The effect of number of pulses on vibrotactile thresholds¹

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Abstract

Absolute thresholds for vibration were determined as a function of pulse number and contactor area on human glabrous skin. The results indicate that if a sufficiently large contactor is used, the skin summates the energy over pulse number and over the contactor area. The results also support the hypothesis that cutaneous tissue may contain more than one type of mechanoreceptor.

Introduction

The threshold for vibration in human cutaneous tissue has been determined as a function of sinusoidal frequencies (Verrillo, 1962; Verrillo, 1963), for various temporal patterns of pulses (Verrillo, 1965), and for changes in contactor area (Verrillo, 1963; Verrillo, in press). From this series of experiments emerges a consistent set of observations showing that the mechanoreceptors in the skin exhibit summation both spatially and temporally. It is also apparent that the energy summation is independent of the shape of the individual stimulus event, sinusoidal or short pulse. Furthermore, there appears to be evidence in the data suggesting that the skin contains more than one type of mechanoreceptor. A consistent finding throughout these studies shows one response in which there is a summation of energy over frequency (or repetition rate) and over contactor area, and another which is independent of these variables. Very small contactor areas

show no summation over frequency, and spatial summation is absent when low frequencies are used.

In this study the summation effect of varying pulse number is examined, keeping the pulse width, pulse rise time and pulse repetition rate constant.

Method

The apparatus used in this experiment has been described in detail in a previous publication (Verrillo, 1965). Four Ss were tested inside a booth which provided isolation from extraneous vibrations. The method of limits was used in the testing. Each data point represents the median of three testing sessions for each S. The site of stimulation was on the fleshy pad over the first metacarpal of the right hand.

The pulses had a width of 1.0 msec. measured across the half-power point and a rise time of 1.0 msec. They were repeated at the rate of 100 per sec. The pulse numbers used were 1, 2, 4, 9, 17, 33 and 64. In order to determine spatial effects four contactors were used having areas of .005, .02, .32 and 2.9 cm².

Results

The absolute thresholds are plotted as a function of pulse number with contactor area as the parameter in Fig. 1. The slopes of the data for the .32 and 2.9 cm² contactors is about -3.0 db per doubling of the pulse number. It is apparent that the pulse energy is being summated since the threshold decreases in direct

Fig. 1. Absolute vibrotactile thresholds as a function of pulse number. Pulse repetition rate is 100 pps; pulse width is 1.0 msec.

Fig. 2. Absolute vibrotactile thresholds as a function of contactor area.

proportion to the energy increments as the number of pulses increase. This response is predicted by Zwislowski's theory of temporal summation (Zwislowski, 1960).

It is also apparent that such a summation does not appear in response to the small contactors. This is consistent with the dual-receptor hypothesis which states in part that when a very small area of the skin is stimulated the energy increments of the stimulus do not summate.

In Fig. 2 the responses are plotted as a function of contactor area. It is apparent that there is spatial summation here and that the summation appears to exceed the energy increment as contactor area increases. Similar data obtained using sinusoids produced the expected slope of about -3.0 db per doubling of contactor area. The slopes of the pulses in Fig. 2 range from -3.5 to -5.0 db. This is probably due to the fact that these slopes are based on two data points while the sinusoidal curves were based on four points. If the curves for the sinusoidal data are drawn through the same two area points (.32 and 2.9 cm²) represented in Fig. 2, the resultant slopes are comparable to the pulse data.

In conclusion, it may be stated that the threshold for vibration varies inversely with the number of pulses presented and that an inverse proportionality exists between the threshold and the contactor area. The results are consistent with a dual-receptor hypothesis of mechanoreception.

References

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Notes

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