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ABSTRACT

In order to test detection thresholds and discrimination for certain speech sounds, 10 individuals received tape recorded programs of speech signals transduced into vibrotactile information. Stimuli were presented to the fingertip, palm, wrist, forearm, and thigh. Results indicated that thresholds of detection could be elicited at all five body loci. Ss' discrimination performances showed high intra test-retest reliability, with Ss consistently judging pairs as "same" or "different" for each body locus tested. Results had implications for use of vibrotactile stimuli with the hearing impaired. (Author/CL)

VIBROTACTILE RECEPTION AND DISCRIMINATION OF SPEECH SIGNALS
A COMPARISON AMONG BODY LOCI

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The efficacy of virbotactile reception of ongoing speech signals has renewed interest in the last couple of decades (Geldard, 1960; Goldstein, 1972; Haas, 1970; Higgins, 1971; Pickett and Pickett, 1963; etc.).

Research has shown that the cutaneous receptors cannot serve as a substitute for the more complex, analytical hearing mechanism. A more recent viewpoint is that tactile stimulation can provide a supplement for auditory and visual communication for persons with seriously impaired hearing (Guberina, 1965; Pickett, 1963; Haas, 1970; Geldard, 1960; and Kirman, 1973).

The use of cutaneous sensory receptors to provide information is a basic aspect of the Verbotonal Method of aural habilitation as described by Guberina and his associates. Guberina (1965) has claimed that even if the ear is completely useless, many patients can learn to perceive sound vibrations through their bodies. However, Guberina does not specify any particular body loci which are best for perceiving sound vibrations. He states that, "each person has a preferential area for perceiving vibrations most clearly - the chest, the hand, sometimes the fingertips" (1965).

The vibromechanical device Guberina uses is referred to as the VIBAR. Guberina (1965) and his associates have reported considerable success in employing this device with the hearing impaired and deaf. The relevant literature does not describe, however, the information transmittable and receivable. It was the intent of this study, therefore, to answer some basic questions relative to tactile stimulation and speech signals. More specifically, subject performances were studied relative to detection thresholds for certain speech signals and the resolving power of the cutaneous receptors and the human sensory processing system in the ability

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to discriminate among speech signals as a function of site of coupling.

METHOD

The stimulus materials that were used for the experimental programs consisted of magnetic tape programs of recorded speech signals. Eight logotomes, as described by Guberina (1965) and his associates, served as the stimulus events. The logotomes (nonsense syllables included: /mu/, /bru/, /bu/, /vo/, /la/, /ke/, /si/, and /şi/. The rationale for using logotomes was based on the frequency band that is optimal for the detection of each logotome. For each logotome, the consonant and vowel are purported to have similar frequency bands according to the Verbotonal advocates. Thus /mu/ is combination of a relatively low-frequency consonant and vowel combination; whereas /si/ is a combination of relatively higher frequency phonemes (Asp. 1973.)

RESULTS

Initially, attention was focused on determing if detection thresholds could be obtained for the /mu/ and /si/ logotomes at each of the 5 body sites selected for study, namely, the fingertip, palm, wrist, forearm, thigh.

The /mu/ and /si/ logotomes were chosen for this experiment because of the relative low and high frequency composition of each logotome.

To provide a more meaningful method of comparison voltage readings were converted into relative decibels. The lowest threshold voltage (41.66 mv.) was found at the fingertip, and the highest threshold voltage (2565 mv.) was found at the thigh. The largest range of thresholds among subjects for the logotome /mu/ was 5.67 dB (re: 980 mv.) at the forearm. The smallest range of thresholds among subjects for the logotome /mu/ was 3.67 dB (re: 1546.66 mv.) at the thigh. For the logotome /si/, the largest range of thresholds among subjects was 6.0 dB (re: 980 mv.) at the forearm and 6.0 dB (re: 48.33 mv.) at the palm. The smallest range of thresholds for all subjects for the logotome /si/ was 4.33 dB (1546.66 mv.) at the thigh. It was found that the detection thresholds of the /mu/ and /si/ logotomes did not differ from one another by more than 2 dB for each of the ten subjects at each of the five body sites. These ranges of threshold indicate considerable consistency of the group data among the different logotomes.

The group data show that the best thresholds were obtained at the fingertip, palm, and wrist respectively with a sharp decrease in tactile sensitivity at the forearm and thigh. The best threshold at the fingertip differs from the worst threshold at the thigh by 12 dB (re: 41.66 mv.).

The low threshold energy required for the fingertip, palm, and wrist and the high threshold energy required for the forearm and thigh are in agreement with the findings of von Bekesy, Roth, Gilmer, Ahrens, [illegible] and Zubak, and others.

Threshold performance with regard to sex differences showed females as a group gave relatively better thresholds across all body loci than males. However, these differences do not appear to be highly significant.

The purpose of the second experiment was to determine if a common optimal sensation level could be found in testing the fingertip, palm of the hand, wrist, forearm, and thigh. A modified articulation gain function test for tactile operations was employed with five subjects (two male and three female). The subjects were required to make paired-comparison discrimination judgments in order to ascertain the optimal sensation levels for each coupling site. The group mean scores show the greatest range in percent correct among all body loci and for all sensation levels to equal only 7.9 percent.

Since the results of Experiment 2 indicate that a common optimal sensation level could not be established for the fingertip, palm of the hand, wrist, forearm, and thigh, the purpose of Experiment 3 was to determine:

1) If at the optimal sensation level, subjects could distinguish the sight logotomes from each other as "same" or "different" in paired comparisons at each body locus.

2) If at the maximum sensation level for the second five subjects (15 dB sensation level being the maximum at the wrist, palm and fingertip) the subjects would significantly differ from the first five subjects in percent correct discrimination judgments across body loci.

3) If the ten subjects would consistently reflect better discrimination judgments for one coupling site as compared to the other coupling sites evaluated.

The discrimination performances obtained at optimum sensation level for subjects indicate the ranking of body loci from highest to lowest percent correct for the discrimination task to be as follows: wrist, fingertip, palm, forearm, thigh.

The group mean at the wrist was 68 percent correct and at the thigh 61 percent correct. Thus, the total range of correct discrimination for the five body sites tested was only 7 percent.

The discrimination performances of 5 subjects obtained at fixed sensation levels indicate the ranking of body loci according to percent of correct judgments to be similar.

A group mean of 66 percent was found for the wrist and fingertip, and a group mean of 61 percent was established at the forearm and thigh. The range for correct discrimination judgments across all body loci was only 5 percent. This suggests no significant differences in percent of discrimination judged to be correct between the first five subjects (who were tested at optimal sensation levels) and the second five subjects (who were tested at maximum sensation levels) for any of the five coupling sites analyzed.