The Effects of Tactile Defensiveness and Tactile Discrimination on In-Hand Manipulation

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Key Words: gross and fine motor evaluation • hand functions • sensory integrative dysfunction • touch and tactile sensation

The purpose of this study was to compare in-hand manipulation efficiency in children with and without tactile defensiveness and low tactile discrimination. Fifty children, aged 4 to 6 years, were tested with the use of three subtests of the Southern California Sensory Integration Tests (SCSIT) (Ayres, 1980), which measured tactile function, and three in-hand manipulation tasks. Tactile defensiveness was rated during performance of the selected SCSIT subtests. Nine of the children had mild developmental delays and 41 were without delays. Low correlations between scores on tactile defensiveness and tactile discrimination suggested that these two aspects of tactile function are separate but related phenomena. Children with both defensiveness and discrimination problems demonstrated the least efficiency on all of the in-hand manipulation tasks and had significantly higher time scores on the turn and translation in-hand manipulation tasks. Poor discrimination or tactile defensiveness alone did not relate to poor in-hand manipulation. The results suggest that a child’s tactile function should be considered in therapy to improve manipulation skill. Strategies to decrease tactile defensiveness and improve tactile discrimination may facilitate achievement of higher levels of in-hand manipulation.

Ayres (1972) hypothesized that sensory input from the skin and joints helps develop in the brain the model or internal scheme of the body’s design as a motor instrument. Both tactile and proprioceptive systems are considered to play a primary role in motor development (Royeen & Lane, 1991). Early explorations of objects rely on tactile and proprioceptive receptors of the mouth and then of the hands (Bushnell, 1982). According to Luria (1973), a “normal flow of cutaneous-esthetic afferent impulses is the essential basis of movement” (p. 35).

Relationship Between Tactile Defensiveness and Tactile Discrimination

Tactile defensiveness refers to observable aversive or negative behavioral responses to certain types of tactile stimuli that most people would find to be nonnoxious (Royeen & Lane, 1991). Tactilely defensive children react to benign or nonnoxious tactile stimuli with protective withdrawal responses (Royeen, 1986). Such children often avoid interactions in which they will be touched. As a result, these children may exhibit hyperactivity or distractibility in everyday situations. They may become anxious, emotionally labile, and easily threatened by the environment (Ayres, 1972).


Fisher and Dunn (1983) clarified that tactile defensiveness and impaired somatosensory perception could occur in isolation. Some children who demonstrated tactile defensiveness obtained normal scores on the tactile subtests of the Southern California Sensory Integration Tests (SCSIT) (Ayres, 1980), and some children who showed no evidence of defensiveness obtained low scores. The researchers explained that protective and discriminative function should be considered as separate but related functions of the somatosensory system. The subtests that often elicited tactile defensive responses — Graphesthesia and Localization of Tactile Stimuli — were also the subtests likely to have depressed scores. The low scores, therefore, may reflect poor tactile discrimination or poor ability to attend to the task from aversive reactions to the tactile stimuli (Fisher & Dunn, 1983).
Tactile information is a major source of information about the environment and about the effect of our motor responses on the environment. As such, it is basic to early learning, particularly to motor development (Bruner, 1973; Ginsburg & Opper, 1979; Kravitz, Goldenberg, & Neyhus, 1978). Treharthen (1984, 1986) described the relationship of the body's sensory map to motor coordination. He proposed that when focal sensory input is received, the body orients to the input, and skeletal muscles automatically respond. The muscle response has a direct relationship to the sensory stimulus. He further explained that as a person moves, he or she continuously assimilates sensory information to guide the movement. Tactile perception integrates with information from proprioceptors in guiding movement and makes "possible smoothly coordinated movement (and) well conceived prehension" (Treharthen, 1986, p. 212). Ayres (1972) described this direct relationship: "Sensory input from the skin and joints, but especially from the skin, helps develop in the brain the model or internal scheme of the body's design as a motor instrument" (p. 168).

Researchers have discussed the importance of tactile-kinesthetic function in the development of manipulation skill (Henderson & Duncombe, 1982; Laszlo, 1967). Kephart (1975) suggested that tactile-kinesthetic deficits were related to clumsiness in children with learning disabilities. Children labeled as clumsy were found to have problems in discriminative abilities such as finger localization (Cermak, 1985; Lesny, 1980; Walton, Ellis, & Court, 1969). Investigations of the effects of dorsal column lesions on the manipulation skills of monkeys have revealed a strong relationship between tactile-kinesthetic input and grasping skills. Following dorsal column lesions, the monkeys demonstrated decreased manual dexterity, clumsiness in handling objects in space, and difficulty prehending small objects (Vierck, 1978).

The development of praxis appears to be directly dependent on tactile discrimination function (Ayres, 1985; Ayres, Mailloux, & Wendler, 1987). Praxis is required when the task is unfamiliar and when the conceptualization of a motor plan prior to execution is needed. In studies on the development of praxis, Gubbay, Ellis, Walton, and Court (1965) found a relationship between tactile perception and praxis. A consistent relationship between the tactile system and dyspraxia has been demonstrated in factor-analytic studies with the SCSIT (Ayres, 1965, 1966, 1969, 1977). Ayres et al. (1987) found that tactile processing is a primary factor in praxic skill. The Sensory Integration and Praxis Tests (SIPT) identify dyspraxia based on somatosensory dysfunction as a key pattern of problems with sensory integration (Ayres, 1990).

In-hand manipulation refers to use of the fingers to manipulate a hand-held object. Exner (1989) defined three categories of in-hand manipulation: translation of the object from the palm to the fingers or from the fingers to the palm; shift of the object between or among the fingers; and rotation of an object around its axes. Efficient manipulation involves well-controlled movements in which muscle agonists and antagonists work in smooth synergy. When a person manipulates an object in the hand, finger movements respond to the sensory properties of the object (White, Castle, & Held, 1964). The discrete and precise finger movements for manipulation are tuned, or refined, by somatosensory information (Kelso, Holt, & Platt, 1980).

Relationship Between Tactile Discrimination and Manipulation

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Relationship Between Tactile Defensiveness and Manipulation

Originally, Ayres defined a relationship of tactile defensiveness to movement based on the results of factor analyses (1965, 1966, 1969) that “consistently linked hyperactivity and distractibility, tactile defensiveness and diminished tactile discrimination. . . The syndrome (defensiveness) is also frequently, but not consistently associated with apraxia” (Ayres, 1972, p. 207). Other behavioral problems frequently associated with tactile defensiveness are hyperactivity, emotional lability, and distractibility (Ayres, 1972; Bauer, 1977; Royeen, 1986; Sears, 1981). Two aspects of defensiveness suggest that it might have a relationship to manipulation skill. First, the child with tactile defensiveness may avoid activities that involve the handling of objects and textures. He or she may limit the variety of textures and media manipulated. Second, hyperactivity and distractibility may interfere with the child’s experience in manipulating objects. The child may have fewer opportunities to practice manipulation skills due to his or her short attention span during fine motor activities (Sears, 1981).

Study Purpose

The purpose of this study was to investigate whether preschool children with problems in tactile function demonstrate less skill in specific in-hand manipulation tasks than do children with normal tactile function. The specific questions addressed were as follows:

1. Do children with decreased tactile discrimination demonstrate less in-hand manipulation skill?
2. Do children with tactile defensiveness demonstrate less in-hand manipulation skill?
3. Do children with problems in both discrimination and defensiveness have the greatest delays and deficits in efficient manipulation skill?
4. What are the relationships among the variables of tactile defensiveness, tactile discrimination, and in-hand manipulation skills?
Method
Sample
The sample involved 50 children, aged 4 to 6 years. Forty-one of these children attended a day-care center and did not have any documented developmental delays or problems. I assumed, a priori, that some of the children without delays would demonstrate tactile defensiveness and problems in discrimination and different levels of in-hand manipulation skill and that the tests used would be sensitive to these differences.

Nine of the 50 children attended a preschool for children with developmental disabilities. They were included in the sample to ensure heterogeneity and thus increase the probability that significant relationships and effects would be found when they did exist. Children with documented motor disabilities, such as cerebral palsy, were excluded. None of the children with developmental disabilities had severe visual impairment, although 3 wore eyeglasses. Eight of the 9 children in this group had mild cognitive or speech delays of less than 18 months. One child had developmental dyspraxia and no cognitive delays, 1 had severe language delays and mild cognitive delays, and 7 had both perceptual motor delays and cognitive delays, 2 of whom were diagnosed with specific syndromes—1 with Williams and 1 with Neumann syndrome.

The mean age of the study sample was 58.6 months (4.9 years). For the 41 nondysfunctional children, consisting of 23 boys and 18 girls, the mean age was 57.9 months (4.8 years) (SD = 7.29, range = 48–74 months); 35 were white, 3 were black, and 3 were Asian. For the 9 children with developmental disabilities, consisting of 8 boys and 1 girl, the mean age was 62.4 months (5.2 years) (SD = 6.67, range = 54–72 months); all of these children were white.

Data Collection and Instrumentation
All of the subjects were tested at a small table in a quiet room. I served as the examiner and sat to the subject's right. Three tactile discrimination subtests of the SCSIT were administered with the standard procedures in the following order: Finger Identification, Graphesthesia, and Localization of Tactile Stimulation. The child's score on each test was the standardized score, on the basis of the age and sex of the child, as reported in the test manual (Ayres, 1980).

Tactile defensiveness was measured through clinical observation during administration of the tactile discrimination subtests. Evidence of tactile defensiveness is most readily discerned and most commonly evaluated during administration of the tactile tests (Ayres, 1972; Fisher & Dunn, 1983). Both physical and verbal behaviors provided evidence of tactile defensiveness, that is, in each of the three tactile subtests administered, 1 point was recorded for verbal responses and 1 point for physical responses that indicated discomfort when touched. Examples of physical responses were the child's excessive squirming and scratching or rubbing the place touched. Several of the children withdrew their hands from the table surface. Remarks about discomfort from the tactile stimuli were scored as verbal indicators of tactile defensiveness. Examples of verbal responses were, “That hurts,” “I don't like this test,” and “That tickles.” Additionally, after each test, the examiner asked the child if the test items bothered him or her. If the child responded yes, he or she was asked to explain why. The defensiveness score reflected the total number of tests in which physical or verbal indications of defensiveness occurred. The highest possible score of 6 indicated that physical and verbal defensive behaviors were observed in all three subtests.

Before evaluating in-hand manipulation skills, the examiner determined handedness by asking the children to draw a happy face. The hand that the child used to draw the face was assumed to be the preferred hand. In-hand manipulation was evaluated in three tasks—turn, translation, and rotation—with the use of small pegs and a pegboard. The test was based on the work of Exner (1986, 1987, 1989) and Pehoski (personal communication, April 1990). Each peg was 2.2 cm in height and 0.55 cm in diameter. The 13.2-cm square pegboard had five holes on each side. The child sat at a small table that offered an optimal height for manipulation.

The turn task involved fingertip prehension and one rotation of the peg. The child was presented with the pegboard with five pegs in place in the row nearest to him or her and five pegs in the row farthest away. The child was instructed to use his or her preferred hand only and to place the other hand in his or her lap. The child was instructed to prehend each peg, turn it over, and replace it in its original hole. The examiner said, “This man wants to stand on his head; turn each man over onto his head,” while demonstrating the task. Because the test was timed, the examiner prompted the child by saying after the first turn, “Now turn the next one over.” After recording the time for the first five rotations, the examiner said, “Now let's put them back on their feet.” Further prompting was given often (e.g., “Put the first man back on his feet; now the second”). Then the pegboard was turned, and the same instructions were given for the second set of pegs. The examiner recorded the time it took the child to turn each set of five pegs. The sum of times in whole seconds was recorded as the score for the first manipulation test.

The translation task involved fingers-to-palm and palm-to-fingers translation with stabilization (Exner, 1989). The child was presented with the pegboard with two pegs placed in the row closest to him or her at midline. The examiner introduced the task by saying, “I am going to pick up the first man and hide him in my hand.” The examiner demonstrated by picking up one
peg and transferring it into the ulnar area of the palm. She then said, "Now I will pick up the second man and hide him in my hand," and picked up the second peg and moved it into the ulnar fingers. Then the examiner brought the peg out of the palm to the fingertips and replaced it in the board. She said, "Now I will bring them out to play. Out comes the first man and out comes the next man." The examiner instructed the child to pick up one peg and hide it in his or her hand, then pick up the next peg and hide it in her or his hand. The child was presented with two, three, four, and then five pegs. In each task, he or she was instructed to hide the pegs one at a time in the palm and then to replace them in the pegboard. Replacement of the pegs anywhere on the board was acceptable. Each task was timed and recorded, and the sum of times for the fingers-to-palm and palm-to-fingers translation tasks was used in the data analysis.

In the rotation task, the examiner demonstrated by rotating a peg in her fingertips continuously five to seven times, saying, "I am going to make the little man do somersaults like this." The child was handed a peg and instructed, "See how many somersaults you can make him do." The child was stopped after 10 rotations and received a maximum possible score of 10 for that trial. If the child dropped the peg or stabilized it on the table or in another body part, the number of rotations prior to dropping or stabilizing was recorded. The number of rotations in the best two out of three trials was recorded as the child's test score.

Results

Because a significant correlation of the test scores with age would have necessitated consideration of age as a covariate, the data were examined for correlation with age. None of the tests were significantly correlated with age; therefore, in the remainder of the analyses the effect of age was not considered. Table 1 shows the mean, standard deviation, and range for each of the dependent variables.

**Table 1**

<table>
<thead>
<tr>
<th>Test Score Statistics for Tests of In-Hand Manipulation, Tactile Defensiveness, and Tactile Discrimination (N = 50)</th>
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</thead>
<tbody>
<tr>
<td>Test</td>
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<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>In-hand manipulation</td>
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<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td>Tactile defensiveness</td>
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<tr>
<td>Tactile discriminationa</td>
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</tbody>
</table>

*aMeasured by subtests of the Southern California Sensory Integration Tests (Ayres, 1980).

**Table 2**

<table>
<thead>
<tr>
<th>Pearson Correlations Between Tactile Function and In-Hand Manipulative Skill (n = 49)</th>
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<tbody>
<tr>
<td><strong>Tactile Function</strong></td>
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<tr>
<td>---------------------------------</td>
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<tr>
<td><strong>Defensiveness</strong></td>
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<tr>
<td><strong>Discrimination</strong></td>
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<tr>
<td><strong>Finger Identification</strong></td>
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<tr>
<td><strong>Graphesthesia</strong></td>
</tr>
<tr>
<td><strong>Localization of Tactile Stimulation</strong></td>
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</tbody>
</table>

*High score = higher skill. **Significant at p < .05. *Significant at p < .01.

**Relationships Among the Variables**

The Pearson product-moment correlation between tactile defensiveness and Finger Identification was -.302 (p = .031); between tactile defensiveness and Graphesthesia, -.435 (p = .001); and between tactile defensiveness and Localization of Tactile Stimulation, -.199 (p = .161). The negative correlations indicate that high defensiveness scores were associated with low discrimination scores. Only two of the correlations were significant, and tactile defensiveness was most related to graphesthesia. These results support the hypothesis of a significant but weak relationship between tactile defensiveness and discrimination. Next, Pearson correlation coefficients were computed to examine the relationship between in-hand manipulation and tactile defensiveness and discrimination. The highest correlations emerged between graphesthesia and in-hand manipulation (see Table 2).

**Effect of Tactile Defensiveness and Tactile Discrimination on In-Hand Manipulation**

To determine whether children with high defensiveness or low discrimination had significantly lower in-hand manipulation, the sample was divided into four groups based on their tactile defensiveness and discrimination scores. The subjects who scored 3 or higher in tactile defensiveness (i.e., exhibited defensiveness on at least two of the tests) were placed in the high defensiveness group; those who scored 2 or less were placed in the low defensiveness group. The children placed in the low discrimination group were those who scored below -1.0 on two or more of the tactile tests. The children in the high discrimination group scored above -1.0 on two or more of the tactile tests. One subject was eliminated due to missing data. The numbers of subjects in the four groups are listed in Table 3. The means for the in-hand manipulation scores of each group are listed in Table 4.
Examination of the mean scores for each group revealed that only one group demonstrated poorer performance (i.e., had higher times and fewer rotations) than the others. Children who exhibited both defensiveness and poor discrimination consistently demonstrated the least efficiency in each of the manipulation tasks. Due to the unequal sample sizes, a Kruskal-Wallis procedure, which is a nonparametric equivalent of a one-way analysis of variance (Hollander & Wolfe, 1973), and multiple comparisons were completed to determine if this group was significantly less efficient. The results of this analysis revealed that the four groups were significantly different for the turn task ($\chi^2 = 8.82, p = .032$) and translation task ($\chi^2 = 9.62, p = .022$). The rotation task was not significant ($\chi^2 = 7.57, p = .066$).

Post hoc multiple comparisons for the turn and translation tasks were made to determine whether differences between pairs of groups were significant. In the turn task, only one comparison was significant; the children who demonstrated high defensiveness and low discrimination had scores that were significantly higher (i.e., less efficient) than those of the nondysfunctional children (i.e., those without defensiveness and with high scores on tactile discrimination) ($p < .05$). The differences between the children with high defensiveness and poor discrimination and the other two groups approached significance, but were not significant. In the translation task, the children who exhibited defensiveness and poor discrimination received higher scores than each of the other three groups; however, the difference between each was not significant ($p = .062, .065,$ and .079 for the between-groups comparisons).

### Discussion

**Relationship Between Tactile Defensiveness and Tactile Discrimination**

The correlations between tactile defensiveness and discrimination demonstrate a significant but weak relationship. Although Ayres (1964, 1966, 1969, 1972) originally hypothesized that tactile defensiveness interfered with accurate discrimination of touch, more recent literature has defined the two conditions as separate but related types of tactile dysfunction (Fisher & Dunn, 1983; Royeen, 1989). On the basis of the correlations found by Ayres ($r = .54$) (as cited by Fisher & Dunn, 1983) between children with impairment in one function who also demonstrated impairment in the other, I expected a moderate correlation. In the present study, all of the correlations were less than expected ($r = -.199$ to -.435) and were not high enough to have meaningful implications for practice. The moderate correlations of the Graphesthesia and Finger Identification subtest scores with defensiveness do not suggest that defensiveness and discrimination would occur together in most instances or that these phenomena can be considered to reflect the same condition. The highest number of tactile defensive responses was demonstrated in the Localization of Tactile Stimulation subtest, yet the lack of significant correlation indicates that defensiveness did not interfere with localization of touch. The tactile stimuli were accurately located despite obvious discomfort with that touch. When the children were placed into groups, 6 children who exhibited defensiveness demonstrated problems in discrimination, and 7 demonstrated discrimination within normal limits. Group membership in the categories defined for this study confirmed the impressions of Fisher and Dunn (1983), Ayres (1990), and Royeen (1989) that tactile defensiveness and impaired tactile perception can occur in isolation.

**Relationship Between Tactile Variables and In-Hand Manipulation**

Moderate correlations emerged between defensiveness and in-hand manipulation and between graphesthesia ability and in-hand manipulation. Although Ayres discussed a possible relationship between defensiveness and apraxia (Ayres, 1972), she did not suggest a linkage between defensiveness and manipulation. Others who have described children's behaviors associated with def-

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**Table 3**

<table>
<thead>
<tr>
<th>Tactile Defensiveness Score</th>
<th>Tactile Discrimination Score</th>
<th>Non-dysfunctional Children (n = 4)</th>
<th>Children With Developmental Disabilities (n = 8)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Low</td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
<td>27</td>
<td>4</td>
<td>31*</td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>High</td>
<td>High</td>
<td>6</td>
<td>1</td>
<td>7</td>
</tr>
</tbody>
</table>

*These children showed no evidence of tactile function problems.*

**Table 4**

<table>
<thead>
<tr>
<th>Task</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turn (in sec)</td>
<td>65.3</td>
<td>13.8</td>
<td>64.4</td>
<td>3.6</td>
<td>115.0**</td>
<td>37.5</td>
<td>71.0</td>
<td>13.4</td>
</tr>
<tr>
<td>Translation</td>
<td>68.6</td>
<td>22.0</td>
<td>60.0</td>
<td>16.4</td>
<td>99.3*</td>
<td>25.8</td>
<td>62.3</td>
<td>12.4</td>
</tr>
<tr>
<td>Rotation</td>
<td>36.4</td>
<td>5.1</td>
<td>14.6</td>
<td>7.6</td>
<td>8.2</td>
<td>8.1</td>
<td>14.4</td>
<td>7.4</td>
</tr>
</tbody>
</table>

*Significantly different from non-dysfunctional ($p < .10$) by Kruskal-Wallis test and multiple comparisons. **Significantly different from nondysfunctional ($p < .05$) by Kruskal-Wallis test and multiple comparisons.
fensiveness have not hypothesized a relationship with manipulation skill (Bauer, 1977; Royeen, 1986, 1987; Sears, 1981). The correlations, although significant, account for less than 28% of the variance in manipulation skill.

The relationship between tactile discrimination and in-hand manipulation was primarily expressed through one variable, graphesthesia, which was significantly related to all three tests of manipulation. A probable explanation for this relationship is that graphesthesia requires a precise motor response that involves motor planning, whereas the other two tactile subtests rely less on motor planning. In research that involved use of the SIPT, the Graphesthesia subtest was the only tactile subtest to have a consistent relationship with praxis disorders (Ayres, 1990).

**Effects of Tactile System Function on Manipulation**

When the children were categorized according to their level of defensiveness and discrimination, those with both defensiveness and discrimination problems had significantly poorer performance on two of the in-hand manipulation tasks. Specifically, the subjects with both tactile problems required more time to complete the turn and translation tasks. Although problems in both defensiveness and discrimination are associated with poor in-hand manipulation skill, either problem in isolation does not seem to affect in-hand manipulation. Researchers have found that children who are clumsy often have deficits in tactile discrimination (Cermak, 1985; Kephart, 1975; Lesney, 1980; Walton et al., 1969). The results of the present study suggest that this finding cannot be reversed, and children with poor discrimination alone do not necessarily have difficulties with in-hand manipulation. Children with tactile discrimination deficits may be able to compensate using other sensory systems, such as vision, to accomplish efficient manipulation. Many researchers (e.g., Hofsten, 1982, 1984; Lasky, 1977; McDonnell, 1975; White et al., 1964) have demonstrated the critical importance of vision in the development of reach and grasp. Researchers and theorists agree that visual, tactile, and proprioceptive perceptions contribute to the learning of skilled hand movement (Hofsten & Fazel-Zandy, 1984; Hofsten & Spelke, 1985; Lockman, Ashmead, & Bushnell, 1984; Roy, Starkes, & Charlton, 1986).

The contributions of each of these sensori-perceptual functions to the development of grasp and manipulation seem to vary among individuals. Strengths in one perceptual system may compensate for deficits in another.

Children with both tactile defensiveness and discrimination problems may avoid manual tactile input due to their defensiveness and may interact with objects less often. Distractibility due to defensiveness may interfere with the child's attention to and engagement in manipulation tasks. With less experience and fewer opportunities to practice manipulation, the child may not be able to compensate for tactile discrimination problems.

**Implications**

The results of this investigation of the effects of tactile defensiveness and discrimination on in-hand manipulation skill have implications for therapy focused on the development of manipulation skill. Although tactile defensiveness or discrimination problems alone do not affect in-hand manipulation performance, high defensiveness and low discrimination combined tend to result in poorer performance.

Therapy for children with both defensiveness and discrimination problems should involve goals to improve manipulation that include strategies to decrease defensiveness and enhance tactile discrimination. To decrease defensiveness, the therapist should give teachers and parents methods for calming and focusing the child before presenting him or her with fine motor activities. Strategies to increase attention, enhance ability to concentrate, and stay with fine motor activity may help the child refine manipulation skill. Preparing the child's sensory system to interact with the environment in active manipulation may promote the practice needed to improve skills. Techniques such as touch pressure or slow linear vestibular stimulation may decrease arousal and inhibit defensive responses (Ayres, 1972; Farber, 1982; Fisher & Dunn, 1983). Sensory stimulation to inhibit defensiveness should be followed with opportunities to practice and develop in-hand manipulation skills.

Activities that use textures and materials that the child tolerates may decrease defensiveness and indirectly increase the child's motivation to explore and handle a variety of textured materials. Children with sensory problems have been shown to prefer heavier objects with smooth surfaces rather than lightweight, fuzzy, or furry objects (Curry & Exner, 1988; Danella, 1973). Therapy sessions might begin with manipulation of heavier, smooth objects and progress toward objects with varying textured surfaces and weights. Unfamiliar textures and shapes should be introduced slowly with textures known to be tolerated or perceived as pleasurable to the child. Therapy to remediate tactile discrimination problems may focus on the improvement of tactile awareness and the use of tactile information.

**Study Limitations**

A major limitation of this study was the unequal numbers of subjects within the comparison groups. With only 5 to 7 subjects in each group with high defensiveness or low discrimination, the estimate of differences between groups may be low. Equal numbers in each group would increase the confidence level for the estimates of vari-
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References


Recommendations

Future studies examining the effects of tactile function on in-hand manipulation skill should include a larger sample of children with tactile problems. The use of more subjects would increase the external validity of the results and increase our confidence in generalizing the results.

The use of additional assessments of tactile defensiveness would strengthen the measurement of that construct. Royeen (1987) developed a tactile defensiveness scale for preschoolers on the basis of interviews with their parents. Royeen's scale provides a history of the child's defensiveness and would increase the validity of the clinical observations of defensiveness.

Future research should investigate the effects of therapy that uses sensory modalities on manipulation skills. The results of the present study suggest that upper extremity tactile function affects manipulation skills; therefore, intervention to directly improve sensory function should have a positive effect on the development of manipulative skill. Efficacy studies of sensory education (Curry & Exner, 1988) with the use of tactile and proprioceptive experiences would validate this assumption.

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