Grooved Pegboard Test

User's Manual

Lafayette Instrument

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Purpose

The Grooved Pegboard task measures eye-hand coordination and motor speed.

Administration Instructions

The apparatus is placed with the peg tray oriented above the pegboard. The person is instructed to insert the pegs, matching the groove of the peg with the groove of the hole, filling the rows in a given direction as quickly as possible, without skipping any slots. Using the right hand, the patient is asked to work from left to right, and with the left hand, in the opposite direction. The dominant hand is tested first. The patient is warned that only one peg should be picked up at a time and that only one hand is to be used. If a peg is dropped, the examiner does not retrieve it; rather, one of the pegs correctly placed (usually, the first or second peg) is taken out and used again.

The examiner demonstrates one row before allowing the patient to begin. A practice trial is not given, and a trial may be discontinued after 5 min. In the HRNES (Russell and Starkey, 1993) version, the person continues until all pegs have been placed or until a time limit of 3 min has been reached. In both versions, the examiner begins timing after cueing the individual to begin.

Administration Time

The time required is 5 minutes.

Scoring

The score is computed for each hand separately and is the time required to place the pegs. Some researchers also record the number of pegs not placed and the number of pegs dropped; these errors may be considered clinically and are rarely seen in neurologically normal individuals (Heaton et al., 2004).

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Demographic Effect

When each hand is considered separately, several trends emerge.

Age

Age has a strong impact on test scores, with performance improving (faster times) in childhood (Rosselli et al., 2001; Solan, 1987) and declining with advancing age (e.g., Bornstein, 1985; Concha et al., 1995; Mitrushina et al., 2005; Ruff & Parker, 1993; Selnes et al., 1991). According to Heaton et al. (2004), about 30 degrees to 31 degrees of the variance in test scores is accounted for by age.

Gender

Some have found significant gender differences in performance, with women outperforming men (Bornstein, 1985; Ruff & Parker, 1993; Schmidt et al., 2000), perhaps reflecting differences in finger size (Peters et al., 1990). However, others have noted that gender has little effect on test scores (Concha et al., 1995; Heaton et al., 2004; Mitrushina et al., 2005), accounting for less than 1% of the variance in test scores (Heaton et al., 2004). No gender effect has been found in children (Rosselli et al., 2001).

Hand Preference

Performance is faster with the dominant/preferred hand (Bryden et al., 1998; Heaton et al., 2004). Handedness (right, left) does not affect test scores (Ruff & Parker, 1993).

Education/IQ

Some have reported that better educated individuals perform faster (Ruff St Parker, 1993). However, others have found that education has little or only a small effect (Bernstein, 1985; Concha et al., 1995; Mitrushina et al., 2005; Selnes et al.,1991), accounting for about 3% to 6% of the variance test scores (Heaton et al., 2004).

Ethnicity

The impact of ethnicity has not been reported.

Intermanual Differences

Neither age, education, nor hand preference is related to intermanual differences scores on the Grooved Pegboard (Bornstein, 1986c; Ruff & Parker, 1993; Thompson et al., 1987); however, intermanual differences tend to be larger for females than for males (Rosselli et al., 2001; Thompson et al., 1987; but see Bornstein, 1986c).

Normative Data

Adults

Heaton et al. (2004) have developed normative data based on a large sample of Caucasians and African Americans (see Table 14-15), They provide norms separately for these two ethnicity groups, organized by age, gender and education.

The data set covers a wide range in terms of age (20-85 years) and education (0-20 years), and exclusion criteria are specified. T scores lower than 40 are classed as impaired. According to Heaton et al. (2004). Unfortunately, the method for determining hand preference was not described. Mitrushina et al. (2005) provide meta-norms, based on six studies and representing 2382 participants, aged 20 to 64 years. They noted that the integrity or the results is undermined by the lack of consistency in reporting of hand preference. Table 14-16 provides data (Ruff and Parker, 1993) based on a sample of 357 individuals aged 16 to 70 years, ranging in education from 7 to 22 years. Participants were screened to exclude those with a positive history of psychiatric hospitalization, chronic polydrug abuse, or neurological disorders. Hand preference was evaluated using a lateral dominance examination. The data agree reasonably well with those provided by Mitrushina et al. (2005).

Children/Adolescents

Older normative data sets are available for children (Knights, 1970; Knights & Moule, 1968; Trites, 1977). However, use of these norms is not recommended, because they are quite dated and cell sizes are quite small. Recently, Rosselli et al. (2001) used the 25-hole pegboard and provided data (see Table 14-17) on a sample of 290 Spanish-speaking children (141 boys, 149 girls), aged 6 to 11 years, in Bogota, Colombia. None of the subjects was mentally retarded. Based on the Waterloo Handedness questionnaire, 268 children were right-handed, and 22 were left-handed. Rosselli et al. (2001) noted that the older the group, the smaller the difference in performance between hands.

The performance of older children was similar to that of adults aged 40 to 59 years (e.g., Bernstein, 1985; Ruff & Parker, 1993), suggesting that additional gains are made during adelescence. In line with this proposal, are the findings by Paniak (personal communication, April 10, 2004) for a sample of 358 adolescents living in a large western Canadian city (see Table 14-18). The exclusion criteria for this sample included failure of one or more grades, enrollment in an English as a Second Language program, a history of hospitalization for brain injury or behavioral problems, or participation in a self-contained special education program. The sample was largely right-handed and had a WISC-III Vocabulary scaled score of about 10 (SD=3).

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Table 14-15
Characteristics of the Grooved Pegboard Normative Sample provided by Heaton et al. (2004)

Number	1482
Age (years)	20-85[a]
Geographic location	Various States in the United States and Manitoba, Canada
Sample Type	Individuals recruited as part of multicenter studies
Education (years)	0-20[b]
Gender (%)	
Male	60.1
Female	39.9
Race/Ethnicity	
Caucasian	839
African American	643
Screening	No reported history of learning disability, neurological disorder, serious psychiatric disorder, or alcohol or drug abuse

[a] Age groups: 20-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74, 75-79, and 80-89 years

[b] Education groups: 7-8, 9-11, 12, 13-15, 16-17, and 18-20 years

Table 14-16
Mean Performance of Adults for Grooved Pegboard, by Education, Age, and Gender

	Less than or Equal To Grade 12			Greater than Grade 12		
Age Group (Years)	N	M	SD	N	M	SD
Females, Preferred hand						
16-39	30	62.8	8.9	60	57.8	6.2
40-54	14	63.1	4.4	30	63.3	7.4
55-70	15	78.6	11.7	29	75.3	11.3
Females, Nonpreferred hand						
16-39	29	66.8	10.7	60	65.2	10.3
40-54	15	69.6	6.5	30	70.8	8.9
55-70	13	84.3	15.3	29	82.0	12.5
Males, Preferred hand						
16-39	29	67.8	9.2	60	64.7	10.9
40-54	15	71.9	15.1	30	70.4	10.9
55-70	15	83.7	10.2	30	74.1	13.0
Males, Nonpreferred hand						
16-39	29	74.5	10.9	59	67.8	10.8
40-54	15	79.1	14.9	30	73.7	9.9
55-70	15	91.0	12.7	28	83.5	13.4

Note: Based on a sample of 357 healthy participants

Source: From Ruff & Parker 1993 © Perceptual and Motor Skills 1993. Reprinted with Permission.

Table 14-17
Grooved Pegboard (Time in Seconds) Normative Data for Spanish-Speaking Boys and Girls Aged 6-11 Years (25-Hole Pegboard), by Age

	6-7 years (n=83)	8-9 years (n=121)	10-11 years (n=86)
Preferred Hand	92.46 (17.80)	81.96 (13.79)	69.47 (10.47)
Nonpreferred Hand	104.00 (21.44)	93.58 (17.67)	76.41 (12.22)

Source: Adapted from Rosselli et al., 2001.

Table 14-18
Mean Performance (Seconds) on Grooved Pegboard in Adolescents

	Males			Females		
Age (Years)	**N**	**Right Hand**	**Left Hand**	**N**	**Right Hand**	**Left Hand**
12	38	64.61 (10.8)	70.03 (10.85)	56	66.05 (8.64)	71.61 (9.37)
13	39	61.82 (6.74)	67.33 (10.85)	57	62.93 (6.27)	70.60 (9.57)
14	46	64.00 (10.54)	70.09 (10.88)	70	62.43 (9.12)	67.30 (10.06)
15	29	62.21 (7.04)	63.34 (8.95)	23	64.78 (9.52)	67.48 (10.72)

Note: Based on a sample of 358 healthy adolescents in a large Western Canadian city.
Source: C. Paniak, H. Miller & D. Murphy (personal communication, April 10, 2004).

Table 14-19
Grooved Pegboard Test-Retest Effects in 121 Normal Individuals Assessed After Intervals of 2 to 16 Months

	Time 1		Time 2		T2-T1		T1,T2
	(1)		(2)		(3)	(4)	
Measure	Mean	*SD*	Mean	*SD*	*M*	*SD*	r
Dominant	69.66	19.27	68.68	21.04	-.98	10.03	.86
Nondominant	75.80	21.56	73.70	19.69	-2.09	11.11	.86

Note: Based on a sample of 121 normal individuals (mean age=43.6, SD=19.6; mean education=12.0, SD=3.3) after retest intervals of about 2-16 months (mean=5.4, SD=2.5) One first subtracts the mean T2-T1 change (column 3) from the difference between the two testings for the individual and then compares it to 1.64 times the standard deviation of the difference (column 4). The 1.64 comes from the normal distribution and is exceeded in the positive or negative direction on 10% of the time if indeed there is no real change in clinical condition.

Source: Adapted from Kikmen et al., 1999.

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Table 14-20
Grooved Pegboard Test-Retest Effects in 605 Healthy Males Assessed After Intervals of 2 to 24 Months

	Time 1		Time 2		T2-T1		T1,T2
	(1)		(2)		(3)	(4)	
Measure	Mean	*SD*	Mean	*SD*	*M*	*SD*	r
Dominant	64.2	8.94	61.7	8.16	-2.50	7.01	.67
Nondominant	69.1	10.39	66.5	9.55	-2.61	7.37	.73

Note: Based on a sample of 605 healthy males, mostly Caucasian (mean age=39.5, SD=8.5; mean education=16.4, SD=2.3) after retest intervals of about 2-24 months (mean=218 days, SD=95).

Source: Adapted from Levine et al., 2004.

Table 14-21
Regression Equasions for Estimating Restest Scores

Measure	Regression Equasion	Regression *SD*
Dominant	22.57 + (.609 x Time 1 score)	6.08
Nondominant	20.15 + (.671 x Time 1 score)	6.53

Note: Based on a sample of 605 healthy males, mostly Caucasian (mean age=39.5, SD=8.5; mean education=16.4, SD=2.3) after retest intervals of about 2-24 months (mean=218 days, SD=95).

Source: Adapted from Levine et al., 2004.

Reliability

Test-Retest Reliability ond Practice Effects

With retest intervals of about 4 to 24 months, reliability coefficients are marginal/high (.67 to .86) in normal individuals (aged 15 years and older; Dikmen et al., 1999; Levine et al.,2004; Ruff & Parker, 1993). No information is available for children. When repeated trials are given within a session, performance improves particularly after the first trial (Schmidt et al., 2000). With two or more sessions (e.g., assessments 1 and 2 occurring within 1 week of each other, assessments 3 and 4 about 3 and 6 months later), performance improves steadily (McCaffrey et al., 1993; but see Bornstein et al.,1987).

Detecting Change

When individuals are retested after intervals of about 2 to 24 months, practice effects are evident (Dikrnen et al., 1999; Levine et al., 2004; Ruff & Parker, 1993). Dikmen et al. (1999) examined a sample of 121 normal adults (age M=43.6,SD=19.6; education M=12.0, SD=3.3) after retest intervals of about 2 to 16 months (M=5.4, SD=2.5). Table 14-19 provides information to assess change, taking practice effects into account (RCI-PE). Using values in Table 14-19, one first subtracts the mean T2 — T1 change (column 3) from the difference between the two testings for the individual and then compares the result with 1.64 times the standard deviation of the difference (column 4). The 1.64 comes from the normal distribution and is exceeded in the positive or negative direction only 10% of the time if indeed there is no real change in clinical condition. Drawing from a database of 605 well-educated men (education M=16.4, SD=2.3), mostly Caucasian males (age M=39.5, SD=8.7), Levine and colleagues (2004) used both RCI-PE and simple linear regression approaches to derive estimates of change. The retest interval ranged from 4 to 24 months (M=218 days, SD=95). The length of retest interval did not contribute significantly to the regression equation. Table 14-20 shows the means, standard deviations of the change scores, and test-retest correlations for use in RCI equations. Table 14-21 shows the regression formulas used to estimate time 2 scores. The residual standard deviations for the regression formulas are also shown and can be used to establish the normal range for retest scores. For example, a 90% confidence interval can be created around the scores by multiplying the residual standard deviation by 1.645, which allows for 5% of people to fall outside of both the upper and lower extremes. Individuals whose scores exceed the extremes are considered to have significant changes.

Validity

Relationships With Other Measures

Pegboard time (dominant hand) shows a modest relation with tapping speed (—.35; Schear & Sato, 1989), and factor analytic findings indicate that the two tasks load differently (Baser & Ruff, 1987). Examination of relations among manual performance tasks in healthy individuals suggests that finger tapping and pegboard tasks are more closely related to one another than to grip strength (Corey et al., 2001).

In addition to requiring motor execution, the pegboard task also requires adequate vision. Schear and Sato (1989) found a moderately strong correlation (—.62) between nearvisual acuity and dominant-hand pegboard time.

Moderate/high associations have also been reported with measures of attention (e.g., reaction time r= .31; TMT-Br=.46; Schear & Sato, 1989; Strenge et al. 2002), perceptual speed (Digit Symbol r= —.60; Schear & Sato, 1989) and nonverbal reasoning (Block Design r= -34; Object Assembly r= —.45; Schear & Sato, 1989; see also Haaland & Delaney, 1981).

There is little relation between pegboard scores (preferred hand) and grades in academic subjects (Rosselli et al., 2001), although Solan (1987) noted a moderate relation (r=~.41) with WRAT arithmetic.

Clinical Findings

There is evidence that pegboard-placing speed is reduced in a number of conditions, including stroke (Haaland & Delaney,1981), tumor (Haaland & Delaney, 1981), autism (Hardan et al.,2003), nonverbal learning disabilities (Harnadek & Rourke,1994), Williams syndrome

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(MacDonald & Roy, 1988), bipolar disorder (Wilder-Willis et al., 2001), end-stage heart disease (Putzke et al., 2000), toxic exposure (Bleecker et al., 1997; Mathiesen et al., 1999), substance abuse (withdrawn cocaine users; Smelson et al., 1999), and HIV-1 infection (Carey et al.,2004; Hestad et al., 1993). Various drug treatments (carbamazepine, phenytoin) also impair performance (Meadoret al., 1991).

The test is also a sensitive, but not totally accurate, indicator of lateralized disturbances (Bornstein, 1986a; Haaland & Delaney, 1981).

Left cerebral lesions tend to attenuate the more typical pattern of manual asymmetry; right lesions move the discrepancies in the opposite direction. However, ipsilateral impairment is also seen—perhaps a reflection of the significant sequencing, visual-spatial, and monitoring requirements of the tasks (Haaland & Delaney, 1981). Lewis & Kupke (1992) also suggested that difficulty adapting to a novel task, especially with the nonpreferred hand, may affect performance. Typically, performances of the preferred and nonpreferred hands are compared on motor tasks to determine whether there is consistent evidence of poor performance with one hand relative to the other. In general, performance with the preferred hand is superior (by about 10%) to that with the nonpreferred hand (Mitrushina et al., 2005; Thompson et al.,1987). However, there is considerable variability in the normal population, and the preferred hand is not necessarily the faster one (Bornstein, 1986c; Corey et al., 2001), especially when left-handed people are considered (Corey et al., 2001; Thompson et al., 1987). Patterns indicating equal or better performance with the nonpreferred hand occur with considerable regularity in the normal population (about 25%), and neurological involvement should not be inferred from an isolated lack of concordance. Fairly large discrepancies between the hands on the Grooved Pegboard Test alone also cannot be used to suggest unilateral impairment, because discrepancies of large magnitude are not uncommon (about 20%) in the normal population (Bornstein, 1986a, 1986c; Thompson et al., 1987). In addition, intermanual discrepancies (even of large magnitude) are not perfect predictors of the side of lesion (Bornstein, 1986a). Greater confidence in the clinical judgment of impaired motor function with one or the other hand can be gained from consideration of the consistency of intermanual discrepancies across several motor tasks, because truly consistent, deviant performances are quite rare in the normal population (Bornstein, 1986a, 1986b; Thompson et al., 1987).

It is important to note that there may be reasons other than neurological impairment for an individual to perform poorly on this task.

Deficits in tactile acuity at the fingertips can also translate into significant difficulties in tasks, such as the Grooved Pegboard, that require fine manipulations (Tremblay et al., 2002), Depression has also been associated with lower performance (Hinkin et al., 1992) as are some medications (e.g., Meador et al., 1991).

Ecological/Predictive Validity

Weak/modest associations have been noted between pegboard scores and daily functioning (complex activities of daily living) in patients with multiple sclerosis (Kessler et al.,1992) and after head injury (Farmer & Eakman, 1995). In those with HIV infection, poor performance may represent an early sign of a dementing process: Defective performance on the Grooved Pegboard was linked with an increased risk of becoming demented over a 30-month foliow-up period (Stern et al., 2001).

Malingering

Individuals simulating head injury tend to suppress their performance on the Grooved Pegboard (Johnson & Lesniak-Karpiak, 1997; Rapport et al., 1998; but see Wong et al., 1998), although warning participants of the possibility of detection (Johnson & Lesniak-Karpiak, 1997) or coaching them on how to avoid detection (Rapport et al., 1998) may improve test scores.

Greiffenstein and colleagues (1996) examined the average performance of the dominant and nondominant hands on tests of motor functioning and reported that compensation-seeking patients with postconcussion syndrome (PCS) demonstrated a nonphysiological profile on grip strength, finger tapping, and Grooved Pegboard (grip strength < finger tapping < grooved pegs). However Rapport et al. (1998) found that the presence of nonphysiological configurations (grip strength < finger tapping < grooved pegs) showed poor predictive accuracy among simulators and controls.

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