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ABSTRACT

Applied classical measurement theory was used to study the measurement characteristics of Forms A and B of the Finding Embedded Figures Test (FEFT) when the test is administered in a "no-guessing" or "supply" format. Data provided by 69 students at a private university in the southern United States were used. Both forms of the FEFT were administered in counterbalanced order to different subjects; 36 subjects completed Form A, and then Form B. Specifically, the study was designed to compare: (1) the alpha coefficient reliabilities of data from the two administration formats; (2) test and item difficulty data across administration methods; and (3) corrected item-total correlation of discrimination coefficients across test administrations. Results are contrasted with those of a previous study involving a multiple-choice "selection" format administration of the FEFT to 302 subjects. The alpha correlation associated with scores of the 69 subjects on Form A was 0.66 and that for Form B was 0.83. In terms of test difficulty, Form A scores ranged from 16 through 32, and Form B scores ranged from 13 through 34. Form A items were more likely to behave differently across administration formats. Both the selection- and supply-format administrations of each form had positive discrimination coefficients. The two FEFT forms provide data with reasonable reliability and psychometric integrity. The FEFT may assist researchers who want to use a selection format to measure field independence. (TJH)

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MEASUREMENT CHARACTERISTICS OF A "NO-GUESSING" ADMINISTRATION OF HE FINDING EMBEDDED FIGURES TEST--RESEARCH EDITION

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ABSTRACT

The study applied classical measurement theory to investigate the measurement characteristics of both forms of the Finding Embedded Figures Test, when the test is administered in a "no-guessing" or "supply" format. Analysis was based on data provided by 69 subjects. Results are contrasted with those in a previous study involving a multiple choice "selection" format administration of the FEFT to 302 different subjects, and suggest that the two FEFT forms provide data with reasonable psychometric integrity.

In the years immediately following World War II, Herman A. Witkin and his colleagues performed a series of historically important studies (e.g., Witkin, 1949) involving stylistic variations in perceptions of visual stimuli. These initial studies investigated variations in ability to perceive the upright in the absence of normally-available orienting stimuli. Witkin, Moore, Goodenough and Cox (1977, pp. 3-4) present photographs of the apparatuses used in these early "rod-and-frame" and "body-adjustment" tests. Heesacker (1981) presents a summary of the early years of this important research, and of the antecedents of the work dating back to the previous century (Jastrow, 1892).

Witkin's early work led to the development of the theory of psychological differentiation and the delineation of a cognitive style that has come to be called field independence/dependence (Goodenough & Witkin, 1977, pp. 2-3). As Witkin (1979, p. 359) explains,

> We designate the tendency to rely on the self as a primary referent in information processing as a field-independent mode of functioning and the tendency to rely on external referents as a field-dependent mode of functioning. These tendencies find widespread expression in an individual's perceptual, intellectual, and social activities.

Persons who tend to operate on the field independence (FI) end of this cognitive style continuum tend to perceive themselves as more segregated from their environments; these persons tend to be more analytical in their abilities and interests.

Persons who tend to operate on the field dependence (FD) end of the continuum, on the other hand, tend to be less able either to distinguish among or to reorganize stimuli. More field dependent persons also tend to be more social in their abilities and interests. Thus, more field-dependent persons have a greater preference to be with people (Bard, 1972; Coates, Lord & Jakobovics, 1975) and may be more popular with their peers (Wong, 1976). Similarly, more field-dependent persons may be more attentive to social cues (Eagle, Goldberger & Breitman, 1969; Fitzgibbons & Goldberger, 1971; Ruble & Nakamura, 1972) and may even prefer to be physically closer to other people (Holley, 1972; Justice, 1969). In summary, as Jacobs and Gedeon (1982, p. 19) explain,

> Field independent persons are those who tend to process information with greater isolation from their environment. Thus, they have been shown to have less sensitivity to social cues and less developed interpersonal skills; they tend to process information more analytically since parts of their environment are more apparent to them.

Field independence is the most researched of the 19 cognitive styles that have been identified (Goldstein & Blackman, 1978; Messick, 1976). For example, a comprehensive bibliography of studies involving the field-independence construct cites several thousand studies (Cox & Gall, 1981). Various researchers (cf. Doebler & Eicke, 1979, p. 226; Donlon, 1977, p. 1; Laosa, 1978, p. 3; Witkin, Moore, Goodenough & Cox, 1977, p. 1) concur

that the construct of field-independence has stimulated great interest:

> Field dependence/independence has been studied extensively for over three decades... Of all the cognitive styles it is by far the most well-researched and has the greatest application potential to educational problems... This is clearly no overnight product of some academic fad. (Rasinski, 1983, p. 1)

Numerous studies indicate that field-independence has noteworthy associations with myriad outcomes; several reviews of these studies are available elsewhere (cf. Goodenough, 1976; Goodenough & Witkin, 1977; Melancon & Thompson, 1987; Witkin, Moore, Goodenough & Cox, 1977). However, the general tenor of these diverse findings can be gleaned by considering a few of the many available citations. Field-independence has been found to be related to marital satisfaction (Sabatelli, 1982); to vocational choice (Witkin, Moore, Oltman, Goodenough, Friedman, Owen & Raskin, 1977); to general academic achievement during elementary school years (Wicker, 1980) and in certain cases in older subject groups (Donnarumma, Cox & Beder, 1980); to problem-solving abilities (Ronning, McCurdy & Ballinger, 1984); to concept-learning abilities (Stasz, Shavelson, Cox & Moore, 1976); and to performance in specific subject areas such as art (Copeland, 1983), engineering graphics (Wilson & Davis, 1985), and reading (Pitts & Thompson, 1984; Spiro & Tirre, 1979). Field-independence also affects reaction to different instructional interventions and conditions (cf. Bolocofsky, 1980; Frank & Davis, 1982;

Jolly & Strawitz, 1984; Paradise & Block, 1984; Renninger & Snyder, 1983; Saracho, 1980).

Witkin and his colleagues eventually discovered that the ability to perceive the upright was associated with the ability to disembed or locate target figures hidden in a stimulus field. Thus, perceptual disembedding tasks have frequently been used in research "in place of the rather complex gadgets required for some of the early laboratory tests of field-dependence-independence" (Witkin, Moore, Goodenough & Cox, 1977, p. 7). Cox and Gall (1981, p. 5) cite 16 measures that have been employed with varying frequency to measure aspects of perceptual disembedding ability. Campbell and Donlon (1980) report initial development of a disembedding measure that was administered to 12,681 adults as part of a GRE administration.

However, the most frequently used measures have been the Preschool Embedded Figures Test (PEFT) (Coates, 1972), the Children's Embedded Figures Test (CEFT) (Witkin, Oltman, Raskin & Karp, 1971), and the Group Embedded Figures Test (Witkin, Oltman, Raskin & Karp, 1971). The Group Embedded Figures Test (GEFT) has been frequently used, in part because the measure has exceptional psychometric integrity even when evaluated by sophisticated measurement theory such as generalizability theory (Thompson & Melancon, 1987b), or when used with children (Thompson, Pitts & Gipe, 1983).

Although the GEFT has proven to be a very useful measure of aspects of field independence, the measure does have some limitations. The primary limitation is that the GEFT employs a

"supply" format in which subjects literally draw on the target figure embedded within a stimulus. As Donlon (1977, pp. 1-2) notes, "From the standpoint of a large-scale administration, however, the GEFT has the drawback of requiring trained personnel to score each item."

Melancon and Thompson (1987) present in detail the first phase of development of a multiple-choice perceptual disembedding measure, the Finding Embedded Figures Test (FEFT). The FEFT (Thompson & Melancon, 1987a) was developed to provide a multiple-choice, machine-scoreable measure of perceptual disembedding or restructuring as an alternative to supply-format tests such as the GEFT. A multiple-choice test avoids difficulties associated with supply-format requirements for use of scorers and concerns about interrater reliability. However, for those desiring a supply-format administration, the FEFT can be administered in either a selection or a supply administration mode.

A five-choice item response format was selected for use on the Finding Embedded Figures Test (FEFT) in order to maximize "true" test length and reliability (Thompson & Levitov, 1985, pp. 164-165). Form A and Form B of the FEFT each consist of 35 items, although 15 items are common or linking items that can be used for test equating or to evaluate the attentativeness and motivation of individual subjects who complete both FEFT forms (Melancon & Thompson, 1987). Each item presents a target figure which is located in only one of the five response alternatives. In the "supply" administration format, subjects respond to each item by indicating the letter code for the response alternative containing the target. In the "selection" format administration,

used in the present study, subjects locate the response alternative shape containing the target stimulus, and are then required to trace the target within the response alternative.

There were several reasons for interest in results from a supply-format administration of the FEFT. Theoretically, tests have "floors" at a "chance score" level, and these floors affect true test length (Thompson & Levitov, 1985). For example, Form A of the FEFT consists of 35 items, each with five response alternatives. In a selection-format administration, the theoretical "floor" score that is expected for the person who simply guesses each answer is 7.0 (35/5), and the theoretical test length is 28.0 (35 - 7.0). In a supply-format administration, the theoretical "floor" score is zero, since guessing should not affect performance, and the true test length is 35.0. These dynamics might make data from a supply-format administration more variable and more reliable than data from a selection-format administration.

Thus, the present study was conducted to determine the psychometric properties of the FEFT forms when a supply-format administration was used, and results were compared with those from a previous study (Melancon & Thompson, 1988, 1989) in which 302 subjects completed the FEFT in a selection-format administration. Three questions were posed in the present study. First, how do the alpha coefficient reliabilities of data from the two administration formats compare? Second, how do test and item difficulty data compare across administration methods? And third, how do corrected item-total correlation or discrimination

coefficients compare across administrations?

Method

Subjects

Subjects (n=69) in the present study were students enrolled in mathematics courses at a private university in the southern United States. The mean age of the subjects was 20.04 (SD=3.12). A somewhat larger proportion (60.9%) of subjects were were females. The two FEFT forms were administered in counterbalanced order to different subjects; 36 (52.2%) of the subjects completed Form A and then FEFT Form B.

For comparative purposes, it should be noted that the subjects (n=302) in the previous study (Melancon & Thompson, 1988, 1989) who completed the FEFT in a selection-format administration were also students enrolled in mathematics courses at the same university, although the two studies involved different students. In the previous study, slightly more students (52.7%) were males than were females. The mean age of the students in the previous study was 19.52 (SD=3.06).

Results

The study's first research question involved the reliability of FEFT test scores. In a previous study (Melancon & Thompson, 1989), some of the 302 subjects completed both FEFT forms, some subjects completed the GEFT and FEFT Form A, and some subjects completed the GEFT and FEFT Form B. Cronbach's alpha for the 225 out of 302 subjects who completed FEFT Form A was 0.81. Cronbach's alpha for the 232 out of the 302 subjects who completed FEFT Form B was also 0.81.

In the present study, the alpha coefficient associated with the scores of the 69 subjects on Form A was 0.66. The alpha coefficient for Form B scores was 0.83. Table 1 presents the alpha coefficients for combined FEFT forms across both the previous study (Melancon & Thompson, 1989) and the present study.

INSERT TABLE 1 ABOUT HERE.

The study's second research question involved test and item difficulty data. In the previous study (Melancon & Thompson, 1989) involving a selection-format administration, Form A FEFT scores ranged from 10 through 35, inclusive (M=25.18, SD=5.41). Form B FEFT scores ranged from 8 through 34, inclusive (M=23.60, SD=5.51). In the present study, Form A FEFT scores ranged from 16 through 32, inclusive (M=26.61, SD=3.79). Form B FEFT scores ranged from 13 through 34, inclusive (M=23.29, SD=5.53).

Tables 2 and 3 present item difficulty coefficients across the two administration formats, and the rank orders for these "proportion correct" (P) statistics for each item. The table also presents the means of these item statistics and the standard deviations for the estimates. The Pearson r for the P values for the 35 items on Form A, across the two administration formats, was +0.34, while Spearman's rho for the same comparison was +.36. For Form B, the Pearson r for the P values for the 35 items, across the two administration formats, was +0.68, while Spearman's rho for the same comparison was +.71.

INSERT TABLES 2 AND 3 ABOUT HERE.

The study's third research question involved item-score-to-

total-test-score correlation coefficients, sometimes referred to as discrimination coefficients. These values also were presented in Tables 2 and 3 for both test forms, as are the means for these statistics. The table column titled "Corrected IxTot A [or B] r" presents the bivariate correlation coefficients between item scores ("0" or "1") of the 69 subjects on the 35 FEFT items for a given form with total test scores (potentially "0" through "34") on all 35 items excluding the item being evaluated in a given calculation. The table column titled "Corrected IxTotal r" presents the bivariate correlation coefficients between item scores ("0" or "1") of the 69 subjects on the 70 FEFT items from both forms with total test scores (potentially "0" through "69") on all 70 items excluding the item being evaluated in a given calculation. The table column headed "Corrected IxT Sel r" presents classical item discrimination coefficients from the selection-format administration (n = 225 or 232); these coefficients are directly comparable to those presented in the "Corrected IxTot A [or B] r" column for the 69 subjects who completed the supply-format administration. Finally, the tables present the "Validity Coef r" coefficients for the subjects (70 or 77) in the selection-format administration who completed both the GEFT and either FEFT form; the table column presents the correlation coefficients between item scores ("0" or "1") and total scores (potentially "0" to "52") on all other 34 FEFT form items and the 18 GEFT items.

Discussion

The present study focused, respectively, on the reliability,

the test and item difficulty, and the item discrimination coefficients for the two forms of the Finding Embedded Figures Test (FEFT) (Thompson & Melancon, 1987a). Results were compared across studies involving selection-format administration of the FEFT to 302 undergraduate students (Melancon & Thompson, 1988, 1989) and a supply-format administration of the FEFT to 69 undergraduate students.

In the previous selection-format administration of the FEFT, both FEFT forms had alpha reliability coefficients of 0.81. In the present supply-format administration the alpha coefficient for Form A was 0.66, while for Form B the coefficient was 0.83. As reported in Table 1, in both studies the combined forms had alpha coefficients of between 0.83 and 0.90.

One psychometric view characterizes reliability as the ratio of systematic variance to total variance. Many factors affect score variance. For example, tests with more items can yield scores that are more variable and that thus may be more reliable. In the present study, two competing influences may have affected test reliability.

The use of a supply-format administration theoretically made the test "longer", and should yield higher reliability coefficients. Theoretically, the supply-format administered test form was seven items longer than the selection-format administration, as explained previously. However, the numbers of subjects and the variability of subject aptitudes also affect reliability. Thus, the use of 69 rather than of several hundred subjects may have constrained reliability estimates. In any case,

the results of all these analyses suggest that the use of the combined test forms insures acceptable reliability for interpreting FEFT scores.

With respect to item difficulty (P) statistics, reported in Tables 2 and 3, P values tended to be more comparable across administration formats for Form B items (r=.68; rho=.71) than for Form A items (r=.34; rho=.36). Taken together with reliability results, this finding suggests that Form A items were more likely to behave differently across administration formats.

One purpose of the supply-format administration employed in the present study was to identify correct item choices which subjects selected, but which were selected by incorrect identification of the target within the shape in which the target was actually located, where the target was located in a position different than that isolated by the subjects. Such items will tend to lower reliability because in a selection-format administration subjects will receive credit for correct responses actually based on invalid rationale. Examination of the few such occurences led to minor modifications in correct choice stimuli for three items unique to Form A (5, 9, and 27), two items unique to Form B (2 and 17), and three linking items (A7-B6, A10-B11, and A15-B17).

The study's third research question involved the item discrimination coefficients for the FEFT items presented in Tables 2 and 3. In both the selection-format and supply-format administrations both forms tended to have positive discrimination coefficients. However, in the supply-format administration two items (5 and 19) had negative discrimination coefficients when

both within-set "Corrected IxTot" Form A discrimination coefficients or "Corrected IxTotal r" item-with-combined-forms-FEFT-scores correlations were consulted. This result partially explains the lower reliability coefficient produced for the supply-format administration of FEFT Form A, although the fact that all subjects correctly answered two Form A items (3 and 23) also was doubtless a contributing factor.

Perusal of Tables 2 and 3 suggests that items with less desirable discrimination coefficients, i.e., small or negative coefficients, tended to be disproportionately easy, reflected in larger P values. This result suggests that administration of the FEFT forms to less able subjects might yield smaller P values, larger item discrimination coefficients, and larger reliability coefficients. Thus, the FEFT forms may be appropriate for use with subjects who are not yet in college. This possibility is being explored in ongoing research.

In summary, field independence is an important cognitive style that has been shown to explain impressive amounts of variation in diverse phenomena. The results of the present study, taken together with those of previous studies (Melancon & Thompson, 1988, 1989), suggest that the combined FEFT forms provide reasonably reliable and psychometrically sound data. Thus, the FEFT may be useful in investigations in which researchers are interested employing a selection-format measure of field independence.

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Table 1
Alpha Coefficients for Combined FEFT Forms

Item Set	Items	Select r[a]	Supply r[b]
Non-linking items from both Form A and Form B	40	.84	.83
35 Form A items and 20 non-linking Form B items	55	.88	.84
35 Form B items and 20 non-linking Form A items	55	.88	.85
All 70 items from both Form A and Form B	70	.90	.86

a
n = 155

b
n = 69

Table 2
FEFT Form A Item Statistics

Item	Supply Format (n=69) P		Corrected IxTot A r		Corrected IxTotal r		Selection Format (n=225/70) P		Corrected IxT Sel r		Validity Coef r	
33	.522	31	.290	11	.394	1	.733	21	.232	29	.370	9
31	.725	24	.351	6	.392	2	.773	14	.329	13	.270	14
28	.899	11	.451	1	.384	3	.760	16	.298	17	.018	34
34	.638	28	.357	5	.380	4	.836	8	.299	16	.270	15
13	.768	21	.388	2	.371	5	.671	25	.408	3	.402	5
8 L04	.652	27	.322	8	.355	6	.756	17	.268	22	.118	30
35	.884	13	.384	3	.330	7	.862	5	.154	34	.277	13
16 L09	.899	12	.234	14	.303	8	.800	12	.328	14	.293	12
20 L11	.710	25	.292	10	.298	9	.636	30	.389	5	.201	22
25	.841	16	.310	9	.296	10	.800	11	.382	6	.437	3
6 L02	.942	6	.263	12	.271	11	.747	19	.263	24	.360	10
10 L05	.667	26	.191	19	.270	12	.653	28	.268	23	.115	32
27	.783	19	.205	18	.263	13	.862	6	.285	20	.481	1
22 L13	.928	8	.341	7	.251	14	.929	1	.207	30	.210	21
30	.797	18	.374	4	.247	15	.502	31	.151	33	-.012	35
17	.551	29	.166	22	.240	16	.662	27	.250	27	.185	24
21 L12	.928	9	.218	17	.238	17	.858	7	.294	18	.136	28
9	.319	34	.175	21	.231	18	.369	35	.181	32	.183	25
24 L14	.536	30	.145	23	.221	19	.738	20	.249	28	.116	31
4	.855	14	.230	15	.218	20	.773	15	.356	8	.220	19
32	.768	22	.250	13	.201	21	.791	13	.272	21	.394	6
11	.768	23	.144	24	.192	22	.720	22	.335	11	.253	17
12 L06	.841	17	.221	16	.186	23	.684	24	.354	9	.386	7
15 L08	.362	33	.072	26	.178	24	.382	34	.250	26	.122	29
18	.957	3	.056	27	.116	25	.884	3	.463	1	.380	8
2	.783	20	.186	20	.095	26	.693	23	.314	15	.137	27
1	.942	5	.028	29	.057	27	.649	29	.289	19	.147	26
29 L15	.913	10	-.052	31	.042	28	.756	18	.406	4	.420	4
26	.855	15	.028	28	.031	29	.662	26	.455	2	.473	2
7 L03	.275	35	.111	25	.024	30	.387	33	.261	25	.268	16
14 L07	.928	7	.006	30	-.008	31	.809	10	.133	35	.076	33
19 L10	.957	4	-.057	32	-.035	32	.836	9	.346	10	.186	23
5	.420	32	-.203	33	-.075	33	.427	32	.206	31	.216	20
3 L01	1.000	1	---	34	---	34	.911	2	.331	12	.243	18
23	1.000	2	---	35	---	35	.867	4	.376	7	.355	11
Mean	.760		.185		.193		.719		.297		.249	
SD	.196		.151		.135		.147		.080		.127	

Note. The rank order out of 35 of each item statistic is presented next to each item statistic. For example, the item difficulty statistic, P, for item 33 in the supply-format administration was 0.522, and this item was ranked 31st in terms of the number of subjects who got the item correct.

Table 3
FEFT Form B Item Statistics

Item	Supply Format (n=69) P		Corrected IxTot B r		Corrected IxTotal r		Selection Format (n=232/77) P		Corrected IxT Sel r		Validity Coef r	
13	.188	34	.524	2	.527	1	.278	34	.252	25	.289	12
31	.609	22	.537	1	.489	2	.796	11	.346	11	.400	4
20	.768	14	.423	8	.485	3	.765	12	.409	4	.482	1
27	.797	13	.441	6	.449	4	.874	5	.239	28	.271	14
8	.580	24	.491	3	.445	5	.683	20	.282	20	.123	28
2	.406	29	.480	4	.436	6	.370	32	.204	31	.048	33
7	.333	32	.456	5	.427	7	.509	30	.379	6	.242	17
25	.652	21	.411	10	.426	8	.665	21	.485	1	.349	7
16	.754	16	.394	11	.423	9	.626	24	.290	17	.121	29
22 L11	.696	18	.433	7	.407	10	.722	16	.444	2	.465	3
35	.406	30	.416	9	.381	11	.604	25	.280	21	.190	22
3	.174	35	.392	12	.372	12	.200	35	.330	12	.370	5
17 L08	.304	33	.315	19	.350	13	.374	31	.270	23	.306	11
10	.681	19	.264	22	.347	14	.596	27	.409	3	.137	26
9 L04	.710	17	.327	17	.344	15	.809	10	.243	27	.207	20
11 L05	.681	20	.354	13	.339	16	.661	23	.361	10	.481	2
18 L09	.942	4	.302	20	.338	17	.848	8	.371	8	.261	15
30	.522	26	.336	16	.329	18	.517	29	.292	16	.091	31
12	.580	23	.318	18	.325	19	.691	19	.246	26	.017	34
24	.493	28	.344	15	.325	20	.557	28	.370	9	.236	19
34	.841	10	.347	14	.315	21	.913	2	.226	30	.206	21
4	.551	25	.211	26	.293	22	.600	26	.114	35	-.034	35
5 L02	.884	7	.169	30	.270	23	.757	13	.297	15	.326	8
33	.826	12	.289	21	.264	24	.700	17	.393	5	.320	9
19	.971	3	.184	29	.223	25	.952	1	.285	19	.272	13
28 L13	.870	8	.205	27	.211	26	.865	6	.287	18	.171	24
21 L10	.971	2	.248	24	.193	27	.878	4	.172	32	.087	32
29 L14	.507	27	.159	31	.191	28	.752	14	.230	29	.124	27
6 L03	.333	31	.136	32	.191	29	.357	33	.274	22	.259	16
26 L12	.899	6	.219	25	.171	30	.830	9	.372	7	.354	6
23	.768	15	.258	23	.168	31	.691	18	.157	33	.189	23
32 L15	.855	9	.193	28	.153	32	.735	15	.329	13	.238	18
14 L06	.841	11	.101	33	.097	33	.661	22	.326	14	.320	10
15 L07	.899	5	.042	34	.079	34	.852	7	.152	34	.142	25
1 L01	1.000	1	---	35	---	35	.909	3	.266	24	.116	30
Mean	.665		.306		.308		.674		.297		.234	
SD	.227		.133		.125		.186		.084		.126	

Note. The rank order out of 35 of each item statistic is presented next to each item statistic. For example, the item difficulty statistic, P, for item 13 in the supply-format administration was 0.188, and this item was ranked 34th in terms of the number of subjects who got the item correct.