Bulletin of the Psychonomic Society
1977, Vol. 10 (4), 347-349

Lingual clamping procedures for measuring oral vibrotactile thresholds: I. Effects of using a free-surround disk

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Lingual vibrotactile thresholds were obtained from four groups of subjects using a different tongue-clamping procedure with each group. The four experimental conditions were designed to assess the effect on threshold sensitivity, across five frequencies, which results when using a free-surround clamping disk. Data indicated that the free-surround clamping disk used limits stimulus spread and results in greater threshold sensitivity than that obtained for conditions which do not employ this procedure. Findings supported the view that pressure receptors in the anterior dorsal surface of the tongue are selectively responsive to differences in vibratory rates of mechanical displacement.

Different methodologies using mechanical sinusoidal stimuli to measure vibrotactile threshold sensitivity for the tongue have produced some varying results. Sherrick (1953) compared vibrotactile thresholds obtained from the fingertip with thresholds obtained from the anterior lingual surface. He reported that the fingertip and tongue tip both produce thresholds which are differentially sensitive to frequency, with maximum sensitivity around 250 Hz.

Verrillo (1968) compared vibrotactile thresholds obtained from the palmar surface with those obtained on the dorsal lingual surface. Thresholds obtained from the palm for three subjects showed a U-shaped curve across frequency for the range 60 to 640 Hz. Testing the tongue in the same manner resulted in a flat curve, indicating no selective frequency response. The differences between the results obtained by Verrillo and those obtained by Sherrick have been attributed to different procedures used. Verrillo used a free-surround disk in obtaining lingual thresholds. Sherrick did not. According to Verrillo, the free-surround disk functioned to limit the spread of vibratory stimuli to Pacinian receptors present in the ventral aspect of the tongue.

More recent investigations have attempted to develop a specific instrumentation and methodology for measuring oral lingual vibrotactile sensation (Fucci & Kelly, 1972; Telage, Fucci, & Arnst, 1972). These and other studies have consistently demonstrated differential threshold responses for the tongue across frequencies, with maximum sensitivity occurring between 250 and 400 Hz (Fucci, Crary, Wilson, & Curtis, 1976; Fucci, Curtis, & McCaffrey, 1975; Telage & Fucci, 1973, 1974a, 1974b).

The discrepancy between the latter findings and those reported by Verrillo (1966) has implications which relate specifically to the nature of mechanoreceptors in the lingual surface and to procedures used in measuring lingual sensitivity. For these reasons, it is important to attempt to identify possible factors which may contribute to the observed lack of agreement.

The first and most obvious area for study concerns differences in the apparatus which delivers the stimulus to the tongue. It is the purpose of this study to evaluate the contribution of the free-surround disk to observed vibrotactile thresholds obtained from the anterior lingual surface.

METHOD

Subjects

Forty subjects, divided into four groups of 10 subjects in each group, comprised the experimental population. The mean age was 21 years, and all subjects reported no history of hearing, speech, or sensorimotor disorders. Lingual vibrotactile thresholds were obtained for each group using one of four experimental conditions.

Apparatus

The equipment used in this study has been described in a previous publication (Fucci & Kelly, 1972). The stimulus unit included a sine-wave generator, frequency counter, electronic switch-interval timer, amplifier, variable attenuator, and electromagnetic vibrator. The pulsed vibratory signal generated had a 50% duty cycle (on ½ sec and off ½ sec) with a rise and decay time of 100 msec. The measurement unit consisted of an accelerometer, cathode follower, microphone amplifier, and voltmeter. A white-noise generator was used to present auditory masking at 80-85 dB HTL to subjects through TDH-39 headphones (Figure 1).

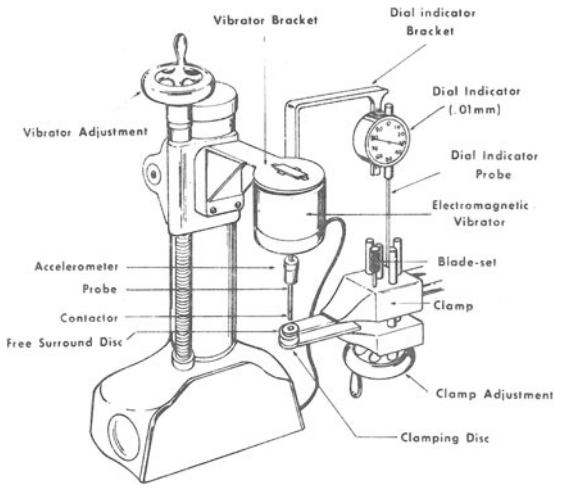

Figure 1. A schematic diagram of the vibrator and clasp assembly portion of the vibrotactile stimulator.

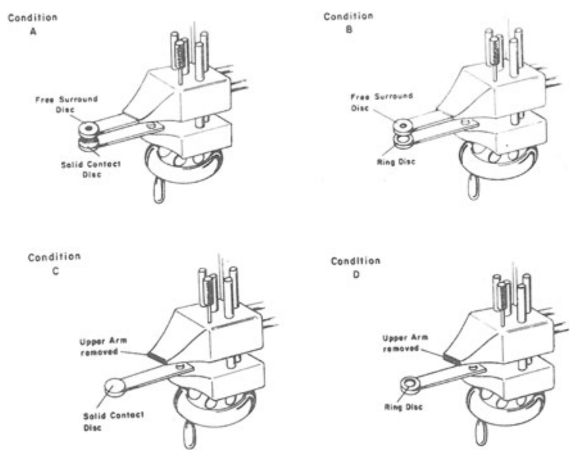

Figure 2. Schematic drawings showing the four clamping conditions used in the present investigation.

Procedure

Condition A represents the common clamping procedure used for lingual vibrotactile measures and includes an upper free-surround disk and a solid lower clamping disk (Figure 2). Condition B provides for retention of the free-surround disk, but substitution of a specialized rubber ring disk for the solid lower clamping disk (Figure 2). The ring disk is designed to minimize upward pressure on ventral lingual tissue. Since the lower clamping disk may be an independent variable affecting lingual responsiveness, the ring disk is used as a control procedure to better assess the influence of the free-surround disk on threshold sensitivity. Condition C provides for retention of the lower clamping disk but the elimination of the free-surround disk, producing an experimental situation which does not restrict stimulus spread and limits interaction from the lower clamping disk since the tongue is not clamped (Figure 2). Condition D provides for the elimination of the free-surround disk and substitution of the ring disk for the lower clamping disk (Figure 2). This condition is designed to provide for stimulus spread while maximally limiting upward compression of ventral mucocutaneous tissues.

Lingual vibrotactile thresholds were obtained for each group at frequencies of 100, 200, 250, 300, and 400 Hz, using an ascending psychophysical method of limits. Frequencies were randomized to cancel out any possible extraneous variables. A median of three millivolt threshold trials was accepted as a subject's lingual threshold. These data were later converted to peak displacement in microns by using a standard g formula for acceleration conversion.

Subjects were seated in a dental chair and extended their tongues either on or between the clamping disks, as prescribed by the experimental condition used. During Conditions A and B, the tongue was clamped tightly enough to assist in maintaining its position while still permitting easy withdrawal. The stimulus was applied either directly or through the free-surround disk. The contactor area was .128 cm^2 in all conditions and, when the free-surround disk was used, the area around the contactor was 1 mm (Figure 1).

RESULTS AND DISCUSSION

Threshold results for the experimental conditions are presented in Table 1. The data evaluating the effects of using a free surround are summarized for Conditions C-A, in which the lower control disk is held constant, and for Conditions D-B, where the lower ring disk is held constant. The data are compared in this way to isolate the possible influence of the lower clamping disk on threshold sensitivity.

An evaluation of the data shows that both sets of conditions in which a free-surround disk was used produced more sensitive thresholds. As anticipated, the free-surround disk used in conjunction with the solid lower clamping disk produced the most sensitive mean threshold results.

Table 1
A Comparison of Mean Threshold Differences in Microns of Peak Displacement Between the Free-Surround and No-Free-Surround Conditions

		Frequencies (Hz)				
	Conditions	100	200	250	300	400
C	Lower Clamping Disk/No-Free Surround	6.7	2.6	1.8	1.7	1.1
A	Lower Clamping Disk/Free-Surround Disk	4.8	2.6	1.7	1.3	.7
	Difference	1.9	.0	.1	.4	.4
D	Ring Disk/No Free Surround	7.7	3.2	2.2	2.0	1.7
B	Ring Disk/Free-Surround Disk	5.3	2.8	2.1	1.5	.9
	Difference	1.4	.4	.1	.5	.8

Clearly, some effect on threshold sensitivity results from using the lower clamping disk. The clamping procedure used for current oral vibrotactile testing (Condition A) maximally increased threshold sensitivity. A plausible explanation might be that using either type of lower disk in conjunction with a free-surround disk tends to flatten and spread the tongue. This condition serves to produce a more rigid lingual mass which maintains a tightly fixed position against the inward displacement of the contactor. This conjecture is supported by the data showing that the ring disk with a free surround resulted in more sensitive thresholds than the lower clamping disk used without a free surround. Furthermore, both no-free-surround conditions in which the tongue just rested on a lower platform obtained higher thresholds, the least sensitive occurring when the ring disk was used for support.

The present findings support the view that tactile receptors in the lingual surface are selectively responsive to frequency parameters. This conclusion is consistent with previously cited research employing the same instrumentation. Future investigations may wish to modify the design of this study by entirely eliminating the lower disk. This could be accomplished by having subjects press the tongue up against the free-surround disk. Such a procedure would entirely offset the clamping influence but would retain control over the stimulus spread. The resulting threshold pattern across frequency might shed more light on the nature of lingual vibrotactile sensation.

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(Received for publication June 22, 1977)