BARNSLEY HANDEDNESS: PROFICIENCY VERSUS STATED PREFERENCE

Abstract

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Handedness: Proficiency versus stated preference

Department of Psychology

Master of Arts

Summary

An investigation into the performance factors of developed hand preference was undertaken. Measurements taken from both the preferred and non-preferred hands of 50 males and 50 females yielded scores on 61 dependent variables from 32 tests. Factor analyses of the scores produced nine interpretable factors of hand performance. Each of the nine factors were common to male-female; and preferred—non-preferred performance. However, preferred hand performance was superior on almost all tasks. It was suggested that preferred hand performance is characterized by "Automatization" of the skills involved in hand performance. The results cast serious doubt on the validity of using questionnaires of hand preferences to measure the degree of established handedness.

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HANDEDNESS: PROFICIENCY VERSUS STATED PREFERENCE

by

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Introduction

The impetus for this study lies in the conflicting results of investigations of the relationship between handedness and reading ability. A thorough examination of these discrepant reports suggested that an explanation lay in the procedures used for assessing handedness. It became clear that before a more definitive answer could be given concerning the relationship of handedness to reading ability, the approach to the assessment of handedness would have to be examined more closely. It was to this end that this investigation was directed.

The relationship of handedness to reading ability has been discussed by a number of authors. Coleman and Deutsch (1964, p.43) in their summary state, "The failure of children to establish complete unilateral preferential usage has been seen as an expression of incomplete cerebral dominance which itself causes reading disability (Orton, 1937), or—in a modification of this theory—as an expression or neural maturational lag underlying reading disability (De Hirsch, 1952). Others (Benton and Menefee, 1957) have considered the possible interference of incomplete lateral dominance with the development of right-left discrimination, which itself is considered essential to learning to read." Palmer (1964) suggests that the proper assessment of handedness could act as an index of general development. For him the failure to establish handedness would indicate retarded development and hence, one would expect reading ability or more specifically, reading readiness to be associated with degree of handedness.

Studies investigating this proposition have produced conflicting results. The studies of Dearborn (1933), Harris (1957) and Vernon (1957) lend support to the relationship between reading ability and handedness. Balow (1963), Balow and Balow (1964), Capobianco (1966) and (1967), Chakrabarti and Barker (1966), Coleman and Deutsch (1964), and Silver and Hagin (1960) provide data which do not support this relationship.

Examination of the procedures used for assessing handedness suggests an explanation for the inconsistency. Some studies have determined handedness by asking the subject to state with which hand he writes and throws, (e.g. Chakrabarti and Barker, 1966). Other studies have asked several questions about hand preferences, such as, enquiring into the hand used for cutting with scissors and turning a door knob (e.g. Belmont and Birch, 1963). From such tests, conclusions are drawn about whether the subject is right-handed (if he says he uses the right hand for all or most of the activities); left-handed (where the left hand is used for all or most of the activities); or ambidextrous (if the subject responds by saying he used the right hand for some activities and the left hand for the other activities).

Clearly, in such studies the conclusions are determined by procedures which rely completely on the subject's report. In long questionnaires, such as those used by Harris (1958) and Crovitz and Zener (1962), and especially with young children, perseveration of responses may be involved. Further, implicit in this procedure is the assumption that the activities sampled are an unbiased selection of the population of tasks performed with the hands. The ramifications of this assumption are most evident when one considers the case where a subject is labelled ambidextrous because he states a mixed preference for the tasks sampled. It would not be unreasonable to suspect that the tasks (for example, those the subject answered "left" to) may be the entire population of tasks that he performs with that hand. In such a case, the subject would be wrongly classified. It may also be seen that questionnaires of hand preferences generally lack standardization; often necessitate qualitative assessment by the tester; and the resulting classification is too rigid to adequately define the range of handedness.

A further confusion is evident in these studies. The use of the questionnaire or hand preference technique for measuring handedness does not allow the distinction to be made between whether a subject is ambidextrous or whether he is ambilateral or ambisinistral. Ambidextrous subjects are those who have not established a dominant hand, but can use both hands with the same facility as a unilateral person can use his dominant hand. Whereas, ambilateral or ambisinistral individuals are those who have not established a dominant hand and can not use either hand as well as the unilateral person can use his dominant hand. Palmer (1964) suggests that the failure to make this distinction may be part of the explanation for the conflicting results among the studies cited above.

Of more importance, however, is the question of whether such scales actually measure what is meant by the concept of handedness. Harris has said that, "Lateral dominance means the preferred use and better performance of one side of the body as compared to the other side." (Harris, 1958, p.3) Hildreth in her exhaustive review of the theory and research on handedness states that, "Handedness is a matter of degree determined by the difference in skill with which both hand are used." (Hildreth, 1949, p.201) Benton, Myers and Polder (1962, p.331) state that, "Handedness is far too complex to be defined adequately in simple typological terms." Indeed, it appears that the questionnaire approach, which has been used almost exclusively to the present time, is not only psychometrically inadequate, but it does not seem to measure what is in fact meant by handedness, namely, the degree of proficiency.

Thus, the need is to develop a scale of handedness by the use of performance measures rather than the usual hand preference questionnaire. Such a plan concurs with a statement by Hildreth (1949, p.205) that, "The essential problem in studying handedness is to determine the relative skill and dexterity of the two hands..." The same idea was again stated by Palmer (1964, p.261), "By measuring an individual's proficiency with each hand separately, and in different tasks, more complete information could be obtained than through exclusive reliance on a questionnaire." Hence, although others have recognized and pointed out the need for a handedness scale based on the relative performance of each hand, few appear to have attempted the task.

Benton, Myers and Polder (1962) investigated the relationship between hand preference (as measured by a self-rating scale and questionnaire of hand preferences) and relative manual dexterity (as measured by the Small Parts Dexterity Test and a scissor cutting task). The results suggested that the added use of manual dexterity tests in assessing handedness gave more information than a preference questionnaire alone. However, no statement could be made about the validity of the combined measurements. Simon (1964) measured the relationship of hand preference to a steadiness task, and he concluded that, "steadiness cannot be rearded as a reliable index of handedness, for while the right-handed group performed significantly better with the preferred hand, the left-handed group did not," (Simon, 1964, p.205). This conclusion loses its cogency when consideration is given to the questionable value of stated hand preference as a criterion variable for handedness.

Thus, a scale for an adequate assessment of handedness is still lacking. In accordance with Palmer (1964) it is here suggested that the development of a scale could best be accomplished by measuring the proficiency of each hand separately on a wide variety of tasks. The tasks would be chosen to measure many different facets of hand performance. By factor analyzing such measurements, it would be possible to isolate the factors involved in hand differentiation. These factors would then form the basis of a comprehensive scale of handedness. The construction of such a scale has been the purpose of the study.

Method

Subjects

The subjects were 50 females, 17.9 - 27.4 years of age ($\bar{X}$=20.6), who were employed by the Montreal Children's Hospital; and 50 males, 17.3 - 34.1 years of age ($\bar{X}$=21.5), most of whom were undergraduate Psychology students at either McGill University or Loyola College. Ss were screened for permanent injury or deformity to either of their arms or hands. An assumption was made that these subjects possessed established hand preferences and that a factor analysis of their scores on the various tasks would yield factors associated with developed handedness.

Tasks

Fleishman and Hempel (1954, 1955 and 1958) and Fleishman and Ellison (1962) have factor analyzed the results of a large number of psychomotor tests which are performed with the hands. As many of the tasks were performed with either one hand only or bimanually, the results were used only as a guideline for the selection of the tasks used in this study. A number of the tests in the present investigation were chosen with reference to their loading on the relevant factors observed in the studies by Fleishman and his colleagues. Tests were also chosen with a view to other relevant studies, while some tasks were picked solely for intuitive reasons.

Abbreviations by which the dependent variables will be referred to in the following sections precede the definition of each variable.

Test-retest reliability coefficients corrected by the Spearman-Brown formula (r) have been calculated from the data and are included after the description of each dependent variable, except for Left-right discrimination; Hand preferences; and Handedness--self-classification.

Factor: Finger or Fine Dexterity (Fleishman and Hempel, 1954)

Test 1: Purdue Peg Board: A board containing two columns of small holes (25 holes in each column) and a container holding pegs, are used. The S is required to pick up pegs, one at a time, and place them in the holes as quickly as possible.

Purdue PB=Time to fill one column. (r=.85)

Test 2: O'Connor Finger Dexterity Test: A board containing 100 holes and a tray holding 300 pins is used. The S picks up three pins at a time and places them in each hole.

Connor FDT = Time to fill one row of 10 holes. (r=.73)

Test 3: Grooved Peg Board (Klövè Motor Steadiness Battery): The S places grooved pegs into holes which are arranged in differing positions on a board.

Grooved PB = Time to fill three rows of five pegs each. (r=.78)

Factor: Manual Dexterity (Fleishman and Hempel, 1954)

Test 4: Minnesota Rate of Manipulation--Turning: A large board containing 58 holes and 58 cylindrical blocks is used. The S removes a block; turns it over; replaces it; and so on.

Minn RM = Number of blocks turned in 30 seconds. (r=.89)

Test 5: Marble Board (Hempel and Fleishman, 1955): The S places marbles, one at a time, in a groove on a board.

Marble Bd = Time to fill the groove (20 marbles). (r=.81)

Factor: Wrist-Finger Speed (Fleishman and Hempel, 1954)

Test 6: Tapping--Large: With a pencil, the S places three dots successively in each of a series of 7/16 inch circles.

Tap--Large = Time to complete one block of circles (40). (r=.96)

Test 7: Tapping--Small: With a pencil, the S places one dot in each of a series of 1/8 inch circles.

Tap Sm-Time = Time to complete one block of circles (40). (r=.97)

Tap Sm-Err = Number of dots not in the respective circles (errors). (r=.91)

Tap Sm-TxE = One plus number of errors multiplied by the time. (r=.91)

Factor: Aiming (Fleishman and Hempel, 1954)

Test 8: Square Marking: The S marks an "X" in each of a series of 1/8 inch squares.

Sq Mk-Time = Time to complete two rows (36 squares). (r=.99)

Sq Mk-Err = Number of "X's" protruding from the squares (errors). (r=.93)

Sq Mk-TxE = One plus number of errors multiplied by the time. (r=.95)

Test 9: Marking Accuracy: On an IBM answer sheet various slots are circled. The S is required to move from item to item filling in the circled slots as quickly as possible.

Mk Acc-Item = Number of items marked in 30 seconds. (r=.97)

Mk Acc-Err = Number of marks protruding outside the circle (error). (r=.88)

Mk Acc-I-E = Number of items correctly marked. (r=.96)

Factor: Arm-Hand Steadiness (Hempel and Fleishman, 1955)

Test 10: Hand Steadiness (Klövé Motor Steadiness Battery): The S rests his arm against a table and places a stylus in successively smaller round holes. The S holds the stylus in each hole for ten seconds while attempting not to touch the sides of the hole.

Hd St-Hole = Smallest hole (numbered ordinally) in which S first produced five touches. (r=.67)

Hd St-Touch = Cumulative number of touches for the nine holes. (r=.86)

Hd St-Dur = Cumulative duration of touches for the nine holes. (r=.58)

Test 11: Arm Steadiness (Klövé Motor Steadiness Battery; and Simon, 1964): This test is identical to Test 10, except that the S is not allowed to rest his arm against the table which holds the apparatus.

Arm St-Hole (r=.77); Arm St-Touch (r=.92);

Arm St-Dur (r=.78) = Same as for Test 10.

Factor: Response Orientation (Fleishman, 1958)

Test 12: Discrimination Reaction Time: Although Fleishman (1958) used a four choice discrimination, it was decided to use a two choice discrimination at this time. To a red and green light, mounted vertically, the S responds to either the left or right reaction time key (colour-coded red and green) depending on which light is activated.

Discrim RT = Median of five trials recognition time (the length of time S takes to begin a response after the stimulus has been presented). (r=.70)

Discrim MT = Median of five trials movement time (the length of time that S takes to move from the start button to the response button--does not include recognition time). (r=.79)

Discrim TT = Reaction time (the sum of the median recognition time and the median movement time). (r=.71)

Test 13: Printed Discrimination Reaction Time: Going from item to item as rapidly as possible, the S makes a check mark in one of four slots (arranged in an up-down, left-right pattern) according to the configuration of black and white dots.

Pr Disc Rt = Time to complete 32 items. (r=.88)

Factor: Fine Control Sensitivity (Fleishman, 1958)
Test 14: Rotary Pursuit: The S attempts to keep a flexible stylus on a circle (one inch in diameter) which is mounted on a turntable moving at 45 r.p.m.

Rot Purs = Amount of time that the stylus is in contact with the target during a 20 second trial. (r=.92)

Factor: Reaction Time (Fleishman, 1958)
Test 15: Auditory Reaction Time: The S responds to the onset of a tone by pressing, as quickly as possible, a response key which is mounted one inch away from a start key.

Aud RT (r=.85); Aud MT (r=.89); and Aud TT (r=.86) = Same as for Test 12.

Test 16: Visual Reaction Time: This test is identical to Test 15, except that the S responds to the onset of a light, rather than a buzzer.

Vis RT (r=.77); Vis MT (r=.87); and Vis TT (r=.85) = Same as for Test 12.

Factor: Speed of Arm Movement (Fleishman, 1958)
Test 17: Jump Visual Reaction Time: This test is identical to Test 16, except that the S moves from a start key mounted six inches from the response key.

J Vis RT (r=.85); J Vis MT (r=.90); and J Vis TT (r=.89) = Same as for Test 12.

Test 18: Jump Auditory Reaction Time: This test is identical to Test 17, except that the S responds to the onset of a buzzer, rather than a light.

J Aud RT (r=.89); J Aud MT (r=.89); and J Aud TT (r=.89) = Same as for Test 12.

Factor: Aiming (Fleishman and Ellison, 1962)

Test 19: Pursuit Aiming: The S is required to follow a pattern of small circles (3/16 inches in diameter) placing one dot in each circle around the pattern.

P Aim-Time = Time to dot all 80 circles. (r=.97)

P Aim-Err = Number of dots not in their respective circle (error). (r=.88)

P Aim-TxE = One plus number of errors multiplied by time. (r=.86)

Other Tests

Test 20: Hand Preferences (Harris, 1958): S is asked with which hand he performs each of ten different activities.

Hand Pref = Number of activities performed by each hand.

Test 21: Printing Name (Harris, 1958): Although Harris asks his Ss to write their name (first and last), it is felt that printing will circumvent the consideration of abbreviations that are frequently found in adults' signatures.

Print Name = Time taken to complete the response divided by the number of characters produced. (r=.98)

Test 22: Dynamometer (Harris, 1958): The S is asked to squeeze a dynamometer as hard as he can.

Dynamom = The strength of grip exhibited in kilograms. (r=.97)

Test 23: Dealing Cards (Harris, 1958): The S deals 26 cards alternately to the E and himself as fast as he can.

Deal Cards = Time time to complete the task. (r=.97)

Test 24: Dowel Balancing (Palmer, 1963): The S balances an 18 inch long by 5/16 inch diameter dowel on his forefinger.

Dowel Bal = The amount of time that the S is able to balance the dowel. (r=.80)

Test 25: Left-Right Discrimination (Benton, 1959): The S is tested concerning his knowledge of left-right awareness for both self and other person items.

L-R Dis = Number of correct items out of 32.

Test 26: Small Parts Dexterity Test (Crawford and Crawford, 1956; and Benton, Myers, and Polder, 1962): With tweezers, the S picks up small pins; places them in holes; then picks up a small metal collar and places it on the pin.

Sm Pt Dex = Time to assemble a row of six such units. (r=.77)

Test 27: Vertical Movement Steadiness (Klövé Motor Steadiness Battery): The S moves a stylus through a 16 inch long by 4.00 mm. wide, vertically mounted track while attempting not to touch the sides.

Ver St-Touch = Number of touches. (r=.75)

Ver St-Dur = Cumulative duration of the touches. (r=.79)

Ver St-Time = Time to complete the task. (r=.85)

Test 28: Horizontal Movement Steadiness (Klövé Motor Steadiness Battery): This test is the same as Test 27, except that the track is mounted horizontally.

Hor St-Touch (r=.74); Hor St-Dur (r=.65); and Hor St-Time (r=.72) = The same as for Test 27.

Test 29: Maze Movement Steadiness (Klövé Motor Steadiness Battery): The S traces a track through a maze with a stylus while attempting not to touch the walls of the track.

Maz St-Touch (r=.85); Maz St-Dur (r=.84); and

Maz St-Time (r=.90) = The same as for Test 27.

Test 30: Finger Tapping--Short (Reitan, 1955): The S taps a mechanical tapper with his forefinger as fast as he can for ten seconds.

F Tap-Short = Number of taps. (r=.88)

Test 31: Finger Tapping--Long: This test is the same as Test 30, except that the S is required to tap for one minute. This test is an attempt to assess differences in fatigue between the hands.

Tap Long-TT = Total number of taps. (r=.90)

Tap Long-31 = Number of taps in the last 30 seconds of the trial. (r=.86)

Test 32: Handedness--Self-Classification (Adapted from Benton, Myers and Polder, 1962): On a line seven inches long, with the left-hand pole marked "Strong Left"; the middle marked, "No Preference"; and the right hand pole marked, "Strong Right", the S is asked to rate himself as to how handed he thinks he is.

H Self Clas = Distance of rating from the center or "No Preference" point.

Procedure

To facilitate the administration of the large number of tests they were divided into five divisions: 1. reaction time tests (includes tests 12, 15, 16, 17 and 18); 2. steadiness tests (tests 10, 11, 14, 27, 28, and 29); 3. pencil and paper tests (tests 6, 7, 8, 9, 13, and 19); 4. apparatus tests (tests 1, 2, 3, 4, 5, and 26); and 5. miscellaneous tests (tests 20, 21, 22, 23, 24, 25, 30 and 31). By use of random number tables, the tests were assigned to an order within their respective classification. This order may be found in Appendix A.

Reaction time tests, steadiness tests and tapping--large, tapping--small, and marking accuracy formed Battery A. Administration of Battery A always began with the pencil and paper tests (all possible combinations of order were used). The reaction time and steadiness tests were given in a forward order one-half of the time and in a backward order the other half. Reaction time and steadiness tests each followed immediately after presentation of the pencil and paper tests an equal number of times. This procedure resulted in 24 different orders of administration.

Battery B consisted of the apparatus tests, the miscellaneous tests, and square marking, pursuit aiming and printed discrimination reaction time tests. All possible combinations of order of administration were used between the classifications. The order of presentation within the classifications was reversed one half of the time. This procedure yielded twelve different orders of administration.

All tests (except tests 20, 25, and 32) were administered twice to each hand in a counter-balanced order. Test 32 (which was always the first test administered) was used to determine the preferred hand which was then always used first in the counter-balanced order.

Testing was done in two sessions, each of approximately an hour and a quarter duration, on separate days. Battery A was administered during one session, Battery B during the other. One-half of the subjects performed Battery A first; one-half Battery B. The order of administration in each battery was assigned to each S at the time of testing.

A detailed account of the administration procedure for each test may be found in Appendix A.

All testing was performed by two Es. Each E did approximately one half the testing of Battery A and Battery B. All tests were individually administered in appropriate rooms containing only the subject and the E.

Design

All tests (except Hand Pref, H Self Clas, and L-R Dis) yielded four scores, two for preferred hand performance and two for non-preferred hand performance. In each case the two scores were summed. This procedure produced a non-preferred hand performance score (called "NP") and a preferred hand performance score (called "P"). These scores were classified by sex and four groups resulted: 1) Male P (called "M-P"); 2) Male NP (called "M-NP"); 3) Female P (called "F-P"); and 4) Female NP (called "F-NP").

The skewness and kurtosis of the distributions of each variable was calculated and compared with that of a normal distribution. Where the skewness or kurtosis of a variable differed significantly from "normal", appropriate transformations were applied. This procedure yielded all distributions essentially "normal". From these calculations four inter-correlation matrices were derived from the following dependent variables: 1) M-P; 2) M-NP; 3) F-P; and 4) F-NP. Two remaining inter-correlation matrices, one for males and one for females, were formed by correlating ratios between P and NP (P/NP). This procedure was used by Palmer (1967) as a method of quantitatively describing factor differences between preferred and non-preferred performance.

Factor analysis (principal component method) was performed on each of the outlined inter-correlation matrices. A Varimax rotational solution was applied to all non-rotated factors possessing an Eigenvalue rating of greater than one.

A "t" test for independent samples was performed on each variable in the following comparisons: 1) M-P vs. F-P; and 2) M-NP vs. F-NP. Correlated "t" comparisons were made between: 1) M-P and M-NP; and 2) F-P and F-NP.

Results

Although no distribution is available by which the significance of a factor loading may be assessed, a cutoff score for significance at $p<.01$ was determined to be ± 0.3648 for $N=50$. This value was obtained by assuming the S_e (Standard Error) of a factor loading to be equal to one divided by the root of N ($1/\sqrt{N}$). A significant factor loading was thus equal to $\pm 2.58S_e$. Only those variables which loaded significantly ($>\pm 0.36$) on a factor are reported.

<u>M-P; M-NP; F-P; and F-NP Factors</u>

Factors from these four factor analyses have been qualitatively assessed, and where intrepretable, labels have been applied to the skill represented. In order to present these data in a comprehensible form, four factors (one from each of the four analyses) have been grouped. Factors presented together in such a manner are thought to be representative of similar skills and are called factors of hand performance. Included with the factor loadings are: 1) factor number ("Factor No."), which is the ordinal position of that factor's extraction in its group's Varimax solution; and 2) % Variance, which is the percentage of the total variance accounted for by the factor within its group. Factors of hand performance are numbered by their rank order based upon the mean of % Variances (ie., the percentage of variance accounted for across all four groupings).

FACTOR I

	M-P	M-NP	F-P	F-NP
Factor No.	3	3	1	1
% Variance	7.6	8.6	18.1	19.0
Variable	Loading	Loading	Loading	Loading
Aud RT	.75	.68	.88	.90
Vis RT	.84	.87	.84	.88
Aud TT	.58	.47	.69	.87
Vis TT	.60	.64	.68	.83
J Aud RT	.71	.86	.80	.82
J Vis RT	.86	.86	.84	.82
J Vis TT	.56	.60	.68	.81
J Aud TT	.53	.62	.56	.62
Vis MT				.53
Aud MT				.52
J Vis MT				.50
Discrim RT	.55	.51	.79	.50
Discrim TT			.60	.46
Grooved PB		.36		

Factor I is identified as a <u>Reaction Time</u> factor. The scores which load on this factor are basically all measures of the speed with which an <u>S</u> can respond to the onset of a stimulus. These results replicate the Reaction Time factor of Fleishman (1958), however, the loadings found on these factors are substantially higher than those witnessed by Fleishman. The data also support his findings that: 1) tasks of more complexity do not load on this factor; and 2) the ability to respond to the onset of a light or a buzzer is similar. Although this factor accounts for a greater amount of variance in the female groups, qualitatively there is no sex difference. Similarly, there appears to be no difference between preferred and non-preferred hand performance. The Grooved PB seems out of place on the M-NP factor, but this may be due to chance. The <u>Reaction Time</u> factor accounts for a mean % variance across the four groups of 13.3%.

FACTOR II

	M-P	M-NP	F-P	F-NP
Factor No.	2	1	3	9
% Variance	9.6	24.5	8.5	3.3
Variable	Loading	Loading	Loading	Loading
J Vis MT	.91	.88	.80	.40
J Aud MT	.88	.88	.86	.92
Vis MT	.86	.82	.61	
Aud MT	.71	.80	.44	
Discrim MT	.76	.80		
J Aud TT	.68	.69	.70	.65
J Vis TT	.71	.67	.57	
Aud TT		.62		
Vis TT	.66	.60	.46	
Discrim TT	.48	.56		
Hor St-Dur		.44		
Hor St-Touch		.43		
Sq Mk-TxE		.38		
Arm St-Hole	-.36			
Minn RM			-.43	
Hd St-Dur			.38	
L-R Dis				-.37

Speed of Arm Movement appears to be the basic characteristic of tests which load on Factor II. The dependent variables which are found on this factor measure the speed with which S moves from a start button to a response button--a gross, but discreet movement. Basically, these findings are the same as those found by Fleishman (1958), however, the loadings on these factors are once again substantially higher than the loadings on Fleishman's Speed of Arm Movement factor. This is probably due to the greater control exerted in this study in separating the reaction time from the movement time. Furthermore, these data demonstrate that Speed of Arm Movement is not specific to the direction or length of the movement (e.g. compare J Vis MT, Vis MT and Discrim MT). It is noted that F-NP is a weak factor, however, it still appears as a stronger factor than that observed by Fleishman. With this possible exception, there seems to be no sex or preferred--non-preferred differences with regard to speed of arm movement. This factor accounts for a mean percent variance of 11.5.

Factor III is identified as a factor which measures Wrist-Finger Speed. This factor has previously been identified by Fleishman and Hempel (1954), Hempel and Fleishman (1955), and Fleishman and Ellison (1962).

FACTOR III

	M-P	M-NP	F-P	F-NP
Factor No.	1	4	5	5
% Variance	22.4	6.4	6.1	5.4
Variable	Loading	Loading	Loading	Loading
P Aim-Time	.85	.73	.68	.55
Sq Mk-Time	.83	.76	.79	.59
Tap Sm-Time	.79	.78	.65	.65
Mk Acc-I-E	-.78	-.62		-.79
Mk Acc-Item	-.75	-.54		-.84
Pr Disc RT	.70	.39		
Tap--Large	.67	.50		.43
Print Name	.55	.83		.50
P Aim-Err	-.50		-.46	
Minn RM	-.45			
Aud TT	.42			
Deal Cards	.40			.38
Hd St-Dur	.40			
Grooved PB	.37			
Dynamom			-.38	
Marble Bd			.38	

Basically, these data replicate all of the previous findings. Fleishman and Ellison's (1962, p.101) description of the performance involved in Wrist-finger speed is appropriate here. "...Wrist-Finger Speed is a narrow factor emphasizing rapid pendular and/or rotary wrist movements, best measured by printed tests involving rapid, repetitive jabbing movements with a pencil, where accuracy is not critical." In light of the finding that this factor is best measured by printed tests, it is intriguing that the factor is produced in non-preferred hand performance.

Indeed, except for the large proportion of variance accounted for by the factor in the M-P group, there is essentially no difference between sex or preferred—non-preferred performance. This factor, Wrist-Finger Speed accounts for an average of 10.1% of the variance of all four groups.

FACTOR IV

	M-P	M-NP	F-P	F-NP
Factor No.	7	5	4	3
% Variance	4.2	5.6	8.0	9.5
Variable	Loading	Loading	Loading	Loading
Hd St-Hole	-.73	-.84	-.39	-.82
Hd St-Dur		.59	.44	.77
Dowel Bal				-.73
Hd St-Touch	.90	.83	.47	.72
Arm St-Hole	.70	.63	.87	.60
Arm St-Dur		.54	.88	.58
Arm St-Hole	-.51	-.49	-.91	-.56
Rot Purs				-.48
Tap—Large				.40
Sm Pt Dex				.38
Ver St-Touch	.42			
Mk Acc-I-E		-.39		

Factor IV has been identified as representing Arm-Hand Steadiness. This name has been borrowed from Fleishman (1958), but the data bear little relation to his so named factor. More closely resembling Fleishman's Arm-Hand Steadiness Factor is this study's Factor V which is discussed next. Factor IV, Arm-Hand

Steadiness, is represented mainly by loadings on the two tests: arm steadiness and hand steadiness. Both tests measure a static-type steadiness, that is, a tremor or a shake. From these data it may be concluded that arm steadiness is no different from hand steadiness in a static task. However, this may be because hand steadiness is really the crucial variable in the arm steadiness task. Once again, a qualitative analysis of the four factors in this factor of hand performance suggests no sex or hand preference difference. Arm-Hand Steadiness accounts for 6.8% of the average variance.

FACTOR V

	M-P	M-NP	F-P	F-NP
Factor No.	6	8	6	2
% Variance	4.9	3.4	5.2	12.9
Variable	Loading	Loading	Loading	Loading
Maz St-Dur	.85	.39	.38	.85
Maz St-Touch	.85		.36	.85
Hor St-Touch		.38	.83	.74
Ver St-Dur		.84	.52	.72
Ver St-Touch		.85	.50	.72
Hor St-Dur		.40	.85	.70
Discrim RT				.42
Arm St-Hole				-.39
Arm St-Dur	.45			.37
Hd St-Dur	.51			
Sm Pt Dex	.39			
Deal Cards			.52	
Marble Bd			.41	

Factor V has been named and interpreted as an Arm Movement Steadiness factor. All three tests, Maze, Horizontal and Vertical Movement Steadiness, require the S to move a stylus through an apparatus without touching the sides. It was noted that nearly all the Ss performed this task with a rigid wrist and with the stylus held still in the hand. It is for this reason that the factor appears to measure only "arm" movement steadiness. It is suggested that this factor may be the same factor identified by Fleishman (1958) as Arm-Hand Steadiness. The comparison is made because his highest loading test, Track Tracing, is very similar to the Maze Movement Steadiness Test of this study. With the possible exception of the M-P group, which is not as general a factor as found in the remaining three groups, lack of sex and preferred hand differences is again evident. This factor accounts for 6.6% of the average variance across the four groups.

Although Factor VI appears similar to Factor III regarding the tests that load on each, it should be noted that the dependent variables in either case are very different. Whereas the measurements in Factor III were representative of fast movement only, the loadings on Factor VI are basically error measurements.

FACTOR VI

	M-P	M-NP	F-P	F-NP
Factor No.	4	2	7	7
% Variance	6.2	10.9	4.2	3.7
Variable	Loading	Loading	Loading	Loading
Tap Sm-Err	.90	.88	.89	.89
Tap Sm-TxE	.90	.84	.86	.90
P Aim-Err	.66	.82	.51	
P Aim-TxE	.75	.80	.51	
Mk Acc-Err		.75	.46	.72
Sq Mk-Err		.74		
Sq Mk-TxE		.65		
Maz St-Dur		.43		
Pr Disc RT			-.38	
Sm Pt Dex				.36

Thus, Factor VI appears to be measuring the accuracy of wrist-finger speed. Because of its similarity to the factor found by Fleishman and Hempel (1954) and Fleishman and Ellison (1962), this factor has been named Aiming. This factor appears to be measured by printed tests which require strict visual-motor control of a pencil in keeping marks within a specified enclosure. As noted with regards to Factor III, it is extremely interesting that the abilities necessary to perform on printed tests is as evident in non-preferred as in preferred hand performances. Once again, no difference appears to exist between the groups. The Aiming factor accounts for an average of 6.3% of all groups' variance.

FACTOR VII

	M-P	M-NP	F-P	F-NP
Factor No.	5	7	2	8
% Variance	5.4	3.6	10.0	3.5
Variable	Loading	Loading	Loading	Loading
Ver St-Time	.91	.86	.88	.80
Maz St-Time	.69	.60	.86	.81
Hor St-Time	.86	.88	.83	.85
Ver St-Touch	-.55		-.71	
Ver St-Dur	-.49		-.70	
Maz St-Touch			-.36	
P Aim-Err			-.35	
Minn RM			.33	
P Aim-TxE			-.31	
Arm St-Hole	-.36	-.58		
Arm St-Touch		.47		
Arm St-Dur	.38	.37		

Factor VII, because of the diverse nature of its loadings, proves to be a very difficult factor to identify in terms of hand performance. However, the suggestion that the four groups belong together under a single factor is supported by the identical three highest loadings on each. These three tests (Ver St-Time, Maz St-Time, and Hor St-Time) do not appear to measuring steadiness or loadings on Factors IV and V would have been observed. Therefore, it seems appropriate to seek an explanation for this factor in terms other than hand performance. In the administration of all three tests the S was instructed to perform the task "as slowly as you need to not to make errors". The S's willingness to follow these directions, therefore, would be measured by the three scores under consideration. It is suggested that the similar factor loadings found in the four groups are explained best by this reasoning. To conclude, Factor VII emerges as a motivational rather than a hand performance factor. 5.6% of the mean variance is accounted for by this factor.

FACTOR VIII

	M-P	M-NP	F-P	F-NP
Factor No.	9	6	8	4
% Variance	3.3	4.1	4.1	8.1
Variable	Loading	Loading	Loading	Loading
Tap Long-TT	.95	-.83	.92	-.94
Tap Long-31	.95	-.86	.90	-.92
F Tap-Short	.53		.51	-.77
Connor FDT				.66
P Aim-Time				.56
Sq Mk-Time				.44
Grooved PB				.39
Mk Acc-Item		-.52		
Mk Acc-I-E		-.41		
Aud RT		.37		
L-R Dis			.48	

Factor VIII is a specific factor basically loading only on the Finger Tapping tests. For obvious reasons, this factor has been named Finger Tapping. The skill found in finger tapping is more generalized for the non-preferred groups as witnessed by the loadings of other tests on these factors.

However, that this is a similar factor across the four groups is demonstrated by the consistently high loadings of the finger tapping tests in each analysis. Except for the small difference already noted, sex and preferred—non-preferred factors appear similar. It is interesting to note that Tap Long-31, a measure of fatigue, loads on the same factor in each group as Tap Long-TT. This observation contradicts the finding by Palmer (1967) that a fatigue measure discriminates preferred from non-preferred hand performance. Finger Tapping accounts for 4.9% of the average variance.

FACTOR IX

	M-P	M-NP	F-P	F-NP
Factor No.	11	9	13	6
% Variance	2.6	3.1	2.6	4.8
Variable	Loading	Loading	Loading	Loading
Marble Bd		.51	.49	.79
Purdue PB	.57		.73	.70
Grooved PB	.51	.61	.63	.57
Minn RM		-.66	-.48	-.56
Discrim RT				.52
Discrim TT				.40
Hor St-Dur				.38
Deal Cards		.51		
Connor FDT	.55	.37		
Sm Pt Dex	.62			
Ver St-Dur	.44			

Factor IX has been interpreted as a Dexterity factor. In previous studies, Fleishman and his co-workers (1954, 1955, and 1962) found two dexterity factors--Fine or Finger Dexterity and Manual Dexterity. The four groups found in Factor IX present a pattern very similar to the combination of the two dexterity factors found by the above researchers. Therefore, these data do not support the distinction made by Fleishman of finger versus hand dexterity. It is most surprising to note that on the Dexterity factor of hand performance no preferred--non-preferred hand difference is in evidence. Similarly, no sex difference is found. This factor accounts for 3.3% of the average variance across the four groups.

FACTOR X

	M-P	M-NP	F-P	F-NP
Factor No.	14	13	14	11
% Variance	2.2	2.1	2.3	2.8
Variable	Loading	Loading	Loading	Loading
Hand Pref	-.85	.73	.67	-.78
H Self Clas		-.66		.73
Print Name			.80	.42
F Tap-Short		.51		
Mk Acc-Err	.41			
Tap--Large			.49	
L-R Dis			-.41	

Factor X, a very weak, but common factor, has been interpreted as a measure of Stated Hand Preference. With the possible exception of the Print Name task, this factor is limited to the S's verbal statement about his preferred hand. Several other tests are found on these factors, but they possess very low loadings and are not consistently observed in the four groups. These results cast serious doubt on the validity of using a questionnaire of hand preference (Harris, 1958) or the self rating method (Benton, Myers and Polder, 1962) to assess preferred hand performance. These data do not support Palmer's (1967) finding that the "conventional questionnaire measure of handedness" is related to behavioral measures. This factor accounts for 2.4% of the average variance of the four groups.

In the M-P and F-P groups there are seven factors which have not been reported and in the M-NP and the F-NP there are six factors yet to be reported. These factors have not been placed in the text, but they may be found in Appendix B. They have been relegated to the Appendix section for either one of the two following reasons: 1) the factor is uninterpretable (most fall into this category); or 2) no meaningful pattern is observed between the four groups.

As even the largest of these factors accounts for only 3.6% of its group's variance, only a small oversight could be committed. These 26 factors presented in the Appendix accounted for a mean percentage of the variance across the four groups of 14.7, whereas the 40 factors which made up the 10 factors of hand performance accounted for 70.8% of the four groups' average variance.

M-P/M-NP and F-P/F-NP Factors

In order to render the data of this study comparable to those of Palmer (1967) factor analysis on ratio scores derived by dividing P by NP were performed for both sexes. This method was devised to quantitatively demonstrate factor differences between preferred and non-preferred hand performance. The two principle component solutions were rotated for ten factors with a Varimax solution.

The resultant factors for each analysis are presented in Appendix C. The factors are not reported in this section because they are uninterpretable and not at all qualitatively meaningful.

A possible explanation for this lack of meaningful factors may lie in the procedure of forming ratios between P and N-P. It is suggested that this method effectively removed all of the common variance from the test scores. The validity of this contention is supported by two observations. First, the percentage of the variance accounted for by the factors fails to show the characteristic large drop between the first few factors extracted. In fact each of the ten factors in both analyses account for approximately 5% of the variance (for M-P/M-NP, Factor I = 6.5% and Factor X = 3.9%; for F-P/F-NP, Factor I = 7.3% and Factor X = 3.7%). These low and consistent percentages of variance accounted for suggest that the factor loadings are representing mainly specific and error variance.

Secondly, the inter-correlation matrices upon which the factor analyses were performed were examined for the number of significant correlations. Applying a Chi Square test of significance, it was found that in the Male group the number of correlations significant at $p<.05$ was no more than could be expected by chance ($\chi^2=1.26$, df=1, $p<.30>.20$). The results are not as clear for the Female group ($\chi^2=8.07$, df=1, $p<.01>.001$), however, the absolute number of significant correlations is not impressive (118 correlations significant at $p<.05$; 91.5 correlations expected to be significant by chance alone). Therefore, an explanation for the lack of meaningful factors which is based upon the premise that the formation of ratio scores removed most of the common variance, seems very reasonable.

"t" Comparisons

Independent "t" comparisons performed between M-P and F-P; and between M-NP and F-NP are reported in Appendix D. Also included in Appendix D are the means and standard deviations of each variable in the four groups. A summary list of those comparisons yielding significant "t's" ($p < .05$) are reported in Table 1.

Table 1

M-P vs. F-P Comparisons

Female performance better	Male performance better
Arm St-Touch	J Aud MT
Arm St-Hole	Vis MT
Hd St-Touch	Vis TT
Hor St-Touch	J Vis MT
Ver St-Touch	J Vis TT
Maz St-Touch	Discrim MT
Marble Bd	Ver St-Time
P Aim-Err	Maz St-Time
P Aim-TxE	Rot Purs
Tap Sm-Err	Dynamom
Tap Sm-TxE	Dowel Bal
L-R Dis	Tap Long-TT
	Tap Long-31
	F Tap-Short

Table 1 (cont.)

M-NP vs. F-NP Comparisons

Female performance better	Male performance better
Discrim RT	J Aud MT
Arm St-Touch	J Aud TT
Hd St-Touch	J Vis MT
Hor St-Touch	J Vis TT
Ver St-Touch	Discrim MT
Maz St-Touch	Ver St-Time
Purdue PB	Rot Purs
Marble Bd	Dynamom
Sq Mk-Time	Dowel Bal
Sq Mk-Err	Tap Long-TT
Sq Mk-TxE	Tap Long-31
P Aim-Err	F Tap-Short
P Aim-TxE	
Tap Sm-Err	
Tap Sm-TxE	
Mk Acc-I-E	

The "t" tests for correlated samples that were performed on M-P vs. M-NP groups and F-P vs. F-NP groups are reported in Appendix E. Also included in Appendix E are the means of the differences ($\bar{D}$) and the standard deviations of the differences (S_D).

In the female group all reaction time dependent variables were not significant, except for J Aud MT, J Aud TT, Aud RT and Discrim RT. With the exceptions of Hd St-Touch and Hor St-Dur, all other measures of hand performance differed significantly (all but three at $p<.01$). All demonstrated superior preferred hand performance.

In the male group all reaction time dependent variables were not significant, except for J Aud MT, J Aud TT and J Vis RT. With the exceptions of Hor St-Dur, Hor St-Time and Ver St-Time, all other measures of hand performance differed significantly (all at $p < .01$). Each comparison demonstrated superior preferred hand performance.

Discussion

The results of the factor analyses performed on the four groups, M-P, M-NP, F-P, and F-NP demonstrate one major finding. There appears to be no factor or qualitative skill difference between preferred hand performance and non-preferred hand performance. Also, no qualitative sex difference was found. The identified factors of hand performance closely resemble the results found by Fleishman and his co-workers (1954, 1955, 1958 and 1962). However, these investigators did not consider the major question of this study--differences in preferred--non-preferred hand performance. The fact that the findings of this study can be considered to closely replicate the previous results of Fleishman and his colleagues, comments favourably on the reliability of these data. Therefore, it can be stated with confidence that the same skills are involved in non-preferred hand performance as in preferred hand performance.

The results of the factor analyses performed on the ratio scores (M-P/M-NP; and F-P/F-NP) are consistent with the conclusion already reached. As no psychologically meaningful factors emerged from these analyses, the only acceptable explanation available is that the skills involved in non-preferred hand performance are essentially the same as the skills involved in preferred hand performance.

The results of "t" tests carried out on M-P vs. M-NP and F-P vs. F-NP data add another dimension to the findings of the factor analyses. With the exception of the reaction time tests, there is a consistent and reliable superiority on all behavioral tests of preferred hand performance. Therefore, although the same skills are to be found in either hand, the preferred hand is characterized by better performance in each skill.

The "t" comparisons for sex differences produced some interesting findings. Basically, female performance was better on tasks demanding finely controlled and accurate movements. To be specific, female performance exceeded that of the males on the following factors: 1) Arm-Hand Steadiness; 2) Arm Movement Steadiness; 3) Aiming; and 4) Dexterity. These results are consistent for preferred and non-preferred hands.

Male performance was superior on tasks involving quick, gross movements. The factors on which male performance exceeded that of the females were: 1) Speed of Arm Movement; and 2) Finger Tapping.

Males were obviously stronger, as measured on the dynamometer test and they also showed superior performance on Rotary Pursuit and Dowel Balancing. To conclude, although no qualitative skill differences were observed as a function of sex, sex differences were noted relevant to the level of performance on various factors.

The results of this study strongly question the validity of using preference questionnaires for assessing the degree of established handedness (e.g. Belmont and Birch, 1963; Chakrabarti and Barker, 1966; and Harris, 1957). As handedness has been shown to be characterized by superior performance of the preferred hand on many independent skills, it is obvious that such performance differences cannot be measured by a questionnaire technique. The Stated Preference factor of hand performance provides direct quantitative support for this proposal. On this factor, the questionnaire of hand preferences (Hand Pref) and the self-rating scale (H Self Clas) were the only consistent loadings. As factor extractions were orthogonal, it may be stated that these measurements are not quantitatively related to the factors of hand performance.

The findings of this study do not support the conclusions reached by Palmer (1967)[1]. In a study (conducted only on males) similar in design to the present investigation, Palmer isolated two factors which differentiated preferred--non-preferred hand performance. He identified these factors as measuring: 1) strength-power; and 2) precision-control in fine hand movements. As already noted, no factor differences between preferred--non-preferred hand performance were observed in the present study. More specifically, Tap Long-31 (designed as a measure of fatigue) loads on the same factor as other tests of finger tapping which do not appear to measure fatigue. Further, Wrist-Finger Speed, which appears similar to Palmer's second factor, was found in both preferred and non-preferred hand performance.

The conclusion reached by Palmer (1967) that handedness is not a unitary phenomenon is not supported by this study. Indeed, handedness appears to be a single dimension characterized by the superior performance of the preferred hand. This

[1]This paper, as yet unpublished, was presented at the annual meeting of the Eastern Psychological Association while the present study was in progress. A detailed report of the investigation has not been made available to the author.

relationship holds for all of the factors of hand performance isolated in this study except, Reaction Time and Speed of Arm Movement which do not differentiate preferred from non-preferred hand performance.

It is suggested that the single dimension which defines hand performance is the production of highly practised and over-learned skills in the preferred hand. Broverman's (1960) concept of "Automatization" may be applicable to this hypothesis. Broverman has demonstrated that individuals differ in the degree to which they perform simple repetitive tasks. Performance on these tasks that demonstrates a greater ability than would be predicted from an individual's general level of performance is called "Strong Automatization". "Weak Automatizers" are classified by poorer performance than would be predicted from their general ability level. Possibly, preferred hand phenomena are understandable as stronger automatization of the skills involved in hand performance. It should be noted that Palmer (1967) found a positive relationship between hand differentiation and Broverman's "Automatization" dimension. Possibly, these considerations could lead to a fruitful area of research.

Also of interest here, is the recent finding by Mathewson (1967) that oral reading ability in ten year old boys was positively related to strong automatization. In future investigations concerning the relation of handedness to reading ability, it may be wise to consider the ability to automatize as a common link.

Future research in the area of handednes should be immediately concerned with repeating the present study with young children. Factor analyses of the hand performance of children aged five or six would yield much information concerning the early development of preferred hand performance. The results of this type of study in conjunction with the data from the present investigation should yield sufficient information to assemble a valid handedness battery; a battery based on hand performance. Hopefully, such a battery would include only a small proportion of the original tests. An item selection procedure based on the results of an adult and child study should produce a scale for the measurement of handedness that would be applicable to a wide age range.

Further research might seek to standardize a scale of handedness on many different age levels.

This type of study would allow a developmental examination of the sex differences observed in the present investigation. Further, possible differential factor growth rates of the differences found between preferred and non-preferred hand performance could be explored. The age that handedness becomes completely developed could be ascertained. Finally, the normative data gained in a study of this type would be of clinical value in assessing one aspect of the degree of a child's motor development.

Summary

An investigation into the performance factors of developed hand preference was undertaken. Measurements taken from both the preferred and non-preferred hands of 50 males and 50 females yielded scores on 61 dpendent variables from 32 tests. Factor analyses of the scores produced nine interpretable factors of hand performance. Each of the nine factors were common to male-female; and preferred--non-preferred performance. However, preferred hand performance was superior on almost all tasks. It was suggested that preferred hand performance is characterized by "Automatization" of the skills involved in hand performance. The results cast serious doubt on the validity of using questionnaires of hand preferences to measure the degree of established handedness.

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Appendix A

Included in Appendix A are the standardized instructions used for the administration of all tests. The order of the tests within each classification is that order which was achieved by a random selection.

BATTERY A

REACTION TIME TESTS

Jump Auditory Reaction Time

Instructions: Each test will begin with your index finger depressing the yellow button closest to you. When the buzzer sounds, hit the blue button as quickly as possible and keep it depressed until the buzzer is turned off.

Practice: S practices movement three or four times with each hand.

Visual Reaction Time

Instructions: You will begin each test with your index finger on the yellow button farthest from you. When the white light goes on, hit the blue button as quickly as possible and keep it depressed until the light is turned off.

Practice: S practices movement three or four times with each hand.

Jump Visual Reaction Time

Instructions: You will begin each test with your index finger depressing the yellow button closest to you. When the white light goes on, hit the blue button as quickly as possible and keep it depressed until the light is turned off.

Practice: S practices movement three or four times with each hand.

Auditory Reaction Time
Instructions: You will begin each test with your index finger on the yellow button farthest from you. When the buzzer sounds, hit the blue button as quickly as possible and keep it depressed until the buzzer is turned off.
Practice: S practices movement three or four times with each hand.

Discrimination Reaction Time
Instructions: You will begin each test with your index finger on the yellow button closest to you. If the green light goes on, hit the green button to your right. If the red light goes on, hit the red button to your left. Keep the button depressed until the light is turned off.
Practice: S practices movement three or four times with each hand.

STEADINESS TESTS

Arm Steadiness
Instructions: Put the stylus inside the designated hole and hold it as still as possible. You may not rest your wrist or arm on the table or against your body. You may find it easier if you hold your breath during the tests.
Practice: None.
Administration: For each hole, one through nine, administer a trial of ten seconds duration. Requirement—beginning hole has no touches.[1]

Hand Steadiness
Instructions: Put the stylus inside the designated

hole and hold it as still as possible. You may rest your wrist on the edge of the table. You may find it easier if you hold your breath during the tests.
Practice: None
Administration: For each hole, five through nine, administer a trial of ten seconds duration. Requirement--beginning hole has no touches.[1]

Horizontal Movement Steadiness
Instructions: Move the stylus back and forth through this groove without touching the sides. No part of your hand or arm may rest on the table or apparatus. Go through the groove as slowly as you need to not to make errors. With your right hand begin at the left side OR With your left hand begin at the right side.
Practice: None.

Vertical Movement Steadiness
Instructions: Move the stylus up and down through this groove without touching the sides. No part of your hand or arm may rest on the table or apparatus. Go through the groove as slowly as you need to not to make errors. With each hand, start at the bottom; go up; and then come down.
Practice: None.

Maze Movment Steadiness
Instructions: Take this stylus and put it in this opening (start position) and move it all the way through the maze (point to end). Try to go through

[1]After one of these tests has been competed E may begin the first series of the remaining test with the hole of his discretion. Requirement of no touches on the first hole must be met.

the maze without touching the sides. Go through the maze as slowly as you need to in order not to make errors. Make sure you do not rest your hand or arm on your side; or on the stand; or brace it in any way.
Practice: None.

<u>Rotary Pursuit</u>
Instructions: As the turntable rotates try to keep the stylus on the metal disc. Hold the stylus lightly. Try to keep your body still.
Practice: one 20-second trial with each hand.
Administration: <u>S</u> standing.

PENCIL AND PAPER TESTS
<u>Tapping-Large</u>
Instructions: Put three dots in each circle. Work horizontally across the page and as quickly as possible. With your right hand begin the block at the top left-hand corner, <u>OR</u>, with your left hand begin the block at the top right-hand corner and continue alternating direction on each succeeding row until you have completed the whole block of circles.
Practice: One line practice with each hand.
Administration: Demonstrate rhythm.

<u>Tapping-Small</u>
Instructions: Place one dot in each circle, working as quickly as you can across the rows. With your right hand begin a block at the top left-hand corner, <u>OR</u>, with your left hand begin the block at the top right-hand corner and continue alternating direction on each succeeding row until you have completed the whole block

or circles. An error is counted if each dot is not completely in a circle. Work as quickly as you can without errors.
Practice: Two rows per hand.

Marking Accuracy
Instructions: Going from item to item mark each circled slot as quickly as possible. An error is counted if any part of the mark extends from the circle. Work as quickly as you can without making errors.
Practice: None.

BATTERY B

APPARATUS TESTS

Purdue Peg Board
Instructions: Picking up the pegs one at a time, fill one vertical column. If you happen to pick up two pegs, pretend it is only one and repeat the movement to the dish before using the second peg. Begin at the top of the column.
Practice: Ten pegs with each hand.

Minnesota Rate of Manipulation
Instructions: Turn over as many cylinders as you can in 30 seconds. Pick each cylinder up cleanly, before turning it over and replacing it. With your right hand begin the first row from the left side, OR, with your left hand from the right side. When you come to the end of the first row return in the opposite direction on the following row. Follow the same procedure for

succeeding rows.
Practice: Ten cylinders with each hand.

Crawford Small Parts Dexterity
Instructions: Use the tweezers to pick up one of these pins, gripping the pin at right angles to the tweezers. You will find it easier to pick up the pin at the end that will be the top when you place the pin in the hole. Place the pin in a small hole. Next, pick up a collar and put it down over the pin so that the flange is on the plate. You will find it easier to choose collars that are already sitting on the flange. Each hole must be filled with a pin and collar before moving on to the next hole. Complete one row working with right hand from left to right, OR, Complete one row working with your left hand from right to left. There are extra pins so don't stop to pick up any you may have dropped.
Practice: Fill one row with each hand.

Grooved Peg Board
Instructions: Picking up the pegs one at a time, place them in the holes as rapidly as possible. Since each peg is "keyed", it will fit only one way in the grooved hole. Fill three horizontal rows, working from right to left with the left hand, OR, from left to right with the right hand.
Practice: One row with each hand.

Marble Board
Instructions: Take the marbles one at a time from the dish and fill one row as quickly as possible. With

your right hand work from left to right, OR, With your left hand work from right to left.
Practice: Ten marbles with each hand.

O'Connor Finger Dexterity

Instructions: Pick up three pins at a time and fill the holes as fast as you can. Be sure to fill each hole completely before you start the next. There are extra pins in this tray so that if you drop one or two on the floor you still will have enough left, so do not stop to pick them up. With your right hand move horizontally from left to right, OR, with your left hand move horizontally from right to left.
Practice: One row per hand.

PENCIL AND PAPER TESTS

Square Marking

Instructions: Mark "X's" in the small squares in the corners of the large squares. Do two horizontal rows beginning with your right hand on the left side and then returning on the next row in the opposite direction, OR, beginning with your left hand on the right side and then returning on the next row in the opposite direction.
Practice: None.

Pursuit Aiming

Instructions: Place one dot in each circle, starting bere (E points) until you come to the end. An error is counted if each dot is not completely in a circle. Work as quickly as you can without errors.
Practice: None.

Printed Discrimination

Instructions: S reads from the direction sheet.

Practice: Last sheet. Half for each hand.

Administration: Check not necessary, just a line in the appropriate space. Sheets up-side-down for left hand.

MISCELLANEOUS TESTS

Left-Right Discrimination

Instructions: Respond as directed.

Administration: Ask questions.

Hand Preferences

Instructions: Respond by naming the hand you prefer for each of the following activities.

Administration: Ask questions. S may act-out.

Dynamometer

Instructions: This is a test of your hand strength. Hold your arm by your side. When I say BEGIN, squeeze as hard as you can.

Practice: None.

Administration: S standing. Adjust handle to comfort.

Dowel Balancing

Instructions: See how long you can balance this stick on your forefinger. Steady the dowel with your other hand and remove it when you are ready to start. You may move around as much as you wish.

Practice: Once with each hand.

Administrations: Standing in an open area.

<u>Dealing Cards</u>
Instructions: Deal the 26 cards alternately to the two squares before you. Work as quickly as possible.
Practice: None.
Administration: Hand throwing card denotes trial.

<u>Finger Tapping--Long</u>
Instructions: Tap on this lever as quickly as you can. This is to be a finger movement only, so rest your wrist on the board and move only the index finger. This test will last 60 seconds.
Practice: Sufficient for smooth operation.

<u>Finger Tapping--Short</u>
Instructions: Tap on this lever as quickly as you can. This is to be a finger movement only, so rest your wrist on the board and move only the index finger. This test will last ten seconds.
Practice: Sufficient for smooth operation.

<u>Printing Name</u>
Instructions: Print your first and last name in capital letters of normal writing size. Work as quickly as you can.
Practice: None.

<u>Handedness--Self Classification</u>
Instructions: Consider how much you prefer one hand or the other for all manual tasks. Then place a mark on the line between "Strong Left" and "Strong Right" to describe how handed you think you are.

Appendix B

In Appendix B are the factors from the M-P; M-NP; F-P; and F-NP factor analyses that were not reported in the results section.

M-P FACTORS

Factor No. 8, % Variance 3.6

Variable	Loading
Sq Mk-TxE	.87
Sq Mk-Err	.82
H Self Clas	.59

Factor No. 10, % Variance 3.0

Variable	Loading
Hor St-Touch	.87
Hor St-Dur	.85
Mk Acc-Err	-.37

Factor No. 12, % Variance 2.5

Variable	Loading
Marble Bd	.75
Deal Cards	.67
Connor FDT	.39

Factor No. 13, % Variance 2.3

Variable	Loading
Dowel Bal	-.76
Discrim TT	.48
Discrim RT	.41

Factor No. 15, % Variance 2.1

Variable	Loading
Dynamom	.76
Minn RM	-.41
Arm St-Touch	.38

Factor No. 16, % Variance 1.7

Variable	Loading
L-R Dis	-.79

Factor No. 17, % Variance 1.6

Variable	Loading
Print Name	.45
Mk Acc-Err	.40

M-NP FACTORS

Factor No. 10, % Variance 2.7

Variable	Loading
Maz St-Touch	.71
L-R Dis	-.66
Maz St-Dur	.62

Factor No. 11, % Variance 2.3

Variable	Loading
Hor St-Touch	.58
Connor FDT	.54
Hor St-Dur	.53
Pr Disc RT	.46
Tap--Large	.40
Dowel Bal	-.38

M-NP FACTORS (cont.)

Factor No.	12
% Variance	2.3
Variable	**Loading**
Discrim TT	.62
Discrim RT	.60
F Tap--Short	-.57
Marble Bd	.37

Factor No.	14
% Variance	2.0
Variable	**Loading**
Sm Pt Dex	.70
Dynamom	-.63

Factor No.	15
% Variance	1.8
Variable	**Loading**
Rot Purs	.79

Factor No.	16
% Variance	1.6
Variable	**Loading**
Maz St-Time	.44
Dowel Bal	-.42

F-P FACTORS

Factor No.	9
% Variance	3.2
Variable	**Loading**
Mk Acc-Item	.85
Mk Acc-I-E	.84
Tap--Large	-.37

Factor No.	10
% Variance	3.0
Variable	**Loading**
H Self Clas	-.72
Discrim MT	.70
Discrim TT	.57
Aud MT	.47
Vis MT	.40

Factor No.	11
% Variance	2.8
Variable	**Loading**
Sq Mk-Err	.95
Sq Mk-TxE	.93
P Aim-TxE	.33
P Aim-Err	.33

Factor No.	12
% Variance	2.7
Variable	**Loading**
Connor FDT	.70
Mk Acc-Err	-.50
Pr Disc RT	.49
Maz St-Dur	.48
Deal Cards	.37
Maz St-Touch	.36

F-P FACTORS (cont.)

Factor No.	15
% Variance	1.9
Variable	**Loading**
Rot Purs	-.78
F Tap-Short	-.55
Discrim MT	.38
Tap-Large	.36

Factor No.	16
% Variance	1.7
Variable	**Loading**
Hd St-Hole	-.65
Hd St-Touch	.63
Hd St-Dur	.49
Dowel Bal	-.47

Factor No.	17
% Variance	1.6
Variable	**Loading**
Sm Pt Dex	.83
Dowel Bal	-.37

F-NP FACTORS

Factor No.	10
% Variance	2.9
Variable	**Loading**
P Aim-Err	.83
P Aim-TxE	.80
Discrim MT	.36

Factor No.	12
% Variance	2.3
Variable	**Loading**
Sq Mk-Err	.90
Sq Mk-TxE	.89

Factor No.	13
% Variance	2.0
Variable	**Loading**
Dynamom	-.79
Arm St-Touch	.36

Factor No.	14
% Variance	1.9
Variable	**Loading**
J Vis MT	.36
Sq Mk-Time	.40

Factor No.	15
% Variance	1.7
Variable	**Loading**
Pr Dis RT	.61
Minn RM	-.47

Factor No.	16
% Variance	1.5
Variable	**Loading**
Deal Cards	.58
Discrim MT	.50
Sm Pt Dex	-.38

Appendix C

In this appendix are the factors extracted in the factor analyses performed on the ratio scores (M-P/M-NP and F-P/F-NP).

M-P/M-NP FACTORS

Factor No.	1
% Variance	6.5
Variable	**Loading**
P Aim-Time	.90
Connor FDT	-.90
Arm St-Touch	.86
J Vis MT	.69
Aud RT	-.49

Factor No.	2
% Variance	5.8
Variable	**Loading**
J Vis RT	.79
Ver St Dur	.73
Maz St-Time	.71
Vis TT	.56
Sm Pt Dex	.53
Hand Pref	-.52

Factor No.	3
% Variance	5.4
Variable	**Loading**
Hor St-Touch	-.73
J Aud RT	.69
Aud TT	.61
J Aud TT	-.57
Aud RT	.56
Discrim RT	.41

Factor No.	4
% Variance	5.2
Variable	**Loading**
J Vis TT	.62
Marble Bd	.58
Ver St-Touch	.48
Mk Acc-Err	-.46
Sm Pt Dex	.40
J Aud MT	.37

Factor No.	5
% Variance	4.9
Variable	**Loading**
Sq Mk-Time	.77
Hd St-Dur	.70
Arm St-Hole	-.54
Hd St-Hole	-.49
Mk Acc-Err	.46
H Self Clas	.43

Factor No.	6
% Variance	4.7
Variable	**Loading**
P Aim-Err	.87
Sq Mk-TxE	.84
Vis MT	.79
P Aim-TxE	.41

M-P/M-NP FACTORS (cont.)

Factor No.	7
% Variance	4.6
Variable	**Loading**
Aud MT	-.72
Tap Sm-Time	.65
Tap Long-31	-.49
L-R Dis	.44
Sq Mk-Err	.40
P Aim-TxE	.39
Tap--Large	-.38
J Aud TT	.35

Factor No.	8
% Variance	4.3
Variable	**Loading**
Rot Purs	.71
Arm St-Dur	-.66
Maz St-Dur	.65
Ver St-Touch	.41
Arm St-Hole	.41

Factor No.	9
% Variance	4.1
Variable	**Loading**
Tap Sm-Err	-.89
Purdue PB	-.63
Maz St-Touch	.60
Mk Acc-Item	.53
Discrim RT	.41
Print Name	.37

Factor No.	10
% Variance	3.9
Variable	**Loading**
Ver St-Time	.80
Vis RT	-.76
Mk Acc-I-E	.43
Tap--Large	.39
Hor St-Dur	.38
Minn RM	.36

F-P/F-NP FACTORS

Factor No.	1
% Variance	7.3
Variable	**Loading**
Aud RT	.88
P Aim-TxE	-.86
P Aim-Err	-.80
Discrim RT	.72
Ver St-Touch	.42
Hd St-Touch	-.42
Hd St-Hole	.41
Pr Disc RT	-.37

Factor No.	2
% Variance	6.8
Variable	**Loading**
Print Name	.86
Discrim TT	-.84
Mk Acc-I-E	.67
Rot Purs	-.56
Marble Bd	-.55
Arm St-Dur	-.49
Tap Sm-Time	.37

F-P/F-NP FACTORS (cont.)

Factor No.	3
% Variance	5.4
Variable	**Loading**
Arm St-Hole	.81
Tap Sm-TxE	-.71
Dynamom	-.68
Hd St-Touch	.68
Tap Sm-Err	.45
Hd St-Hole	.39
Sq Mk-TxE	.36

Factor No.	4
% Variance	5.3
Variable	**Loading**
Discrim MT	.74
Mk Acc-Item	-.69
Sq Mk-Time	.61
Rot Purs	-.55
Tap--Large	.42
Hor St-Dur	.41
Mk Acc-I-E	.40

Factor No.	5
% Variance	5.1
Variable	**Loading**
Sq Mk-Err	.66
Sq Mk-TxE	.55
H Self Clas	.53
Purdue PB	-.38
Dynamom	-.37
Pr Disc RT	-.37
Sm Pt Dex	.37
Ver St-Time	-.37

Factor No.	6
% Variance	4.7
Variable	**Loading**
J Vis TT	-.76
Tap Sm-Err	.74
Deal Cards	-.73
Maz St-Time	.53
Grooved PB	.44
L-R Dis	.41
Purdue PB	-.37

Factor No.	7
% Variance	4.4
Variable	**Loading**
Hd St-Dur	-.84
Mk Acc-Err	.78
Tap Long-TT	.75

Factor No.	8
% Variance	4.2
Variable	**Loading**
Vis RT	.63
F Tap-Short	.50
Tap Long-31	-.48
Arm St-Dur	.43
J Aud RT	.43
Hor St-Touch	.41
Tap Sm-Time	.38

Factor No.	9
% Variance	3.8
Variable	**Loading**
Minn RM	-.84
J Vis MT	.68
Hor St-Dur	-.37

Factor No.	10
% Variance	3.7
Variable	**Loading**
Maz St-Touch	-.66
Vis TT	.60
Maz St-Dur	-.58
Hand Pref	.44
Vis MT	.42

Appendix D

The results of independent "t" comparisons performed between M-P and F-P (numerator = (F-P)-(M-P)) and between M-NP and F-NP (numerator = (F-NP)-(M-NP)) are reported here. Also included in this appendix are the means and standard deviations (S.D.) of each variable in the four groups. Reaction time tests are recorded in milliseconds.

	Female P		Male P		
Variable	Mean	S.D.	Mean	S.D.	"t"
J Aud RT	401.4	65.5	397.7	75.3	0.26
J Aud MT	342.7	74.9	299.1	69.7	3.02
J Aud TT	741.8	111.7	696.8	117.0	1.97
Vis RT	405.7	61.8	386.1	57.9	1.64
Vis MT	289.0	56.7	261.3	65.4	2.27
Vis TT	694.0	92.3	647.4	102.4	2.39
J Vis RT	464.4	71.4	458.1	81.6	0.41
J Vis MT	370.8	73.2	305.7	78.7	4.29
J Vis TT	835.2	109.2	763.8	120.8	3.10
Aud RT	337.3	44.8	335.8	61.2	0.15
Aud MT	268.2	48.6	258.9	56.6	0.88
Aud TT	599.5	68.3	594.7	94.6	0.29
Discrim RT	682.5	130.9	710.7	96.3	-1.23
Discrim MT	430.4	100.8	371.6	100.8	2.92
Discrim TT	1111.0	145.4	1082.3	134.9	1.02
Arm St-Touch	119.4	51.3	166.6	63.1	-4.10
Arm St-Dur	27.1	8.0	24.1	9.0	1.76
Arm St-Hole	13.6	1.8	12.5	2.0	2.68
Hd St-Touch	46.7	33.4	60.4	33.3	-2.04
Hd St-Dur	11.0	5.1	9.2	5.1	1.85
Hd St-Hole	17.2	1.0	17.1	1.1	0.66
Hor St-Touch	5.3	3.8	8.1	4.6	-3.32
Hor St-Dur	.9	.9	1.1	.9	-0.89
Hor St-Time	47.4	23.8	39.4	27.2	1.55
Ver St-Touch	4.6	3.7	7.4	5.2	-3.07
Ver St-Dur	.6	.6	.6	.5	-0.14
Ver St-Time	53.4	24.0	42.2	20.2	2.52
Maz St-Touch	12.9	7.4	18.0	9.7	-2.92
Maz St-Dur	2.0	1.2	2.0	1.4	-0.10
Maz St-Time	116.3	47.7	98.8	37.9	2.03
Purdue PB	89.2	8.1	91.7	6.9	-1.66
Minn RM	61.7	6.3	59.9	6.1	1.45
Sm Pt Dex	67.4	15.5	72.8	16.1	-1.69
Grooved PB	60.0	5.7	60.5	5.8	-0.43
Marble Bd	35.6	3.1	37.2	3.1	-2.67
Rot Purs	14.9	6.8	21.3	8.8	-4.12
Connor FDT	79.5	12.4	84.0	11.4	-1.89

Appendix D (cont. 1)

Variable	Female P Mean	Female P S.D.	Male P Mean	Male P S.D.	"t"
Sq Mk-Time	48.9	6.2	50.9	9.5	-1.27
Sq Mk-Err	3.0	4.8	4.2	5.1	-1.25
Sq Mk-TxE	121.6	111.4	148.9	115.2	-1.20
P Aim-Time	72.1	8.3	72.5	12.5	-0.23
P Aim-Err	2.0	2.5	3.9	5.7	-2.10
P Aim-TxE	141.4	80.5	198.8	179.3	-2.06
Pr Disc RT	74.4	13.1	71.6	17.2	0.92
Tap—Large	53.3	6.5	52.2	9.4	0.63
Tap Sm-Time	35.4	6.2	36.7	6.7	-1.00
Tap Sm-Err	.9	1.4	2.2	3.5	-2.50
Tap Sm-TxE	49.5	23.1	73.9	58.4	-2.75
Mk Acc-Item	124.4	24.0	122.8	32.6	0.27
Mk Acc-Err	4.8	10.2	6.8	11.3	-0.95
Mk Acc-I-E	119.5	24.0	116.0	31.0	0.64
L-R Dis	63.1	1.6	61.4	5.5	2.12
Hand Pref	18.6	3.0	19.3	1.8	-1.30
Dynamom	54.7	10.0	86.0	12.4	-13.90
Dowel Bal	6.4	4.4	16.1	14.0	-4.68
Deal Cards	24.7	5.3	22.7	6.0	1.88
Tap Long-TT	459.0	56.5	515.3	61.8	-4.75
Tap Long-31	209.0	35.8	233.7	37.0	-3.40
FTap-Short	100.6	11.8	111.3	12.4	-4.43
Print Name	9.7	2.0	10.2	2.1	-1.24
H Self Clas	44.6	14.5	50.3	15.9	-1.87

Variable	Female NP Mean	Female NP S.D.	Male NP Mean	Male NP S.D.	"t"
J Aud RT	406.5	69.5	395.7	77.8	0.73
J Aud MT	358.3	67.5	318.8	81.2	2.64
J Aud TT	762.7	103.2	714.5	124.5	2.11
Vis RT	409.6	75.2	386.8	66.1	1.62
Vis MT	290.9	66.1	267.3	77.8	1.63
Vis TT	700.5	118.2	656.0	115.8	1.90
J Vis RT	557.5	63.0	440.0	68.8	1.33
J Vis MT	380.4	76.1	313.5	76.6	4.38
J Vis TT	837.9	109.0	753.4	108.9	3.88
Aud RT	348.1	64.4	332.6	53.7	1.31
Aud MT	269.4	61.4	259.6	71.2	0.74
Aud TT	617.5	100.3	594.4	105.7	1.12
Discrim RT	651.2	106.0	698.0	106.4	-2.20
Discrim MT	444.3	92.3	380.4	100.7	3.30
Discrim TT	1095.5	118.5	1069.0	170.1	0.90

Appendix D (cont. 2)

Variable	Female NP Mean	Female NP S.D.	Male NP Mean	Male NP S.D.	"t"
Arm St-Touch	134.6	67.7	181.2	78.3	-3.18
Arm St-Dur	31.6	13.5	28.6	11.3	1.19
Arm St-Hole	12.7	2.4	11.8	2.0	1.90
Hd St-Touch	51.8	34.8	79.9	46.8	-3.41
Hd St-Dur	13.5	6.4	11.4	6.0	1.69
Hd St-Hole	16.6	1.4	16.2	1.6	1.24
Hor St-Touch	6.7	4.0	11.2	7.5	-3.77
Hor St-Dur	1.0	.7	1.2	.8	-1.39
Hor St-Time	50.6	24.6	46.5	45.1	0.57
Ver St-Touch	8.0	8.0	11.8	6.9	-2.51
Ver St-Dur	1.1	1.4	1.2	1.0	-0.47
Ver St-Time	61.6	33.7	44.1	20.5	3.14
Maz St-Touch	19.8	16.0	26.0	12.5	-2.15
Maz St-Dur	2.8	2.2	3.1	1.9	-0.61
Maz St-Time	131.3	55.5	113.6	53.5	1.63
Purdue PB	94.3	8.9	98.8	9.0	-2.52
Minn RM	58.4	6.3	57.9	6.4	0.38
Sm Pt Dex	88.8	24.4	86.6	15.5	0.52
Grooved PB	66.7	6.5	65.4	7.8	0.89
Marble Bd	37.8	3.5	39.5	3.8	-2.37
Rot Purs	11.3	6.0	17.8	7.6	-4.75
Connor FDT	87.2	14.5	89.6	11.5	-0.93
Sq Mk-Time	83.6	17.8	92.6	22.4	-2.23
Sq Mk-Err	12.6	12.3	19.5	14.6	-2.54
Sq Mk-TxE	597.2	460.0	964.5	646.5	-3.27
P Aim-Time	105.7	16.5	105.5	23.0	0.04
P Aim-Err	6.5	6.1	14.1	14.3	-3.45
P Aim-TxE	436.3	290.5	800.8	677.6	-3.50
Pr Disc RT	81.2	16.6	81.1	18.4	0.03
Tap--Large	61.3	11.7	58.7	10.8	1.17
Tap Sm-Time	52.5	11.1	54.6	12.3	-0.90
Tap Sm-Err	4.8	6.1	8.8	8.1	-2.81
Tap Sm-TxE	169.3	133.0	285.8	219.6	-3.21
Mk Acc-Item	81.3	19.4	78.3	25.0	0.66
Mk Acc-Err	11.3	11.9	16.4	16.9	-1.76
Mk Acc-I-E	69.9	19.1	62.3	17.7	2.07
L-R Dis	63.1	1.6	61.4	5.5	2.12
Hand Pref	2.7	3.9	1.9	2.9	1.09
Dynamom	49.5	8.3	80.8	14.9	-12.97
Dowel Bal	4.6	3.1	8.3	8.3	-2.97
Deal Cards	32.0	8.6	31.6	8.5	0.21
Tap Long-TT	404.2	46.1	463.7	54.8	-5.88
Tap Long-31	183.3	25.6	211.6	30.7	-5.01
FTap-Short	86.1	11.3	95.4	9.3	-4.52
Print Name	19.6	6.3	22.0	5.4	-2.02
H Self Clas	44.6	14.5	50.3	15.9	-1.87

Appendix E

The "t" tests for correlated samples that were performed on M-P vs. M-NP groups (numerator = (M-P)-(M-NP)) and F-P vs. F-NP groups (numerator = (F-P)-(F-NP)) are reported here. Also included in this appendix are the means of the differences (Mean) and the standard deviations of the differences (S.D.). Reaction time tests are recorded in milliseconds.

Female Comparisons

Variable	Mean	S.D.	"t"
J Aud RT	-5.1	36.6	-0.99
J Aud MT	-15.5	46.5	-2.36
J Aud TT	-21.0	59.5	-2.49
Vis RT	-3.9	48.7	-0.56
Vis MT	-1.8	37.5	-0.35
Vis TT	-6.5	63.3	-0.73
J Vis RT	6.9	53.4	0.92
J Vis MT	-9.6	42.8	-1.59
J Vis TT	-2.7	65.7	-0.29
Aud RT	-10.8	35.0	-2.18
Aud MT	-1.2	36.9	-0.22
Aud TT	-18.0	63.5	-2.00
Discrim RT	31.3	81.7	2.71
Discrim MT	-13.9	69.8	-1.41
Discrim TT	15.4	96.5	1.13
Arm St-Touch	-15.2	37.7	-2.84
Arm St-Dur	-4.5	9.5	-3.34
Arm St-Hole	.9	1.5	4.32
Hd St-Touch	-5.1	19.9	-1.80
Hd St-Dur	-2.4	5.7	-3.00
Hd St-Hole	.6	1.2	3.45
Hor St-Touch	-1.4	4.3	-2.28
Hor St-Dur	-0.1	1.0	-0.44
Hor St-Time	-3.2	9.9	-2.31
Ver St-Touch	-3.4	6.7	-3.63
Ver St-Dur	-0.5	1.0	-3.63
Ver St-Time	-8.2	22.3	-2.61
Maz St-Touch	-6.9	12.7	-3.83
Maz St-Dur	-0.8	1.7	-3.38
Maz St-Time	-15.0	18.2	-5.83
Purdue PB	-5.1	7.7	-4.71
Minn RM	3.3	5.3	4.39
Sm Pt Dex	-21.3	19.8	-7.60
Grooved PB	-6.7	5.6	-8.42
Marble Bd	-2.2	3.6	-4.26
Rot Purs	-3.6	5.1	4.98
Connor FDT	-7.7	15.8	-3.43

Appendix E (cont. 1)

Female Comparisons

Variable	Mean	S.D.	"t"
Sq Mk-Time	-34.7	16.5	-14.88
Sq Mk-Err	-9.6	9.6	-7.11
Sq Mk-TxE	-475.7	413.7	-8.13
P Aim-Time	-33.6	14.4	-16.49
P Aim-Err	-4.4	5.1	-6.18
P Aim-TxE	-294.9	264.6	-7.88
Pr Disc RT	-6.8	8.5	-5.66
Tap--Large	-8.1	7.3	-7.82
Tap Sm-Time	-17.1	8.6	-14.09
Tap Sm-Err	-3.9	5.3	-5.28
Tap Sm-TxE	-119.8	124.6	-6.80
Mk Acc-Item	43.1	16.1	18.89
Mk Acc-Err	-6.5	8.3	-5.55
Mk Acc-I-E	49.6	19.8	17.70
Hand Pref	16.0	6.6	17.17
Dynamom	5.2	6.1	6.03
Dowel Bal	1.9	2.9	4.57
Deal Cards	-7.3	11.2	-4.57
Tap Long-TT	54.9	51.4	7.54
Tap Long-31	25.7	30.1	6.04
FTap-Short	14.5	12.1	8.51
Print Name	-9.9	5.3	-13.28

Male Comparisons

Variable	Mean	S.D.	"t"
J Aud RT	2.0	45.9	0.31
J Aud MT	-19.7	39.8	-3.50
J Aud TT	-17.6	59.5	-2.10
Vis RT	-0.7	42.4	-0.11
Vis MT	-6.0	38.8	-1.10
Vis TT	-8.7	52.8	-1.16
J Vis RT	18.1	58.6	2.19
J Vis MT	-7.8	47.7	-1.16
J Vis TT	10.4	77.0	0.95
Aud RT	3.2	45.2	0.49
Aud MT	-0.7	42.3	-0.11
Aud TT	0.3	61.4	0.03
Discrim RT	12.8	78.1	1.16
Discrim MT	-9.0	70.9	-0.90
Discrim TT	13.3	122.9	0.77

Appendix E (cont. 2)

Male Comparisons

Variable	Mean	S.D.	"t"
Arm St-Touch	-14.5	37.4	-2.75
Arm St-Dur	-4.5	6.4	-4.97
Arm St-Hole	0.7	1.4	3.53
Hd St-Touch	-19.6	34.6	-4.00
Hd St-Dur	-2.2	5.0	-3.15
Hd St-Hole	0.8	1.5	3.99
Hor St-Touch	-3.1	7.0	-3.15
Hor St-Dur	-0.1	.7	-1.14
Hor St-Time	-7.0	37.8	-1.32
Ver St-Touch	-4.4	7.0	-4.46
Ver St-Dur	-0.6	1.0	-4.36
Ver St-Time	-1.9	8.8	-1.53
Maz St-Touch	-8.0	9.3	-6.10
Maz St-Dur	-1.0	1.2	-6.05
Maz St-Time	-14.8	26.6	-3.93
Purdue PB	-7.2	6.3	-8.09
Minn RM	2.0	4.6	3.03
Sm Pt Dex	-13.8	9.9	-9.88
Grooved PB	-4.9	6.6	-5.25
Marble Bd	-2.2	2.9	-5.38
Rot Purs	3.5	5.3	4.76
Connor FDT	-5.6	11.2	-3.53
Sq Mk-Time	-41.7	16.7	-17.63
Sq Mk-Err	-15.2	11.6	-9.28
Sq Mk-TxE	-815.7	579.9	-9.95
P Aim-Time	-32.9	15.5	-15.00
P Aim-Err	-10.2	11.0	-6.54
P Aim-TxE	-602.1	587.8	-7.24
Pr Disc RT	-9.5	8.5	-7.86
Tap--Large	-6.4	4.5	-10.03
Tap Sm-Time	-17.9	8.0	-15.80
Tap Sm-Err	-6.7	5.9	-7.98
Tap Sm-TxE	-211.9	188.9	-7.93
Mk Acc-Item	44.5	16.9	18.61
Mk Acc-Err	-9.6	13.2	-5.14
Mk Acc-I-E	53.7	20.0	18.99
Hand Pref	17.4	4.5	27.34
Dynamom	5.2	9.1	4.08
Dowel Bal	7.8	10.8	5.11
Deal Cards	-9.0	10.9	-5.81
Tap Long-TT	51.6	54.8	6.66
Tap Long-31	22.2	33.6	4.66
FTap-Short	15.9	13.9	8.09
Print Name	-11.8	4.8	-17.46