Power law fits to magnitude estimates of groups and individuals

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Differential sensitivity to grit and weight stimuli was compared for lateral differences using power law coefficients based on unanchored magnitude estimations. Ss were 120 college students run in a parametric design with sex, handedness, and order of testing right and left controlled. Findings on lateral differences were unreliable. Power law functions were shown to fit group (N = 10) data consistently but not individuals. These results indicate that without specification of several implicated variables, the use of UME and the power law to compare sensory functions in individuals is of dubious validity.

This study was designed to determine whether the greater sensitivity in the nondominant, as compared with the dominant, side found in punctuate pressure thresholds (Weinstein & Sersen, 1961; Ghent, 1961), and position sense (Lloyd & Caldwell, 1965) is paralleled in reactions to roughness (grit) and weight. The method of unanchored magnitude estimations (UME) with the data treated according to an hypothesized power law, as advocated by Stevens (1961, 1962), was employed as a means of obtaining a single measure of the sensing system's reactions to a range of stimulation. The measure was the slope (beta) of the line fitted to the log-log plot of geometric means of the raw data. The study was designed parametrically with handedness, sex, and order of testing on the right and left controlled, and all estimates of grit preceding those of weight. The results of the study were equivocal. However, the data bear on the question of whether the power law, UME method, holds for the individuals as well as groups.

Method

Subjects. Ss were 60 male and 60 female experimentally naive college students under age 30, equally divided among three handedness groups according to criteria similar to those employed by Weinstein & Sersen (1961): Right-Right, S and all members of his nuclear family are dextral; Right-Left, S is dextral but some family members are not; and Left, S is sinistral.

Apparatus. The texture stimuli were the five smoothest grades of emery cloth employed by Stevens & Harris (1963) mounted with rubber cement on 2 x 2 in. blocks of quarter inch plywood. The weight stimuli were cylindrical pill bottles 6 cm tall and 2-1/2 cm in diameter filled to weigh 100, 104, 112, 124 and 140 gm. Sight of the stimuli was prevented by means of a two-compartment, curtained box through which S's arms could extend comfortably.

Procedure. S was instructed to stroke each texture with the index and middle fingers twice. He was then to assign a whole number to the stimulus which indicated how rough it felt. During a series of familiarization trials, each stimulus was encountered at least five times. During test trials two stimuli were presented, one immediately following the other, before judgment for both was elicited. Order of testing each hand was systematically varied among conditions. Each hand was administered ten pairs of stimuli, thus requiring 20 UMEs. Each of the five stimuli was presented twice in the first and twice in the second position of a pair. Beyond these restrictions, the order of administration was random. Following administration of the grit stimuli, the weights were given according to the same pattern, with instructions to heft each stimulus twice.

Results and Discussion

Ten Ss were run in each handedness, by sex, by order of hand combination, with the right and left hands on the grit and weight tasks. It was consequently possible to fit power function curves to 48 arrays of data, each N = 10, with four arrays coming from the same Ss. After fitting straight lines (least squares criterion) to the log-log plots of the geometric means of the UMEs for each stimulus, Pearson rs were computed between the empirical data and the points specified by the line of regression. High correlation coefficients assure that the fitted power function indeed is in close agreement with the data. In the present instance, all but two of 48 correlations were greater than .95 (and those two were .93 and .94), and the power law hypothesis appeared to yield an accurate index of the empirical data.

Power functions and Pearson rs were also computed for each S individually. The results are summarized in Table 1. It is apparent that in substantially more than

Table 1. Frequency of size of correlations in individuals between fitted power law functions and geometric means of raw UMEs by handedness group, hand, and task

	Gp. R-R				Gp. R-L				Gp. L			
	Right		Left		Right		Left		Right		Left	
r	Grit	Weight	Grit	Weight	Grit	Weight	Grit	Weight	Grit	Weight	Grit	Weight
1.000 - .950	20	15	21	8	14	17	18	11	20	17	16	12
.949 - .900	12	16	16	14	18	9	14	11	12	10	19	11
.899 - .850	4	7	1	10	6	10	6	9	4	6	5	6
<.849	4	2	2	8	2	4	2	9	4	7	0	11

half the Ss, power functions did not correlate with the raw data with sufficient precision to assure that the derived measure could be interpreted as a measure of sensitivity. With four curves fitted to data on each S, and using a correlation of .95 as a criterion, 23 Ss did not have even one criterial fit; 35 had one out of four; 37, two; 20, three; and only five Ss had all four. Examination of individual data plots revealed some in which the stimulus range was essentially dichotomized and not further differentiated. These Ss obtained comparatively high beta coefficients but low correlations of fitted line to raw data.

Present results are consistent with those of Pradhan & Hoffman (1963) who found that power functions did not fit data from individual Ss but did fit group data. There is also a direct parallel with the results obtained by Jones & Marcus (1961) who found the median correlation between individual data and fitted power function to be .95 but did not specify the range. These two cited studies differ from the present one in many procedural details but are similar in that they used experimentally naive Ss.

Present results contrast with three papers which indicated that the power law assumption fits individual data. Stevens & Mack (1959), and Ekman, Hosman, & Lindström (1965) came to this conclusion but provided no supporting quantitative evidence. The latter paper contains individual data arrays with fitted curves but inspection suggests that closeness of fit is often poor. Stevens & Guirao (1964) provided quantitative evidence of power law fit but used nonnaive Ss, a factor also present in the study of Ekman et al.

S. S. Stevens, on several occasions (e.g., 1962), has published power law coefficients purportedly indicative of the operating characteristics of sensory systems. These coefficients derived from group data have been shown to have useful applications and have led to verified predictions in research on cross modality matching. Nevertheless, published individual power law coefficients show much variation relative, say, to variation in purported coefficients among modalities. Some of this variance can be attributed to experimentally controllable external variables. Much of what remains can be attributed to intrasubject response variables among which the modulus of estimation, and the range and incremental units of the numbers employed have been discussed in the literature. However, it remains the measurement of differences in the sensory system that is the target of the power law hypothesis. Present results, along with findings of other studies (e.g., see Beck & Shaw, 1965, on group data), indicate that without further specification regarding such factors as S selection, training, and response variables, the use of UME to compare sensory functions among individuals is of dubious validity.

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