difficulties on the praxis tests. These praxis tests also demonstrated a strong developmental trend, with each test in the praxis domain showing a significant correlation coefficient (see Figure 1).

One puzzling finding was that this study's normative sample performed worse on the Finger Posture Imitation Test than did Druker's (1980) original sample (see Figure 3). A sampling difference may explain this. The non-delinquent-prone sample might have come from a lower socioeconomic status, as compared with Druker's sample. The consent procedure might have been biased for sample selection, that is, adolescents who disliked physical education classes might have been more likely to consent. Moreover, the test administration in Druker's study and in the present study might have differed. A highly significant Kendall's tau B correlation coefficient (r = .3, p < .001 [see Figure 1]) showed some developmental trend of the scores of the Finger Posture Imitation Test (see Figure 3). This was expected, because the Finger Posture Imitation Test was designed to be used with persons aged 10 through 18 years.

A significant correlation coefficient of the MacQuarrie test (r = .3, p < .001 [see Figure 3]) suggested a developmental trend, because the test is designed for persons aged 10 years through adulthood. Figure 4 shows the overall lower scores of the MacQuarrie test between Standing and Walking Balance: Eyes Open and Standing and Walking Balance: Eyes Closed were not as wide in the delinquent-prone group may suggest that the delinquent-prone subjects failed to develop adaptive responses with respect to poor vestibular processing. This difference was supported by the comparison between the two groups (see Figure 2).

![Figure 3. Comparison of the Finger Posture Imitation Test (FPUT) (Druker, 1980) mean scores between the Druker norms, the limited norms, and the individual scores of the delinquent-prone adolescents.](image-url)
norms as compared with the limited norms. Perhaps this is because the MacQuarrie test norms were gathered in the 1950s, whereas adolescents of the late 1980s are likely to have developed at a faster rate. A vast score change occurred at the age intervals of 12 and 13 years in the limited norms, as compared with the steady score increment in the MacQuarrie test norms. The adolescents in the present study, therefore, seemed to plateau in visual perceptual-motor abilities beyond the age of 13 years, thus suggesting a possible ceiling effect.

The scores of the 17- and 18-year-old groups on both the Finger Posture Imitation Test and the MacQuarrie test seemed to drop (see Figures 3 and 4). Sampling bias resulting from differing consent rates across age groups could account for this phenomenon. The 17- to 18-year-old age range had fewer subjects than did the 12- to 16-year-old age range.

As shown in Figure 3, the Finger Posture Imitation Test scores of the delinquent-prone adolescents seem to separate into two groups, one with low performance and another with performance that was close to normal. These results may coincide with the notion that there are different types of sensory integrative dysfunction (Ayres, 1979). The two-group tendency was not found on the MacQuarrie test performance (see Figure 4). Almost every delinquent-prone subject performed more poorly on the MacQuarrie test when compared with the MacQuarrie test norms and the limited norms. Accordingly, no conclusive inference regarding typology can be made. One should always consider, however, a possible variation in sampling; future research related to the issue of typology may clarify this.

Research has consistently shown an association between praxis and tactile functioning (Ayres, 1966; Ayres & Mailloux, 1985). The results on the SIPT somatosensory-related tests between the two groups did not differ significantly, perhaps because the tactile tests reached their ceiling. Parham (1989) also found a ceiling effect by ages 10 to 12 years on the tactile subtests of the SIPT. Thus, possible subtle tactile problems in the delinquent-prone group were not detected. Graphesthesia, however, demonstrated some age trend \( r = .2, p < .01 \) [see Figure 1], that is, the performance of Graphesthesia was significantly related to age; and a ceiling effect was not evident. The comparison of Graphesthesia between the two groups was very close to a significant level. If indeed tactile problems were present but undetected in some of the subjects, then other behaviors associated with a disordered tactile system may also have been present. Research has shown that hyperactivity and distractibility are associated with both tactile problems (Ayres, 1979) and delinquency (Loney et al., 1981). Perhaps in the present study some subjects had problems with both tactile processing and hyperactivity. We did not collect behavioral information on hyperactivity and distractibility. Future research using more sensitive tactile measures with a larger sample size and a different research design may be able to address this question.

We conducted a further analysis to determine if using a set of tests from the same category could best discriminate between the two groups. Of the four praxis-related tests, the MacQuarrie test was the best significant discriminator. Thus, the MacQuarrie test is providing information that duplicates or overlaps the information provided by the praxis-related tests as a group. Statistically, this approach could lead to a model-overfitting problem. We believe, however, that this information could be useful in clinical application. The possible ceiling effect of age 13 years and beyond and the sound quality of discrimination between the groups suggested that the MacQuarrie test could be used as a screening tool for the detection of possible praxis difficulty in adolescents within this age range. Further studies examining construct validation of the MacQuarrie and other praxis-related tests and the sensitivity versus specificity issue are warranted.
Study Limitations
Given the study's results, possible limitations must be considered. The delinquent-prone adolescents with learning problems were referred by a psychologist who was familiar with sensory integrative theory and thus more likely to refer delinquent-prone subjects with suspected sensory integrative difficulties. Because the testing of the delinquent-prone group was not blind, a scoring bias may have existed. The testing environment or procedures for the non-delinquent-prone group may not have been ideal. In addition, the non-delinquent-prone group may not have been representative of the non-delinquent-prone population.

Nevertheless, this study still showed significant results on the vestibular- and praxis-related tests. If the sample size were increased, the results would likely be even more supportive in the determination of the performance difference of the delinquent-prone group. Furthermore, the relation between delinquency, learning problems, and sensory integrative dysfunction needs to be clarified through a random selection of delinquent-prone subjects and an objective, measurable definition of learning problems.

Summary
The results of this study indicated a difference in sensory integrative processing between non-delinquent-prone adolescents ($n = 114$) and delinquent-prone adolescents ($n = 12$) based on the results of praxis- and vestibular-related tests. We concluded that some of the delinquent-prone adolescents with learning problems had difficulty with sensory integrative processing. The delinquent-prone adolescents scored lower on the praxis- and vestibular-related tests than did the non-delinquent-prone group. The somatosensory-related tests (i.e., Localization of Tactile Stimuli and Kinesthesia) reached their ceiling effect when given to children older than 8 years of age. If the number of delinquent-prone adolescents were increased, however, a significant result would still be likely in a few of the somatosensory-related tests. Some of the SIPT subtests did show a possible developmental trend in adolescents aged 11 to 18 years, especially the praxis-related tests.

This study has several implications for the field of occupational therapy. First, at the time of this writing, no measurement of sensory integrative dysfunction in juvenile delinquents has been reported in the literature. The results of this study have expanded current knowledge regarding sensory integrative processing in non-delinquent-prone and delinquent-prone adolescents. Second, although the SIPT is designed to assess 4- to 8-year-old children, some of the subtests may still provide valuable information for the testing of children over 8 years of age. Third, limited norms of the SIPT, MacQuarrie test, and Finger Posture Imi-

Acknowledgments
We are grateful for the assistance of the late A. Jean Ayres, PhD, OTR, and for the expertise and guidance of Florence Clark, PhD, OTR, Ruth Zemke, PhD, OTR, Diane Parham, PhD, OTR, and Zoe Mailloux, MA, OTR.

We thank the Torrance (California) Unified School District, the Torrance Police Department's Diversion Program, the Ayres Clinic, Torrance, California, and Western Psychological Services, Los Angeles, for their support.

This project was funded through grants from the American Occupational Therapy Foundation and the California Foundation for Occupational Therapy.

References


