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PERCEPTUAL CORRELATES OF THE ROD-AND-FRAME TEST[1]

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Summary.—A randomly selected group of 92 male college students were given a battery of 10 perceptual tests, most of which have been used to separate field-independents from field-dependents in earlier studies of relationships between perceptual mode and physiological response tendencies. Test scores were factor analyzed in an attempt to define the psychological domain measured. Four factors accounted for most of the test score variance; the embedded figures test, sharing much of its variance with quantitative-spatial IQ tests, was the test with least of its variance accounted for. The rod-and-frame test, core test for field-dependence, correlated best with mirror-tracing speed, mirror-tracing accuracy, and the embedded figures test and had small or moderate positive correlations with all of the other tests except letter discrimination, which showed little relationship to any other test. Subject-controlled rod-and-frame correlated highly with experimenter-controlled rod-and-frame, suggesting their interchangeability as measures of field-dependence. *Ss* with rod-and-frame errors of 1.5° or less did significantly better on the rest of the perceptual battery than *Ss* with errors of 8° or more The embedded-figures test and the Draw-A-Person test were especially divergent for the two extreme rod-and-frame groups, suggesting their efficacy as screening devices for extreme field-dependents and independents.

In earlier studies by this group and other investigators, physiological differences in response to various stressors have been obtained from *Ss* differing in certain perceptual characteristics (Silverman, Cohen, Shmavonian, Greenberg, 1961; Culver, Cohen, Silverman, Shmavonian, 1963; Silverman, McGough, Bogdonoff, 1967). Specifically, extremes on the field-dependence-independence dimension have demonstrated these differing physiological responses. In response to a test dose of insulin, for example, the field-independent group revealed sharp cardiovascular changes in contrast to the field-dependent group (Silverman, *et al.*, 1967). Measures used to characterize the field-dependence dimension have derived from the rod and frame, an embedded-figures test (Witkin, 1950), laterality orientation (Culver, *et al.*, 1963), two-point discrimination, and letter identification.

In order to determine more precisely the nature of this perceptual-physiological relationship, a large-scale experimental program was implemented in which these and other perceptual tests were administered to a large randomly-selected population whose physiological responses in a variety of experimental situations were also assessed.

This program was divided into three stages. (1) The perceptual test scores were subjected to correlation and factor analytic procedures in the hope of ob-

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taining a parsimonious and fundamental description of the psychological domain that was being measured. (Up to the present time no attempt had been made to define experimentally the area of cognitive functioning which the tests were tapping, although the assumption seems to have been made that all of the tests were enhancing the separation of extreme field-independents and field-dependents.) (2) The relationships between perceptual scores and physiological responses were determined. (3) The final step will be the construction of a perceptual battery for the prediction of physiological responses by omitting tests which are poorly loaded on the useful factors and devising and adding others which are found to have strong loadings on those factors.

The results of the first stage of the program, i.e., description of the relationships prevailing among the perceptual tests, are presented here. The perceptual tests discussed include those mentioned above plus two additional related measures, mirror-tracing (Starch, 1910) and Draw-A-Person (Machover, 1949). These additional tests, like the ones used in previous studies, are not simple tests of sensory acuity. All the tests seem to require two types of sequential performance on the part of the perceiver: (1) the breaking down of a complex perceptual influx into discretely experienced cues and (2) the re-combination of these cues, with each cue appropriately weighted and allocated in terms of the particular response which is being required.

METHOD[2]

A group of 92 male Rutgers University students randomly selected from the freshman class list were given the following perceptual tests.

(1) *Rod and Frame, Experimenter-operated (RAF I).*—After a 15-min. dark-adaptation period, *S* was seated in a dark room and confronted with a luminous tilted rod within a luminous tilted frame, at a distance of 6 ft. 6 in. from his eyes. He then directed *E*'s turnings of the rod until the rod appeared to him to be in true vertical position. (The presence of the tilted frame distracts *S*s to a greater or lesser degree.) A series of eight rod-and-frame positions were presented, with 28° deviations being used throughout. *S*'s test score was the average of his deviations from 0° on his eight settings of the rod. A clamping system of two foam-rubber-padded disks adjustable in height and width was used to keep *S*'s head erect.

(2) *Rod and Frame, Subject-operated (RAF II).*—This test was the same as RAF I except that *S* himself adjusted the rod to perceived vertical by means of a remote control switch. In a previous study (Silverman, 1964) a correlation of .92 between experimenter-operated and subject-operated RAF had been obtained. The reason for including the two kinds of rod-and-frame test in the

[2]For a more detailed coverage of method, see G. Adevai, "Manual of Procedures and Scoring for Perceptual Tests Used in Psychophysiology Laboratory, Rutgers Medical School," on file with American Documentation Institute, Auxiliary Publications Project, Photoduplication Service, Library of Congress, Washington, D. C. 20540. Request Document No. 9972; remit $5.00 for photocopies or $2.25 for 35-mm. microfilm.

present investigation was to check this correlation on a larger, randomly selected group.

(3) *Gottschaldt Embedded Figures (EFT).*—A shortened form of the test, including designs A-1, C-1, C-2, C-3, D-1, D-2, E-1, E-2 and G-1 of the original Gottschaldt series, was used. *S* had to locate a simple geometrical design, which he had previously seen, within a complex geometrical design, and his latency in doing so was the response measure.

(4) *Laterality Orientation (LO).*—*S* was shown 32 drawings of right or left body parts (hands, feet, eyes, and ears) and had to identify the sidedness—right or left—of each. The score for the test, expressed as total latency, was actually a combined time and error score since each error was penalized by adding 5 sec. to the latency. Because latencies on this test tend to be brief, timing was to the nearest ¼ sec.

(5) *Tactile Localization (Tact. Loc.)*—In this test *S* was lightly stimulated at some point on the ventral surface of his hand which was hidden from his sight. After each stimulation *S* made an "x" on an outline drawing of his hidden hand at the point where he felt he had been stimulated. Twenty stimulations were given on each hand. Accuracy of performance was computed by measuring each distance between *S*'s mark and the actual point of stimulation. The sum of all these differences was the gross error score.

(6) *Draw-A-Person (DAP).*—Each *S* was asked to draw a man and then a woman. These drawings were scored on the sophistication-of-body-concept scale devised by Marlens (Witkin, *et al.*, 1962, p. 119). Three categories of graphic features were used in rating the drawings: form level (including proportion and perspective); role and sex differentiation; and level of detailing. The final score was a global rating on a 5-point scale from most sophisticated to most primitive and infantile drawings, with a rating of one indicating the most sophisticated category.

(7) *Two-point Discrimination (TPD).*—*S* was blindfolded and the back of his left hand was stimulated 50 times with two points located 5, 10, 15, 20, or 25 mm. apart, the stimuli being presented according to a predetermined random order. Stimulus points were applied by an automatic device, which was contoured individually for each *S*'s hand, and delivered the two points simultaneously at equal pressure and duration. *S* reported "one" or "two" and the two-point limen was calculated by the method of least squares (Woodworth & Schlosberg, 1954, pp. 206-207).

(8) *Traced Letter Identification (TLI).*—*S* was blindfolded and was asked to identify four printed letters—E, B, F, and R—traced first on the forehead and then on the back of each hand in a predetermined random order. Letters were traced in standard fashion by means of a pressure controlled stylus moved by *E* within a stencil form applied to *S*'s skin surface. An accuracy score was obtained, with partial credit given for responses similar to the stimulus letter.

(9) *Mirror-tracing Accuracy (M-T ACC.)*.—Using a pencil, *S* traced a path around a double-ruled six-pointed star (width ⅜ in., length of arm side 2 in.), guided only by a mirror reflection of the star. (Only one trial was given, since we were interested at this point in individual differences in the initial approach to and handling of this task and not in factors relevant to the process of learning the mirror-tracing task.)

(10) *Mirror-tracing Speed (M-T Speed)*.—A latency score was also obtained for the mirror-tracing task described above. Time and error scores were treated as two separate measures because of the possibility that they might relate differently to the rod-and-frame test or to other tests of the perceptual battery.

For all the above tests, scoring was adjusted so that lowest numerical scores corresponded with best performance.

Results and Discussion

The means and standard deviations and a correlation matrix for the perceptual tests ($N = 92$) are presented in Tables 1 and 2.

A number of interesting observations can be made. First, it is obvious that RAF I (experimenter-operated) and RAF II (subject-operated) are testing much the same ability. Previous research (Silverman, 1964) showed that under self-adjustment conditions *S*s do tend to decrease their error by about 20%, but it has been thought that inter-subject rankings still remain much the same as with the standard RAF I procedure. The present correlation of .83 between the two tests supports this, and suggests that the subject-administered form, which is both easier to administer and more interesting to most *S*s, can be used validly to assess field-dependence.

Other *E*s have reported correlations among some of these tests, usually from smaller subject populations. Witkin reported a correlation of .64 between RAF I and EFT for 46 male college students (Witkin, *et al.*, 1962). Sugerman and Haronian (1966) reported an r of .38 for 102 male college *S*s. The present cor-

TABLE 1

MEANS AND STANDARD DEVIATIONS OF PERCEPTUAL TESTS ($N = 92$)

Perceptual Tests	*M*	*SD*
RAF I	4.46	3.29
RAF II	3.79	3.32
EFT	255.73	182.08
LO	94.62	44.28
DAP	2.74	1.26
TPD	12.04	4.47
TLI	10.14	4.91
Tact. Loc.	622.61	123.67
M-T Acc.	21.14	31.99
M-T Speed	238.19	150.35

TABLE 2

PEARSONIAN CORRELATIONS BETWEEN PERCEPTUAL TESTS

	1	2	3	4	5	6	7	8	9	10
1. RAF I		.83†	.49†	.39†	.40†	.19	−.03	.16	.46†	.53†
2. RAF II			.35†	.37†	.32†	.22†	.04	.18	.45†	.50†
3. EFT				.28†	.38†	.05	.05	.20	.36†	.39†
4. LO					.17	.06	.01	.52†	.18	.22*
5. DAP						.08	.10	.21*	.22*	.24*
6. TPD							−.27†	−.02	−.19	−.11
7. TLI								.05	.10	.07
8. Tact. Loc.									.15	.11
9. M-T Acc.										.77†
10. M-T Speed										

*$p = .05$. †$p = .01$.
Note.—1.00 used in the diagonal.

relation of .49 between RAF I and EFT was somewhat closer to the latter finding. A number of investigators studying relationships between RAF and EFT (Gruen, 1955; Bound, 1957; Young, 1959) have shown that these two tests have perhaps 20% of their variance in common. The correlation of .49 obtained in the present study is congruent with this finding.

With respect to relationships between sophistication of body concept (as measured by the DAP) and field dependence, correlations somewhat lower than those reported by Witkin for college males (Witkin, *et al.*, 1954) were found. Witkin reported an r of .55 between RAF I and DAP and of .63 between EFT and DAP; the corresponding findings in the present study were .40 and .38. Sugerman (1967) reported still lower correlations for his group of 102 college males, $r = .12$ between RAF I and DAP and $r = .24$ between EFT and DAP. Interestingly enough, in a group of 51 hospitalized schizophrenic males, Sugerman and Cancro (1964) found an r of .43 between RAF I and DAP scores, which was more in line with the findings of Witkin and the present investigators.

It is interesting to note that both time and error scores on mirror-tracing correlated as well or better with rod-and-frame as did the embedded-figures test, which is usually cited as one of the principal tests for field-dependence. (For RAF I vs mirror-tracing accuracy, $r = .53$.) As would be expected (Whipple, 1915) time and error scores on mirror-tracing are closely related ($r = .77$).

Although the correlations between RAF I and the other perceptual tests are small or moderate, extreme field-independents (RAF I score 1.5° or less) obtained better scores than extreme field-dependents (RAF I score 8° or more) on all the other tests except letter identification and two-point discrimination (see Table 3).

Note that the DAP, because of its speed and simplicity of administration

TABLE 3

EXTREME FIELD-INDEPENDENTS AND EXTREME FIELD-DEPENDENTS COMPARED ON OTHER PERCEPTUAL TESTS OF BATTERY

Perceptual Tests	M_{FI}	M_{FD}	t	p*
EFT (sec.)	149.36	488.33	5.47	<.0005
LO (sec.)	84.27	128.75	3.03	<.005
DAP (rating)	2.20	4.50	7.80	<.0005
TPD (mm.)	12.50	14.60	1.40	n.s.
TLI (accuracy credits)	9.82	9.10	–.37	n.s.
Tact. Loc. (mm.)	577.36	660.08	1.73	<.05
M-T Acc. (errors)	13.82	44.75	1.89	<.05
M-T Speed (sec.)	197.82	363.42	2.28	<.025

*One-tailed.

to large groups, might serve as a good screening device to pick up extreme scorers on RAF.

The correlation matrix was subjected to a principal factor analysis with rotation to the varimax solution (Kaiser, 1958, 1959). Four rotated factors were extracted. Factor loadings are presented in Table 4.

Factors 1 and 4 will be discussed first because together they suggest a bifactorial division of what has been broadly termed field-dependence. Note that the mirror-tracing test loads heavily on Factor 1 and very little on Factor 4. Conversely, DAP loads heavily on Factor 4 and negligibly on Factor 1. RAF and EFT, long used as key tests for field-dependence, load moderately on both factors. The "meanings" of these two factors are hypothesized below.

TABLE 4

FACTOR LOADINGS FOR PERCEPTUAL TESTS

Test	Factors				% Variance Accounted for by factors
	1	2	3	4	
LO	.19	.13	.83*	.12	76
Tact. Loc.	.01	–.10	.87*	.11	78
RAF I	.63*	.33	.18	.53*	81
M-T Acc.	.88*	–.19	.07	.06	82
M-T Speed	.89*	–.09	.05	.12	82
RAF II	.61*	.32	.18	.47*	73
EFT	.38*	.01	.20	.56*	50
TPD	–.18	.78*	–.03	.29	73
DAP	.09	–.05	.09	.80*	66
TLI	–.06	–.73*	–.04	.39*	69

*Loadings over .35; loadings are reflected where necessary so that stronger loadings on a given factor are represented by positive scores.

Factor 1

Possibly Factor 1, with heaviest loadings by the two mirror-tracing tests, defines "pure" field-dependence, narrowly conceived, i.e., the simple ability to overcome the misleading visual cues of an embedding context.

Note that Factor 1 accounts for 40% of the RAF variance and only 14% of EFT variance. It has already been demonstrated that RAF and EFT, although sharing a moderate variance, have "a marked degree of statistical alienation" (Elliott, 1961). The EFT is significantly related to quantitative-spatial IQ subtests, sharing about 30% of its variance with them, while RAF has slightly negative relationships with such variables. The relationships of mirror-tracing to intelligence subtests are unknown. Another area in which EFT differs from RAF is in terms of its higher correlation with Rorschach C scores (Witkin, 1954), suggesting that people with low emotional control have particular difficulty in extracting a simple figure from its complex context. Of all the tests in the perceptual battery, EFT is the one with least of its variance accounted for by the present factor analysis.

Factor 4

This factor may have to do with the capacity to separate sets of perceptual cues—either within the same sense modality or different modalities—from each other. DAP loaded heavily on this factor, RAF and EFT moderately. As Witkin, *et al.* point out (1962, p. 115) there is similarity in a person's manner of experiencing the world around him: "the person who cannot readily project a complex, well-proportioned image of the human body typically does not readily perceive his body as separate from the field and also has difficulty in identifying a simple figure embedded in a complex design." Separating capacity would also enter into RAF since accurate performance would be facilitated by the awareness of body position cues as an entity separate from the misleading visual field cues. Note that two-point discrimination, also involving a "separateness" judgment, had its second highest loading on this factor.

There are some grounds for speculating that tests loading substantially on Factor 4, as opposed to those loading solely on Factor 1, involve an emotional-adjustment component. It is well known, for example, that the DAP is used clinically as a rough screening device for psychological pathology. A number of figure-drawing characteristics which would hint at psychological disturbance to the eye of the clinician are also features that would tend to throw a drawing into the poorer categories on the Marlens Sophistication of Body Concept Scale, e.g., omission of body parts, distorted proportions, poor sexual differentiation, etc. It appears, then, that "perceptual" performance on EFT, RAF, and DAP has already been shown to have some relationship to clinical factors in studies by Witkin and others (Witkin, *et al.*, 1962). As Witkin summarized, the better performers on these three tests, although apparently no less prone to psychological illness than the poorer performers, have been found more likely (1) to organize and direct their experiences actively and (2) to use relatively complex and specialized controls and defenses, e.g., isolation and intellectualization as opposed to simple denial and repression. The "ego" is allegedly the actor in cognition, impulse control, and mobilization of the defenses, and relatively greater ego-strength in the better perceptual group might be a prerequisite for the two action tendencies described above.

In a preliminary test of this hypothesis, Barron Ego-strength scores (Barron, 1953) were obtained from the MMPIs given to these *S*s. Their scores ranged from 32 to 59. Cut-off scores of 56 and above defined the 10% with highest ego-strength; scores of 42 and below, the 10% with lowest ego-strength. It was thought that the high E-S people would do significantly better on the perceptual tests which load on Factor 4 (EFT, DAP, RAF) but that there would be no difference between high and low E-S people on the two mirror-tracing measures which load only on Factor 1. This was borne out (see Table 5).

TABLE 5

COMPARISON OF HIGH AND LOW EGO-STRENGTH GROUPS ($Ns = 9, 10$) ON PERCEPTUAL TESTS

Perceptual Test	*M* High Ego Strength	*M* Low Ego Strength	p*
EFT (sec.)	156.6	367.6	<.025
DAP (rating)	2.7	3.9	<.05
RAF (degrees)	2.7	6.0	<.05
M-T Accuracy (errors)	18.89	22.60	n.s.
M-T Speed (sec.)	243.40	237.50	n.s.

*One-tailed.
Note.—The Mann-Whitney *U* test was used to determine significance of differences between groups.

It is possible that some of the physiological response differences which have been reported for groups separated on the basis of their perceptual scores may relate to that part of the variance of perceptual scores which reflects a clinical component—something akin to ego-strength. This might be the reason that investigators obtained larger differences on physiological parameters when they separated their experimental groups with a battery of perceptual tests rather than with RAF alone (Culver, *et al.*, 1963), that is, with more tests there was a greater likelihood of tapping this variable. If such is the case, a more direct measure or measures of the crucial affective variable(s) might yield more clear-cut relationships to physiological response than perceptual scores do.

Factor 2

The second factor was loaded by two tactile tests, two-point discrimination (positive loading) and traced letter identification (negative loading). However, a third test also involving the tactile modality (i.e., tactile localization) had no loading on Factor 2. It appears, therefore, that Factor 2 does not represent simple tactile sensitivity.

It was rather surprising to find that two-point discrimination and letter identification had loadings of opposite sign (+.78 and —.73, respectively) on Factor 2. Both these tests have long been used in neurological examinations as tests for tactile sensory integration, in part a function of the parietal cortex. Patients with parietal lobe damage generally perform poorly on both tests. On this basis one would predict a positive correlation. However, in the present non-brain-damaged population there appeared to be if anything an *inverse* relationship ($r = -.27$) between the two types of performance. To check this, the correlation for a second group of 92 randomly-chosen students was obtained ($r = .006$). With results as inconclusive as these, theoretical speculation on Factor 2 seems premature. However, if future experimentation substantiates a moderate inverse relationship between these two tactile tests, we might postulate that a bipolar separating-vs-fusing factor is operating, i.e., a tendency to perceive closely applied tactile stimuli as separate, vs a tendency to fuse them into a unitary Gestalt in the perceptual process.

It should be pointed out that scores on both of these tests are subject to a relatively large degree of experimental error. Although the two-point discrimination apparatus is automated so as to control for errors in timing and intensity of stimulus delivery, nevertheless subtle attitudinal variables influence *S*s' judgments. For example, people vary, and a given person may differ from test to retest, in how much subjective certainty of doubleness is required before the judgment "two" will be pronounced. Also, as Titchener (1909) has discussed at length, normal *S*s vary in their tendency to commit the object error, i.e., to take a detective attitude and "figure out the right answer" rather than attending to the phenomenological stimulus experience. As far as letter identification is concerned, *E* may differ slightly from time to time in the the placement, speed, and smoothness of the letter tracings. Thus, although the two tests may be reliable and useful for making gross neurological assessments of pathology or normality, small differences among normal *S*s are perhaps not sufficiently repeatable or valid to be treated as finely graded quantitative scores, which was the innovation we introduced in the use of these two techniques.

Factor 3

This factor is loaded heavily by laterality orientation and tactile localization and to a lesser extent by the two rod-and-frame tests.

Although the naming of a factor loaded substantially by only two tests is highly speculative, we might postulate a spatial visualization component common to both tests. The laterality orientation test, for instance, requires the ability to imagine what a right hand would look like, as opposed to a left hand, in various positions, some of them twisted. In the tactile localization test where *S* is touched at an unseen point on his palm, he must be able to visualize his own (touched) hand (its sidedness, its proportions) in order to localize correctly the stimulation point on the standard hand-drawing placed before him. This visualization factor, if it is that, may enter into rod-and-frame performance as an ability to visualize gravitational vertical in the absence of the usual external cues. Certainly many of our *Ss* tell us they try to visualize flagpoles, fence posts, plumb lines and the like, while trying to set the rod at vertical.

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