

The Measurement of Handedness

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A handedness scale consisting of 13 questionnaire items selected from those of D. Raczkowski, J. W. Kalat, and R. Nebes (1974, *Neuropsychologia*, 12, 43-47) was found to have high internal consistency for both males and females (coefficient $\alpha = .96$ for both sexes), high test-retest reliability ($r = .97$ for males and $.96$ for females), and a correlation of $.83$ with a behavioral measure of handedness. Males exhibited more nonfamilial, but not familial, left-handedness than did females. Self-description as strongly right-handed or as strongly left-handed predicted questionnaire handedness categorization better than did hand used for writing. © 1987 Academic Press, Inc.

Investigators of lateralized cerebral functioning often report their subjects' handedness. Their measures of handedness have been diverse and have included questionnaires, behavioral measures, and verbal self-report about hand preference or about the hand used for writing. The better known questionnaires include Oldfield's (1971) Edinburgh Inventory and the questionnaires of Annett (1970), Crovitz and Zener (1962), and Raczkowski, Kalat, and Nebes (1974). None of the authors of these scales reported the reliability or validity of their scale as a whole, although McMeekan and Lishman (1975) have reported reliability data for Annett's (1970) scale and the Edinburgh Inventory (1971). The present paper examines the internal consistency, test-retest stability, and validity of a questionnaire measure of handedness that consists of 13 items selected from the 23 items of Raczkowski et al. (1974). The present paper also compares the questionnaire with two briefer indices of handedness.

As a starting point for the investigation, we chose the 14 handedness questionnaire items for which, in our judgment, the published reliability and validity data are most convincing. These are the 14 items for which

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Raczkowski et al. (1974) found that percentage agreement between a first and second administration was 93% or above, as was agreement between the questionnaire item and hand preference on a performance test. The same or similar versions of 10 of these 14 items appear on the 20-item Edinburgh Inventory (1971), 8 appear on Annett's (1970) 12-item questionnaire, and 8 appear on Crovitz and Zener's (1962) 14-item questionnaire.

The instructions for the Raczkowski et al. questionnaire ask subjects whether they perform each of several specific activities with the left hand, the right hand, or both. We found in preliminary testing that some subjects misinterpreted the term *both* to mean with the two hands simultaneously. Therefore we replaced the term *both* with *either*. The final version of our questionnaire appears in Table 1.

The questionnaire was administered to 1442 female and 1489 male college students who were enrolled in the introductory psychology course at the University of Wisconsin. The point-biserial item-scale correlations, broken down by sex, are shown in Table 2. All of the items except Items 3 and 14 yielded item-scale correlations of .64 or greater for both males and females. Item 3, which asks which hand the subject uses to remove the top card of a deck of cards in dealing, was difficult for some subjects who said that they were not sure which hand they used. Our data concerning this item are consistent with Annett's (1970) finding that it had only a modest consistency with performance on other items. Consequently, we dropped Item 3. The data for Item 14, which asks on which shoulder

TABLE 1
HAND USAGE QUESTIONNAIRE

Please indicate below which hand you ordinarily use for each activity.			
With which hand do you:			
1. draw?	1. Left	2. Right	3. Either
2. write?	1. Left	2. Right	3. Either
3. remove the top card of a deck of cards (i.e., dealing) ^a	1. Left	2. Right	3. Either
4. use a bottle opener?	1. Left	2. Right	3. Either
5. throw a snowball to hit a tree?	1. Left	2. Right	3. Either
6. use a hammer?	1. Left	2. Right	3. Either
7. use a toothbrush?	1. Left	2. Right	3. Either
8. use a screwdriver?	1. Left	2. Right	3. Either
9. use an eraser on paper?	1. Left	2. Right	3. Either
10. use a tennis racket?	1. Left	2. Right	3. Either
11. use a scissors?	1. Left	2. Right	3. Either
12. hold a match when striking it?	1. Left	2. Right	3. Either
13. stir a can of paint?	1. Left	2. Right	3. Either
14. On which shoulder do you rest a bat before swinging?	1. Left	2. Right	3. Either

^a This item is omitted in the final form.

TABLE 2
ITEM-SCALE CORRELATIONS FOR THE 14-ITEM QUESTIONNAIRE

Item	Females ($N = 1442$)	Males ($N = 1489$)
1	.89	.87
2	.89	.87
3	.56	.50
4	.75	.68
5	.79	.82
6	.86	.83
7	.77	.71
8	.80	.70
9	.72	.75
10	.78	.81
11	.68	.69
12	.70	.71
13	.68	.64
14	.55	.44

the subject rests a bat before swinging, was retained since no subjects reported an inability to answer it. The modified 13-item questionnaire had a coefficient α internal consistency reliability of .96 for males (as compared to .96 for the 14-item scale) and .96 for females (as compared to .95 for the 14-item scale).

The 13-item questionnaire was administered in groups to an additional 2786 male and 3039 female college students. Each item was scored as "1" for right, "2" for either, or "3" for left. This scoring yielded a total score that could range from 13 (completely right-handed) to 39 (completely left-handed). The distribution of obtained scores is shown in Table 3. As can be seen there, the distribution is fairly continuous and is *J*-shaped. Whereas Annett (1970) chose to designate as right-handed only those subjects who reported a preference for the right hand on every item in her questionnaire, we prefer to use the term in its more conventional sense to designate subjects who are predominantly right-handed. Accordingly, we include as right-handed those subjects who answered most, but not necessarily all, of the items in the right-handed direction. The cutting points for designating subjects as right-handed, left-handed, or ambilateral are necessarily arbitrary. Usage of these terms varies immensely. Porac and Coren (1977, p. 4) reported that estimates of the incidence of right-handedness have ranged from 80% to 95%. Most of the estimates were based, however, on a dichotomization of persons as left-handed or right-handed, rather than allowing for an ambilateral category. Because we do use an ambilateral category, we decided to choose a cutting point for right-handedness that yields a percentage near the low end of the range. We designated as right-handed those subjects with

TABLE 3
PERCENTAGE OF MALES AND OF FEMALES WITH EACH HANDEDNESS SCORE

Score	Female (<i>N</i> = 3039)	Male (<i>N</i> = 2786)
13	65.84	57.07
14	5.03	7.32
15	6.19	9.19
16	3.72	3.55
17	3.16	3.52
18	1.71	2.91
19	1.71	2.15
20	0.76	1.26
21	0.99	1.26
22	0.53	0.54
23	0.66	0.47
24	0.20	0.39
25	0.53	0.54
26	0.33	0.39
27	0.53	0.61
28	0.13	0.32
29	0.33	0.54
30	0.23	0.25
31	0.69	0.47
32	0.53	0.32
33	0.69	0.50
34	0.30	0.54
35	1.35	1.11
36	0.46	0.18
37	1.61	1.90
38	0.30	0.29
39	1.51	2.40

scores of 13 to 17, which included 82.4% of our sample. We wished to use a slightly broader range of scores for left-handedness because left-handed people are less consistent than right-handed people in their handedness (Porac & Coren, 1977). We designated as left-handed subjects with scores of 33 to 39, which included 6.6% of our sample. There remained for the ambilateral category those subjects with scores from 18 to 32, or 11.0% of the sample.

TEST-RETEST RELIABILITY

A group of 266 subjects completed the questionnaire a second time about 6 weeks after the first testing. The test-retest reliability was .97 for males (*N* = 79) and .96 for females (*N* = 187). In interpreting these and other correlation values in this paper, one should bear in mind that the *J*-shaped distribution of handedness scores is expected to yield higher correlation values than would a normally distributed measure.

THE BEST SINGLE ITEM

Annett (1970) found the item concerning hand used "to hammer a nail into wood" the best single item in her scale as measured by consistency with other items. Table 2 shows that among our subjects the hammer item ranked third in item-scale correlation, being edged out by the items for writing and drawing. Perhaps the better relative showing for the writing and drawing items in our data compared to Annett's data reflects the fact that our subjects learned to write and draw during a period in which school children were less often required, as a matter of educational policy, to use their right hand for these activities.

Investigators often identify handedness merely by asking for the hand used for writing. Table 4 shows the relationship between our writing item and handedness categorization using total score on our questionnaire. The data do not strongly support using report of this single behavior to identify handedness. Among those who write with their right hand, almost none are left-handed on our questionnaire and among those who write with their left-hand, none are right-handed, but substantial percentages of both groups are ambilateral.

COMPARISON OF MALE AND FEMALE SUBJECTS ON HANDEDNESS

Porac and Coren (1977), in reviewing the literature on gender differences in handedness, reported that many investigators have found more left-handedness among males than among females. Porac and Coren concluded that findings of no sex difference in other studies probably reflected restricted sample sizes. Accordingly, since our sample was very large, we expected to find sex differences.

The male subjects as a group received slightly higher handedness scores ($M = 16.25$) than did the females ($M = 15.83$), that is, the males scored a bit more in the left-handed direction, $t = 2.55$, $p = .01$. The males were also less often labeled right-handed (80.6% for males and 83.9% for females), $\chi^2(1) = 10.60$, $p < .001$. The percentage of subjects who

TABLE 4
RELATIONSHIP OF ITEM ON HAND USED FOR WRITING WITH TOTAL SCORE ON QUESTIONNAIRE

Hand used for writing	N		Questionnaire					
			Right		Ambilateral		Left	
	M	F	M	F	M	F	M	F
Right	1306	1278	89.7	94.9	10.2	5.1	0.1	0
Either	12	12	8.3	16.7	91.7	83.3	0	0
Left	169	149	0	0	38.5	40.3	61.5	59.7

scored 33 and above on the test, and hence were designated left-handed, was similar for the two sexes (6.9% for males and 6.2% for females), $\chi^2(1) = 1.08$, n.s. The largest sex differences were in the number of subjects who reported themselves as completely left-handed or completely right-handed, that is, as using the same hand for all 13 activities. More females than males reported themselves as completely right-handed (65.8% for females and 57.1% for males), $\chi^2(1) = 46.94$, $p < .001$, and more males than females reported themselves as completely left-handed (2.4% for males and 1.5% for females), $\chi^2(1) = 5.61$, $p < .05$. Bryden (1977) has speculated that earlier questionnaire findings of a greater propensity toward either non-right-handedness or left-handedness in males than in females might simply reflect a response bias. He suggested that males are less likely to choose extreme categories so that, in the case of handedness, they more often claim to be ambilateral rather than right-handed or left-handed. The present finding of more frequent complete left-handedness (left-handed on all items) in males than in females is not subject to this interpretation because such a bias in males would reduce, rather than increase, the number of subjects who score as completely left-handed.

Bakan (1971) has suggested that the higher rate of left-handedness in males than in females is due to the elevated incidence of early brain injury at birth for males, and he has made clear elsewhere (Bakan, 1973) that he extends this theory to ambilaterality as well as left-handedness. Bakan's contention is that everyone is naturally right-handed, but that some persons shift to use of the left hand as the result of early damage to the portion of the left hemisphere that controls the right hand. If, unlike Bakan, one should accept the existence of some "natural" left-handers, one would expect that a portion of them would similarly shift to right-handedness as a result of brain damage. However, as Satz (1972) has pointed out, since "natural" right-handedness is far more common than "natural" left-handedness, brain damage should be responsible for much more left-handedness than right-handedness. It follows that if brain damage should be the explanation of much non-right-handedness, one would expect the excess of non-right-handedness among males to be entirely nonfamilial.

To gain some tentative evidence on whether non-right-handedness is familial or nonfamilial, we used a questionnaire to ask each of 2113 male and 2265 female subjects about left-handedness in their mothers, fathers, brothers and sisters, and other blood relatives. Those non-right-handed (either ambilateral or left-handed) subjects who reported at least one left-handed, first-degree relative were considered to be familial non-right-handed, and those who reported having no left-handed relatives of either first or second degree were considered to be nonfamilial. Those non-

TABLE 5
FAMILIAL AND NONFAMILIAL NON-RIGHT HANDEDNESS AMONG MALES AND FEMALES

	N	Right	Nonright		
			Familial	Nonfamilial	Indeterminate
Males	2113	80.9%	8.2%	7.8%	3.1%
Females	2265	84.5%	7.3%	4.6%	3.6%

right-handed subjects who reported only second-degree, left-handed relatives were considered indeterminate and were omitted from the analysis. We tabulated the incidence of right-handedness and of familial, nonfamilial, and indeterminate non-right-handedness. The data are presented in Table 5. It appears that the more frequent non-right-handedness of males was almost entirely due to nonfamilial cases. The difference between the two sexes on relative frequency of familial and nonfamilial non-right-handedness was significant, $\chi^2(1) = 5.64$, $p < .05$. One reason for reservation concerning the finding is uncertainty concerning the validity of the subjects' reports of handedness in their family members.

THE VALIDITY OF THE QUESTIONNAIRE

A behavioral test of handedness was used to assess the validity of the 13-item questionnaire. Each of 53 subjects was asked to perform the following 10 tasks.

1. Sign his or her name
2. Unscrew the lid of a jar
3. Bounce a ball
4. Shoot a marble
5. Cut with a scissors
6. Strike a match
7. Thread a needle
8. Hammer a nail
9. Turn a screw with a screw driver
10. Stir a glass of water with a rod

This behavioral test was administered about 8 weeks after the paper-and-pencil questionnaire.

As with the 13-item paper-and-pencil questionnaire, scores of "1" and "3" were given for right-handed and left-handed performance, respectively. The rare subject who alternated in using the two hands was scored "2" for that item. The correlation between the paper-and-pencil questionnaire and the behavioral handedness test was .83.

THE RELATIONSHIP OF SELF-CATEGORIZATION OF HANDEDNESS TO SCORE ON THE HANDEDNESS QUESTIONNAIRE

Many investigators, especially those who study hemispheric laterality, have categorized their subjects on handedness using only the subjects' self-descriptions as left-handed or right-handed, but this practice is often dismissed by other researchers as invalid (Benton, Meyers, & Polder, 1962; Crovitz & Zener, 1962; Provins & Cunliffe, 1972; Satz, Achenbach, & Fennell, 1967). We used a slightly more elaborate single item and examined its relationship to handedness as indicated by the questionnaire. Each of 2774 male and 3035 female subjects was asked to describe herself/himself as left-handed or right-handed, using the following item.

Which description best applies to you? (Circle one)

1. Right-handed and strongly so
2. Right-handed but only moderately so
3. Left-handed but only moderately so
4. Left-handed and strongly so

Table 6 gives the percentage of subjects designated as right-handed, ambilateral, or left-handed by the handedness questionnaire for each of the above self-descriptions. Those subjects who called themselves right-handed (the strongly right-handed or moderately right-handed) were mostly, but not always, right-handed according to the questionnaire (91.1% for male, 94.2% for female), but only a little more than half of those who called themselves left-handed (either strongly or moderately so) were left-handed according to the questionnaire (male, 60.3%; female, 57.3%). These findings support the widespread skepticism concerning the usefulness of merely asking subjects their handedness. Yet, the item appears more promising for subjects who label themselves as strongly right-handed or strongly left-handed. The self-labeled strongly right-handed subjects were almost entirely right-handed on the questionnaire (98.8% female and

TABLE 6
PERCENTAGE OF QUESTIONNAIRE HANDEDNESS FOR EACH CATEGORY OF SELF-LABELED HANDEDNESS

Self-labeled	N		Questionnaire					
			Right		Ambilateral		Left	
	M	F	M	F	M	F	M	F
Strongly right	1719	2132	96.9	98.8	3.1	1.2	0.1	0
Moderately right	738	573	77.6	77.0	22.2	23.0	.2	0
Moderately left	137	155	2.9	1.3	66.4	69.0	30.7	29.7
Strongly left	180	175	0	0	17.2	18.3	82.8	81.7

96.9% male). Investigators who wish to select only right-handed subjects from a larger group would apparently not err badly by using this single question if they choose those subjects who label themselves as strongly right-handed. The self-labeled strongly left-handed are uniformly non-right-handed according to the questionnaire but are less often left-handed (81.7% female and 82.8% male).

CONCLUSIONS

This 13-item questionnaire has high reliability, in the sense of internal consistency, and high test-retest reliability, as well as a strong relationship to a behavioral handedness test. The single item of hand used for writing almost never errs by labeling right-handers as left-handed, or vice versa, but does mislabel substantial numbers of ambilateral subjects as left- or right-handed. A single four-choice self-labeling item does better at identifying handedness than does hand used for writing when only the self-labeled strongly right-handed and strongly left-handed subjects are considered. When greater accuracy in measuring handedness is needed, both of these single items are inadequate and the use of the full questionnaire is recommended.

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