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ON THE EXPONENTS IN STEVENS' LAW AND THE CONSTANT IN EKMAN'S LAW [1]

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It follows from Stevens' psychophysical power law, $\psi = \alpha\phi^n$, that the exponent $n = \log R_\psi / \log R_\phi$, where R_ϕ is the ratio of the greatest to the least stimulus intensity and R_ψ is the ratio of corresponding sensory magnitudes. Data from 21 experiments by S. S. Stevens show a correlation (Pearson r) of $-.935$ between $\log R_\phi$ and $1/n$, implying that $\log R_\psi$ is nearly constant. On this basis it is proposed that a single scale of sensory magnitude serves a wide variety of perceptual continua, and that variation in power law exponents is primarily due to variation in dynamic ranges. The hypothesis that there is just one scale of sensory magnitude suggests that there may be just one value for subjective resolving power. When Weber fractions are transformed to their subjective counterparts by the psychophysical power law, the result for nine different continua is nearly constant at about .03.

Since the development of the direct judgment techniques by S. S. Stevens and his associates, an impressive array of data has accumulated showing that judgments of sensory magnitude grow as power functions of stimulus intensity. Each sensory mode yields a characteristic exponent which has been thought to indicate the rate at which log sensory magnitude grows with log stimulus intensity. For example, the exponent of about $\frac{1}{3}$ for brightness has been interpreted as indicative of the decreasing rate at which brightness grows with luminance; at the other extreme, the exponent of 3.5 for judgments of the subjective intensity of electric shock has been regarded as evidence that this experience grows increasingly more rapidly than the current which produces it. Thus, power law exponents can be viewed as measures of an important property of the relevant sensory apparatus.

But other interpretations are possible. Poulton (1967), among others, has raised the possibility that "the sizes of exponents are merely a function of the experimental conditions under which they were determined [p. 316]." Instead of providing us with information about the nervous system, exponents may simply reflect certain parameters of the test situation; the most important of these, according to Poulton, is the geometric range (ratio of extreme intensities) of stimuli employed. As represented in Figure 1, an exponent is the slope of the linear function relating $\log \psi$ (sensory magnitude) to $\log \phi$ (stimulus intensity). To the extent that the subjects' (*S*s') judgments cover a constant range of log magnitudes, exponents will reflect only the range of log intensities selected by the experimenter (*E*). There is then a possibility that *S*s' judgments are to some degree insensitive to the subjective magnitudes which they are supposed to represent, and tend to cover a constant ratio no matter what range of stimuli is presented. In that case, exponents may only be indirect measures of *E*'s arbitrary selection of stimulus intensities. In support of this view, which may be called the "procedural artifact theory," Poulton (1967) reports that for 21 studies conducted by S. S. Stevens and his co-workers, there is indeed a moderate correlation between exponent and geometric range of stimulus intensities (tau = $-.60$).

My purpose in this article is twofold. First, a reexamination of the data considered

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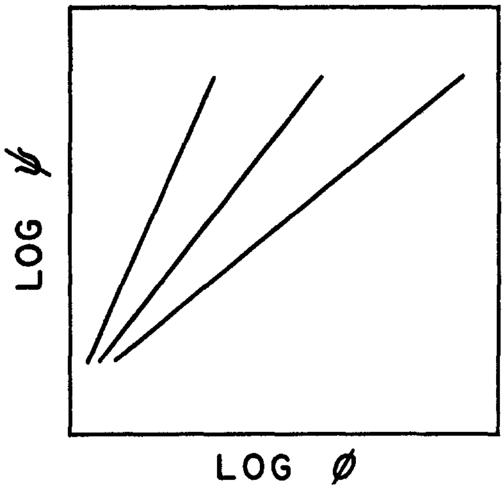

FIG. 1. The effect on power law exponents of variation in range log ϕ when range log ψ is constant.

by Poulton leads me to suggest that he has underestimated the closeness with which exponents are related to the stimulus ranges[3] employed. As is shown below, about 87% of the variance in exponents is accounted for by variation in stimulus range. Second, I wish to propose a hypothesis about this striking relation which is consistent with Stevens' view that exponents reflect an important property of the associated sensory systems. Briefly, this hypothesis proposes that the ratio of the greatest to the smallest possible sensory magnitude is approximately constant for all perceptual continua, and that variation in power law exponents among continua reflects variation in the ratio of the greatest to the smallest stimulus intensity to which S is responsive (a ratio which is sometimes called the dynamic range). In short, widely varying dynamic ranges may all be mapped into the same sensory range; and if some nearly constant proportion of those dynamic ranges is presented, the result will still be a nearly constant sensory range, although proportionately smaller than its maximum value.

This hypothesis differs from the procedural artifact theory in two important ways. First, it holds that variation in stimulus range, while certainly under E's control, may be heavily constrained by the sensitivity of S's nervous system. For example, the fact that E presents, say, three log units of sound pressure in a loudness scaling experiment but only one log unit of width in scaling the apparent extent of finger span, may reflect the dynamic ranges of the two sensory systems involved rather than E's arbitrariness in determining experimental parameters. Second, this hypothesis holds that the approximate constancy in the ratio spanned by S's judgments is due to the underlying constancy in sensory range rather than to the judgmental rigidity posited by the procedural artifact theory. But before further elaboration of this hypothesis, let us review the evidence considered by Poulton (1967) in assessing the relation between exponents and stimulus range.

[3] Throughout this paper, the phrase "stimulus range" refers to the *ratio* of stimulus intensities, and "sensory range" refers to the ratio of corresponding sensory magnitudes.

S. S. STEVENS' SCALING DATA

These data are drawn from 21 experiments conducted in Stevens' laboratory and are summarized in Poulton's (1967) Table 1. My analysis of these data is based on the following considerations.

It follows from the simple form of the power law

$$\psi = \alpha\phi^n \qquad [1]$$

that

$$n = \frac{\log R_\psi}{\log R_\phi} \qquad [2]$$

where $R\phi$ is the ratio of the greatest to the smallest stimulus intensity, and $R\psi$ is the ratio of corresponding sensory magnitudes. If the range of log judgments provided by Ss is nearly constant, we may substitute K for log $R\psi$. Then

$$n = \frac{K}{\log R_\phi}. \qquad [3]$$

An estimate of this constant K may be obtained by determining the value of n log R_ϕ for each of the 21 experiments, and calculating the mean. The resulting value, 1.53, was used in Equation 3 to generate a theoretical function relating the value of the exponent to log R_ϕ. That function is shown in Figure 2 together with the 21 points taken from Poulton's table, each represented by a filled circle. The exponents are plotted on the ordinate against the log stimulus range on the abscissa.[4] (The results of three additional experiments are plotted with unfilled circles. They do not figure in the data analysis, but are included to diminish the importance that a viewer might otherwise attach to the single points at each end of the abscissa.) The quality of the fit can be assessed by replotting the data with the reciprocal of the exponent, $1/n$, on the ordinate against log R_ϕ on the abscissa. If Equation 3 is true, the results should be well fitted by a straight line. Such a fit was made by the method of least squares; a Pearson r of .935 indicates that over 87% of the variance in the reported exponents is accounted for by the stimulus range employed.[5]

INTERPRETATIONS

Although the stimulus range may vary from .5 to 6.0 log units, the judgmental range is approximately constant at about 1.5 log units. According to the procedural artifact theory, this constancy represents S's inflexibility in making judgments and, extending Poulton's argument, we could conclude that the exponent is almost entirely determined by E's choice of stimulus range. The alternative interpretation that I have proposed is based on two concepts: (a) dynamic range and (b) the constancy of the maximum range of subjective magnitude.

[4] The points for binaural loudness, monaural loudness, vocal effort (the autophonic response), and vibration intensity are plotted using values of log R_ϕ which are just half those shown by Poulton. In expressing a given number of decibels as a ratio, Poulton has not taken account of the fact that in these four cases the reported exponents were calculated for ranges of stimulus pressure or amplitude; in such cases the number of decibels is 20 log R_ϕ, not 10 log R_ϕ as Poulton assumed.

[5] Jones and Woskow (1962) report a tau of .93 for nine continua tabled by Stevens (1960). It should be noted that the exponents came from one set of experiments using numerical magnitude estimation, while the stimulus ranges applied to another set of studies using cross-modal matching. Jones and Woskow also were led to surmise that judgmental ranges are approximately constant.

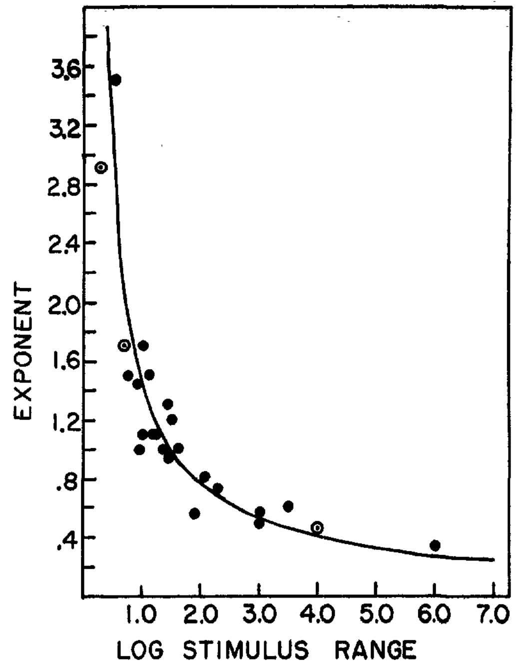

FIG. 2. The filled circles are for 21 experiments by Stevens and his associates tabled by Poulton (1967). The unfilled circles, from left to right, are for saturation of yellow (Indow & Stevens, 1966), saturation of red (Panek & Stevens, 1966), and apparent viscosity (Stevens & Guirao, 1964).

Dynamic Range

The notion that the perceptual continua differ in the ratio of extreme intensities to which S can respond is not a novel one, but there is regrettably little direct evidence on its validity. Much of the uncertainty concerns the problem of determining upper bounds to the range of sensitivity. In some cases, there is a fairly obvious physical limitation; for example, finger span simply cannot go much beyond 140 millimeters (mm.), and similarly the capacity to sense a lifted weight will be limited by muscular strength. In other cases, the problem is more difficult, and indeed some may question whether there is an upper limit to sound pressures that can be heard or to luminances that can be seen. Yet even in these cases, the occurrence of physical damage to the receptor system may establish an upper bound.

Despite the obvious difficulties in achieving precise measurement of dynamic range, the concept should not be overlooked as a factor influencing E's choice of stimulus intensities. For example, when scaling the subjective intensity of electric current applied to the fingers, it is just not possible to vary current by much more than a factor of four. By contrast, the ear readily responds to sound pressures varied by a factor of at least 100,000. It is this striking variation in dynamic range that imposes an upper limit on E's selection of R_ϕ, and according to the present hypothesis, it is this same variation which accounts for the variation in power law exponents.

Of course it is unlikely that any of Stevens' 21 experiments made use of the full dynamic range; that is, $\log R_\phi / \log R_\phi$ max was always less than unity. But to the extent that this fraction is nearly the same in all experiments, it would still follow that for $\log R_\psi$ a constant, the relative size of exponents reflects the relative size of dynamic ranges. Is $\log R_\phi / \log R_\phi$ max in fact a constant for the 21 studies in question? Lacking definitive measures of dynamic range, a direct empirical answer is not available. But since it is the practice in Stevens' laboratory (as in others) to conduct scaling experiments with the largest value of R_ϕ commensurate with S's comfort, it is not unlikely that a nearly constant proportion of the dynamic range is thereby selected.

Range of Subjective Magnitude

If the maximum value of R_ψ is the same for all perceptual continua, it is of interest to know how large that value may be. The estimate of about 1.5 log units reported above is probably lower than the true value. Suppose, as I have argued above, that $\log R_\phi / \log R_\phi$ max for Stevens' 21 studies is some constant C, less than unity. In that case, an estimate of $\log R_\psi$ max is provided by $1.5/C$; and if C is not less than .5, then $\log R_\psi$ max is located in the range from 1.5 to 3.0 log units. Only through a determination of values for dynamic range can a more precise estimate be developed.[6]

What kind of perceptual structure might generate the same value of R_ψ max for all continua? The present data are consistent with a model that posits a single central mechanism responsible for all judgments of sensory magnitude. Such a sensory magnitude monitor would impose the same range of possible outputs regardless of the receptor system in the periphery to which it was responding. In this context, the various receptor systems can be regarded as performing the necessary expansions or compressions required to map the widely varying dynamic ranges into this constant range of subjective magnitudes. Empirical investigation is required for a more rigorous evaluation of this construct and the development of additional defining properties. For the present, it is proposed only for its heuristic value in conceptualizing a structural basis for the constant in Equation 3.

INTRAMODAL VERSUS INTERMODAL VARIATION IN STIMULUS RANGE

Given the two interpretations of Equation 3, are there grounds for preferring one to another? Do they generate differential predictions? The present hypothesis of a constant sensory range relates exponents to an inherent characteristic of the relevant receptor system and does not in itself anticipate any effect of intradmodal variation in R_ϕ. But as the procedural artifact theory regards the actual value of R_ϕ as critical, the effect on exponents should be no different whether R_ϕ is varied intermodally (as in Figure 2) or intramodally. Indeed, Poulton's (1968) review of the pertinent literature reveals that for some continua there are conditions under which the exponent declines as R_ϕ grows. For example, Stevens and Poulton (1956) had separate groups of Ss make magnitude estimations of a 1000-Hertz (Hz.) tone 6, 10, 20, or 40 decibels (db.) less than a standard set at about 100 db. above threshold. The exponents estimated for these conditions are approximately .67, .60, .52, and .46, respec-

[6] An estimate of $\log R_\psi$ can also depend on the exact form of the power law which is employed. The version which translates stimulus intensity by an additive constant, $\psi = \alpha(\phi - \phi_0)^n$, can be used in conjunction with the present data to generate an estimate of $\log R_\psi = 2.11$.

tively. However, if these values are referred to the coordinates of Figure 2, it is evident by inspection that this effect of variation in log R_ϕ falls far short of an inverse relation to n. It seems that loudness judgments cannot be made to grow as rapidly as judgments of the subjective intensity of, say, electric shock by using the same value of R_ϕ for sound pressure as for electric current. While more evidence is needed to resolve this point, the results of Stevens and Poulton suggest that the intramodal effects of variation in R_ϕ may be quite different in magnitude, and hence probably in cause, from the intermodal effects depicted in Figure 2.

RESOLVING POWER

What has been called Ekman's law (Stevens, 1966) states that the subjective size of the just noticeable difference (jnd) is linearly proportional to the subjective magnitude of the standard; there appears to be a relativity for sensory magnitudes analogous to that defined by Weber's law for stimulus magnitudes. But if there is just one range of sensory magnitudes, it is tempting to consider that there may be just one constant of proportionality for Ekman's law. Thus S might be able to resolve a 100 $C\%$ change in sensory magnitude (where $C = \Delta\psi/\psi$) regardless of the form of stimulus input. Such a conclusion is consistent with the hypothesis that discriminations are based on the output of the sensory magnitude monitor discussed above.

If one selects the simplest version of the power law,

$$\psi = \alpha\phi^n,$$

then it follows that, for any continuum,

$$\psi + \Delta\psi = \alpha(\phi + \Delta\phi)^n$$

and therefore

$$1 + \frac{\Delta\psi}{\psi} = \left(1 + \frac{\Delta\phi}{\phi}\right)^n \qquad [4]$$

where $\Delta\phi/\phi$ is the Weber fraction and $\Delta\psi/\psi$ is the associated fractional growth in ψ. To test the constancy of $\Delta\psi/\psi$ requires that empirical values of $\Delta\phi/\phi$ obtained for various continua be inserted in Equation 4. An unequivocal specification of $\Delta\phi/\phi$ is notoriously difficult; the value is dependent on many parameters of the test situation. Nonetheless, it seemed reasonable to search for values of $\Delta\phi/\phi$ that could be regarded as characteristic of a particular continuum. The values of $\Delta\phi/\phi$ shown in Table 1 are for stimuli that resemble as closely as possible the stimuli that were employed in the scaling experiments which generated the tabled exponents. In the following sections, the sources for these data are cited, and any analyses which go beyond what the authors provide are explained.

TABLE 1

INVARIANCE OF $[1 + (\Delta\phi/\phi)]^n = 1 + (\Delta\psi/\psi)$

Continuum	$\Delta\phi/\phi$	n	$\Delta\psi/\psi$
Brightness	.079	.33	.026
Loudness	.048	.6	.029
Finger span	.022	1.30	.029
Heaviness	.020	1.45	.029
Length	.029	1.04	.030
Taste, NaCl	.083	.41	.033
Saturation, red	.019	1.7	.033
Electric shock	.013	2.5	.033
Vibration			
60 Hz.	.036	.95	.034
125 Hz.	.046	.67	.031
250 Hz.	.046	.64	.029
Mean			.031
Grand mean for nine continua			.030

Note.—$\Delta\phi/\phi$ is the Weber fraction, $\Delta\psi/\psi$ is the associated fractional growth in sensory magnitude, and n is the exponent of the power function relating subjective magnitude to physical intensity.

The Data

Brightness. One must be especially uneasy about selecting a single value to represent the Weber constant for brightness discrimination, since measures of resolving power depend at least on target size, duration, and retinal location, as well as the state of the retina at the time of the test. But there is also evidence that the measured size of the difference limen (DL) becomes increasingly insensitive to changes in duration and area beyond certain critical levels. For duration, Anglin and Mansfield (1968) have summarized evidence that at very high luminances (around 95 db.) 25 milliseconds is the critical value; longer exposures will

TABLE 2

SUMMARY OF FIVE STUDIES OF DIFFERENTIAL SENSITIVITY FOR BRIGHTNESS

Study	Method	No. *S*s	Target diameter (minutes)	Duration (seconds)	Log $\Delta\phi/\phi$
Herrick (1956)	Limits, ascending	2	60	.032 to 2.013	−1.2
Hattwick (1954)	Limits, ascending	1	60	.02	−1.1
Mueller (1951)	Constant stimuli 60% point	2	40	.02	−1.1
Keller (1941)	Limits, ascending and descending	2	88	.20	− .9
Graham & Bartlett (1940)	Limits, ascending and descending	2	56	.03	−1.4

not further reduce the DL. In the studies to be considered, exposure times were near or greater than this critical duration. For target size, relatively little improvement in differential sensitivity occurs beyond diameters of about 1° (e.g., Blackwell, 1946); the studies to be considered all employed targets near that size. To obtain from those studies the best estimate of the slope constant in the linear generalization of Weber's law, the value of the Weber fraction was taken at the highest intensity studied (or the point at which the fraction was minimized). Five experiments which met these conditions are summarized in Table 2; they are in fairly good agreement about the value of log $\Delta\phi/\phi$ despite variation in psychophysical method and experimental conditions. The median value of log $\Delta\phi/\phi$, −1.1, was selected and its antilog is the value shown in Table 1. Of course the list of studies in Table 2 is not exhaustive, but the reported values seem to be representative. Two well-known studies which report markedly lower values of $\Delta\phi/\phi$, Steinhardt (1936) and Blackwell (1946), were excluded because of the unusual degree of training provided the *S*s; both authors comment on the many thousands of judgments made over prolonged periods of time. Further, Blackwell's *S*s were encouraged (successfully) to respond at levels of awareness well below those usually required by the classical psychophysical methods.

The exponent of the power law describing the brightness function has been reported as .33 by Stevens and Stevens (1963).

Loudness. For loudness, the value .048 is due to Miller (1947) and refers to discrimination of the intensity of white noise. He found that at levels greater than 30 db. above threshold, the increment (1.5-second pulse) heard 50% of the time was nearly constant at .41 db.; his sample was composed of two experienced *S*s. A similar value has been reported by Harris (1963) for a wide range of pure tones (125 Hz. to 6000 Hz.) using the method of constant stimuli. The exponent of .6 for the power function relating loudness to sound intensity was reported by Stevens (1956) and has been recognized as the standard value.

Finger span. Differential sensitivity for finger span has been studied by Gaydos (1958) using the method of adjustment. In his Experiments 1 and 2, a total of 100 *S*s made matches to standards ranging from 17.7 to 100 mm. Probable errors can be plotted against the lengths of the standards, yielding a linear function with a slope of .024. In his Experiment 3, Gaydos reports data obtained from a group of 20 *S*s for a shorter range of standards; ignoring an anomalous value for the shortest standard, a linear fit of the probable errors to the standards yields a slope of .020. A similar value, .019, has been reported by Stevens and Stone (1959) for data obtained by G. J. Huberman.[7] Giving double weight to the value derived from Gaydos' Experiments 1 and 2, these three results have a mean of .022.

Stevens and Stone (1959) reported that magnitude estimation of apparent finger span

[7] Stevens and Stone (1959) plotted standard deviations rather than probable errors and reported a slope of .0286. I have multiplied this by .6745 to obtain the slope for probable errors.

yields a power function with an exponent of 1.33. More recently, Mashhour and Hosman (1968) have obtained an exponent of 1.26 using a standard in the middle of a series of 11 stimuli ranging from 10 mm. to 110 mm. The mean of these two results, rounded to 1.30, is the value listed in Table 1.

Heaviness. For differential sensitivity to lifted weights, the work of Oberlin (1936) is most frequently cited. In his Experiment II, five *S*s judged the second of pairs of weights as heavier, lighter, or equal in comparison to the first. Standards varied from 25 grams (gm.) to 600 gm. Urban's process was used to determine the upper and lower DLs. When half of the interval is calculated, the average over *S*s is nearly linear with the standard weight (although the value for 600 gm. is aberrant); the slope is .02. This slope fits the data of Experiment I (in which only "heavier" and "lighter" judgments were allowed) over the lowest four standards, 50 gm. to 250 gm., for each of four *S*s.

The exponent of the power function for apparent heaviness is 1.45 as reported by Stevens and Galanter (1957). Although Mashhour and Hosman (1968) reported 1.13 for a range from 70 gm. to 700 gm. with a 222-gm. standard, the figure reported by Stevens and Galanter is an average over several studies and is therefore preferred.

Length. In measuring DLs for length, Ono (1967) employed a variant of the method of limits for standard lengths of 5, 10, and 15 centimeters, at distances of 1.5, 3.0, and 4.5 meters. Although standard and comparison stimuli were displayed together, their lateral displacement was sufficient to ensure nonsimultaneity of viewing. When the size of the DL is plotted against the distal size of the standard, the slope of the linear relation is .029. Stevens and Galanter (1957) reported that magnitude estimations of apparent length are "very nearly a linear function of physical length"; the exponent of the power function is close to 1.00. Mashhour and Hosman (1968) reported an exponent of 1.08 for lengths ranging from 15 mm. to 150 mm. with a standard of 55 mm. The mean of these two values is 1.04.

Saltiness. McBurney, Kasschau, and Bogart (1967) measured the size of the jnd for NaCl after adaptation to water, and also after adaptation to a .1 molar solution of NaCl. The results of the latter condition, although representing just one point on the function relating the Weber fraction to intensity, are reported here. The average of $\Delta\phi/\phi$ for three *S*s following a method of constant stimuli was .09. Using an ascending method of limits with a criterion of two successive correct responses, the average $\Delta\phi/\phi$ for two *S*s was .075. The mean of these two values, .083, is used. McBurney (1966) used magnitude estimation with 10 *S*s judging the apparent intensity of solutions of NaCl ranging from water and .001 molar to 1.0 molar concentrations. Using empirically determined threshold corrections for each of several adapting intensities, the data can be well described by a power function with an exponent of .41.

Saturation. Panek and Stevens (1966) obtained magnitude estimations of the saturation of red, and measured jnd over a range of saturations. The latter was done using the method of constant stimuli for four *S*s and the method of single stimuli for four *S*s, for saturations varying from 20% to 80% red. The jnd was defined as *Q*, half the distance between the 25% and 75% values, and the results averaged over both methods are reported. The relation between *Q* and the standard saturation is well fitted by a straight line (discounting the value for the weakest standard) with a slope of .019. Data are also reported for the method of constant stimuli alone at standards of 20% and 80%; a straight line connecting these two values of *Q* has a slope of .019, and this is the value shown in Table 1. The results of the several magnitude estimation experiments are well described by a power function with an exponent of 1.7.

Shock. Hawkes (1961) measured Weber fractions for the intensity of electric shock to the finger tip, for a range of frequencies, using both the beat method and the method of successive stimuli. From his graphical display of Weber fractions, values of $\Delta\phi$ were calculated for each of three *S*s. Only two intensities were studied, 120% and 200% of each *S*'s absolute threshold, so it is the slope of the straight line connecting these two points in the plot of $\Delta\phi$ against ϕ that can be calculated. Since there appears to be little effect due to psychophysical method or frequency, slopes were obtained for all three *S*s at 100 Hz. and at 1500 Hz. using both methods. The median value of this (somewhat skewed) distribution of 12 scores is .013.

Stevens, Carton, and Shickman (1958) scaled the subjective intensity of electric shock covering a range from .38 milliampere (ma.) to 1.15 ma. and reported a power function with an exponent of 3.5. Ekman, Frankenhaeuser, Levander, and Mellis (1966) had 15 *S*s judge the unpleasantness of electric shock varying in intensity from 1.5 to 3.5 times each *S*'s mean sensation threshold. The results together with findings from a previous study by the same authors are well fitted by Ekman's version of the power law (involving an additive translation of stimulus intensity) with an exponent of 1.54. The mean of these two values is 2.5.

Vibration. The case of tactile vibration is interesting because the exponent of the power function varies with frequency. Stevens (1959) has reported that magnitude estimation of a 60-Hz. vibration to the fingertip follows a power function with an exponent of .95. Later, Stevens (1968) found that if a 60-Hz. vibration is adjusted to match a 125-Hz. vibration or a 250-Hz. vibration, the resulting power functions have exponents of .70 and .67, respectively. These two values may be multiplied by .95 to generate estimates of the exponents—.67 and .64—of power functions obtained by magnitude estimation.

Knudsen (1928) measured DLs for vibration at 64 Hz., 128 Hz., and 256 Hz., values which are similar to those employed in Stevens' scaling studies. He employed a method of limits with both ascending and descending series. His data are average values for two *S*s and are presented in the form of Weber fractions. From his graphs, estimates of $\Delta\phi$ can be derived, and when plotted against ϕ (expressed relative to approximate threshold), are well fitted by straight lines. The slopes are .036, .046, and .046 for vibration frequencies of 64 Hz., 128 Hz., and 256 Hz., respectively.

Invariance of $\Delta\psi/\psi$

The apparent stability in the computed values of $\Delta\psi/\psi$ is impressive, especially in view of the difficulty of demonstrating, first, that the several values of $\Delta\phi/\phi$ are comparable, and second, that they are each preferable to alternatives that may be found in the literature. Despite these difficulties, the values of Table 1 raise the possibility that a constant percentage change in sensory magnitude is just discriminable, regardless of the nature of the stimulus. The view that the steepness of the psychophysical function is directly related to differential sensitivity was of course Fechner's idea, and has in recent years provoked severe criticism (e.g., Stevens, 1961), as well as frequent restatements (e.g., Heinemann, 1961; Luce, 1959). But it is important to recognize, as Heinemann (1961) has pointed out, that this aspect of Fechner's speculation is quite separable from his ill-fated hypothesis that jnd's define subjectively constant *intervals*. Instead, what seems to be constant is the *ratio* of subjective magnitudes generated by stimuli one jnd apart, and the evidence of Table 1 shows that the value of this ratio is constant for a wide variety of continua.

A final word of caution may be useful. A critic could of course dispute any one of the empirical values in Table 1; the Weber constants are especially vulnerable, and there are undoubtedly anomalous cases that do not fit the pattern. But it seems evident that, without being subject to gross distortion, many of the data in the discrimination literature fall into a simple and conceptually attractive pattern. What remains to be seen is whether this pattern extends over an even broader domain than is indicated here, or whether it is liable to so many exceptions that its value is lost.

In summary, one can point to two large areas of data suggesting that the experience of sensory magnitude is governed by a single mechanism. Two of its properties have been described here; further research may reveal others.

CONCLUSIONS

Three hypotheses have been proposed together with supporting evidence:

1. There is a common scale of sensory magnitude for a wide variety of perceptual continua.

2. The maximum range of log sensory magnitudes defined by this scale accounts for the inverse relation between power law exponents and the range of log stimulus intensities, when the latter are proportional to their maximum values (dynamic ranges).

3. Data from a number of discrimination studies are consistent with the view that just noticeable changes occur when sensory magnitudes are altered by a constant fraction, and that this fraction is the same regardless of the form of input energy.

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