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A method for analysing performance in the rod-and-frame test. I

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Abstract.—Scoring only the unsigned (absolute) errors in the Rod-and-Frame Test (RFT) is questioned because the method confounds a number of variables. Another way of scoring the RFT is proposed which differentiates between (1) the subject's constant error, (2) the effect of the tilted frame, and (3) the rod starting position effect. The method also allows estimation of the response consistency of the subject. What is more, the values for each subject of the constant error, of the frame tilt effect, and of the rod starting position effect may be tested for significance on the basis of the degree of response consistency observed for that particular subject, thus making the new method more person-oriented than the unsigned error method.

According to Witkin & Asch (1948) the Rod-and-Frame Test (RFT) gives a measure of field dependence, a term that describes a characteristic way of perceiving. Field dependence is operationalized in the RFT in terms of "frame dependence" and measured by determining how successful the subject is in adjusting a rod within a tilted frame to a physically vertical position. In the RFT the field dependent person has difficulty adjusting the rod to physical vertical because the tilted frame influences his judgment of the upright.

However, in previous research (Nyborg, 1971 *a*; 1971 *b*; 1972) we found the Witkin method of scoring the RFT unsatisfactory in certain respects. For example, we observed that subjects who responded inconsistently to the tilt of the frame nevertheless were scored as systematically frame dependent subjects.

We therefore developed a method of scoring the RFT which takes more variables into account and estimates the response consistency of the subject. This paper presents the method. A following paper deals with the statistical model on which the method is based (Nyborg & Isaksen, 1974).

VARIABLES IN THE RFT

In the usual RFT procedure the rod and the frame are tilted 28 degrees alternately to the same and to opposite sides. Typically the deviation in degrees from physical vertical in the subject's final adjustment of the rod is measured in eight consecutive trials. The most common method of scoring the RFT is described by Witkin et al. (1962, p. 37). They measure the degree of frame dependence by calculating the mean, unsigned (absolute) error of adjustments, which is mathematically written

$$\bar{Y}=\frac{1}{N}\sum Y_i$$

where Y_i=the number of degrees the rod deviates from physical vertical on the ith trial without regard to direction of deviation, and N=number of trials.

This method of scoring does not take into account (1) the direction which the rod deviates from the physical vertical and (2) whether the deviation of the rod from physical vertical are in the same or the opposite direction from the tilt of the frame, although these two cases are obviously different in respect to the relation between the frame and the adjusted position of the rod. Therefore they cannot be considered equivalent as indicators of frame dependence. On the contrary, a number of other variables which are possibly important in the RFT may be assessed if information concerning direction of deviation is not discarded in the process of scoring. These variables include the following.

Perceptual consistency

Witkin & Asch (1948) measured the response consistency of only a few subjects in the first experiments with the RFT (p. 768, 773) and found that most subjects consistently behaved either as field dependent (much influenced by the frame) or as field independent (little influenced by the frame) or something between (moderately influenced) (p. 768); they accounted for the inconsistent behavior of some of the subjects by saying that the luminous frame provides a rather weak frame of reference and that judgments made in its presence will not be very consistent (p. 773).

In our studies we also found subjects responding consistently as well as subjects responding very inconsistently from trial to trial.

The ordinary method of scoring the RFT does not reveal the degree of consistency in the subject's responses, although it seems somewhat misleading to characterize a subject who responds inconsistently as systematically dependent on the frame, just because the mean deviation of his responses from physical vertical is rather great. It therefore seems preferable to regard *response consistency* and frame dependence as variables to be assessed separately. The response consistency variable should be measured for each subject and only scores from trials under identical and therefore comparable conditions of initial rod and frame tilt should be used in the calculation.

Constant error

Gibson & Radner (1937) have shown that most subjects tend to adjust a rod consistently to one side of physical vertical when required to adjust it to an upright position. This asymmetrical performance gives rise to a *constant error* which was also observed in the RFT in our previous studies. The constant error is not systematically related to the tilt of the frame but characteristic of the subject. Therefore it should be separated from the score indicating frame dependence.

Rod starting position effect

In 1952 Werner & Wapner demonstrated that the position from which a rod is moved can have a significant effect on the final position of the adjusted rod when perceived as physical vertical. The subjects tend to see the rod as vertical while it is still inclined towards its original position. The usual way of scoring the RFT confounds this *rod starting position effect* with the effects of the other variables.

To sum up: if a subject obtains a small unsigned error in the RFT he is said to be frame-independent (field-independent); if he gets a large unsigned error he is said to be frame-dependent (field-dependent). But because the scoring of unsigned errors does not allow the sources of the errors to be discriminated the group of so-called frame-dependent subjects may include (1) persons who do respond consistently to the tilt of the frame (frame-dependent), (2) persons who respond inconsistently (disoriented), and (3) persons whose judgments are consistent but related to a personal bias (constant error) and/or to a rod starting position effect.

Table 1. *The 2×4 observations obtained from a single subject in the RFT*

Frame position	Rod starting position: Right	Left	Total
Right	a_1a_2	b_1b_2	$a_1+a_2+b_1+b_2$
Left	c_1c_2	d_1d_2	
Total	$a_1+a_2+c_1+c_2$		$a_1+a_2+b_1+b_2+$ $c_1+c_2+d_1+d_2$

A new method was therefore developed which takes the type of error into account in order to discriminate between the effects of the tilt of the frame, the constant error, and the rod starting position on each subject's RFT performance. Furthermore, the method allows estimation of the consistency with which each subject responds to the test.

THE METHOD

The statistical basis of the method is described in greater detail elsewhere (Nyborg & Isaksen, 1974). Here it will only be shown how the method is used in practice.

Data from the RFT are collected in the usual way, i.e. deviations of the rod in degrees off physical vertical are registered at least twice in each of the four possible tilt combinations of the frame and rod (frame left or right tilted and rod starting left or right tilted). However, the deviations of the rod are recorded signed, clockwise deviations with a positive sign and counter-clockwise deviations with a negative sign.

In the usual case of double observations these signed scores can be arranged as in Table 1. Separate measures of the constant error (μ), the frame dependence (φ), and the rod starting position effect (ϱ) are now calculated in the following way.

The constant error, μ

From Table 1 it is easily seen that the effect of tilting the rod to the right counterbalance tilting it to the left. Similarly the effects of tilting the frame to the right and the left are counterbalanced. Therefore the total sum of the 8 observations is neither influenced by the tilt of the frame, nor by the rod starting position. The subject's constant error, μ, may therefore be determined as the mean of all 8 observations when these are expressed as signed scores:

$$\mu = \frac{a_1+a_2+b_1+b_2+c_1+c_2+d_1+d_2}{8}$$

The frame effect, φ

For each of the two conditions of frame tilt the effects of left and right rod starting position are counterbalanced in Table 1. Therefore the frame effect, φ, can be found as the mean of the four observations in the "frame tilted right" condition. Since the subject's constant error, μ, contributes to all observations it must be subtracted from this mean:

$$\varphi = \frac{a_1+a_2+b_1+b_2}{4} - \mu$$

By definition, the two values of φ based on the two conditions of frame tilt will be exactly symmetrical.

The rod starting position effect, ϱ

The effect of starting with the rod tilted to the right is counterbalanced by the effect of starting with the rod tilted to the left. Therefore, the rod starting position effect, ϱ, can be found as the mean of the four observations in the "rod starting tilted to the right" condition with μ subtracted:

$$\varrho = \frac{a_1+a_2+c_1+c_2}{4} - \mu$$

By definition, the two values of ϱ based on the two conditions of rod tilt will be exactly symmetrical.

The response consistency, σ

Provided that the deviations of the rod are observed twice (as usual) in each of the four possible tilt combinations of the frame and the rod it is possible to estimate the response consistency of the subject by calculating the standard deviation which in this case may be written

$$\sigma = \sqrt{\frac{1}{4}\left[\frac{(a_1-a_2)^2}{2} + \frac{(b_1-b_2)^2}{2} + \frac{(c_1-c_2)^2}{2} + \frac{(d_1-d_2)^2}{2}\right]}$$

This formula estimates the variability of the subject's error scores in successive trials under comparable tilting conditions. A large value of σ indicates that the subject is not responding systematically. We consider such a subject to be disoriented in the RFT.

Significance tests

By chance the subject may get high values of μ, φ, and ϱ; to test if the values are significantly different from zero they may be compared with the subject's response consistency, ϱ, by means of the following formulas:

$$t\mu = \frac{\mu}{\sigma} 2\sqrt{2}; \quad t\varphi = \frac{\varphi}{\sigma} 2\sqrt{2}; \quad t\varrho = \frac{\varrho}{\sigma} 2\sqrt{2}$$

Table 2. *Comparison between the method of unsigned errors and the new method of scoring the RFT: Fictive data*

	Mean errors in the tilt conditions of Table 1				Calculations			
					Unsigned error score	New error scores		
Subjects	*a*	*b*	*c*	*d*		μ	φ	ϱ
I	5	5	5	5	5	5	0	0
II	5	5	−5	−5	5	0	5	0
III	5	−5	5	−5	5	0	0	5

The resulting values are evaluated after a *t*-distribution with four degrees of freedom.

In case of more than two observations in each of the four conditions of rod and frame tilt the appropriate procedure of calculation may be deduced from Nyborg & Isaksen (1974).

COMPARISON BETWEEN THE TWO METHODS

The following illustrates the discriminative power of the present method of scoring the RFT, compared with the unsigned error method of Witkin.

If three subjects are tested in the four tilt conditions shown in Table 1 and obtain the corresponding mean deviation scores *a*, *b*, *c*, and *d* shown in Table 2, they will all indiscriminately be assigned an error score of 5 degrees because the score is calculated numerically as

$$1/4\,(|a|+|b|+|c|+|d|)$$

thus ignoring the direction of tilt.

By the present method the direction of tilt is registered and the data (arranged according to Table 1) can by virtue of the previously mentioned procedures be dissolved into μ, φ, and ϱ (the values of which are to be found in Table 2). The response consistency of the subjects can be estimated by σ.

The examples in Table 2 are constructed. The empirical data in Table 3 illustrate values of μ, φ, and ϱ which are more typically obtained. By the method of calculating the unsigned error these subjects get scores of 12.00, 8.13, and 3.25 degrees, respectively, and no information about how they got their scores is obtained. The new method gives more detailed information. For subject A32 a subjective bias, μ, is seen to be the main determiner; for subject V28 the frame plays the important role; and for subject V22 the rod starting position, ϱ,

Table 3. *Comparison between the method of unsigned errors and the new method of scoring the RFT: Observed data*

Subjects	Mean Errors in tilt conditions of Table 1				Calculations: Unsigned error score	New error scores: μ	φ	ϱ
A32	−5.5	−12.5	−13.0	−17.0	12.00	−12.00*	3.00	2.75
V28	+10.0	4.5	−7.0	−10.0	8.13	−0.63	7.88*	2.13
V22	1.5	−4.0	0.5	−5.0	3.25	−1.75	0.50	2.75*

*$p<0.05$.

dominates his attempts to adjust the rod to physical vertical.

As mentioned earlier, Witkin considers the subject's responses to be determined by the effect of the tilt of the frame. From Table 3 is seen that this is not always the case.

To investigate how frequently the subjects' scores depend significantly on the tilt of the frame alone and how often other variables contribute to the subject's adjustment of the rod, the following analysis was performed on the 2×37 sets of data in the experimental series mentioned in Nyborg & Isaksen (1974). In both series subjects with unsigned error scores amounting to two degrees or higher were selected for analysis. For each of these subjects it was determined which variable(s) reached a significant level (p 0.05) in his RFT performance. In one of the series it was found that 35.7 percent of the subjects were significantly dependent exclusively on the tilt of the frame while the scores of the other 64.3 percent in the group also depended on other variables. In the other series the figures were 21.9 and 78.1 percent, respectively.

The fact that the RFT performance of a great majority of these subjects are influenced by variables other than the tilt of the frame underscores the need of using a method of scoring which discriminates between the effects of such factors.

CONCLUDING REMARKS

In this paper it has been argued that Witkin's unsigned error method of scoring the RFT confounds a number of important variables by assuming that the frame tilt alone determines the subjects' performance. Furthermore, the method leaves the subject's degree of response consistency out of consideration. It might be added that by the unsigned error method each subject's score derives its meaning from a comparison to the other subjects' scores and its interpretation is in this way dependent on the tested population; thereby the score loses its individual specificity.

In contrast, the new method traces the source of the subject's errors. It separates the degree to which a subject is influenced by the frame from other variables that may influence his judgments of physical vertical as well, and it allows an estimation of his response consistency. What is more, the estimated response consistency can be related to the subject's calculated values of constant error, frame tilt effect, and rod starting position effect in order to assess the significance level of these values.

Because the values of the constant error, the frame tilt effect, and the rod starting position effect are thus tested for each subject on the basis of his observed degree of response consistency and not in relation to the scores of the other subjects as in the unsigned error method, the new method becomes more person-oriented.

Individual test profiles can now be compared to see if deduction of general traits is appropriate from the empirical data and attempts to correlate scores from the RFT with other data, so often reported in the literature, are on safer ground because we know by the new method in greater detail what is correlated with what.

REFERENCES

Gibson, J. J. & Radner, M. (1937). Adaptation, after-effect, and contrast in the perception of tilted lines. I. Quantitative studies. *J. exp. Psychol. 20*, 453–467.

Nyborg, H. (1971 *a*). Tactile stimulation and perception of the vertical. I. Effects of diffuse vs. specific tactile stimulation. *Scand. J. Psychol. 12*, 1–13.

Nyborg, H. (1971 *b*). Tactile stimulation and perception of the vertical. II. Effects of field dependency, arousal, and cue function. *Scand. J. Psychol. 12*, 135–143.

Nyborg, H. (1972). Light intensity and perception of the

vertical: Two experiments with the Rod-and-Frame Test. *Scand. J. Psychol. 13*, 1–13.
Nyborg, H. & Isaksen, B. (1974). A method for analysing performance in the rod-and-frame test. II. Test of the statistical model. *Scand. J. Psychol. 15*, 124–126.
Werner, H. & Wapner, S. (1952). Experiments on sensory-tonic field theory of perception. IV. Effects of initial position of a rod on apparent verticality. *J. exp. Psychol. 43*, 68–74.
Witkin, H. A., Dyk, R. B., Faterson, H. F., Goodenough, D. R. & Karp, S. A. (1962). *Psychological differentiation*. New York: Wiley.
Witkin, H. A. & Asch, S. E. (1948). Studies in space orientation. IV. Further experiments on perception of the upright with displaced visual fields. *J. exp. Psychol. 38*, 762–782.

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