Estimates of flicker rate can be taught

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Students were taught to assign numbers, which supposedly represented rate of flicker, to flickering lights. In fact, for one group the numbers were proportional to the logarithm of actual rate, and for another group they were exponentially related to actual rate. This tuition influenced the estimated rate of other flickering lights - each group making estimates that followed their training function. The result is consistent with the view that direct estimates of sensory magnitude are learned.

Stevens has shown that direct estimates of sensory magnitudes are proportional to a power of stimulus magnitude. Two conflicting interpretations have been offered of Stevens' Law, as we may call it. One interpretation (Stevens, 1961) is that it reflects the operating characteristics of sensory systems, and that the size of the exponent of the power function is characteristic of the transducing properties of a particular receptor. Another interpretation (Warren, 1958) is that Stevens' Law reflects the fact that people learn to estimate, in the course of everyday life, the magnitude of physical stimuli. The size of the exponent, on this view, depends upon the relation between the aspect of the stimulus estimated by the S and that measured by the E.

Our purpose is to show—for the dimension of flicker rate—that Ss can be taught an arbitrary relation between estimated magnitude and physical magnitude, and that this tuition can determine what estimates Ss make of new magnitudes about which they have had no special instruction. In a sense, therefore, we present evidence from a laboratory setting that is consistent with Warren's inferences about the origin of Stevens' Law.

Procedure

A Dawe "Strobflash" (Type 1200E) provided a flickering source. It illuminated an opal glass plate that was masked by a black card in the center of which was a 1 in. diameter hole. Immediately in front of this was a large screen whose mechanical shutter (operated manually) allowed the stimulus to be exposed or occluded.

Our procedure was adapted from one developed by Herrnstein & van Sommers (1962) for obtaining sensory estimates from animals. Ss were taught to estimate that five stimuli—called training stimuli—were flickering at a rate which in fact bore an arbitrary relation (either logarithmic or exponential) to their actual rate. They were then required to estimate the rate at which three training stimuli were flickering, and the rate at which four new test stimuli, interpolated among the training stimuli, were flickering. The training rates were 5, 15, 25, 35,

and 45 flashes/sec, and their arbitrary relations to estimated rate are illustrated by the two curved lines in Fig. 1. The parameters of these functions were specified by the restriction that they pass through the coordinates (5, 5) and (45, 60). The test rates were 10, 20, 30, and 40 flashes/sec.

The teaching consisted of the E presenting a training light for 10 sec and, 5 sec after its onset, calling out a number that supposedly represented its rate of flicker in flashes/sec. The training stimuli were presented in this way in random order, each stimulus appearing four times. Then the Ss were required to estimate the rate at which the training and test stimuli were flickering by assigning them a number which they wrote on prepared sheets of paper. Each stimulus was presented twice in random order for 5 sec.

The logarithmic function was taught to 25 Ss, and the exponential to another group of 26. A third group of 14 Ss was exposed to no teaching; they estimated the rate at which the nine stimuli were flickering by the method of magnitude estimation. The light of 25 flashes/sec was presented first and arbitrarily assigned the number 10. The Ss estimated the rate of flicker of the other lights by assigning them a number proportional to their rate of flicker. Each of the nine stimuli was presented for 5 sec, twice in random order.

All experimentation was done under group conditions during normal laboratory classes of a second-year course in psychology. Ambient lighting was fluorescent.

Fig. 1. Estimated rate of flicker as a function of actual rate for three groups of Ss: those taught a logarithmic function (circles), those taught an exponential function (squares), and those not taught a function (triangles). The triangles have been subjected to a linear transformation so that their best-fitting straight line passes through the coordinates (5, 5) and (45, 60).

Table 1. Comparison of Parameters of Prescribed Function with those that best fit the Obtained Points

	Logarithmic		Exponential	
	a	b	a	b
Prescribed	57.6	-35.3	3.7	0.06
Obtained	58.8	-36.3	4.3	0.06

Results

Figure 1 shows the geometric means of estimates under the three conditions. Circles depict estimates for Ss who underwent training on the logarithmic function, squares represent those who underwent training on the exponential function, and triangles those who made magnitude estimations. Clearly, for those Ss undergoing teaching, estimates of the test and training stimuli were principally a function of the teaching. A numerical indication of the degree to which the experimental points fit the prescribed functions can be gained by comparing the best fitting parameters for the experimental points with the parameters of the prescribed function; that is, by evaluating a and b in the equations $R = a \log F + b$, and $R = ae^{bF}$ (where R is estimated rate, F is actual rate in flashes/sec, and e is the base of the natural logarithms). These values are shown in Table 1. The fit appears satisfactory on this criterion.

Figure 1 shows that the magnitude estimations (triangles) are linearly related to flashes/sec. When these estimates were plotted on double logarithmic coordinates the slope of the best fitting straight line, as determined by the method of least squares, was 1.07. That is, these estimates obey Stevens' Law for the special case when the exponent is one. An exponent of one has also been reported by Stevens (1961b) for direct estimates of flicker rate. (For purposes of presentation the magnitude estimations shown in Fig. 1 have been transformed by a linear equation so that their best fitting line passes through the coordinates (5, 5) and (45, 60), which were also common to the logarithmic and exponential functions.)

Discussion

Our experimental procedure and results may, perhaps, be thought of as the converse of Warren's. He has shown that a subject's direct estimates of sensory magnitude can be interpreted as estimates of some physical aspect of the stimulus. His interpretation is necessarily historical, drawing upon plausible inferences about what is learned in the course of everyday life. Our results complement this interpretation by showing directly that estimates of physical magnitude—at least of flicker rate—can be taught, and that this tuition can influence estimates of other magnitudes that have not been taught. In addition, our results suggest that the Ss learned a rule that related physical and estimated magnitude and applied this rule to new stimuli. Learning a rule is implied by Warren's interpretation of estimates of loudness and brightness, for example, in which the inverse square law relating intensity to distance is said to be learned.

The results of the magnitude estimations came as a surprise to us. We had expected no simple relation here, since we supposed that Ss would have had little experience with rate of flicker. Indeed it was for this reason that we chose flicker rate for investigation. If we are to preserve Warren's explanation of Stevens' Law, then our results suggest that skill at estimating rate of flicker is, in fact, acquired in the normal course of events, or, perhaps, that skill at estimating rate of repetitive events is acquired and this skill is transferred to estimating rate of flicker. The docility of our other two groups shows that such learning can readily occur.

References

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