Magnitude scales of line lengths¹

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Abstract

A comparison was made of magnitude estimation and magnitude production methods of scaling line lengths. Magnitude estimates gave functions with exponents significantly less than one, and which were affected by the size and presence or absence of the standard during judgment. Magnitude production scales were more regular in form, were not affected by attributes of the standard, and had slopes of approximately one.

Problem

Support for the widely held theory that the psychophysical function is a power function is based primarily on the use of magnitude scaling techniques. Frequently, however, magnitude estimation data has been obtained which has indicated that there are consistent deviations of judgments from a power function (Stevens, 1956; Pradhan & Hoffman, 1963). It has been suggested that the use of numerical responses in the magnitude estimation procedure may introduce biases, and that attributes of the standard stimulus may affect the results. Alternative magnitude scaling techniques have been suggested. In this study, the relatively simple task of line-length estimation was used to explore these possibilities further.

Method

The apparatus consisted of a white board, into which were set horizontally two black strips, 5/8 in wide, and 5 in apart. The visible length of the strips could be adjusted either by O, sitting in front of the board, or by E, sitting behind the board. The maximum visible length of the strips was 12 in.

Two groups of Os were used, recruited from introductory psychology classes at Southern Illinois University. One group, of $N=11$, gave magnitude estimations of line length; the second group, $N=15$, gave magnitude production estimates. For magnitude estimation, a standard length was shown, and was given a value of 10. The relative length of a variable line was estimated by O. In magnitude production, O was again shown a standard, and was asked to produce a line length corresponding to a variable magnitude. Each O gave judgments under four conditions. The standard line was either 4 in or 8 in in length, and was either present or absent when O made his judgment. If present, one black strip was used to present the standard length, and the other was the variable. If absent, the same strip was used for both standard and variable, the standard being presented before each variable. Three judgments were given to each value of the variable stimulus under each experimental condition.

Results

All responses were converted to logs for the purpose of analysis. Best-fitting linear functions were computed

Table 1. Power function exponents for the experimental conditions

	4 in Standard		8 in Standard	
	Absent	Present	Absent	Present
Magnitude Estimation	.883	.873	.930	.918
Magnitude Production	1.019	1.000	1.023	1.017

by least squares for the log means as a function of the log stimulus values. The slope of the straight line was taken as the exponent of the psychophysical power function. Since the stimuli for the magnitude production group were numerical magnitudes rather than line lengths, the reciprocal of the slope was used as the exponent of the power function for that group. The exponents for the eight experimental conditions are given in Table 1.

The significance of the differences of the exponents from unity was evaluated by t tests. All exponents in the estimation conditions were significantly less than 1.0 (5% level), while no other differences approached significance. Comparisons among exponents by orthogonal t tests indicated a general difference between exponents for estimation and production, and, within the estimation group, between 4 in and 8 in standards.

The magnitude scales using a 4 in standard are shown in Fig. 1. Although there was no difference in exponent for the standard-absent versus standard-present conditions, there was clearly a difference in the form of the two functions. Further analysis indicated that there was a significant difference in vertical placement of the linear functions in log-log coordinates, or a difference in multiplicative constant for the power function. For comparison purposes, Fig. 1 includes the overall magnitude production scale for the 4 in standard,

Fig. 1. Geometric mean responses for magnitude estimation and magnitude production, using a 4 in standard.

where the independent variable is the magnitude plotted on the ordinate. The straight line in the figure is the line representing the objectively correct response, or constant proportionality of responses to stimuli.

Discussion

The exponents derived from magnitude production were similar to the exponent obtained in a study by Stevens & Guirao (1963), which used similar methods. Using this technique, it appears that perceived length is essentially proportional to objective length. Magnitude estimates, on the other hand, gave rather different results. Not only were exponents noticeably less than 1.0, but the size of the standard, and its presence or absence, had a significant effect upon the obtained judgments. The effects obtained by a change in standard were not those which Stevens (1956) reported for loudness. They were, however, similar to those found by Wong (1963), who observed a decrease in exponent as the modulus for the standard was increased, the size of the standard remaining constant. In this study, the exponent decreased as the size of the standard was decreased, with the modulus staying the same. Modulus and standard size, then, have complementary effects.

The most likely explanation for these effects is in terms of response biases introduced through the use of numbers. Undoubtedly, certain numbers exercise a strong anchoring effect on judgments. The differences seen in Fig. 1 between standard-absent and standard-

present conditions may represent a time-order effect for the former, and this effect also disappears when numbers are not used as responses. Number biases not only affect the general shape of the curve, they also produce local irregularities. The uneven functions shown in Fig. 1 for estimation were quite stable. The same form has been found with other groups whose data is not reported here. It was also noted that another group which made estimates directly in inches had an average exponent of .97, which was not significantly less than 1.0. The data for this third group was rather more variable than that for the magnitude estimation and production groups, but gave average functions which were indistinguishable from the functions for the production group. Apparently, in this more familiar task, number biases have a less obvious effect upon responses.

References

- PRADHAN, P. L., & HOFFMAN, P. J. Effect of spacing and range of stimuli on magnitude estimation judgments. *J. exp. Psychol.*, 1963, 66, 533-541.
- STEVENS, S. S. The direct estimation of sensory magnitudes—loudness. *Amer. J. Psychol.*, 1956, 69, 1-25.
- STEVENS, S. S., & GUIRAO, M. Subjective scaling of length and area and the matching of length to loudness and brightness. *J. exp. Psychol.*, 1963, 66, 177-186.
- WONG, R. Effect of the modulus on estimates of linear extent. *Amer. J. Psychol.*, 1963, 76, 511-512.

Note

1. The author wishes to thank Robert Mills for assistance in the running of this experiment.