Psychophysical scaling of corneal sensitivity¹

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Judgments of corneal sensitivity to pressure are carried out as a function of increased pressure by means of the method of magnitude estimation with a free modulus. The apparatus used is an aesthesiometer consisting of a nylon thread of constant diameter but of variable length. The results suggest that the judgments are governed by a power function with an exponent of 1.01.

Sensation has been shown to follow a power law relating psychological magnitude to a physical stimulus (Stevens, 1961). However, it seems that scaling of corneal sensitivity has not yet been carried out, doubtlessly because of the difficulty of obtaining an appropriate instrument for the presentation of stimuli on the cornea. The corneal aesthesiometer of Cochet & Bonnet (1960) is at present probably the most suitable instrument to carry out this experiment. The purpose of this paper is to see whether the apparent magnitude of the sensitivity to pressure of the cornea is also governed by the psychophysical power law.

METHOD

Sixteen graduate students in psychology took part in this experiment. None wore contact lenses or had had any injury to his cornea. One had to interrupt the experiment and declined to continue. None had ever served as a S in an experiment of this type.

The apparatus used was the Cochet and Bonnet corneal aesthesiometer. It consists of a nylon thread, the length of which can be varied by retracting the thread into the body of the instrument. The end of the thread is pushed against the cornea and because the length to diameter ratio of the thread is high it bends to one side. The length of the thread may be varied and different forces may be applied to the cornea for a given angle of bend. The length of the thread ranges from 5 to 60 mm transmitting a pressure varying from 200 mg/sq mm to 12 mg/sq mm when bending is about 5 deg. A bending of 5 deg is difficult to assess although it corresponds approximately to the minimum angle of bending. The dexterity of the E is important in repeating every measurement with the same amount of bending, and only such measurements were used in the present experiment.

The sensitivity of the cornea varies across its surface being at a maximum in the center (Boberg-Ans, 1955; Cochet & Bonnet, 1961; Millodot & Larson, 1968). However, the threshold of corneal sensitivity measured in the center of the cornea is affected by a bias which is probably caused by the apprehension of the S on seeing the instrument approaching the eye, and the thresholds are lower when the S cannot see the instrument under infrared light (Bonnet & Millodot, 1966). The thresholds are the same when the measurements are made on a peripheral point of the lower part of the cornea (about 2 mm from the limbus) by having the S fixate a target directly above the horizontal plane of the eyes.

Eight values of the pressures were used (11, 16, 22, 36, 52, 75, 100, and 145 mg/sq mm). These pressures are obtained by varying the lengths of the thread according to a calibration provided with the instrument.

The S was seated comfortably with his head leaning against a head rest. The thresholds to touch were first determined by a method of constant stimuli and in this case the value at which it was felt 50% of the time was used. A certain number of blanks were made to control for the fact that the S may utilize the faint movement of the instrument seen in peripheral vision as a cue and after a few trials all Ss ignored this cue. The thresholds were determined only to ascertain that the stimuli utilized for scaling were supraliminal.

The magnitude estimation method was then employed to scale the pressure applied to the cornea. A free modulus technique was used. The first six observations were used for practice and were not recorded. The stimuli were presented in random order and twice each.

RESULTS AND DISCUSSION

The results were analyzed by the computer program "Psychofit" (Kalikow, 1968). The purpose of this program is to minimize the two problems arising from the variability within Ss and the fact that Ss use a different modulus. This was the case in the present experiment as the task was somewhat difficult. The raw data, i.e., two observations per stimulus, per S were fed into the program. The program computes, among other things, a slope for each S. The mean slope for all Ss was 1.014 and the standard deviation of the slopes was 0.24. The equation passing through the geometric means is,

$$\log R = 1.014 (\log S) - 0.79 \quad (1)$$

where R is the magnitude estimation and S the stimulus. The r^2 of this relationship is 0.99. This value provides an indication of the "goodness" of fit of the curve to the data. The data are plotted in Fig. 1.

These results show that corneal sensitivity to pressure is a power function of the pressure applied to the cornea. The exponent is 1.014. The variations in the slopes may be accounted for by the fact that many Ss displayed some fear of the experiment. The procedure of magnitude estimation often gives a slight underestimation of the value of the exponent (Stevens & Greenbaum, 1966) and the value of the exponent given here probably represents a lower bound.

It is worth noting that the highest stimulus evoked a sensation of pain rather than pressure in almost all Ss and this fact accounts for the limit of the physical range of stimuli used.

The value of the exponent of corneal sensitivity to touch is nearly the same as that of the pressure on the palm which is 1.1 (Stevens, 1961) although a comparison between these two types of responses must take into account the fact that the receptors are totally different. The cornea is believed to have only free nerve

Fig. 1. Apparent magnitude of corneal sensitivity as a function of the pressure applied on the cornea plotted on log-log coordinates. The dots represent the geometrical means.

endings whereas the skin has a multitude of receptors (Maximow & Bloom, 1957). The results obtained on the cornea are a direct description of stimulation affecting free nerve endings alone whereas on the skin all receptors may play a role in the resulting sensation.

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NOTE

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