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SOME CORRELATES OF THE LOUDNESS FUNCTION

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The studies reported in this paper were prompted initially by the need to elucidate the finding that individuals with an extensive history of motion sickness tend to produce relatively steep functions when spiral after-effect (SAE) persistence is plotted against the logarithm of the prior stimulation period (Reason & Benson, 1966). One interpretation put on this relationship was that it reflected idiosyncratic differences in the way the CNS "receives" or transduces stimulus intensity. In other words, it suggested the possibility that those individuals who typically produce steep SAE functions, and who are relatively susceptible to motion sickness, may be those who tend to be more "receptive" to a given level of sensory input, irrespective of modality. If this were the case, then it was reasonable to expect - from the evidence provided by Stevens (1957), and others - that these people would also produce relatively steep psychophysical magnitude functions. The loudness function was selected for its technical convenience, and because it had received considerable attention from previous workers; but, theoretically, any 'prothetic' sensory continuum would have served as well.

The method of obtaining individual loudness functions was similar in most respects to that described by Stevens (1956). Subjects were asked to give numerical magnitude estimates of the loudness of a 1000 Hz tone at six sound pressure levels: 50, 60, 70, 80, 90 and 100dB, re: 0.0002 dynes/cm^2. With one exception (see below), a modulus of 50dB (equivalent to 10 units of psychological magnitude) was presented for comparison on each trial. Individual regression coefficients (i.e. the 'b' values of the regression equation: $\log Y = \log a + bX$, where Y = psychological magnitude) were calculated from the average estimates at each sound pressure level.

1. Relations with SAE slope and motion sickness susceptibility

A significant concordance was found in 40 subjects between (a) the loudness slope, (b) the SAE slope, and (c) motion sickness susceptibility as measured by a personal history questionnaire (MSQ). Subjects reporting a relatively high incidence of past motion sickness also tended to produce relatively steep SAE and loudness functions. The same experiment was repeated with another group of 36 subjects, and a significant concordance was again obtained between these three measures. Spearman rank-order correlations, found in these two studies, are set out in Table 1.

Table 1 : Relations between MSQ score, SAE slope and loudness slope

	r_s	
	Expt. 1 (N=40)	Expt 2 (N=36)
SAE slope/loudness slope	+0.53**	+0.32*
SAE slope/MSQ score	+0.55**	+0.48**
Loudness slope/MSQ score	+0.31*	+0.30*

(Where ** = P < 0.01; * = P < 0.05)

These results lent credence to the idea that the inter-personal variation observed in all three of these measures reflected characteristic differences in receptivity, or the coding of stimulus intensity. In addition, the fact that a rank-order correlation of $r_s = 0.63$** (N=36) was also obtained between the loudness slopes of the same individuals, tested three months apart, suggested that this measure was tapping a fairly stable feature of the CNS.

2. Relations with magnitude functions for other sensory continua

This experiment was designed to test the generality of these slope differences over a wide range of 'prothetic' continua. Magnitude functions were obtained from 40 subjects for six continua: loudness, brightness, angular velocity of a visual target, weight, visual area, and visual length. The modulus, equivalent to 10 units of psychological magnitude, was always close to the centre of the graded stimulus series; in the case of loudness, it was 70dB. Product-moment correlations between the individual regression coefficients obtained for the six continua are shown in Table 2.

Table 2: Inter-relations between the slope values of six sensory continua

	1	2	3	4	5	6
1. Loudness	.	.	.	.	.	.
2. Brightness	.756**	.	.	.	.	.
3. Angular velocity	.518**	.508**	.	.	.	.
4. Weight	.673**	.421**	.542**	.	.	.
5. Size	.433**	.452**	.291	.331*	.	.
6. Length	.307*	.344*	.399*	.167	.433*	.

The high degree of concordance between these different regression coefficients suggested that whatever contributed to variation in the slope of the magnitude function, it was not limited to any one sense modality. Similar findings have been obtained in Sweden (Hosman, 1967). But this consistent interpersonal variation could reflect either (a) idiosyncratic differences in the sensory transduction process, or (b) idiosyncratic differences in the way numbers are assigned to physical magnitudes.

3. Relations with the auditory reaction time (RT) function.

This experiment was designed to investigate this notion further by comparing individual differences in the slope of the loudness function with those revealed in the slope of the plot relating auditory RT to stimulus strength. The same six sound pressure levels were used for both the magnitude estimates and the RT measurements. In addition, the mean of 60 simple RT's to a 70 dB tone was obtained for each of the 32 subjects.

The results showed that while the slope of the loudness function is positively related to the slope of the RT function ($r_s = 0.45$; $P < 0.01$), it is unrelated to the typical RT value obtained at a single level of intensity. This slope relationship suggested that the way in which both loudness estimations and RT vary with stimulus strength is determined by the characteristic mode of operation of the intensity coding mechanism. Clearly, learned habits in assigning numbers could have played little part in this relationship, since numerical estimates were not called for in the RT task.

Conclusions

Taken together, these findings suggested that the slope of the loudness function is influenced by the characteristic way in which the central nervous system, as a whole, transduces stimulus intensity. Individuals producing steep functions were designated as 'receptives', and those producing shallow functions as 'nonreceptives'. This receptive-nonreceptive dimension appears to have a number of theoretical characteristics in common with other sensory typologies; for example, Petrie's (1967) "augmenters" and "reducers", and Teplov's "weak" and "strong" nervous systems (see Gray, 1964).

References

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