SCALING OF VERY, VERY SHORT VISUAL EXTENTS

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Summary. Using the magnitude estimation and production methods, the psychophysical function for very, very short visual extents was shown to be a straight line. The argument is made that the linearity of the psychophysical function is independent of past experience. Such a linear relation is plausibly due to the linearity of the transformation, through perceptual constancy, of the physical extents into apparent extents.

Apparent length has been found to be linearly related to physical length (Baird, 1970, p. 38-47, reviewed the studies on this topic); also, apparent duration seems to increase as a linear function of actual time (Gregg, 1951; Ross & Katchmer, 1951; Gescheider, 1967). Since we have extensive experience with apparent length and time, and have frequent opportunity to have untrue judgments corrected, some authors (see Marks, 1974, p. 50) were led to suggest that such a linear relation is plausibly caused in part by past experience.

It is of interest to ask the observer in a magnitude estimation and production experiment to give estimates of unusual very, very short visual extents. If the extents are some fraction of a millimeter, it may be reasonably predicted that past experience exerts no direct action on formation of judgment. Accordingly neither the psychophysical function that ensues should be the partial outcome of our daily commerce with the behavioral world.

METHOD

Subjects

Two experiments were performed. A different group of observers served in each experiment; in Group A were nine university students and one psychologist; in Group B nine university students.

Stimuli

Two micrometers were fastened over a white board. The bars of the micrometer were 7 mm wide. They were parallel and 2.5 cm apart. The observer had to look at the bars perpendicularly. The eye distance from the bars was kept constant at 15 cm by means of a head rest. The slit of the bars could be narrowed or widened from near zero to some millimeters. The slits were collinear. Shields around the micrometers were used to avoid shine of the bars.

Procedure

Two experiments studied magnitude estimation and production of width of the slit on the right. The slit on the left was used as a standard. In
Experiment A the standard was set at 150 microns and assigned a numerical value of 10. In the magnitude estimation session the stimuli (right slit) were spaced as follows: 50, 70, 90, 110, 130, 150, 200, 250, 300, 350, and 400 µ. The observer gave two estimates per stimulus. In the session for magnitude production, observers had to produce the following numerical values of the right slit: 2, 3, 4, 6, 8, 10, 15, 20, 30, and 40. The observer produced each numerical value two times. The stimuli and the numerical values were presented in random order, a different order for each observer. The observer first served in the estimation session then in the production session. The vernier of the micrometer was hidden from the observer. The magnitude estimation and production sessions lasted about 15 min. altogether.

Exp. B was the same as Exp. A except the standard was set at 300 µ and assigned the numerical value of 10. In the magnitude estimation session the magnitude of the stimuli was doubled. In the magnitude production session the numerical values to be produced were also doubled. The estimation and production sessions lasted about 25 min. altogether.

RESULTS

In Exp. A the magnitude estimation gives points on the diagram in Fig. 1 which are fitted by the straight line $ψ = 0.10 + 0.06 φ$; the coefficient of correlation is 0.993. A power function fit gives an exponent $β = 1.15$; the coefficient of correlation in a log-log plot is 0.978. The points from magnitude production are fitted by the straight line $ψ = –1.08 + 0.06 φ$ ($r = 0.998$). A power function fit gives an exponent $β = 1.19$ ($r = 0.991$ in a log-log plot).

The average straight line is $β = –0.49 + 0.06 φ$; the average exponent of a power function is 1.17.

In Experiment B magnitude estimation gives $ψ = –0.69 + 0.03 φ$ ($r = 0.992$) and $β = 1.22$ ($r = 0.987$ in a log-log plot). Magnitude production gives $ψ = –1.25 + 0.04 φ$ ($r = 0.998$) and $β = 1.13$ ($r = 0.994$ in a log-log plot).

The average straight line is $β = –0.91 + 0.03 φ$; the average exponent of a power function is 1.18.

The magnitudes of the correlations show that the points on the diagram in Fig. 1 are best fitted by a straight line. In the case of the standard set at 150 µ the intercept of the average straight line is –0.49; in the case of the standard set at 300 µ, the intercept is –0.91. A value of the intercept different from zero may be understood as a constant error. Thus, the results represented in Fig. 1 strongly suggest that the exponent for very, very short visual extents is equal or nearly equal to 1.

Since we have infrequent occasions to make estimates of very, very short visual extents, and since we get a psychophysical function with exponent 1 both for very, very short and for longer visual extents, it seems...
plausible to conclude that ontogenetic experience does not influence appreciably the form of the psychophysical function for visual length.

One could say, though, that such a psychophysical relation has been built up through phylogenetic experience. It is in fact of primary biological importance for man, and much probably also for animals, to judge spatial and temporal length correctly. The problem then arises why the linearity of the psychophysical function is maintained also for very, very short extents, whose detection seems not to be relevant for survival.

This problem may be solved perhaps as follows. Since in this experiment the ratios of the modulus to the smallest and greatest stimulus and numerical value was, respectively, not greater than 5 and not lower than 0.2, Garner’s (1958) and Attneave’s (1962) suggestion that observer’s conception of numerical ratios deviate appreciably from nominal numerical values may be disregarded. That is, it may be reliably assumed that the observers used numbers in a linear fashion.

Extents in the physical world \( F \) are linearly transformed into extents in the perceptual world \( P \) through the process of perceptual constancy. What is biologically adapted to \( F \) is \( P \) (Brunswik, 1956). Since number is linearly related to \( P \), and \( P \) is linearly related to \( F \) owing to size and distance constancy—in this experiment cues for distance were in fact present in full—it follows that the psychophysical function for very, very short extents must have an exponent 1.

**References**


FIG. 1. Relation between apparent visual and physical very, very short extents.