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RELATION BETWEEN STIMULUS RANGE, DIRECT LOUDNESS ESTIMATION AND AVERAGED CORTICAL V-POTENTIAL*

Abstract: Twelve subjects estimated the loudness of stimuli, once in a short range (50, 60 and 68 dB), and once in a large range (20, 50, 60, 68 and 80 dB). Concurently, evoked cortical responses to 50 and 68 dB were recorded. The range markedly influenced the loudness estimations but no significant range-effect was found in the peak-to-peak amplitude of the $N_1 — P_2$ waves.

INTRODUCTION AND PROBLEM

The psychologists' interest in problems that cannot be solved exclusively by behavioral measurement on physical scales has led to some rehabilitation of the subject as a direct source of psychological information.

The subject's estimates of a particular aspect of his psychoneural activity as well as estimates of some »stimulus« characteristics based on his subjective experience are being used again.

The use of the subject as a kind of measuring instrument presupposes a defined psychological continuum and a defined measurement scale. Therefore much work has been done on the standardization of estimation procedures and the construction of scales necessary for the measurement of subjective magnitudes.

Particularly in psychophysics a great number of techniques for sensory magnitude estimations have been proposed. The invariance of the psychophysical function is taken generally as the proof of the validity of the procedure used. Hence the investigation and elimination of all relevant factors that apart from the independent variable could influence the estimations is an important task in scaling methodology.

In the so-called subjective or new psychophysics based on the subject's direct estimations, the stimulus range is one of the main

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factors influencing the variability of psychophysical functions. Many studies have shown that with the decreasing of the stimulus range the steepness of the psychophysical function increases and vice versa.

The marked influence of the stimulus range is reflected in the magnitude of the exponent n in the power equation usually used as the expression of the psychophysical function. The effect of the stimulus range is marked when psychophysical functions are compared intermodally. Formerly, differences in the exponent n were considered to reflect the specific characteristics of the psychophysical relation in various sensory modalities. Now, it seems that these differences are primarily due to different dynamic stimulus ranges. The exponents as shown by E. C. Poulton (1968) and R. Teghtsoonian (1971, 1973) are more or less inversely proportional to the *log* stimulus range.

Within a given modality the stimulus range effect is less pronounced but still large enough to produce different psychophysical functions.

Magnitude estimations are based not only on the subject's perceptions but also on his judgment about the quantitative aspect of his perception. Therefore the question of whether the mentioned variations in estimations are due to a particular elaboration of sensory information or to changes in the functioning of receptors seems justifiable. Under the influence of the context the subject calibrates and recalibrates the reference point of his estimations. These changes in calibration might be the result of a change in receptor sensitivity as well as the result of a change in the judgment criterion.

The problem whether different stimulus ranges really change the sensory effect of stimuli or only influence the criterion of the subject's judgments could be solved if besides subjective estimates, also data on the magnitude of neural processes which are the immediate basis of perceived intensity were available.

In man, unfortunately, the peripheral code of stimulus intensity (the number of simultaneously activated afferent neurons and the frequency of afferent impulses) is not easily accessible. As yet only the cortical potentials evoked by sensory stimuli as an indirect indicator of afferent neurophysiological processes can be used. Although it is questionable to what extent the amplitude of evoked cortical potentials might serve as a measure of sensation magnitude, the fact is that the amplitude of this neurotonic cortical reaction grows with the increase of stimulus intensity.

Our problem was to determine whether the well-known steeper rise of loudness estimates in a short intensity range is accompanied also by a steeper rise of the evoked cortical potential amplitude.

As far as we know, there is only one study by G. B. Henry and D. C. Teas (1968) dealing with the influence of the context of acoustic stimuli on the *V*-potential. They used two intensity scales overlapping only in the extreme intensity. They applied in the same experiment both the weak and the strong intensity series. The interstimulus interval was short, and the average record was based on 16 summations. With this experimental design they found that the intensity level of the stimulus scale had no effect on the magnitude and variability of evoked potentials.

PROCEDURE

Twelve subjects, psychology students, participated in the experiment. The experiment was run in a sound-proof, electrically shielded room.

A 1000 Hz tone was presented through a loudspeaker 1.5 m away from the subject. The tone, of a rapid rise and decay time, lasted 2 sec.

The short range comprised sound intensities of 50, 60, and 68 SPL and the large range those of 20, 50, 60, 68, and 80 SPL.

The experiments with the short and the large range were run separately. To six subjects the short range was presented first and the large range seven days afterwards. With the other six subjects the order was inverted.

At the beginning of each experiment the weakest and the strongest stimulus of the range to be used on that day were presented.

The stimuli, in a random sequence, were grouped in eleven series. At the beginning of each series the standard tone of 60 dB was presented. The sensory effect of this tone was set as modulus 10. The subject estimated the loudness of the other tones in comparison with the modulus by the direct magnitude estimation procedure. The interstimulus interval was 15 sec. A rest followed each series.

In the course of eleven series the cortical potential for only one standard intensity (50 or 68 dB) was recorded. After a prolonged rest the whole procedure was repeated with the recording of the potential evoked by the other standard stimulus. The recording order was varied among the subjects.

In this manner, for each subject the magnitude estimations as well as the concurrently recorded evoked potentials for the standard tones of 50 and 68 dB, presented in the short and the large range, were obtained.

The recording electrodes were EEG silver electrodes with contact paste. One electrode was on the vertex and the other on the ear lobe. The electrical brain activity was recorded through an EEG preamplifier at the Northern NS-560 averager. The analysis time was 512 msec and the number of summations 64. The peak-to-peak amplitude of the N_1—P_2 wave was taken as the measure of the magnitude of the evoked V-potential.

RESULTS AND DISCUSSION

The magnitude estimations of the same standard intensities differed far more in the short than in the large range. The perceived magnitude of 50 dB was judged smaller and that of 68 dB greater in the short range than the magnitude of the same intensities in the large range. The ratio between the estimates in the short range was 1 : 4.25 and that in the large range 1 : 2.45.

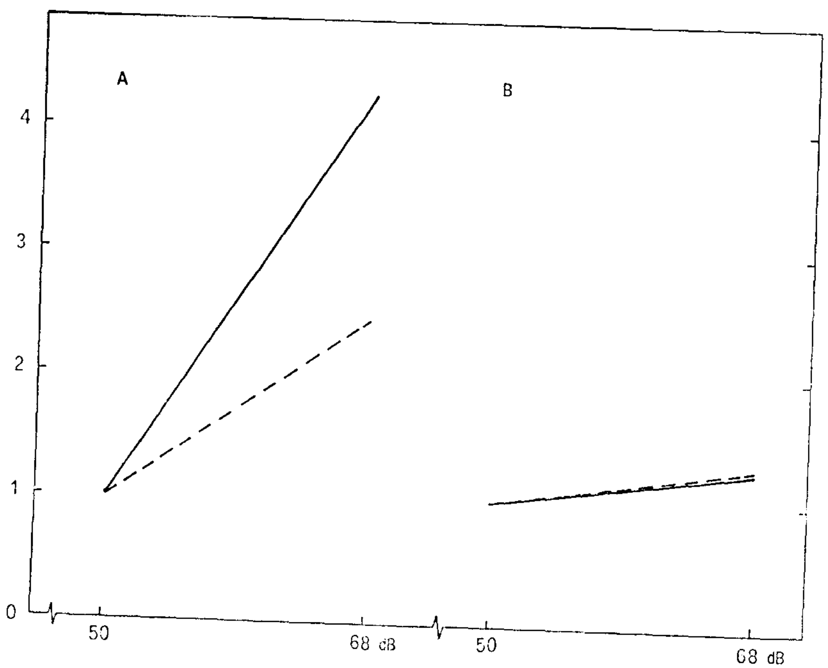

Fig. — Stimulus range effect on loudness (A) and on evoked V-potential amplitude (B). Relative values. Full line: results in the short range; interrupted line: results in the large range. Medians of individual data.

The difference in the amplitude of V-potentials evoked by two standard stimuli in the short and the large stimulus range was similar. In other words, the stimulus range markedly influencing the steepness of the psychophysical function had no effect on the concurrently recorded cortical potentials. The ratio of the evoked potential amplitudes for the same stimuli was 1 : 1.425 in the short range and 1 : 1.430 in the large range.

The ratios cited are based on medians. If the less reliable arithmetic means are taken, the ratios are of the same order: for magnitude estimations 1 : 5.241 in the short range and 1 : 3.127 in the large range; for the peak-to-peak amplitude of the N_1—P_2 waves 1 : 1.491 in the short range and 1 : 1.478 in the large range.

For eleven out of twelve subjects the psychophysical function based on magnitude estimations was steeper in the short intensity range. As to the N_1—P_2 amplitude, the difference was greater in the short range for six subjects and for the other six subjects it was greater in the large range.

If changes in the loudness estimations were accompanied by similar changes in the V-potential amplitude, such a result might mean that the stimulus context changed the sensory effect of standard stimuli. This interpretation would be legitimate because it would be hard to suppose that the evoked potential amplitude depends on the elaboration of sensory signals.

However, we found that changes in the magnitude estimations in the short and the large stimulus range were not accompanied by parallel changes in the V-potential amplitude. Does this fact indicate that the stimulus context influences only processes of judgment but not the magnitude of sensory excitation? The positive answer would be legitimate only if the evoked potential amplitude could be considered as a true measure of perceived intensity. Yet, numerous investigations have shown that there is only a partial association between the sensation magnitude and the evoked potential amplitude. It seems that there is not a direct but an indirect association via the stimulus level influencing both phenomena in a restricted zone. The neurotonic cortical reaction provoked by the arrival of afferent impulses and ceasing quickly in spite of the ongoing activity of the sensory areas cannot be identical with the cortical processes in which the sensation and its intensity are coded. Therefore, the differences between the changes in loudness estimations and the V-potential found in our experiment are not sufficient to answer our initial question. They only show that evoked potentials and their characteristics cannot substitute the subject's reports about the cortical effect of sensory stimuli, and even less to dissociate the perception component from the judgment component in the subject's magnitude estimations.

As to the V-potential, Watson's comment, cited by H. Davis, is still valid: »If a cooperative person's state of consciousness is at issue, information out of his mouth is a lot better than that off the top of his head.«

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