The Effects of Socioeconomic Status on Hand Size and Strength, Vestibular Function, Visuomotor Integration, and Praxis in Preschool Children

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Differences in hand size and strength, vestibular function, visuomotor integration, and praxis in preschool children as a function of socioeconomic status were investigated. Twenty-two children of lower socioeconomic status, aged 3 to 5 years, were each matched with a child of higher socioeconomic status on the basis of race, sex, hand dominance, age, height, and weight. Measures used were the Developmental Test of Visual-Motor Integration (Beery, 1982), hand size and strength, the Standing Balance subtests of the Southern California Sensory Integration Tests (Ayres, 1972), the Bowman Unilateral Hopping Test (Flannigan, 1987), the Southern California Postrotary Nystagmus Test (Ayres, 1975), the praxis tests of the Sensory Integration and Praxis Tests (SIPT) (Ayres, 1984), and the Bowman Quality of Prone Extension Scale (Etheredge, 1987).

Analyses with two separate Hotelling’s $T^2$ for correlated samples (Huck, Cormier, & Bounds, 1974) revealed significant differences in hand size and strength as well as praxis, and subsequent post hoc analyses revealed better scores for the higher socioeconomic status group on right hand strength and on the Praxis on Verbal Command subtest of the SIPT. A paired $t$ test also revealed that the higher socioeconomic status group scored better on visuomotor integration. Analysis with Hotelling’s $T^2$ revealed no significant differences between the two groups on the vestibular measures.

The results of this study suggest that on certain tests used by occupational therapists, children from a higher socioeconomic status group may function at a higher developmental level than those from a lower socioeconomic status group. When interpreting clients’ test results, therefore, therapists should consider the possible influence of socioeconomic status.

Socioeconomic status is considered by some researchers to have a strong influence on normal development. Havinghurst (1971) believed it to be the best predictor of a variety of behaviors and attitudes, including IQ, education, attitudes toward work, age of marriage, and number of children. Therapists, therefore, should be aware of the possible influence that socioeconomic status may have on a person’s functioning and should consider its implications when making clinical judgments. Occupational therapists, who are trained to assess physical, psychological, and social factors and to consider them when planning remediation, should include in such consideration the client’s socioeconomic background, because it is integral to the formation of the whole person (Florey, 1989).

Literature Review

Researchers from fields other than occupational therapy have attributed differences in children’s intelli-
socioeconomic backgrounds—usually with children from upper- or middle-class backgrounds performing at a higher developmental level than children from a disadvantaged background. Research on the effects of socioeconomic status has looked more at its effect on IQ than at any other variable (Basavanna & Rani, 1984; Bogin & MacVean, 1983; Chalip & Stigler, 1986; Cohen, Parmelee, Beckwith, & Sigman, 1986; Dar & Rest, 1986; Deutsch, 1973; Frankenburg, Dick, & Carland, 1975; Golomb & McLean, 1984; Graham & Lilly, 1984; Grewal, 1985; Iretta, Thwing, & Graven, 1970; Kaiser, 1986; Knivetont, 1987; Lesser, Fifer, & Clark, 1965; Lloyd & Barenblatt, 1984; Murthy & Panda, 1987; Poressky, 1982; Sudhir & Muraleedharan, 1987; Walker, 1985; Willerman & Bromann, 1970). A difficulty in measuring intelligence, however, is that variations among socioeconomic groups are sometimes attributed to cultural bias (Graham & Lilly, 1984).

Many researchers have used Piagetian tasks to examine differences in cognitive function, usually finding differences between social classes. Figurelli and Keller (1972) found that after equal training experiences, children of middle socioeconomic status scored significantly higher on conservation and required fewer repetitions to learn a task than did those of lower socioeconomic status. Gaudia (1972) studied conservation in black, white, and Native American children, concluding that socioeconomic status is a better predictor of performance than race. Bardouille-Crema, Black, and Feldhusen (1986) also studied black children, testing them on Piagetian concepts of reasoning, seriation, classification, causation, and conservation, and reported that the children of middle socioeconomic status scored higher on all measures than did those of lower socioeconomic status. Again, socioeconomic status, not race, was the significant factor.

Differences among social classes have also been found in motor behavior, an area frequently evaluated by occupational therapists. Wallach and Martin (1970) used drawing to evaluate motoric expression and found the children from a lower-class background to be more expansive than those from a middle-class background. Isaac (1973) examined perceptual-motor performance using the Bender Motor Gestalt Test (Bender, 1946) on white, advantaged; white, disadvantaged; and black, disadvantaged first-grade children and found no significant difference in perceptual-motor functioning on the basis of socioeconomic status.

In a similar study, Martin, Sewell, and Manni (1977) studied race and social class effects on visuomotor integration, using the 1964 norms for the Developmental Test of Visual-Motor Integration (VMI) (Beery, 1982). They found that children of high and middle socioeconomic status performed significantly higher than the lower socioeconomic group but that race was a more significant predictor. Thus, visuomotor integration may be more strongly influenced by race than by socioeconomic status.

The effect of socioeconomic status on motor skills was studied in Finland by Rantakallio, Von Wendt, and Mäkinen (1985), who classified their subjects as belonging to one of four social classes. They found that children from the two higher social classes tended to develop faster prior to walking, at which time the children from the lower classes began to catch up. Children from the lowest of the four classes were also behind in language production, that is, at age 1 year they spoke fewer words. Judd, Siders, Siders, and Atkins (1986) studied the rate and accuracy of fine motor tasks in first graders and reported a stronger correlation with socioeconomic status than with sex. Their study did not begin as an investigation of the effects of socioeconomic status effects, however, so the divisions between social classes were not clearly defined.

Study Rationale

Researchers have consistently concluded that differences in skills and abilities exist among children from varying socioeconomic backgrounds, usually with the child from an upper- or middle-class background performing at a higher developmental level than the child from a disadvantaged background. Because a pediatric occupational therapist may evaluate the hand strength, vestibular function, visuomotor integration, and practic development of children from different socioeconomic backgrounds, he or she must be able to distinguish dysfunctional performance requiring intervention from suboptimal performance possibly resulting from a client's socioeconomic background. Knowing which evaluation instruments are resistant to environmental bias and which are subject to possible bias can help the therapist interpret results. The specific tests used in the present study were selected because they measure skills frequently assessed by pediatric occupational therapists (especially by therapists who assess sensory integrative dysfunction), such as hopping, prone extension, balance, and motor planning. Because the literature shows that children of higher socioeconomic status consistently perform better on sensorimotor skills, we questioned whether children from a higher socioeconomic status would perform better on perceptual-motor skills. We found no study in the occupational therapy literature that addressed the effect of socio-
economic status on development and performance with the test instruments used in the present study. The effect of race on performance on the Sensory Integration and Praxis Tests (SIPT) is discussed in the SIPT manual (Ayres, 1989); however, the effect of socioeconomic status on the performance of the normal children used to standardize the SIPT was not addressed. Consideration of the effects of socioeconomic status on performance is consistent with a concept basic to the field of occupational therapy, that is, that individuals and their total functioning should be viewed in respect to their environment (Hopkins, 1978). We therefore need to understand how socioeconomic status affects performance in the areas of hand measures, vestibular function, visuomotor integration, and practic development, all of which are assessed frequently by occupational therapists.

The purpose of this study was to ascertain whether two groups of preschool children from different socioeconomic backgrounds would differ on measures of hand size and strength, vestibular function, visuomotor integration, and practic development, thus determining whether the current perceptual-motor tests are free of socioeconomic bias. We believed that if these tests were shown to be free of socioeconomic bias, then therapists could have greater confidence in the validity of evaluations that use them.

**Hypotheses**

Because research shows that children of high or middle socioeconomic status usually perform at a higher developmental level than children of low socioeconomic status on measures of intelligence, language, and motor development, we developed four directional hypotheses, that is, that preschool children from a higher socioeconomic group will perform significantly higher than preschool children from a lower socioeconomic group on the following measures:

1. Hand size and strength
2. Vestibular function
3. Visuomotor integration
4. Practic development

**Method**

The research design of this study is descriptive. Data on two groups of preschool children were collected and analyzed with inferential statistics, and statistically significant differences found in the performances of the two groups are described. If the obtained probability of a result occurring was equal to or less than .05, the result was considered statistically significant. The independent variable investigated was socioeconomic status, an attribute variable, with two levels: low middle to low socioeconomic status and high-middle to high socioeconomic status. Socioeconomic status was defined as the level at which a family falls compared with other families on the basis of occupation held and amount of education achieved by the family provider. *Socioeconomic status* information on each subject was derived from parental responses to a questionnaire. The socioeconomic index developed by Stevens and Cho (1985) was used to rate the socioeconomic status of each child's parents. A rating of 50 or more on this scale is considered high-middle to high socioeconomic status, and a rating below 35 is considered low-middle to low socioeconomic status. If only one parent worked, the rating of that parent's occupation was given to the family. If both parents listed an occupation, the father's occupation was used to assign socioeconomic status to the family.

The dependent variables were the subjects' scores on measures of (a) hand strength and size, (b) unilateral hopping, (c) standing balance with eyes open, (d) standing balance with eyes closed, (e) prone extension (duration and quality), (f) postrotatory nystagmus, (g) visuomotor integration, (h) Sequencing Praxis, (i) Postural Praxis, (j) Oral Praxis, (k) Praxis on Verbal Command, and (l) Constructional Praxis. Performance on several of these tests and measurements resulted in more than one score, for example, Praxis on Verbal Command, Constructional Praxis, and hand strength.

**Subjects**

The subjects were selected from five privately operated preschools located in a large city in the southwestern United States. One of the schools (P1) was located in a high socioeconomic area of the city, and the others (P2, P3, P4, P5) were located in low-middle to low socioeconomic areas. The classroom programs and environments of all of the preschools offered periods for independent work time, group circle time, and outdoor play. The teacher-to-student ratio at P1 was 1:8; at the other schools, the ratio averaged 1:15. P1 required all teachers to be certified; the other schools did not. The tuition for P1 was 65% higher than the mean tuition of the other schools.

All subjects were classified as normal children. They had no known physical, mental, or emotional disabilities and received no speech, occupational, or physical therapy or adaptive physical education. They had not been identified as having learning disabilities or sensory integrative dysfunction, nor were they in the process of being evaluated for possible learning disabilities. Children taking any medication for behavior, mood control, or seizure disorder were ex-
cluded from the study, as were those with known neurological dysfunction or damage. This information was obtained from questionnaires completed by parents and classroom teachers. Additional criteria involved the following: (a) that the parents provide written consent; (b) that the subject be white (to avoid the possibility of bias due to race), aged 36 to 72 months old, and right hand dominant; and (c) that the subject’s parents be either of high-middle to high socioeconomic status or low-middle to low socioeconomic status. Children from middle socioeconomic status were excluded from the study.

Twenty-two subjects from the lower socioeconomic group were selected, and each was matched with a child from the higher socioeconomic group (9 boys and 13 girls in each group) on the basis of race, sex, hand dominance, age, height, and weight. Birth dates of the matched pairs were within 2 months, height within 8 in., and weight within 10 lb.

Procedure

The assessments were performed between 8:30 a.m. and 12:00 noon. Distractions were minimized and each setting made as similar as possible with the use of two testing areas separated by 68-in.-high folding bed screens. All windows were covered and wall hangings were draped or removed. During each administration of the Southern California Postrotary Nystagmus Test (SCPRN) (Ayres, 1975), the lighting was reduced to less than 8 footcandles, as measured by a triple-range light meter. The testing area was draped so that no streaks or flashes of light could be seen while the SCPRN was being administered. Each child was tested individually, with no one in the testing area other than the examiner and the child. Hand strength of all subjects was measured with the second adjustment of the handle on the standard Jamar Dynamometer.1

The dependent variables were divided into two groups, and each half was administered by a separate examiner. Administration of the two groups of tests was counterbalanced to control for the nuisance variable of order. The order of administration within each half of the battery was consistent.

The subjects’ height and weight were measured on the same doctor’s scale before test administration for purposes of matching, but within 1 week of the other tests. Standard instructions were given to the children before each test. When testing a child, the examiners were blind to the pairing of the children. The same tables and chairs were used with all subjects.

The VMI was administered and scored according to the directions for the individual screening approach set forth in the test manual. The first examiner then measured hand size, that is, palmar surface area, and hand strength, using the procedures developed by the first author (Bowman, 1990).

Standing Balance: Eyes Open and Standing Balance: Eyes Closed were administered according to the standard instructions and procedures presented by Ayres in the Southern California Sensory Integration Tests manual (1972), with subjects standing on an uncarpeted floor without their shoes. Unilateral hopping was assessed with the Bowman Unilateral Hopping Test (Flannigan, 1987). The order of the foot to be hopped on first was counterbalanced to control for the nuisance variable of order. The SCPRN was administered according to directions in the test manual.

The praxis tests of the SIPT, given in the order of Sequencing Praxis, Postural Praxis, Oral Praxis, Praxis on Verbal Command, and Constructional Praxis, were administered and scored by the second examiner according to the standard instructions and procedures presented in the manual for normative data collectors (Ayres, 1984). When the subjects were required to stand, they did so on a carpeted floor. Duration and quality of prone extension were assessed with the Bowman Quality of Prone Extension Scale (Bowman & Katz, 1984; Etheredge, 1987).

Results

Demographics. On the socioeconomic index developed by Stevens and Cho (1985), which assigns a number to represent the socioeconomic status of individuals (a higher status is assigned a higher number), the mean socioeconomic index was 26.58 for the parents of lower socioeconomic status and 71.52 for the parents of higher socioeconomic status. The mean combined years of education for the parents of lower socioeconomic status was 25.59; for the parents of higher socioeconomic status, 33.77. The mean number of siblings in the lower socioeconomic status families was 1.18; for the higher, 1.50. All of the children of higher socioeconomic status had both parents in the home, whereas 27.3% of the children of lower socioeconomic status were from single-parent homes.

Homogeneity. The lower socioeconomic status group ranged in age from 36 to 69 months; the higher socioeconomic status group, from 38 to 71 months. To ascertain whether the two groups were homogenous in age, height, and weight, three paired t tests with a two-tailed probability were run. At an alpha level of .05, a statistically significant difference was found between the ages of the two groups, with the higher socioeconomic status group being slightly older (mean age = 56.50 months) than the lower socio-

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1 Available from J. A. Preston Company, 703 Page Road, Clifton, NJ 07012-1421.
As discussed later in this paper, this difference was not considered to have adversely affected the study results.

Data analysis. To contain the alpha level within .05 and to reduce the probability of a Type I error, we used Hotelling's $T^2$ for correlated samples, a multivariate analog of the paired $t$ tests, three separate times to analyze the hand, vestibular, and praxis data. When one uses the Hotelling's $T^2$, if the calculated value exceeds the critical value at the .05 significance level, a null hypothesis of identical mean vectors can be rejected, and further analysis is required to find which dependent variables contributed to the overall significant difference (Huck, Cormier, & Bounds, 1974). This procedure was followed in the present study. When the Hotelling's $T^2$ analysis revealed a statistically significant difference, we performed a post hoc univariate analysis to compare the two groups on all test scores using paired $t$ tests with one-tailed probability. Visuomotor integration data were analyzed with a paired $t$ test.

Hand size and strength. An analysis with the Hotelling's $T^2$ for correlated samples revealed a statistically significant difference in the composite measures of hand strength and size [$T(2, 20) = 3.69, p = .043$], with the higher socioeconomic status group scoring better. For the univariate analysis, to contain the alpha level within the .05 level and to again control for the probability of a Type I error, the .05 alpha level was divided by the number of dependent variables analyzed. For a hand strength and hand size dependent variable to be statistically significant, the obtained probability had to be equal to or less than .005. A univariate analysis to ascertain the specific differences revealed a statistically significant difference between the two groups on right hand strength [$t(df = 21) = -3.12, p = .002$], with the higher socioeconomic status group demonstrating greater strength ($m = 9.75$ lb) than the lower socioeconomic status group ($m = 8.23$ lb). Statistically significant differences were not found in any other measure of hand strength or hand size (see Table 2).

Vestibular function. When comparing the lower and higher socioeconomic status groups on the composite scores of mean average hop, standing balance total scores with eyes opened and closed, duration and quality of prone extension, and the mean of the right and left postrotatory nystagmus scores, we found no statistically significant differences between the two groups [$F(6, 9) = 2.13, p = .148$] (see Table 2). Because no significant difference was revealed through analysis of Hotelling's $T^2$ for correlated samples, further analysis was not appropriate.

Visuomotor performance. Performance on visuomotor integration was analyzed with a paired $t$ test. The higher socioeconomic status group had a significantly higher score ($m = 9.00, SD = 3.91$) on visuomotor integration than the lower socioeconomic status group ($m = 6.68, SD = 9$) [$t(df = 21) = -4.43, p = .000$].

Praxis Analysis with the Hotelling's $T^2$ for correlated samples revealed a statistically significant difference between the lower and higher socioeconomic status groups [$F(6, 16) = 5.00, p = .005$] on the composite measures of praxis. A post hoc test was conducted, therefore, and the univariate comparison of the scores showed two statistically significant differences (see Table 4). Again, to control for the probability of a Type I error, the alpha level of .05 was divided by the number of dependent variables analyzed. To be considered statistically significant, therefore, the obtained probability of a result had to be equal to or less than .006. The higher socioeconomic status group scored better on Praxis on Verbal Command in both accuracy and time [$t(df = 21) = -4.86, p = .000$ and $t(df = 21) = 5.15, p = .000$, respectively]. The mean scores for accuracy were 21.05 for the higher group and 16.50 for the lower. On time, the mean score for the higher group was 105.82 sec; for the lower group, 160.18 sec. This being a time score, the lower number of seconds reflects a faster and thus a better score.

### Table 1

<table>
<thead>
<tr>
<th>Measure</th>
<th>Lower SES ($n = 22$)</th>
<th>Higher SES ($n = 22$)</th>
<th>Paired $t$ ($df = 21$)</th>
<th>$p$ (two-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (months)</td>
<td>55.64</td>
<td>56.50</td>
<td>-3.25*</td>
<td>.004</td>
</tr>
<tr>
<td>Height</td>
<td>41.40</td>
<td>41.87</td>
<td>-1.35 (ns)</td>
<td>.192</td>
</tr>
<tr>
<td>Weight (lb)</td>
<td>105.16</td>
<td>106.35</td>
<td>5.77</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>38.70</td>
<td>38.18</td>
<td>0.50 (ns)</td>
<td>.622</td>
</tr>
<tr>
<td></td>
<td>17.55</td>
<td>17.32</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. ns = not significant.

* Significant at an alpha level of .05.
Table 2  
Post Hoc Analysis Comparing Socioeconomic Status (SES) Groups on Hand Size and Strength

<table>
<thead>
<tr>
<th>Measure</th>
<th>Lower SES</th>
<th>Higher SES</th>
<th>Paired t (df=21)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td></td>
</tr>
<tr>
<td><strong>HAND STRENGTH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left hand strength lb</td>
<td>7.75</td>
<td>2.19</td>
<td>8.70</td>
<td>2.66</td>
</tr>
<tr>
<td>kg</td>
<td>3.51</td>
<td>0.99</td>
<td>3.95</td>
<td>1.21</td>
</tr>
<tr>
<td>Right hand strength lb</td>
<td>8.23</td>
<td>2.47</td>
<td>9.75</td>
<td>2.70</td>
</tr>
<tr>
<td>kg</td>
<td>3.73</td>
<td>1.12</td>
<td>4.42</td>
<td>1.22</td>
</tr>
<tr>
<td>Mean hand strength lb</td>
<td>8.11</td>
<td>2.25</td>
<td>9.30</td>
<td>2.59</td>
</tr>
<tr>
<td>kg</td>
<td>3.68</td>
<td>1.02</td>
<td>4.22</td>
<td>1.17</td>
</tr>
<tr>
<td><strong>HAND SIZE (cm)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left palm length</td>
<td>6.59</td>
<td>0.63</td>
<td>6.59</td>
<td>0.46</td>
</tr>
<tr>
<td>Left palm width</td>
<td>6.04</td>
<td>0.36</td>
<td>6.00</td>
<td>0.40</td>
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<tr>
<td>Left palm surface area</td>
<td>39.88</td>
<td>5.82</td>
<td>39.63</td>
<td>5.30</td>
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<tr>
<td>Right palm length</td>
<td>5.54</td>
<td>0.55</td>
<td>6.56</td>
<td>0.48</td>
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<tr>
<td>Right palm width</td>
<td>6.14</td>
<td>0.46</td>
<td>6.05</td>
<td>0.31</td>
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<tr>
<td>Right palm surface area</td>
<td>40.28</td>
<td>6.33</td>
<td>39.95</td>
<td>4.57</td>
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<tr>
<td>Mean palm surface area</td>
<td>40.08</td>
<td>6.02</td>
<td>39.64</td>
<td>4.62</td>
</tr>
</tbody>
</table>

Note. ns = not significant.  
* Significant at an alpha level of .005.

Discussion

**Demographics.** As with all measures of social status, some limitations were encountered in trying to rate the occupations of the head of household. The job title of the individual did not always precisely represent his or her social standing. A rating of 50 or above according to the scale was considered high-middle to high socioeconomic status and a rating of 35 or below was considered low-middle to low socioeconomic status; the groups, therefore, were referred to as the higher and lower socioeconomic status groups. The difference between the mean socioeconomic status rating of the two groups was 44.94, which was sufficiently large to reveal a difference in the performance of the children on several characteristics examined. Had the groups been farther apart on the socioeconomic index, perhaps more differences would have resulted. The children's performances may have been influenced by the differences in the parents' education. As would be expected, the parents of the higher socioeconomic status group had more combined years of education than did those of the lower group. The nuisance variable of parental education was not controlled, because it is a component of the socioeconomic status. Six of the children in the lower socioeconomic status group came from single-parent homes, whereas all of the children in the higher socioeconomic status group came from families with both parents in the home, which may have affected overall performance. Golden and Birns (1968) stated that a child from a socially disorganized family has a greater chance of developing learning problems than a child from a stable home.  

**Homogeneity.** We attempted to match each lower socioeconomic status child with a child from the higher socioeconomic status group on race, sex, hand dominance, age, height, and weight using the first author's criteria from an earlier study (Bowman, 1985). These criteria, however, had to be expanded, because pairs could not be established: The potential subjects in the higher socioeconomic status group were all white, and matching children reported to be left hand dominant was not possible. To control for...
The groups' mean ages differed by 0.86 months (26 days). This difference of less than 1 month is not clinically significant because it is small and is not as meaningful in the development of a 3- to 5-year-old child as it may be in infancy. Developmental tests used with preschool children generally present a range of a few months when identifying the age at which a particular skill emerges, rather than specifying an exact month, as in the Hawaii Early Learning Profile (Setsu et al., 1979), the Brigance Diagnostic Inventory of Learning Development (Brigance, 1978), and the Bayley Scales of Infant Development (Bayley, 1969). Had the two socioeconomic status groups been randomly selected and not paired for age, we would hesitate to make this clinical judgment.

**Hand size and strength.** When hand size and strength were analyzed, right hand strength was greater in the higher socioeconomic status group. No difference in hand size was found between the two groups. Bowman and Katz (1984) used the same type of dynamometer and methodology to examine hand strength in right-hand-dominant children, 6 to 9 years old, and reported that hand strength increased with age. Robertson and Deitz (1988) examined the hand strength of children aged 3 to 5½ years using the Martin Vigorimeter and also found children's hand strength to increase with age. Those studies along with the present study's results indicate that the higher socioeconomic status group is functioning at a more mature level of development in its hand strength.

The greater hand strength found in the higher socioeconomic status group cannot be attributed to hand size, because no difference was found between the two groups in palm width, palm length, or palmar surface area. Bowman and Katz (1984) reported a strong positive correlation between height and right hand strength, left hand strength, and average hand strength ($r = .78, .70,$ and .78, respectively) and a strong correlation between weight and right hand strength, left hand strength, and average hand strength ($r = .69, .60,$ and .68, respectively). The two groups in the present study were found to be homogeneous on height and weight, so the differences found between the two groups on right hand strength and mean hand strength suggest a true difference not attributable to differences in the subjects' stature.

In comparing the hand strength of non-learning-disabled and learning-disabled children in an earlier study (Bowman, 1985), the first author found that the right and left hand strengths of children without learning disabilities were greater than those of children with learning disabilities and thus hypothesized that a deficit exists in the proprioceptive feedback mechanism of children with learning disabilities. In the present study, however, only the right hand strength of the higher socioeconomic status children was greater than that of the lower socioeconomic status children. Because a difference in the strength of only one hand was found, one can infer that this difference does not result from proprioceptive deficits in the lower socioeconomic status group. One explanation for the higher socioeconomic status group’s greater right hand and mean hand strengths might be...
that they have more opportunities to use crayons, pencils, and scissors, which would increase the chances for earlier development of right hand strength. This view was supported by Less, Krewer, and Eickelberg (1977), who found that hand strength increased with exercise of the intrinsic muscles of the hand.

**Vestibular function.** Deficits found in some populations, such as in persons with learning disabilities, have been associated with dysfunction of their vestibular system (Ayres, 1978), as measured by some of the assessments used in the present study. Because the present study revealed no difference between the two groups, one can infer that any differences found on the other measures are unlikely to result from vestibular system dysfunction. Interestingly, no difference was found between the two groups on the SCPRN, a test often used clinically to measure vestibular integrity (Ayres, 1975; Deitz, Siegner, & Crowe, 1981; Keating, 1979; Punwar, 1982), which was the only neurophysiological measure used in the present study. The literature has questioned whether the SCPRN has validity for young children. Deitz et al. (1981) reported that the SCPRN is not reliable for 3-year-old children because they lose their balance easily. Punwar (1982), however, included 3-year-olds in her study and expanded the original norms to a wider age group (Ayres, 1975). She concluded that because her findings did not differ from Ayres's (1975) findings, the test could be used with children aged 3 to 5 years. The mean scores of the SCPRN in the present study were in the same range as those reported by Ayres (1975) and Deitz et al. (1981). These results suggest that a therapist using those vestibular test items to assess vestibular function can be confident that variation from the norms does not reflect socioeconomic status.

**Visuomotor integration.** A difference was found between the performance of the two groups on the VMI, with the higher socioeconomic status group achieving superior scores. When converted to an age equivalent, the mean raw score of the higher socioeconomic status group was 64 months, which is 7.5 months above their average age. That of the lower socioeconomic status converted to between 52 and 57 months, which is within the range of its mean age of 55.64 months. The higher socioeconomic status group, therefore, appears to be developmentally more advanced than the lower socioeconomic status group in its visuomotor integration. The difference found between the two groups agrees with the findings of Judd et al. (1986), who reported social class differences in writing tasks of first graders, with the subjects from the higher socioeconomic status group writing faster and more accurately. The findings of the present study also agree with those of Wallach and Martin (1970), who found significant differences in the drawing tendencies of children from varying social classes, with the higher socioeconomic status group tending to draw less expansively. The VMI has been reported (Martin et al., 1977; Nye, 1977) to be biased toward white children from middle- to upper-class backgrounds. Beery (1982) insisted, however, that the test is a sensitive predictor of achievement for the child of low socioeconomic status and is one of the least culturally biased tests.

Using the VMI norms published in 1967, Martin et al. (1977) studied the performance of two groups on the VMI to determine if differences as a function of race and socioeconomic status were significant. They found differences favoring the high socioeconomic status group and the white children and attributed these differences to a greater incidence of prenatal or postnatal damage in the lower social classes, differences in intelligence, and differences in experiences with writing utensils. In studying children aged 4 and 5 years, Nye (1977) used the 1967 form of the VMI as part of a screening process for the Head Start program. Thirty-five percent of the children failed the screening, and Nye judged this to be an excessively high rate of failure, stating that it was due partly to the test's age-equivalent scores being too high and partly to a general delay of the children involved in the Head Start program. She concluded that the test was culturally biased toward upper-middle-class white children. The differences found in the present study might lead one to question the validity of other studies that base their results on the VMI as a measure of visuomotor function and do not consider the effects of socioeconomic status. O'Brien, Germak, and Murray (1988) used the VMI to study visual-perceptual-motor abilities and dyspraxia (defined as clumsiness) in children with and without learning disabilities. They found that the children with learning disabilities and dyspraxia scored significantly lower than the children without learning disabilities. Socioeconomic status was not a variable in their study, so they did not address its possible effects on their subjects' performance.

**Praxis.** The post hoc analysis revealed that the higher socioeconomic status group scored significantly higher on Praxis on Verbal Command (i.e., on both accuracy and time scores). Unfortunately, the normative data on these tests are not publicly available, so we could not compare the performance of the 4- and 5-year-old subjects in this study with that of the normative group, as with the VMI. The differences found between the two groups could be attributed to an actual difference in the practic abilities of the social classes, a difference in language and the underlying skills to which it has been suggested that both language and praxis are related (Heilman, 1973; Oje-
mann, 1982), a difference in the developmental level at which the two groups are functioning, or a combination of these differences. Walton (1962) stated that problems in childhood dyspraxia result from defects in cerebral organization. We found no evidence in the present study that the children in the lower socioeconomic status group had dyspraxia, but because cerebral organization occurs on a continuum, the higher socioeconomic status group might possibly function at a higher level on the continuum of cerebral organization than the lower socioeconomic status group. The higher socioeconomic status group may have had a greater variety of tactile stimuli and a broader spectrum of sensory integration treatment on aphasic children, which suggests that those tests are not affected by the types of activities that environmental enrichment provides.

Ayres, Mailloux, and Wendler (1987) stated that two elements of praxic function are tactile processing and ideation, or concept formation, and that the Praxis on Verbal Command subtest depends on language comprehension and memory as well as on somato-practic function. They reported that language skills demonstrate some of the highest correlations with the praxis tests. The higher socioeconomic status group may have had more opportunities to experience a wider variety of tactile stimuli and a broader spectrum of concept formation. Further inquiry in the present study revealed that all of the higher socioeconomic status subjects were involved either in gymnastic lessons, ballet, or swimming on an almost daily basis, and practice in following commands may be responsible for the difference. Because the praxis tests are newly developed subtests of the SIPT, it is especially important to note that the subjects' performances on the other praxis tests were not affected by socioeconomic status, which suggests that those tests are not affected by the types of activities that environmental enrichment provides.

Ayres and Mailloux (1981) examined the effects of sensory integration treatment on aphasic children, administering several of the praxis tests used in the present study along with other tests that measure language comprehension. Their treatment activities were aimed at organizing the subjects' cognitive processes through somatosensory and vestibular stimulation. Each of the 4 children studied gained at least 2 years in language comprehension during the time they were receiving occupational therapy. The researchers concluded that with treatment directed at praxis and problems in cerebral organization, great gains were seen in language development. This suggests the interconnected relation between praxis and language. Other researchers have found evidence to support this relationship. Heilman (1973) studied apraxia in patients with aphasia and concluded that problems with ideational praxis occurred in the process between language comprehension and motor encoding. Ojemann (1982) conducted electrical stimulation mapping studies during neurosurgery and found that the parts of the brain in which language functions could be localized also had specific functions related to motor performance. Language comprehension has been shown to vary among social classes during the preschool years, with children from higher social classes showing superior performance (Parisi, 1979). Because language and praxis have been shown to be closely related both functionally and neurologically, the higher socioeconomic status group's more advanced language skills may have given them an advantage on the Praxis on Verbal Command subtest.

Study Limitations
Unfortunately, we were not blind to the socioeconomic status of the subjects. To do so, we would have had to transport the children to a setting other than their schools, had them wear uniform apparel, and had them cover their heads. Not only would this have been expensive, but the inconvenience to the subjects would probably have reduced the number of parents who were willing to permit their children to participate. We attempted to control for a Type I error by stringently maintaining the preestablished .05 alpha level, but this introduces the possibility of making a Type II error. Additionally, the study involved only white children; we therefore do not know whether black, Native American, or Asian children from higher and lower socioeconomic groups would show the same differences.

Conclusion
The present study suggests that children in a higher socioeconomic status group, as compared with children in a lower socioeconomic status group, function at a developmentally higher level in three areas evaluated by occupational therapists. This could be attributed to the slight difference (less than 1 month) in the mean ages of the two groups, but this difference does not appear to be large enough to account for the differences found. Further research is needed to identify the reasons for differences in children from different social class backgrounds. The existing research has shown a difference in some areas between children from higher and lower social class backgrounds. The specific differences identified through post hoc analysis in the present study supported three of the four hypotheses: Preschool children from a higher socio-
school-aged children as a function of socioeconomic status.

Twenty-two children, aged 3 to 5 years, from a lower economic group were each matched with a child of the same age between socioeconomic status levels. Great variation in height and weight among children from different social classes who do not attend preschool at the time of testing. A comparison of the perceptual-motor development of children of a wider age range, from different ethnic backgrounds, and from a broader spectrum of social classes, the therapist could use it with a child from a low or high social class background and interpret the results according to the norms. If, however, the normative data had been collected on a primarily upper-middle-class population, the therapist might consider the test to be socially biased against a child of lower socioeconomic status. We emphasize, however, that performance on 10 of the 13 assessment tools used in this study did not demonstrate socioeconomic status bias. The results of this study can provide the therapist with confidence that deviation from the norm demonstrated by a client on those 10 tests probably does not result from socioeconomic status bias. Of particular note is that none of the tests used to assess vestibular functioning showed any socioeconomic status bias.

Further research is needed to examine the perceptual-motor development of children of a wider age range, from different ethnic backgrounds, and from a broader spectrum of social classes. The present study included only white children who were attending preschool at the time of testing. A comparison of the hand size, hand strength, vestibular function, visuomotor integration, and praxis development, and perceptual-motor development. Multivariate analyses revealed a statistically significant difference favoring the higher socioeconomic status group on hand strength and praxis but not on vestibular function. A paired t test revealed that the higher socioeconomic status group scored significantly higher on visuomotor integration. The results support three of our four hypotheses and suggest that a child from a higher social class may function at a developmentally higher level in those areas than a child of the same age from a lower social class. The occupational therapist, therefore, must consider the effect of social class needs when interpreting the results of a child's performance on tests of hand strength, the VMI, and the Praxis on Verbal Command subtest. Performance on 10 of the perceptual-motor measures, most of which are frequently used by pediatric occupational therapists, did not demonstrate socioeconomic status bias. This information may be helpful to a therapist when interpreting the results of an assessment.

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