Normative, validation, and reliability studies of the Nine-Hole Peg Test scores with children

Yvonne Smith Widner
University of Nevada, Las Vegas

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NORMATIVE, VALIDATION, AND RELIABILITY STUDIES
OF THE NINE-HOLE PEG TEST SCORES
WITH CHILDREN

by

Yvonne S. Widner
Bachelor of Science
East Carolina University, North Carolina
1984

A thesis submitted in partial fulfillment
of the requirements for the degree of

Masters of Science
in

Educational Psychology

Department of Educational Psychology
University of Nevada, Las Vegas
December, 1998
The Thesis prepared by

Yvonne Smith Widner

Entitled

Normative, Validation, and Reliability Studies of the nine-hole
Peg Test Scores with Children

is approved in partial fulfillment of the requirements for the degree of

Master's of Science in Educational Psychology

Examinatio Committee Chair

Examination Committee Member

Examination Committee Member

Graduate College Faculty Representative
ABSTRACT

Normative, Validation, And Reliability Studies Of The Nine-Hole Peg Test Scores With Children

by

Yvonne S. Widner

Dr. Eunsook Hong, Examination Committee Chair
Professor of Educational Psychology
University of Nevada, Las Vegas

The purpose of this study was to establish norms for fine motor dexterity skills on elementary school children five to ten years old and conduct reliability and validity studies utilizing the Nine-Hole Peg Test. Sample included 1,020 students in ten elementary schools in the Las Vegas area. As children got older, their fine motor speed increased. Significant gender differences were indicated in dexterity in all ages, but only in the dominant hand. Moderately high test-retest reliability and high interrater reliability were obtained. Strong correlation between the NHPT and Purdue Pegboard Test scores provided concurrent validity of the NHPT. Significant difference in dexterity scores between regular and special education groups provided construct validity evidence. Students provided with demonstration and verbal directions showed faster dexterity speed than those with only verbal directions. This study has supported the Nine-Hole Peg Test as an effective screening tool for fine motor dexterity in school-age children.
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CHAPTER 1

INTRODUCTION

Adequate performance in fine motor skills is crucial in the performance of almost all tasks, including daily living, work, school, play, and leisure skills (Exner, 1990). Finger or fine motor dexterity was defined as “the ability to make rapid, skillful, and controlled manipulative movements of small objects, using primarily the fingers” (Fleishman & Ellison, 1962, p. 101). Poirier (1987) defined dexterity as “the manual ability that requires rapid coordination of gross or fine voluntary movements based on a certain number of capacities, which are developed through learning, training, and experience” (p. 71). Super (1949) made a differentiation between gross and fine motor dexterity when he proposed that tests involving arm and hand coordination require gross movement, whereas tests that involve the wrist and fingers require fine motor dexterity. Backman, Cork, Gibson, and Parsons (1992) defined dexterity as “the fine, voluntary movements used to manipulate small objects during a specific task as measured by time required to complete the task” (p. 209). They further held that since time is so easily quantifiable that it is the most widely used measure of dexterity.

Exner (1990) defined in-hand manipulation as “the adjustment of objects that allows for more effective placement of these objects in the hand or for voluntary release” (p. 64).
Between the ages of three and five, children usually demonstrate rapid gains in manipulation skills, finger dexterity, and tool use (Pehoski, 1992). This refinement of hand skill during this period enables the child to perform school readiness activities, such as printing letters and cutting with scissors (Case-Smith, 1995).

McHale and Cermak (1992) conducted a study to obtain a detailed picture of the fine motor requirements in regular elementary classrooms. A written minute-by-minute record of one whole day in six classrooms showed that 30% to 60% of the day was allocated to fine motor activities. These activities included copying from text or the board, writing from dictation, answering questions from text, drawing, folding paper, cutting or pasting, using a computer, and manipulating objects. Eighty-five percent of their time was spent on paper-and-pencil tasks and 15% was spent on manipulative tasks. Thus, fine motor skills are an integral part of elementary school education.

McHale and Cermak (1992) further stated that the incidence of fine motor difficulties among children is not one of the standard reporting categories of federal, state, and local records, yet nearly 10% of elementary school-aged children may experience major difficulty with fine motor tasks. Cratty (1986) supported this statistic that an estimated 8% to 15% of the general elementary school population have such motor coordination problems.

Rationale

The reliable and valid collection of evaluation data depends on the use of accurate instruments that have standardized procedures for their administration (Mathiowetz, Wiemer, & Federman, 1986). The provision of these instruments is crucial in order to identify children with developmental delays early and to provide them with opportunities
for timely interventions (Reid & Rigby, 1997; Russell, Ward, & Law, 1994). Several fine motor tools exist; however, most are costly and time consuming to administer. The need exists for a quick and simple screening tool to identify fine motor delay.

Widner and Presson (1998) conducted a pilot study to estimate reliability and construct validity of the Nine-Hole Peg Test scores with school-aged children in rural elementary school. Both male and female school-age children had faster speed as they got older. The current study extends this pilot study by including elementary schools in both rural and urban areas.

Purpose of the Study

Studies with the Nine-Hole Peg Test (NHPT) have not been conducted in the assessment of children except for a pilot study conducted by Widner and Presson (1998). Since no normative data exists for children below 18 years old, therapists have been relying on their impression and experience regarding normal and abnormal performance. The purpose of this current study was to establish standardized procedures for the administration of the NHPT with children from five to ten years old and to provide clinical norms for the interpretation of this instrument. In addition to establishing normative data, reliability and validity studies were conducted. Specific questions to be answered included:

1) Would children age five to ten demonstrate a significant increase in dexterity with an increase in age?

2) Would children age five to ten demonstrate significant gender differences in dexterity?

3) Would acceptable test-retest reliability estimates be obtained for both hands?
4) Would acceptable interrater reliability estimates be obtained based on the measures from two occupational therapists and from an occupational therapist and a teacher?

5) Would there be a significant correlation between students' performance on the current instrument and that on another existing dexterity test (Purdue Pegboard Test)?

6) Would there be a significant difference in dexterity scores between special education students and those students involved in the norming study?

7) Would there be a significant difference in dexterity speed between urban and rural students?

8) Would there be a significant difference in the mean dexterity scores between children who receive only verbal directions and those in the norming group who receive both verbal and motoric demonstration?
CHAPTER 2

LITERATURE REVIEW

Nine-Hole Peg Test for Adults

Kellor, Frost, Silberberg, Iversen, and Cummings (1971) established norms on a hand dexterity test referred to as the Nine-Hole Peg Test (NHPT). Subjects included 246 normal adults (124 males and 122 females) ranging in age from 18 to 89 years old. The test was scored by the number of seconds subjects required to place nine pegs in a pegboard and then to remove them from the pegboard, using the dominant followed by the nondominant hand. The intent of the test was to utilize the function of age and sex in normal adults to facilitate comparison with a disabled population of the same age and sex.

Mathiowetz, Weber, Kashman, and Volland (1985) presented limitations in the aforementioned study. They indicated that: (a) the description of the pegs and pegboards was provided, but the container for the pegs was not described in sufficient detail to be replicated; (b) the general procedure for testing was described, but there were no standardized instructions reported; and (c) no reliability or validity data were reported in the article. Due to these limitations, the validity of the NHPT and its available norms were comprised. Mathiowetz et al. (1985) therefore conducted a study to establish standardized procedures. The size, material, construction method of the pegs, pegboard, and container, along with the placement of the tool in front of the subject, precise verbal
directions, and evaluation method were described. Their study did include a practice trial of each hand prior to scoring, whereas the Kellor et al. study (1971) did not have a practice trial. Both studies tested the dominant hand first, followed by the nondominant hand.

Subjects in the Mathiowetz et al. study (1985) included 628 normal adults (310 males and 318 females) ranging in age from 20 to 94 years old. Very high interrater reliability estimates (right hand $r = .97$, left hand $r = .99$) and moderate to low test-retest reliability (right hand $r = .69$, left hand $r = .43$) were obtained. It was concluded that the NHPT, believed to be a simple, quick test of finger dexterity with easy-to-decipher norms, might be used cautiously as a screening tool for adults.

Alternative Tests of Fine Motor Dexterity

An alternative test of finger dexterity is the Purdue Pegboard Test. Tiffin and Asher (1948) first provided norms for the Purdue Pegboard in 1948 and since then it has undergone minor design modifications. It was designed to assist in the selection of employees in industrial jobs requiring manipulative dexterity with normative data established for various employee groups (Tiffin, 1968). Five separate measurements can be scored: right hand, left hand, both hands, right+left+both hands, and assembly. However, for the interest of this study, only right- and left-hand measurements will be addressed. Test-retest reliability estimates for single trial administration ranged from .60 and .79 in various employment groups.

In the study by Mathiowetz et al. (1985) each subject performed the right-hand and left-hand subtests of the Purdue to establish concurrent validity with the NHPT. Pearson correlation coefficients revealed inverse relationships (right $r = -.61$; left $r = -.53$) due to
the lower score (shorter time) indicating a better score on the NHPT, whereas the higher score (number of pegs) being more desired on the Purdue Pegboard. In a comparison of hand assessments for adults, the Purdue was recommended over the NHPT, since the Purdue had better test-retest reliability, involved bilateral as well as unilateral hand use, and had a broader age range of normative data (Mathiowetz & Haugen, 1995).

Gardner and Broman (1979) collected normative data on 1334 normal school children (663 boys and 671 girls) ages five to 16, which was divided into half-year groups. They further assessed 212 neurologically involved students and compared their scores to the normative group for a known-group validation. The conclusion was that neurologically involved students did significantly worse than did normal students on the Purdue test. Kane and Gill (1972) conducted a study to determine the value of the Purdue test as a screening device to properly identify children with learning disabilities. The findings resulted in insufficient data to support inclusion as a diagnostic instrument. Two other measures of fine motor dexterity frequently used with pediatric and school-age children, include the Peabody Developmental Motor Scale (Folio & Fewell, 1983) and the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978).

Age Differences in Fine Motor Dexterity

Age showed a negative linear relationship with dexterity in the adult population on the NHPT (Kellor et al., 1971; Mathiowetz et al., 1985). Younger subjects (20-year-olds) were faster, but the speed reduced as one aged. However, this age relationship is contrary to the developmental motor performance in children, according to the Peabody Developmental Motor Scale (Folio & Fewell, 1983) which was normed on children birth to 6 years-11 months and the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks,
1978), which was normed on children 4 to 14 years old. These tests indicated a positive linear relationship between chronological age and motor performance.

Humphrey, Jewell, and Rosenberger (1995) also provided construct validity for the developmental nature of fine motor skills with a positive correlation between increasing age and in-hand manipulation abilities. Other studies involving children substantiate this developmental principle (Pehoski, Henderson, & Tickle-Degnen, 1997a; Pehoski, Henderson & Tickle-Degnan, 1997b).

Gender Differences in Fine Motor Dexterity

While both sexes of adults were approximately equally dexterous, women tended to lose dexterity at a slower rate than did men (Kellor et al., 1971). In the Mathiowetz et al. study (1985) the average female scored slightly faster than the average male but not at a statistically significant level. Rusmore (1942) explored the sex differences in performance on the R-G Pegboard Test of Finger Dexterity. He concluded that although the men were not slower than the women by statistical significance, there was a tendency toward poorer performance on the part of the men. In the two aforementioned pediatric assessments (Folio & Fewell, 1983; Bruininks, 1978), gender differences were referenced but without statistical significance levels obtained. Other studies that also lacked this statistical significance level included Transon et al., 1989; Stein and Yerxa, 1990; O’ Neill, 1995; Pehoski et al., 1997a; and Pehoski et al., 1997b).

When the Jebsen Test of Hand Function was normed on 378 children, the findings indicated statistically significant differences in the direction of faster scores occurring in females (Taylor, Sand, and Jebsen, 1973). In this study, seven dexterity subtest items were tested on children 6 to 19 years old. Females were faster, with the single exception
of the “heavy objects” task, in which boys performed faster at all age levels. In the Gardner and Broman study (1979), the means of male and female scores were compared at every age group (five to 16 years old). Females performed better on the dominant hand dexterity test in 86% of the age groups and 77% of the age groups on the nondominant hand.

Mathiowetz, Rogers, Dowe-Keval, Donahoe, and Renells (1986a) collected normative data on 176 male and female students age 14 to 19 years old, indicating that females scored significantly better on all subtests of the Purdue Pegboard Test, except for the assembly subtest. Agnew and Maas (1982) again explored this gender difference in adults when they readministered the Jebsen Test of Hand Function and concluded that in some age groups, women were generally better at manipulating small objects. Females performed better in writing and in manipulating small objects, while males were better at moving large heavy objects and large light objects.

Instructional Methods

Social learning theory supports that the two most common modes utilized by teachers and trainers to transmit information to the learner about the optimal performance of a motor task are verbal instruction and visual demonstration (Zelaznik, Shapiro, & Newell, 1978). The theory is that the acquisition of novel action patterns is facilitated by demonstration because they provide the information to develop an internal model for response to the task (Bandura, 1965; Newell, Morris, & Scully, 1985). Terms such as demonstration, imitation, observational learning, modeling, and vicarious learning can all be used synonymously (Gould & Roberts, 1982).
In the Kellor et al. study (1971), instructions were given only verbally without a practice trial prior to scoring. In the study by Mathiowetz et al. (1985), the instructions were given verbally as the examiner "briefly demonstrated the test" (p. 29). The interpretation of this was a partial demonstration that did not involve the placement and removal of all nine pegs.

Martens (1975) proposed that visual presentation is preferred over verbal instruction because language is unable to specify with precision critical aspects of human movement. However, it is believed that verbal instructions can positively affect performance on evaluation tests (Davis, 1974), and that instruction about motor action patterns should be unambiguous and simple (Holding, 1965).

Sheffield (1961) found that while demonstration facilitated performance, it was not sufficient to provide complete learning of a motor task. Therefore he supported that demonstration be combined with practice to offer the most effective learning opportunity. Wulf, Shea, and Matschiner (1998) further supported this theory. Demonstration coupled with practice was the most effective way to reduce anxiety of a motor task (Lewis, 1974).

Clinical Use of Nine-Hole Peg Test

The Nine-Hole Peg Test has been primarily utilized in the assessment of dexterity of neurologically impaired adults. Such instances include a study by Yelnik, Bonan, Debray, Gelbert, and Bussel (1996) where the NHPT was considered a complex manual task, with the conclusion that there are ipsilateral motor disturbances after a hemispheric stroke, even without a speed constraint and regardless of the hemisphere damaged. Similarly, the NHPT was considered a valid test to measure hemiplegic patients' dexterity in a study by Marque et al. (1997) with results indicating the bilateral cerebral representation of the
human motor system and suggesting the participation of ipsilateral motor pathways in recovery after a stroke. In a review of the various published measures already available, Wade (1989) concluded that in routine clinical practice, dexterity disability could be best assessed using the NHPT.

The NHPT was included in a study by Felder, James, Brown, Lemon, and Reveal (1994). They suggested that dexterity tests could help identify patients unable to perform adequate oral self-care and that these tests could be used to estimate brushing ability among elderly compromised patients. Transon et al. (1989) also selected it as the tool of choice to evaluate fine manipulative dexterity by comparing scores of adult developmentally delayed individuals with available adult norms.

The NHPT has been shown to improve sensitivity to detect clinically significant differences in adults. Heller et al.’s (1987) findings suggest that the NHPT is a valid and reliable measurement of arm function in the neurologically disabled patient and the use of the NHPT can increase the sensitivity of measurement of arm function at the upper range of ability, even in the population of stroke patients who are likely to have preexisting problems with their hands. In an attempt to improve the assessment sensitivity of upper extremity function in multiple sclerosis, Goodkin, Hertsgaard, and Seminary (1988) compared the NHPT and the Kurtzke Expanded Disability Status Scale. The former (NHPT) was found to be more sensitive in detecting upper extremity functional status changes than the latter. Grant, Slattery, Gregor, and Whittle (1994) selected the NHPT as a previously validated test of limb impairment and suggested that its use would add sensitivity and objectivity to evaluation of neurological response in clinical trials for glioma, a nervous system tumor, and that it can be administered quickly by nonmedical
staff. The NHPT was also chosen as an outcome measure of a single dose of a medication in patients with cerebellar tremors with improvement noted in patients who received ondanestron (Rice, Lesaux, Vandervoort, Macewan, & Ebers, 1997).

The NHPT was included in a study by O’Neill (1995) in which he attempted to standardize the O’Neill Hand Function Assessment and correlated it with the NHPT scores (.98). He tested 140 nondisabled subjects age 16 to 90 year olds. He indicated “this [NHPT] peg test was chosen for comparison due to the wealth of validity and reliability studies performed on it” (p. 479).

Backman, Cork, Gibson, and Parsons (1992) hypothesized that a statistically significant relationship would exist between pegboard dexterity using the NHPT and functional hand performance using the Applied Dexterity section of the Arthritis Hand Function Test. These applied tasks that included lacing a shoe, unfastening and refastening buttons and safety pins, inserting coins in a slot, etc. were timed in seconds required to complete the task. From a sample size of 395 adult subjects, a statistically significant relationship was obtained for each applied dexterity item that suggested a relationship existed between pegboard dexterity and functional tasks that require dexterity. The correlation between aggregate applied dexterity and pegboard dexterity scores for the right hand was .55 and for the left hand .67. The authors concluded that these results suggest that “the NHPT may be a useful screening device for detecting hand dysfunction related to dexterity” (p. 208).

Widner and Presson (1998) conducted a pilot study to estimate the reliability and construct validity of the Nine-Hole Peg Test with elementary school-aged children. Two hundred eight (91 males and 117 females) students in three rural elementary schools were
tested using a modified procedure from that typically given to adults. A factorial analysis of variance was performed to determine if there was an interaction effect between age and gender. There was no interaction effect. No significant gender differences were found on motor dexterity. However, there was a statistically significant main effect between ages on motor dexterity. Both male and female school-age children had faster speed as they got older. A very high interrater reliability was obtained ($r = .98$, dominant hand; $r = .95$, nondominant hand). Test-retest reliability was moderately high ($r = .72$, for dominant hand, $r = .68$, for nondominant hand).

The literature review substantiates the construct validity of the Nine-Hole Peg Test by establishing the relationship of the test to the theories of motor development and evaluation. It is a valid tool for the assessment of fine motor dexterity in adults. Further studies are needed in order to establish this instrument's use with a pediatric population. This current study will submit the NHPT to reliability and validity studies in an effort to determine if the NHPT will be an acceptable screening tool for this purpose.
CHAPTER 3

METHODS

Participants

Subjects of the norming and validation studies included students ranging in ages from five through ten in three public schools in rural Nye County and seven public schools in Clark County, an urban area of Nevada. The total student enrollment of Nye County was 5,089, according to the Nye County School District Fast Fact Brochure, Fall, 1997. Clark County’s student enrollment was 171,110, according to Clark County School District 1997 Annual Report.

In Clark County the entire student body were solicited for involvement in five schools and four of the five tracks in the other two schools. In Nye County students from one track (the largest) were included. This had been the track not previously involved in the pilot study there. Table 1 presents the number of participants for each school involved in this study.

Socioeconomic levels were gauged by percentage of free or reduced lunches, which ranged from 14% to 100% (see Table 1). Thus, it was considered that these students represent a broad range of socioeconomic background. Although no attempt was made to gather data on ethnic background, the observation was made that the majority of students were Caucasians, with African-American and Hispanic-American students being well
were Caucasians, with African-American and Hispanic-American students being well represented in the sample. Table 1 also represents the percentage of students at each school that have special education classification, which ranged from 6% to 14%.

Table 1

Participation of Students by Schools and Specific Programs

<table>
<thead>
<tr>
<th></th>
<th>Number of Participants Per School</th>
<th>% of Students Receiving Free or Reduced Lunches</th>
<th>% of Students Receiving Special Education Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clark County</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School A</td>
<td>96</td>
<td>33</td>
<td>6</td>
</tr>
<tr>
<td>B</td>
<td>284</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>C</td>
<td>133</td>
<td>48</td>
<td>14</td>
</tr>
<tr>
<td>D</td>
<td>66</td>
<td>100</td>
<td>9</td>
</tr>
<tr>
<td>E</td>
<td>182</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>F</td>
<td>71</td>
<td>91</td>
<td>6</td>
</tr>
<tr>
<td>G</td>
<td>37</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td>Nye County</td>
<td>151</td>
<td>42</td>
<td>13</td>
</tr>
<tr>
<td>School A</td>
<td>64</td>
<td>50</td>
<td>13</td>
</tr>
<tr>
<td>B</td>
<td>48</td>
<td>50</td>
<td>8</td>
</tr>
<tr>
<td>C</td>
<td>39</td>
<td>48</td>
<td>11</td>
</tr>
</tbody>
</table>


Overall 1,020 students were involved in this study. For clarity purposes, participants in the norming study will be described first while the participants in each of the other studies will be described separately further in this section.

Data was collected by gender for each of the six age groups, with sample sizes ranging from 29 to 74 students. The norming group size was 542 students, of which 287 were males and 255 were females. Of these, 483 students were right-handed (247 males and
and 236 females) and 59 were left-handed (40 males and 19 females). The incidence of left-handedness in this sample was 11%, which is in agreement with the estimate of the general population, 10% to 15% (Porac & Coren, 1981). Children with a history of neuromuscular disability, with obvious physical indications of hand dysfunction, and with a special education classification were not included in the norming study.

**Testing Instrument**

The Nine-Hole Peg Test measured hand dexterity by the seconds of time a subject takes to place nine pegs in a pegboard and then remove them (Kellor et al, 1971). The original pegboard was a five-inch square. The pegs were 1/4 inch in diameter and 1 1/4 inch in length while the holes were spaced 1 1/4 inches apart measured center to center. The container suggested by the initial authors, Kellor et al (1971), was a sauce dish that was moved from one side to the other but this created replication difficulty due to being non-standardized.

The container constructed for Mathiowetz et al.'s (1985) study was square and placed adjacent to the square pegboard. The latter authors indicated some subjects had difficulty picking up pegs that were in the corners and suggested this might not be a problem with a round container. For this reason, a pegboard with a built-in round shallow peg container was used for this study. This nine-hole pegboard is commercially available from Smith and Nephew Rolyan, Inc. It is constructed of a hard plastic material rather than wood. The outer edges measure 10 inches by 5 inches but the pegboard area remains five-inch square and the hole spacing, peg length, and diameter is consistent with the two aforementioned studies.
Following the pilot study by Widner and Presson (1998), suggestions to improve this instrument for use were made to the commercial supplier as follows: 1) application of a nonskid surface on the bottom of the pegboard to keep the board more stabilized; 2) redesign of the container material from a hard plastic to a shock absorbent surface to prevent the pegs from bouncing out, thus decreasing distractions and; 3) inclusion in the kit of an improved brand of stopwatch due to numerous misstarts.

Smith and Nephew Roylan, Inc. responded favorably with product modifications. They shipped three prototypes with a nonskid bottom and a shock absorbent foam container material. The pegboard kit came equipped with the same brand of stopwatch (Aristo). However, due to malfunctions experienced during the pilot study, another brand of stopwatch was purchased with a digital readout to the 100th of a second. The examiners used these without any equipment malfunction. Figure 1 shows the instrument used in this study.
Figure 1. Photograph of Nine-Hole Peg Test being administered to a child.

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The Purdue Pegboard was selected as the instrument with which to compare the validity of the Nine-Hole Peg Test since it was included in the adult correlation study by Mathiowetz et al. (1985). The Purdue is equipped with pins, collars, and washers located in respective built-in cups at the top of the board. In this study only the pins (25 available for each hand) were used since the right- and left-hand measurements were the only ones of interest to this study. Procedures for administering the Purdue on the preferred and nonpreferred hand required the student to place a number of small pegs individually in a series of small holes as rapidly as possible with each hand. The score was the number of pegs placed in a 30-second trial.

Procedure

Permission to involve Human Subjects was obtained from Social/Behavioral Sciences Committee of the UNLV Institutional Review Board (Appendix A). Both school districts consented for involvement of their students (Appendix B). Meetings were held with the principals from each designated school to present a letter of intent (Appendix C), to obtain approval, and to discuss logistics of the study. Another letter of intent was provided to the teacher (Appendix D). Parental consent letters/forms explained the purpose and the significance of the study and how children would be tested. The forms were printed on one side of the paper in English and the other side was in Hispanic (Appendix E). The forms were distributed via the classroom teachers to the students. The students obtained their parent's signature and return them to their teachers. Approximately 3500 parental consent forms were distributed. The return rate was approximately 33% with vast fluctuations noted by the various schools. Of those parents that returned the form, approximately 10% declined to allow their child to participate.
One or both of the examiners met with each teacher individually to coordinate the schedule of testing and to collect the forms.

**Examiners.** Three examiners participated in data collection. Two were occupational therapists with 12 to 13 years of professional experiences, both having pediatric backgrounds in school-based programs and being familiar with the administration of the NHPT with the adult population. The current investigator, one of the two occupational therapists, had previously administered the NHPT to special education students, using subjective interpretation since no norms existed. The third examiner was a special education teacher with 19 years of teaching experiences but without prior exposure to the NHPT. The teacher was trained by the investigator on desired scoring protocols and practiced several times prior to initiating data collection.

**Physical setting.** Students were tested individually in an area away from their classrooms. The secondary examiner walked younger students (five and six year olds) to and from the testing site, while older students rotated in and out of their classrooms. Efforts were made to insure the use of a properly sized table and chair, with the student comfortably seated upright and forward, and their feet on the floor. Students were positioned approximately three to six inches away from the table while the pegboard was placed horizontally at their midline, approximately two inches from the edge of the table. Students’ clothing and hair were rearranged if either one interfered with testing.

**Testing procedure.** Prior to initial testing, the students were introduced to the primary examiner. A brief interview was performed, at which time their name, age, birth date, sex, grade, and hand dominance was recorded. The age of the student was designated as a 12-month interval from their birthday. All testing was done on a one-on-
one basis. A pencil or pen was presented for grasp at their midline. Five and six year olds were asked to draw a circle, while students seven years and older were asked to sign a Student Assent Form (Appendix F) to indicate their willingness to participate. The hand each student wrote with was recorded as the dominant hand.

The investigator, serving as the primary examiner, provided instructions in both verbal and demonstration formats in order to model the expected behavior to students. Then the students were provided with the opportunity to practice before the timed test. This method was supported by previous studies indicating that performance of a timed task was facilitated when one had the privilege to observe a model and allowed a physical practice (Blandin, Proteau, & Alain, 1994). The verbal directions were modified slightly from the standardized instructions provided in the Mathiowetz et al.'s study (1985) due to the subjects being children. The following verbal instructions (in italic) and motoric demonstration (bold) were given:

**Position the pegboard in front of examiner's body as they prepare to model the same hand that is being tested on the student.** The examiner says, "*The hand you write with [dominant] does all the work while the other hand [nondominant] holds onto the pegboard. Pick up the pegs one at a time as fast as you can and put them in the holes in any order. You can start from any hole. After you put them all in, then you take them out, one at a time as fast as you can and put them back in the container. Now watch me do it.*" While giving the verbal directions, demonstrate picking one peg up, randomly inserting it in one hole of each row and then removing it. Point to the container before putting down the peg. When verbal directions are completed, motorically demonstrate putting all nine pegs in and
out as fast as possible. Examiner repositions the pegboard in front of the student with the container/pegs near the dominant hand while the nondominant hand holds onto the other end of the board. “This first time is a practice. Don’t touch a peg until I say ‘go’. Are you ready? Go!” [The examiner measured the speed of the practice trial with the stopwatch for the purpose of this study]. After the student completes the practice trial, the examiner then says, “OK, this will be the real test with the same hand. Are you ready? Go!” The examiner holds the stopwatch out of view of the student, starts timing when the first peg is touched, and stops when the last peg is dropped back in the container. Record the time. While rotating the pegboard for the nondominant hand, the examiner says, “I’m going to turn the board around and the other hand will now do all the work. This first time is a practice. Are you ready? Go!” After the student completes the practice trial, the examiner then says, “OK, this will be the real test with the same hand. Are you ready? Go.” Record the time. Conversation between the student and the examiner was limited to occasional positive feedback such as “good job” when completing the task unless corrective responses were stated (“don’t use the other hand”, etc.).

Due to the nature of grasping pegs from a rounded surface at a fast rate, it was not uncommon for a peg to be pushed out of the container or dropped during the task. If this occurred with several pegs left, the student was instructed to keep going. If the student continued to reach for the remaining pegs in the container, the examiner would quickly retrieve the loose peg or replaced that peg with a spare one prior to the container being empty, therefore not necessitating the stopping of the test. However, if the loose peg
could not be retrieved before it interfered with the task or the student became distracted by it, then the test was stopped and restarted.

The dominant hand practiced and was tested first, followed by the nondominant hand practice and test. The testing required approximately three to five minutes per student. To maintain confidentiality and to control for possible competition effects between children, students were not told their recorded speed unless they specifically asked.

**Clinical observations.** Students' behaviors were observed in regard to age differences, eye-hand movements, grasping patterns and body posturing to determine the typical performance patterns. Some students appeared competitive or mildly stressed by the task. They were observed to tense up during the task, such as using excessive force, thereby pushing several pegs out of the container at once. Examiner attempted to calm the student and then readministered the test.

**Procedure for the follow-up test.** Each student was involved in two testing sessions (initial and follow-up). The follow-up test was conducted for the majority of students within a four-week interval and for a few students up to six weeks. For the stability of measures, the primary examiner (the current investigator) scored both the initial and follow-up test. For the purpose of maintaining consistency in the testing environment, efforts were made to use the same testing rooms within each school between initial and follow-up session. However, due to available space issues, this was only partially achieved. Efforts were made to schedule the same time of day (a.m. or p.m.) for retesting the students to maintain consistency with the initial testing. Approximately half of the participants were tested in the morning and half in the afternoon.
**Procedure for reliability studies.** During the initial testing, the two occupational therapy examiners collected data to estimate interrater reliability on 416 students in the seven Clark County schools. The interrater reliability was also estimated between the occupational therapist (the current investigator) and the teacher at the follow-up testing session in the three Nye County schools on 106 students. These were subgroups of the norming group. The experimenter-subject gender effects were held constant by the use of three female examiners. For interrater reliability, the primary examiner administered the test and independently scored her readings from the stopwatch, while the second examiner simultaneously timed and recorded her readings. Stopwatches were placed out of the view of the other examiner in order to prevent seeing each other's scores.

**Validation procedures.** For the purpose of validating the Nine-Hole Peg Test, 236 students (119 males and 117 female), ages six, eight, and ten year old were administered the Nine-Hole Peg Test and the Purdue Pegboard Test. The Purdue was positioned directly in front of the student. The standardized directions were followed on the Purdue while the same format used in the norming study was followed for the NHPT. To control for the effect of order, the Purdue and the NHPT were alternated with approximately half of the students tested on the NHPT first and vice versa. The time needed to administer the Purdue increased the testing time by an additional three to five minutes. The second occupational therapist served as the primary examiner. The data from this group were not included in the norming study.

The comparison of a group of students with special education classification (i.e. learning disability, developmental delays, and physical handicapped) were made with the regular education students. The involvement of these students was sought through
collaboration with their homeroom and resource teachers. Initially 47 students were included from Clark County and Nye County. These students were tested on one occasion following the same format as the norming group with the current investigator serving as the primary examiner. However, the sample size from nine year olds (n =19) was the only age group that was usable (the others were smaller than 15). Data for these 19 students were used without separating them by gender. To compare the two groups, 38 students were randomly selected from the corresponding group of regular education students due to the large differences in the sample size. The data from this group were not included in the norming study.

An experimental group of school children, five, seven, and nine year olds, that received only verbal directions were compared to the norming group that received both verbal and motoric demonstration. A total of 194 students (82 male and 112 female) were tested on one occasion. After the dominant hand was determined, the pegboard was placed in front of the student and the same verbal instruction as described above was stated with the exception of the initial statement of “Wait until I give you all the directions before you begin”. The current investigator was the primary examiner. The data from this group were not included in the norming study.

Limitations of the Study

Study limitations are the characteristics of the participants and the limited group size. The current sample was children from within an 80-mile radius of Las Vegas and may not be representative of other geographical locations. Although Las Vegas residents represent a wide range of socioeconomic, ethnic, and culturally diverse population, further replication studies with various samples from other parts of the country would be needed.
The majority of the five-year-olds in this study were between five and a half to six year old. This was because the data were collected in the second half of the school year. Thus the mean score for this age may be inflated and not represent those who have recently turned age five. In addition, maturation of the children’s nervous system from all the ages may have occurred and improvement of their dexterity speed might have resulted due to maturation. Thus, the speed collected in the follow-up session, after the four weeks from the initial test, might reflect this factor to some degree.

Although the test procedures and equipment were standardized throughout the collection of data, the testing location and the time of day varied for some students, which might have impacted individual performance. The return rate of the parental consent forms could have possibly been improved by directly mailing the forms to the parents, thus eliminating the reliance on the teachers to distribute and collect the forms and on the students to deliver and return the forms. However, this would have created a substantial expense in view of the large number distributed.

Furthermore, the quest to find a valid assessment of fine motor skills is confounded by the integral nature of the various skill components. There are contributions of intelligence/ cognitive level (Costa, Vaughan, Levita, & Farber, 1963; Bloom, 1964; and Exner & Henderson, 1995); tactile, kinesthetic, and proprioceptive (McCall, 1974; Eliasson, 1995; Case-Smith, Bigsby, & Clutter, 1998); gross motor development (Haring & Stables, 1966); and visuomotor integration ability (Kepart, 1964; Brenner & Gillman, 1965; and Erhardt, 1992).
CHAPTER 4

RESULTS

Normative Data

To assess whether the data are normally distributed, graphs were drawn to show histograms with normal curve overlaid (Figures 2 and 3). The histograms indicate both the dominant and nondominant hand measures are positively skewed, with only a few students showing extremely slow dexterity speed. Further investigation of this revealed that the same 10 students, in both the dominant and nondominant hand, produced these outliers.

Figure 2. Histogram displaying distribution curve of dominant hand

![Histogram showing distribution curve of dominant hand with statistics: Std. Dev = 3.89, Mean = 21.4, N = 542.00](image)
Figure 3. Histogram displaying distribution curve of nondominant hand

Descriptive data of the group means and standard deviations, obtained during the initial test, stratified by age and gender are reported in Table 2 by the average dexterity performance in seconds on the Nine-Hole Peg Test. For reasons of familiarity in interpretation of the adult normative data (Mathiowetz et al., 1985), percentiles for these dexterity speeds in seconds are provided in Tables 3 to 6 and Figure 4 to 7 using 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles by age, gender, and hand dominance.
Table 2

Mean Speed in Seconds by Age, Sex, and Hand Dominance on the Nine-Hole Peg Test

<table>
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<th>Females</th>
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<table>
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<th>Females</th>
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Table 3

Male Percentile Scores of Fine Motor Dexterity Speed in Seconds of the Dominant Hand

<table>
<thead>
<tr>
<th>Age</th>
<th>5th</th>
<th>10th</th>
<th>25th</th>
<th>50th</th>
<th>75th</th>
<th>90th</th>
<th>95th</th>
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<td>18.13</td>
<td>17.17</td>
<td>16.34</td>
<td>14.70</td>
<td>14.59</td>
</tr>
</tbody>
</table>

Figure 4. Male percentile scores of fine motor dexterity speed in seconds of the dominant hand

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Table 4

**Female Percentile Scores of Fine Motor Dexterity Speed in Seconds of the Dominant Hand**

<table>
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<tr>
<th>Age</th>
<th>5th</th>
<th>10th</th>
<th>25th</th>
<th>50th</th>
<th>75th</th>
<th>90th</th>
<th>95th</th>
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<td>20.88</td>
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<td>19.06</td>
<td>18.14</td>
<td>16.7</td>
<td>16.12</td>
<td>15.15</td>
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</table>

**Figure 5.** Female percentile scores of fine motor dexterity speed in seconds of the dominant hand
Table 5

Male Percentile Scores of Fine Motor Dexterity Speed in Seconds of the Nondominant Hand

<table>
<thead>
<tr>
<th>Percentile Nondominant Hand</th>
<th>5th</th>
<th>10th</th>
<th>25th</th>
<th>50th</th>
<th>75th</th>
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<td>Age 5</td>
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<td>31.09</td>
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<td>22.05</td>
<td>21.39</td>
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Figure 6. Male percentile scores of fine motor dexterity speed in seconds of the nondominant hand

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Table 6

**Female Percentile Scores of Fine Motor Dexterity Speed in Seconds of the Nondominant Hand**

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<tr>
<th>Age</th>
<th>Percentile Nondominant Hand</th>
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<td>9</td>
<td>24.54</td>
</tr>
<tr>
<td>10</td>
<td>23.93</td>
</tr>
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</table>

![Bar Chart](image)  

**Figure 7. Female percentile scores of fine motor dexterity speed in seconds of the nondominant hand**

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Age Differences in Fine Motor Dexterity

Oneway analyses of variance were performed to determine the effect of age on dexterity speed of the dominant hand and the nondominant hand. Significant age differences were found in the speed of the dominant hand, $F(5, 536) = 99.21, p < .0001,$ and of the nondominant hand, $F(5, 536) = 113.13, p < .0001.$ A trend analysis indicated that the mean dexterity speed decreased in a linear fashion with the increase of age, $p < .0005.$ Mean scores and correlation coefficients between the Nine-Hole Peg Test scores and age (males: dominant hand $r = -.73,$ nondominant hand $r = -.69;$ females: dominant hand $r = -.63,$ nondominant hand $r = -.72$) indicated that the seconds required to complete the task decreased as age increased.

Gender Differences in Fine Motor Dexterity

Oneway analyses of variance were performed to determine the effect of gender on dexterity speed of the dominant and the nondominant hand. A significant gender difference was found in the speed of the dominant hand, $F(1, 540) = 8.18, p < .005,$ but not in the nondominant hand, $F(1, 540) = 2.88, p > .05.$ Inspection of the above tables and figures indicated that females were faster than males at every age except on two occasions: Eight-year-old males were faster with their nondominant hand and ten-year-old males were faster with their dominant hand.

Test-retest Reliability

Pearson product-moment correlation coefficients for the dominant and nondominant hands, $r_s (503) = .81$ and $-.79,$ respectively, $ps < .001,$ indicated a moderate to high stability between the initial and follow-up session dexterity speed scores for both hand.
Interrater Reliability

The correlations between the two occupational therapists, $r (416) = .998$ for the dominant hand and $r (416) = .996$ for the nondominant hand, $ps < .0005$, demonstrated very high reliability estimates. The agreement between the occupational therapist and the teacher was extremely high as well, $r_s (106) = .999$, for both the dominant hand and nondominant hand, $ps < .0005$.

Relationship between the Scores of the NHPT and the Purdue Pegboard Test: Concurrent Validity

The Purdue Pegboard Test is a widely used, normed assessment of fine motor dexterity. Significant inverse correlations were obtained, $r = -.80$, for the dominant hand, and $r = -.74$, for the nondominant hand, $ps < .0005$. The inverse correlation was noted due to a lower score indicating a faster performance on the NHPT, in contrast to a higher score indicating a faster performance on the Purdue. Thus the high negative correlation between the two tests indicated that the NHPT scores might be a valid measure for fine motor dexterity. Table 7 and 8 illustrates the means and standard deviations of the students on the NHPT (in seconds) and the Purdue (number of pegs placed) by gender for the dominant hand and the nondominant hand, respectively.
Table 7

Mean and Standard Deviation Scores on the NHPT (in seconds) and the Purdue Pegboard Test (number of pegs placed) for the Dominant Hand by Gender

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<thead>
<tr>
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<th>Female Dominant Hand</th>
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<tbody>
<tr>
<td></td>
<td>NHPT</td>
<td>Mean</td>
<td>SD</td>
<td>Purdue</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>6</td>
<td>39</td>
<td>25.01</td>
<td>3.25</td>
<td>10.28</td>
<td>1.65</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>39</td>
<td>19.82</td>
<td>2.29</td>
<td>13.15</td>
<td>1.44</td>
<td></td>
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<tr>
<td>10</td>
<td>41</td>
<td>17.11</td>
<td>1.66</td>
<td>15.02</td>
<td>1.80</td>
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</tbody>
</table>

Table 8

Mean and Standard Deviation scores on the NHPT (in seconds) and the Purdue Pegboard Test (number of pegs placed) for the Nondominant Hand by Gender

<table>
<thead>
<tr>
<th>Age</th>
<th>Male Nondominant Hand</th>
<th></th>
<th></th>
<th>Female Nondominant Hand</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>SD</td>
<td>Purdue</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>6</td>
<td>39</td>
<td>27.88</td>
<td>4.18</td>
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<td>39</td>
<td>22.13</td>
<td>2.84</td>
<td>12.18</td>
<td>1.65</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>41</td>
<td>19.12</td>
<td>1.47</td>
<td>13.44</td>
<td>1.53</td>
<td></td>
</tr>
</tbody>
</table>

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Fine Motor Dexterity Differences between the Special Education and Regular Education Students: Known-group Validation

There was a significant difference in the dexterity scores between the 9-year-old special and regular education students, $t(20.44) = -3.06$, $p < .01$ in the dominant hand, and $t(20.64) = -2.59$, $p < .05$ in the nondominant hand (equal variances not assumed). Table 9 presents the dexterity scores of the dominant and nondominant hand.

Table 9

<table>
<thead>
<tr>
<th>Age</th>
<th>Regular Education</th>
<th>Special Education</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>9</td>
<td>38</td>
<td>18.56</td>
</tr>
</tbody>
</table>

Nondominant Hand

<table>
<thead>
<tr>
<th>Age</th>
<th>Regular Education</th>
<th>Special Education</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>9</td>
<td>38</td>
<td>20.82</td>
</tr>
</tbody>
</table>

Note. Equal variance was not assumed.

* One student could perform using only one hand, thus reducing the sample size to 18 in the nondominant test.

Rural versus Urban Students’ Dexterity Speed

A significant difference was found in dexterity speed between rural and urban students in Nevada for the dominant hand of six, seven, eight, and nine year olds and for the nondominant hand of seven and eight year olds. For every incidence, significantly faster speed was noted for the urban students. For the remaining nonsignificant value.
levels, the trend was for urban students to be faster, with the exception of five year olds. Means and standard deviation and t-test results are shown in Table 10.

Table 10.

Means, Standard Deviation, and t-Values for Rural Versus Urban Students’ Dexterity Speed

<table>
<thead>
<tr>
<th>Age</th>
<th>Rural N</th>
<th>Mean</th>
<th>SD</th>
<th>Urban N</th>
<th>Mean</th>
<th>SD</th>
<th>t-Value</th>
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<tbody>
<tr>
<td>5</td>
<td>18</td>
<td>26.97</td>
<td>4.48</td>
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<td>26.40</td>
<td>3.78</td>
<td>0.52</td>
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<tr>
<td>6</td>
<td>33</td>
<td>24.58</td>
<td>3.59</td>
<td>88</td>
<td>22.91</td>
<td>3.36</td>
<td>2.38*</td>
</tr>
<tr>
<td>7</td>
<td>25</td>
<td>23.20</td>
<td>2.49</td>
<td>88</td>
<td>20.78</td>
<td>2.10</td>
<td>4.86***</td>
</tr>
<tr>
<td>8</td>
<td>26</td>
<td>21.52</td>
<td>2.81</td>
<td>65</td>
<td>20.92</td>
<td>2.10</td>
<td>2.27*</td>
</tr>
<tr>
<td>9</td>
<td>8</td>
<td>20.22</td>
<td>2.05</td>
<td>68</td>
<td>18.33</td>
<td>1.96</td>
<td>1.07</td>
</tr>
<tr>
<td>10</td>
<td>16</td>
<td>18.30</td>
<td>2.73</td>
<td>57</td>
<td>17.63</td>
<td>1.77</td>
<td>1.17</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age</th>
<th>Nondominant Hand N</th>
<th>Mean</th>
<th>SD</th>
<th>Nondominant Hand N</th>
<th>Mean</th>
<th>SD</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>18</td>
<td>29.92</td>
<td>3.72</td>
<td>49</td>
<td>30.15</td>
<td>3.96</td>
<td>-0.21</td>
</tr>
<tr>
<td>6</td>
<td>33</td>
<td>27.14</td>
<td>3.76</td>
<td>88</td>
<td>26.10</td>
<td>4.00</td>
<td>1.17</td>
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<tr>
<td>7</td>
<td>25</td>
<td>25.57</td>
<td>3.16</td>
<td>88</td>
<td>24.02</td>
<td>2.96</td>
<td>2.27*</td>
</tr>
<tr>
<td>8</td>
<td>26</td>
<td>23.25</td>
<td>3.19</td>
<td>65</td>
<td>21.93</td>
<td>2.10</td>
<td>2.33*</td>
</tr>
<tr>
<td>9</td>
<td>8</td>
<td>21.95</td>
<td>3.86</td>
<td>68</td>
<td>20.47</td>
<td>2.07</td>
<td>1.07*</td>
</tr>
<tr>
<td>10</td>
<td>16</td>
<td>20.92</td>
<td>2.47</td>
<td>57</td>
<td>19.74</td>
<td>2.11</td>
<td>1.90</td>
</tr>
</tbody>
</table>

* Equal variance was not assumed, **p < .05, ***p < .01, ****p < .001.

Effects of Verbal Only Versus Verbal and Demonstration on Dexterity Speed

For the dominant hand, the group of school children that received only verbal directions did have significantly slower dexterity speed when compared to that of the norming group that received both verbal and motoric demonstration. This was not the case for the nondominant hand. However, although statistically nonsignificant, the mean
scores for the nondominant hand indicated that the students who received motoric
demonstration were faster. Means, standard deviations, and t-test results are shown in
Table 11.

Table 11
Means, Standard Deviations, and t-Values for Verbal Only Instructions Versus Norming
Group

<table>
<thead>
<tr>
<th>Dominant Hand</th>
<th>Norming Group</th>
<th>Verbal Only Instruction Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>76</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nondominant Hand</th>
<th>Norming Group</th>
<th>Verbal Only Instruction Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>76</td>
</tr>
</tbody>
</table>

*p < .05. ** p < .005.

Clinical Observations

Observations were made for comparing behavioral differences between the younger
children (ages five through seven) and the older children (eight through ten). These
included the following: The younger children required more verbal cues to execute the
task; required more tactile prompts to prevent the hand not being tested from becoming
involved; evidenced a brief delay between changing the motoric action of placing the pegs
and then removing them; displayed more inconsistencies in the various grasps, in-hand
manipulation, and peg placement styles; and produced more extraneous body movements with increased arm joint movement and/or side-to-side rocking motion with each peg.

Three eye-head movement patterns were noted in the majority of students: The head and eyes moved as a unit from the container side to the hole side of board with the hand; the head remained in a stable position while the eye darted from side to side with the hand producing an isolated eye-hand pattern; and the head was positioned toward the hole side of the board and the eyes stayed directed there, while the hand reached out to pick up the peg in the peripheral field of vision. The older children exhibited this latter adaptation more frequently.

Body mechanics, posture, and grasp patterns of the dominant upper extremity of a typical nine-year-old female were analyzed for comparison to younger children as indicated above. She produced a clinical picture of goniometric readings that approximate the following: upright sitting posture with joint stabilization maintained at 30 degrees of scapular elevation, 25 degrees shoulder flexion and abduction, 90-100 degrees of elbow flexion and 60 degrees of forearm pronation. Mobilization is achieved with 30-45 degrees shoulder internal rotation, 30 degrees of wrist flexion to 10 degrees extension, and 45 degrees finger flexion. The student typically picked up the peg utilizing a palmar prehension grip. Simple rotation and shift as described by Exner (1993) occurred between the thumb and the index finger when the peg was rolled, then the middle finger was used to push it into a vertical position.

As supported in a study by Pehoski et al. (1997a), students used a combination of two different methods to stabilize the peg. They used another surface such as the table, their chest, or their nontesting hand. Some students did not hold onto the end of the
pegboard with their non-testing hand but rather positioned it in their laps or beside the board. The precise sequencing pattern of a few of the students, such as when they made an "X" or square pattern with the pegs, was believed to be a hindrance to their speed.
CHAPTER 5

DISCUSSION

This study utilized the Nine-Hole Peg Test to provide norms on fine motor dexterity for the first time for children of ages five through ten. The need exists for dexterity tests that have standardized procedures for administration. Therapists, heretofore, have interpreted this test for children based on their subjective judgement instead of normative data; however, this study provides data that support this tool as an objective measure.

A shortcoming in both the Kellor et al. (1971) and the Mathiowetz et al. (1985) studies is that neither discussed the interpretation of the findings using this instrument. Therapists have historically referred to clinical norms that have been presented by both groups of authors in a table format of the 10th, 25th, 50th, 75th, and 90th percentile. The therapist would then compare their client's scores with the norming population of the same sex and age. The Mathiowetz et al. (1985) study further provided means and standard deviation values. However, neither a percentile ranking nor a standard deviation level has been suggested as a cutoff score to indicate when the client's score represent a significant level of delay that should cause clinical concern.

Mathiowetz and Haugen (1995) discussed the use of a conventional method to interpret a score using a normative table of means and standard deviations as well as a percentile table such as Table 2 and Table 3, respectively. In this conventional method,
after administering the test according to the standard procedures, the dominant hand score would be compared with the dominant hand normative score appropriate to the age and sex of the child. A student’s standard deviation score could be calculated by a formula: 

\[
\text{Student's score minus norm mean score divided by the norm standard deviation equals student’s standard deviation.}
\]

In a standard normal distribution table, 95.4% of the sample scores are between the 2 standard deviations below and above the mean, which is usually interpreted as within normal limits. Standard deviations between 2 and 3 points below the mean comprise 2.2% of the sample scores and is interpreted to be a mild deficit. However, .1% comprises the children whose scores are lower than 3 SD below the mean and interpreted to be a moderate to severe deficit. Similarly, using the conventional method, scores compared to normative data from a percentile table (such as Tables 3-6) can be interpreted (a score below 0.1 is interpreted to be a moderate to severe deficit).

However, the underlying assumption of using this conventional method is that dexterity scores, from which the normative table was drawn, are normally distributed. In this study, as well as in the Mathiowetz et al. (1985), the NHPT scores were positively skewed, thus causing a higher mean value than would have been computed with a normally distributed scores. This was due to the few subjects with extremely slow scores.

For the purpose of identification of those with delayed fine motor dexterity, these subjects are the specific ones the test should identify. However if the standard deviation method were utilized, some of the subjects with extreme scores would be less likely identified.

Hence, it is recommended that the assumption of a normal curve be dismissed in favor of the actual data that show the positive skewness. Although Mathiowetz et al.'s (1985) study also indicated the positive skewness of the NHPT dexterity scores in adults,
the current study is the first and only large-scale normative study with children. Thus, more NHPT studies with children are necessary to determine the consistency in the distributional findings and to recommend the criteria for the proper interpretation of the scores. In the mean time, the conventional percentile rank interpretation would be used along with close examination of the students who fall in the mild to severe deficit range.

As predicted, as school-age children got older, their fine motor dexterity speed became faster. The positive correlation between age and dexterity speed provides the construct validity of the developmental nature of fine motor skills and establishes the relationship of the test to the theories of motor development. The finding on the age difference in dexterity speed replicates the previous research (Folio & Fewell, 1983; Bruininks, 1978; Humphrey et al., 1995; Pehoski et al., 1997a; and Pehoski et al, 1997b).

A significant gender difference in dexterity was demonstrated with females typically outpacing their male counterparts except when the eight-year-old males were faster with their nondominant hands and the ten-year-old males were faster with their dominant hands. The reason for these exceptions is unknown. The finding on the gender difference replicates most of the previous findings noted in the literature review section.

Extremely high interrater reliability and high test-retest reliability were estimated in this study. Similar findings were also indicated in the Mathiowetz et al. study (1985) with adults for interrater reliability. However, substantially higher test-retest reliability was found in this study with children. These test-retest correlation coefficients compare favorably with those of other commercial hand function tests, some of which were previously referenced.
It is desirable that such a high interrater reliability estimate was obtained between the occupational therapist and a teacher. This implies that those school personnel, less familiar with the test than the occupational therapist, could properly administer this instrument with minimal training. It should be noted that observers generally had greater agreement when they were aware that they were being observed or when their observations were being assessed (Kazdin, 1977). All three examiners in this study were aware that they were participating in a research study.

Performance on the Nine-Hole Peg Test was moderately correlated with that of the Purdue Pegboard Test. This finding provides concurrent validation of the NHPT for its use with children of age five to ten. This study’s correlation with children is even stronger than Mathiowetz et al.'s study (1985) with adults.

The examiner made a few relevant observations when contrasting the Purdue test to the NHPT. The directions for the NHPT were simpler, while the Purdue’s was wordier and less age appropriate for children. The NHPT is task oriented, in that there is a stated goal with a discernible completion, whereas the Purdue test is time oriented without a sense of task completion. The NHPT is more portable in that it is smaller and lighter weight than the Purdue Pegboard. The Purdue’s administration time was approximately the same as the NHPT when using only the right and left hand tests of the Purdue.

The comparison between special education and regular education students further supported construct validity. There was a significant difference between the dexterity scores of the dominant and nondominant hand of the 9-year-old special education students and randomly selected regular education students involved in the norming study of the same age. This evidence of construct validity with children has been supported by other
studies (e.g., Wilson, Pollack, Kaplan, Law, & Faris, 1992; Gardner & Broman, 1979; and Kane & Gill, 1972). In future studies, other age groups should be tested to determine if the same trend continues. Another area of interest would be to examine more closely, the categories of students that comprise the special education classification (e.g., children with learning disability or physically impaired children) to determine if differential trends of fine motor delay would emerge.

A number of factors need to be considered in performing the test with special education students. An influencing factor in time difference may have been that these special education children required more time to mentally process the task and therefore the time scores may have represented delays in mental processing rather than the efficiency in motor execution (Case-Smith, 1993). The examiner in this study promoted the students’ continual efforts by cueing the child to pick up one peg after another. These children needed more verbal cues than those in the norming group.

There was a significant difference in dexterity speed between rural and urban students in Nevada with urban students being faster than their rural counterparts in most age groups. Since data was not collected on socioeconomic status or ethnic background, and since there was only a small sample size involved in this study, no valid conclusions can be drawn from the current findings. Future research might incorporate these variables, as they may have possibly contributed to the rural/urban differences noted in this study.

There was a significant difference in the mean dexterity scores between the children who received only verbal directions when compared to those in the norming group who received both verbal and motoric demonstration; however, this was only for the dominant hand. Students in the norming study received kinesthetic and visual cues during the practice
trial as well as additional verbal cues if incorrectly performed. It is believed that these factors may have increased the speed on the timed test.

Providing demonstration ensured that students understood the task expectation and allowed the rater to observe the motor skill rather than the processing of an out-of-context request (Gebbard, Ottenbacher, & Lane, 1994). Observations of those students that received verbal only instructions included: the tendency to pick up more than one peg at a time; the need for increased verbal prompts to transition between placement of the pegs in and out of the board; and a higher number of retesting on the practice trial. Although the nondominant hand did not display any significant difference, it is possible that if that hand had been tested first, then it may have shown a difference. Studies with the nondominant hand tested first are warranted.

Interesting clinical observations were made in regard to the children’s methodology of task performance during testing on the NHPT. The most striking variations were in relationship to age differences, with the younger students being more awkward in their movement patterns than were the older students were. It is the investigator’s opinion that the motor task was performed in appropriate conditions and that the students produced maximal effort. All the students in this study were able to understand and to execute the task.

Similarities and differences between the current study and the pilot study by Widner and Presson (1998) are worth noting. The normative data of this current study, in general, indicated faster speeds than those of the pilot study. These differences could be due to the aforementioned modifications in the instrument made after the pilot study. Age differences were found in both studies; however gender differences were found only in this

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study. Interrater and test-retest reliability estimates were substantially higher in this study. The pilot study was beneficial in that it strengthened the standardized procedure for this study and provided impetus for the improvement of the instrument.

At the conclusion of this study, the examiners discussed the usability of the physical instrument. The convenience of a single apparatus that includes the peg container, 10 pegs, pegboard, stopwatch, spare battery, written test directions, and a removable cover is desirable. Suggestions to further improve the instrument for this type of use are currently being made to the manufacturer.

The major strength of this study is that it is the first known study of its kind to collect descriptive data on dexterity of children using the Nine-Hole Peg Test. The data from this normative research will provide occupational therapists and other professionals with a baseline of comparison for screening, evaluating, and treating elementary school-aged children. Another major strength of the study is the use of standardized instructions that will ensure consistency and provide a protocol for clinical use in testing children.

Normative data assists in the interpretation of evaluation results and in setting realistic goals (Mathiowetz et al., 1986b). The normative data reported in the study will provide pediatric therapist and school personnel a means for comparing the scores of referred special education students to regular education students of the same age and sex. Such identification could lead to intervention that could positively impact the child’s performance in a variety of functional tasks that require dexterity (Exner, 1997).

Since this was the first study with school-aged children and the NHPT, the need exists for additional studies of this type to determine further age and gender differences in dexterity speed. Future investigations with the NHPT should collect data on a broader
population of children with emphasis on a wider age range. In the Kellor (1971) and Mathiowetz (1985) studies, a linear decline from age 20 to 84 was displayed with an increase in age. As presented in this study, a linear increase is shown from age five to ten. Therefore, it is predicted that a curvilinear relationship of dexterity speed would be demonstrated with the ages from 10 through 20. It is recommended that future research include these age ranges in addition to the younger ages for further validations.

The NHPT is commercially available, cost effective (less than $50.00), easy and quick to administer (less than 5 minutes), and portable, and requires minimal space to administer. It is norm referenced with simple testing procedures and an objective scoring system. The reliability and validity estimates are strong and clearly indicate that the NHPT is a valid instrument that has shown to be developmentally appropriate. It is proposed that it could be used as a screening tool for school-aged children, since it has demonstrated the properties of an appropriate dexterity measurement tool.
APPENDIX A:

Human Subject Protocol Memorandum
DATE: October 2, 1997

TO: Yvonne Widner (EDP)
M/S: 3003

FROM: Dr. Fred Preston
Chairman, Social-Behavioral Committee of the Institutional Review Board

RE: Status of Human Subject Protocol entitled: "Validation of Nine Hole Peg Test as a Screening Tool for Fine Motor Performance of School-Age Children"

OSP #301s0997-080

This memorandum is official notification that the protocol for the project referenced above has been approved by the Social/Behavioral Sciences Committee of the Institutional Review Board. This approval is approved for a period of one year from the date of this notification, and work on the project may proceed after submittal to and approval by the Clark County School District (CCSD). Enclosed is the necessary paperwork for that procedure. Please contact Dr. Judy Costa at 799-5403 for any questions regarding their process. A copy of this memorandum must be submitted with the application to CCSD.

Should the use of human subjects described in this protocol continue beyond a year from the date of this notification, it will be necessary to request an extension.

If you have any questions or require any assistance, please contact Marsha Green, IRB Secretary, at 895-1357.

cc: E. Hong (EDP-3003)
OSP File
DATE: October 2, 1998

TO: Yvonne Widner (EDP)
    M/S 3003

FROM: Dr. William E. Schulze, Director
       Office of Sponsored Programs (X1357)

RE: Status of Human Subject Protocol Entitled:
    "Validation of Nine Hole Peg Test"

1st Year OSP #301s0997-080
2nd Year OSP #301s1098-093s

Your request for extension of a period of one year for the
subject protocol has been received and processed in our
office. This protocol is approved for a renewal period of one
year from the date of this notification and work on the
project may continue.

Should the use of human subjects described in this protocol
continue beyond a year from the date of this notification, it
will be necessary to request an additional extension. You
will be contacted at the end of this period for status of the
project.

If you have any questions regarding this approval, please
contact Marsha Green in the Office of Sponsored Programs at
895-1357 or FDH 302.

cc: E. Hong (EDP-3003)
    OSP File
APPENDIX B:

Clark County School District Inter-Office Memorandum
TO: Elementary School Principals

FROM: Judy Costa, Chairman
Committee to Review Cooperative
Research Requests

SUBJECT: Yvonne Widner’s Cooperative Research Project

Yvonne Widner’s research project—establishment of age norms for fine motor skills of 5- to 10-year-olds—has been reviewed and approved by the Clark County School District’s Committee to Review Cooperative Research Requests.

Thank you for your consideration of her request to involve your school in the project.

JSC:sc
cc: P. Kay Carl
    Area Superintendents
APPENDIX C:

Letter to the Principals
March 24, 1998

School Principal
J.G. Elementary School
Nye County School District

Dear Mr. Eason:

I am seeking your assistance in a thesis research project for my master's degree. The school district has given the approval for the involvement of Nye County students in this project. I am requesting permission to include your students in a fine motor dexterity study to determine the average speed of children from 5 to 10 years of age.

Students will be tested on a one-to-one basis and the test will take approximately 5 minutes on two separate occasions. It is anticipated the students will be pulled out of the classroom, however this will not be during instructional time in reading, math, language, or science. I hope to discuss detailed procedures with you in the near future. I would like to start data collection by late March or early April.

I look forward to meeting and working with you on this project. If there are any questions, please call me at (702) 363-2021. Thank you for your assistance.

Sincerely,

Yvonne Widner
Eunsook Hong, Faculty Advisor
Associate Professor, UNLV

Enc. Parental Consent Forms
APPENDIX D:

Letter to the Teachers
Classroom Teachers
Herbert Derfelt Elementary School
Clark County School District

Dear Classroom Teachers:

I am seeking your assistance in a thesis research project for my master’s degree. The school district has given the approval for the involvement of the students in your school in a fine motor dexterity study to determine the average speed of children from 5 to 10 years of age. I would like to start data collection by late March or early April.

I would greatly appreciate your giving the parental consent form to each of your students, encouraging them to bring the form back, and collecting them upon return. Students will be tested on a one-to-one basis and the test will take approximately 5 minutes on two separate occasions. Detailed procedures will be discussed with you after consulting with your principal. It is anticipated your students will be pulled out of the classroom however this will not be during instructional time in reading, math, language, or science.

I look forward to meeting with you prior to testing the students. If there are any questions, please call me at (702) 363-2021. Thank you for your assistance.

Sincerely,

Yvonne Widner

Eunsook Hong, Faculty Advisor
Associate Professor, UNLV

Enc. Parental Consent Forms
Appendix E:

Parental Informed Consent (English and Spanish)
Parental Informed Consent

I am Yvonne Widner, an Occupational Therapist with 14 years of experience. I am also a graduate student in Educational Psychology at UNLV. I am asking your permission to involve your child in a study, which is part of a thesis research project for completing my Masters degree.

The purpose of the study is to find the average fine motor speed of children from 5 to 10 years of age. Once determined, the information and the testing instrument could be used as a quick screening measure for other children to identify fine motor developmental delay.

Your child will be seated at a table and given verbal directions and demonstration on performing the Nine-Hole Peg Test. Then your child will perform the task while being timed using each hand. This process is anticipated to require less than 5 minutes on two separate occasions.

There is no potential physical risk involved with this procedure and your child will be directly supervised. Your child's identification will remain anonymous so his or her confidentiality will be maintained. Participation is voluntary and your child may withdraw from participation at any time. Although there is no direct compensation for involvement in this study, students who participate will be contributing to the development of a fine motor screening tool for other elementary age children.

If you have further questions about the study, please feel free to contact me at (702) 259-6336 or the Office of Sponsored Programs at UNLV (702) 895-1357.

___Yes, my child can participate in the Fine Motor Screening Study.
Child’s Name_________________________ Age_____ Date of Birth_________ Grade_____
Parent Signature_________________________ Date____________________

___No, I do not consent for my child to participate.
Child’s Name______________________________
Parent Signature_____________________________ Date____________________

Please sign this form and send it with your child back to school. Thank you.
Permiso de Pariente

Yo soy Yvonne Widner, ana Terapista Ocupacional con 14 anos de experiencia. Tambien soy una estudiante graduada en Psicologia Educacional de UNLV. Estoy solicitando su permiso para envolver a su hijo/hija en un estudio que sera parte de un projecto de investigacion de mi tesis para graduarme con mi maesterio.

El proposito de este estudio es para encontrar el promedio de la velocidad de los musculos finos (uso de los musculos de la mano) de ninos de 5 a 10 anos de edad. Ya que la velocidad este determinada, la informacion y la evaluacion puede usarse como medida para identificar algun retraso de desarollo para ostros.

Su hijo sera sentado y le daremos instrucciones y una demonstracion en como usar el Examen de Espiga (Nine Hole Peg Test). Su hijo hara la tarea y a la misma vez ver cuanto tiempo le coje. Este proceso requiere menos de 5 minutos.

No habra nada fisico con este proceso y su hijo estara supervisado directamente.

La identificacion de su hijo se mantendra' confidencialmente. La participación es voluntario y su hijo podra apartarse en cualquier tiempo. Aunque no habra recompensa por participar en este estudio, los que participaran estaran ayudando con el estudio de ninos de escuela elemental.

Si Ud. tiene alguna pregunta de este estudio, favor sentirce libre en llamarme al (702) 259-6336 o la oficina de UNLV (702) 895-1357.

___ Si, mi hijo/hija puede participar en el Estudio de los Musculos Finos.
Nombre del Nino ____________________ Edad ____ Fecha de Nacimietno ____
Grado
Firma del Padre __________________________ Fecha ______________________

___ No, Yo no le doy permiso a mi hijo/hija participar.
Nombre del Nino ____________________ Edad ____ Fecha de Nacimietno ____ Grado
Firma del Padre __________________________ Fecha ______________________

Favor firmar esta hoya y devolverla con su hijo/a a la escuela. Gracias.
APPENDIX F:

Student Agreement to participate
I have been told about the pegboard test to see how fast my hands work. I know I will be timed on how long it takes me to put nine pegs in the holes and then remove them on two occasions. I was told that I will not be harmed and that I can stop the activity at any time. I am aware I will not receive any money or extra credit for doing this but I will be told how fast I did the activity if I ask for that information. My parent has given me permission to participate.

___ Yes, I agree to participate.
Child’s signature ___________________________________________ Date __________

___ No, I do not want to participate.
Child’s signature ___________________________________________ Date __________
REFERENCES


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VITA

Graduate College
University of Nevada, Las Vegas

Yvonne Smith Widner

Local Address:
9324 Provence Garden
Las Vegas, Nevada 89128

Degrees:
Bachelor of Science, Occupational Therapy, 1984
East Carolina University, Greenville, North Carolina

Thesis Title: Normative, Validation, and Reliability Studies of the Nine-Hole Peg Test Scores with Children

Thesis Examination Committee:
Chairperson, Dr. Eunsook Hong, Ph.D.
Committee Member, Dr. Kevin Crehan, Ph. D.
Committee Member, Dr. Peggy Perkins, Ph. D.
Graduate Faculty Representative, Dr. Joe Crank, Ph. D.
IMAGE EVALUATION
TEST TARGET (QA-3)

1.0
1.1
1.25
1.4
1.6

150mm
6"

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