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Notes and Comment

Lingual vibrotactile sensation magnitudes: Comparison of suprathreshold responses in men and women

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The present literature on neurophysiological mechanisms of cutaneous mechanoreception includes a significant amount of research concerned with suprathreshold levels of stimulation. These efforts were initially performed to gain a better understanding of audition (Békésy, 1960) and to aid in the development of cutaneous communication systems (Geldard, 1961). Numerous studies have systematically investigated the skin as a receiver of mechanical vibrations, a receiver that can function in a predictable manner at suprathreshold levels. Stevens (1961) performed a series of investigations relating subjective responses to stimulus intensities. Using the methods of magnitude estimation and production, he demonstrated that a power law function successfully describes the relationship between subjective intensity and the amplitude of vibration at the finger tip (Stevens, 1957). More recently, several researchers have begun to systematically study the various parameters that can have an effect on suprathreshold vibrotactile power functions (Verrillo & Capraro, 1975; Verrillo & Chamberlain, 1972; Verrillo, Fraioli, & Smith, 1969; Verrillo & Smith, 1976; Zwislocki & Goodman, 1980).

The total volume of research concerned with vibrotactile mechanoreception at suprathreshold levels has not provided much information dealing with comparisons of men and women. Verrillo (1979) accomplished a single definitive study, in which he used both magnitude estimation and magnitude production procedures to obtain suprathreshold information from the thenar eminence of the right hands of six men and six women. Results showed women to perceive suprathreshold vibratory stimuli as more intense than men.

The two-fold purpose of the present preliminary study was: (1) to determine if the anterior midline portion of the human tongue can produce vibrotactile suprathreshold power functions compatible with those described in the literature; (2) to compare the lingual suprathreshold subjective magnitude responses of men and women.

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METHOD

The vibrotactile instrumentation used in this study consisted of a stimulus unit and a measurement unit. The stimulus unit was composed of a sine-wave generator, an experimenter-controlled variable attenuator, a subject-controlled attenuator, two universal timers, an audio amplifier, a power amplifier, a preamplifier, and an electromagnetic minivibrator with a probe-contactor extension. The pulsed vibratory signal generated had a 50% duty cycle (on 500 msec and off 500 msec), with a rise-and-decay time of 100 msec. The measurement unit included an accelerometer, a cathode follower, a microphone amplifier, and a voltmeter. A detailed description of the vibrotactile equipment and procedures can be found in a review by Fucci, Petrosino, Wallace, and Small (1982).

A group of 20 subjects consisting of 10 men and 10 women was employed in this study. The subjects ranged in age from 18 to 32 years, with a mean age of 21.6 years. The age range of the 10 males was 19 to 29 years, with a mean age of 21.5 years, and the age range of the 10 females was 18 to 32 years, with a mean age of 21.7 years. All 20 subjects were treated in the same manner. Each subject was seated in an adjustable chair and asked to place his tongue up against the bottom of a rigidly mounted plastic disk. A hole in the center of the disk provided access for the probe-contactor extension of the vibrator to the anterior midline section of the dorsum of the tongue. The contactor on the end of the probe had an area of .128 cm^2, and there was a 1-mm gap between the contactor and the rigidly mounted plastic disk.

The psychophysical method of magnitude production was used to establish suprathreshold magnitude functions for the tongue. This method was selected because it has been shown to be very stable (Zwislocki & Goodman, 1980) and because it facilitates testing the tongue in that the subject can respond by manually adjusting a variable attenuator rather than by providing a verbal numerical response (magnitude estimation) that would be difficult with the tongue in test position. The procedure used did not incorporate a standard modulus. A number of investigators have indicated that the use of a standard reference can have a profound effect on the shape of the resulting magnitude function by interfering with the natural absolute magnitude scales that individuals have internalized (Zwislocki & Goodman, 1980). The magnitude production task was performed at the frequency of 250 Hz. The subject was presented with a random series of six numbers (5, 10, 15, 20, 25, 30) and was asked to adjust the "magnitude" of the stimulus that he was feeling on his tongue to the number being presented. The subject-controlled attenuator consisted of a smooth, unmarked knob (120 dB variable potentiometer) having no visual or mechanical cues. The experimenter was in control of a master attenuator that could be used to vary the actual stimulus amplitude with respect to the position of the subject's attenuator knob (Zwislocki & Goodman, 1980). The numbers chosen for scaling were held to six because of adaptability and of fatigue effects, which appear to be more acute for the tongue than they are for some of the other mechanoreceptor systems that have been studied (Fucci & Crary, 1979).

Three runs of the randomized series of six numbers were presented to each subject. The first run was discarded and the geometric means of the second and third runs were accepted as the produced amplitudes (Verrillo et. al., 1969). The results of the magnitude-production task were recorded in millivolts and converted to displacement in decibels re 1 μ peak. Group data were generated by deriving geometric means of the magnitude production amplitudes across all 20 subjects. Geometric means were also

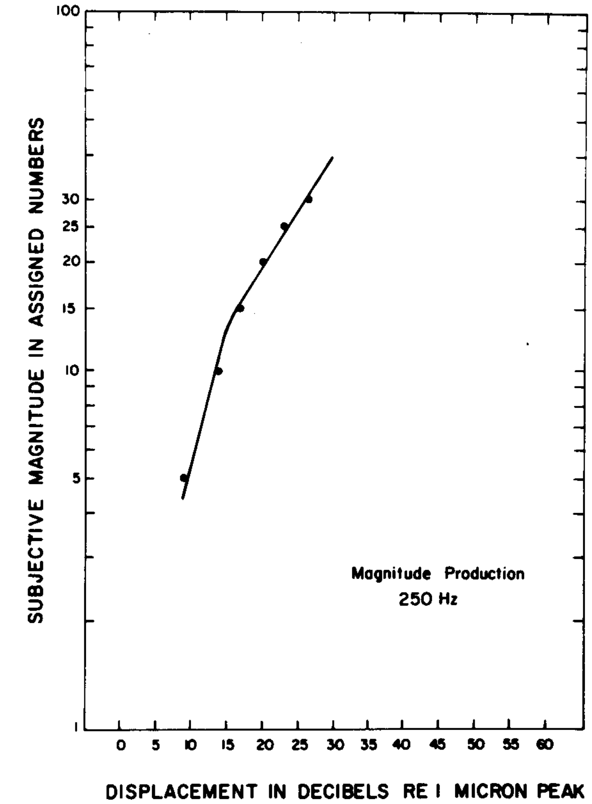

Figure 1. Magnitude production of lingual vibrotactile sensation (geometric means) as a function of displacement in decibels re 1 μ peak for entire group of 20 subjects. Vibration frequency was 250 Hz.

derived for the magnitude production amplitudes of the males and females separately so that comparisons of these two groups could be made.

RESULTS

Figure 1 shows the results of the magnitude production task for the entire group of 20 subjects. The data show that the mechanoreceptive mechanisms located within the anterior dorsal portion of the human tongue can be used to produce suprathreshold magnitude functions that are compatible with those described in the literature. The curve is very similar in shape to those reported by other investigators who did not use a standard reference, and the upper portions of the curve are compatible with Steven's power function law (Stevens, 1961; Verrillo & Capraro, 1975; Verrillo & Chamberlain, 1972; Verrillo et al., 1969; Zwislocki & Goodman, 1980). The entire curve is compatible with Atkinson's (1982) and Zwislocki's (1965) modifications of Stevens's law, which account for the steeper sloping of the curve at values closer to threshold. The actual slope of the upper portion of the curve is higher than that typically reported in the literature for cutaneous receptor mechanisms. The slope value for the upper portion of the curve shown in Figure 1 is 1.58, and those values reported in the literature in terms of amplitude displacement for the arm and hand are closer to or below unity (Stevens, 1961; Stevens, 1968; Verrillo, 1979; Verrillo & Chamberlain, 1972; Verrillo et al., 1969).

Figure 2 shows the results for the 10 men and the 10 women of the magnitude-production task. It can be seen that the lower portion of the curve for women is somewhat steeper than the lower portion of the curve for men. This leads to a small separation of the curves for the higher numbers. As the numbers assigned were increased, the men tended to adjust the stimulus to slightly higher amplitudes of displacement than did the women. The upper portion of the curve for women has a slope value of 1.59, and the upper portion of the curve for men has a slope value of 1.57. These relatively similar values indicate that the growth of sensation is slightly more rapid for the women than for the men at low amplitudes of displacement, but that the growth of sensation appears to be similar for both groups at higher amplitudes of displacement. Overall, the women appeared to perceive the same amplitude as being slightly greater than the men. These results are compatible with those of Verrillo (1979). He performed the magnitude production experiment on thenar eminence of the right

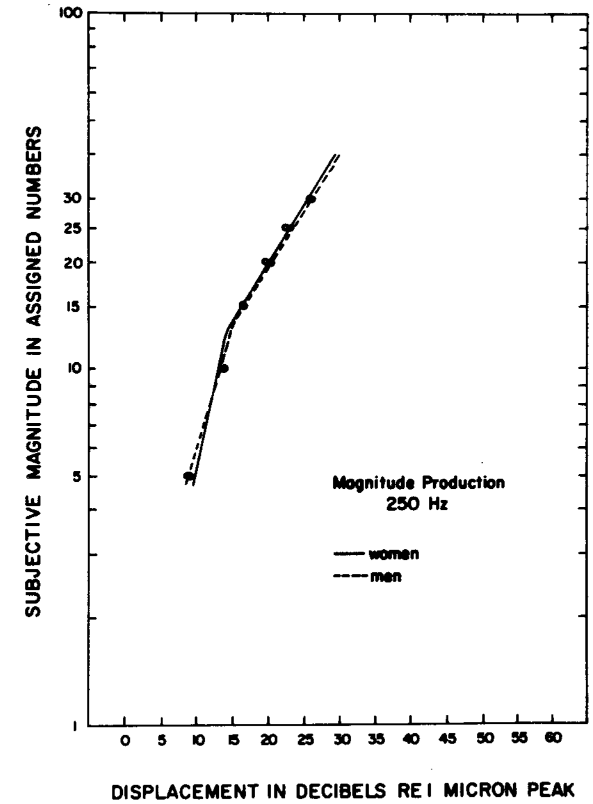

Figure 2. Magnitude production of lingual vibrotactile sensation (geometric means) as a function of displacement in decibels re 1 μ peak for men and women. Vibration frequency was 250 Hz.

hands of six men and six women. The differences between groups that Verrillo found are more pronounced than those recorded in this study, and the approximate upper slope values reported by Verrillo for the hand are less than unity when expressed in amplitude of displacement.

DISCUSSION

Although the tongue can be used to derive suprathreshold functions compatible with those described in the literature, it appears to produce upper curve slope values that are much steeper (Stevens, 1961; Stevens, 1968; Verrillo, 1979; Verrillo & Chamberlain, 1972; Verrillo et al., 1969). A number of possible reasons for these steeper slope values are suggested. First, the method of magnitude production has been described by Stevens (1959) and Zwislocki and Goodman (1980) as producing slope values that are steeper than those produced by the method of magnitude estimation that is commonly used in suprathreshold experimentation. Second, the size of the skin contactor has been shown by Verrillo and Chamberlain (1972) to have a significant effect on slope. The smaller the contactor, the steeper the slope will be. The smallest contactor used by Verrillo and Chamberlain (1972) was .28 cm^2, and the contactor used in this study (.128 cm^2) was only half that size. Small contactors are required in lingual vibrotactile research because of the overall size and location of the tongue itself. Third, the use of a rigid surround also will have an effect on curve slope in a manner similar to that of using a smaller contactor (Verrillo & Chamberlain, 1972). When a rigid surround is employed, as it was in this study, it prevents the spread of vibrations beyond the point of actual skin contact. Fourth, the cutaneous location itself can have an effect on the slope of the curve (Stevens, 1961). Verrillo and Chamberlain (1972) studied suprathreshold responses of three different body sites varying in neural density. They studied the distal pad of the middle finger, the thenar eminence, and the volar forearm. The volar forearm produced the steepest slopes, and it is known to have the least amount of neural density of the three areas tested. In the case of the volar forearm, there were fewer sensory units to be stimulated, all other experimental conditions being equal. A future controlled experiment similar to that conducted by Verrillo and Chamberlain (1972) would have to be performed, in which lingual suprathreshold responses are compared with those of other body sites in order to determine the actual influence on slope that the tongue itself provides.

The reasons for the slight differences between the sexes with respect to scaling of sensory magnitudes are not clear at this time. There is no evidence to suggest that there would be physiological differences in the neural mechanisms of men and women (Verrillo, 1979). Verrillo (1979), in his study of suprathreshold comparisons of men and women, suggests that the differences noted between the sexes are possibly linked to a heightened awareness of bodily sensations due to the focus placed on bodily functions by the onset of menses at puberty, and that this heightened awareness might be reinforced by social conditioning. Why this condition would only be seen at suprathreshold levels is not understood (Verrillo, 1979).

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