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Research Note

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Donald Fucci *(Ohio University)*
Linda Petrosino *(Bowling Green State University)*
Daniel Harris *(Healthcare Rehabilitation Center, Austin, TX)*

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Instrumentation For Assessment Of Oral Vibrotactile Sensation And Perception

Donald Fucci
Ohio University
Athens, Ohio 45701

Linda Petrosino
Bowling Green State University
Bowling Green, Ohio 43403

Daniel Harris
Healthcare Rehabilitation Center
Austin, Texas 78745

The application of servo theory to speech production (Fairbanks, 1954; Van Riper and Irwin, 1962; and Mysak, 1966) has led to a body of research based on possible feedback mechanisms for the monitoring of speech output.

A number of investigators have studied the tactile sensory system as an important element in the speech feedback network and have developed a battery of procedures for use in tactile assessments of oral region structures, particularly the tongue. These procedures have included the use of nylon filaments, electrical stimulation, two-point discrimination, texture discrimination, and oral stereognosis as means for collecting data on oral tactile function (Grossman, Hattis, and Ringel, 1965; Ringel and Ewanowski, 1965; Ringel and Fletcher, 1967; Paine, 1967). For the most part such research has concentrated on stimulus awareness thresholds and gross discriminations between successively presented stimuli. The stimuli and the methodologies of study that have been used have not provided the investigator with the control and flexibility needed to thoroughly explore oral tactile system functioning.

Vibration (dynamic pressure) is a form of cutaneous stimulation which has all of the advantages provided by prior procedures used to study oral tactile sensory function. It further permits the modification of certain stimulus parameters while holding other aspects of the signal constant. Through use of vibration, the experimenter is provided with a form of stimulation which allows him/her to apply various psychophysical methodologies to his/her work (Verrilo, 1962; Stevens, 1964), which has been shown by prior research to be an appropriate tool to study peripheral and central tactile processes (Geldard and Gilmer, 1934; Cummings, 1938; Weitz, 1939), and which permits the systematic manipulation of the parameters of signal frequency, amplitude, and time (Verrillo, 1962).

The instrumentation described in the present paper provides for accurate control of all stimulus variables involved in vibrotactile stimulation of the tongue. It produces a wide range of frequencies and intensities and at the same time provides a unique and precise way in which to position the tongue for testing.

Instrumentation

A block diagram of the lingual vibrotactile instrumentation is shown in Figure 1, and a graphic representation of the vibrator assembly portion of the instrumentation is shown in Figure 2. The vibrotactile stimulus control unit includes a sine-wave generator for the production of single frequencies of vibration, an experimenter controlled variable attenuator for control of stimulus amplitudes, a rise/fall gate to shape the signal being delivered, two universal timers so that the signal can be on for a certain amount of time and off for a certain amount of time, an audio amplifier to boost the signal, a power amplifier to control signal strength, and an electromagnetic minivibrator with a probe-contactor extension for delivery of the vibratory signal to the dorsal surface of the tongue.

The pulsed vibratory signal generated can be of any frequency, but is usualy set at 250 Hz which is the frequency to which the tongue responds with greatest sensitivity. The vibratory signal is usually run on a 50% duty cycle in which it is on for 500 msec. and off for 500 msec providing a pulsed effect which reduces lingual receptor fatigue. The rise/fall time of the vibratory signal us 50-100 msec., providing a smooth signal with no abrupt beginning or ending.

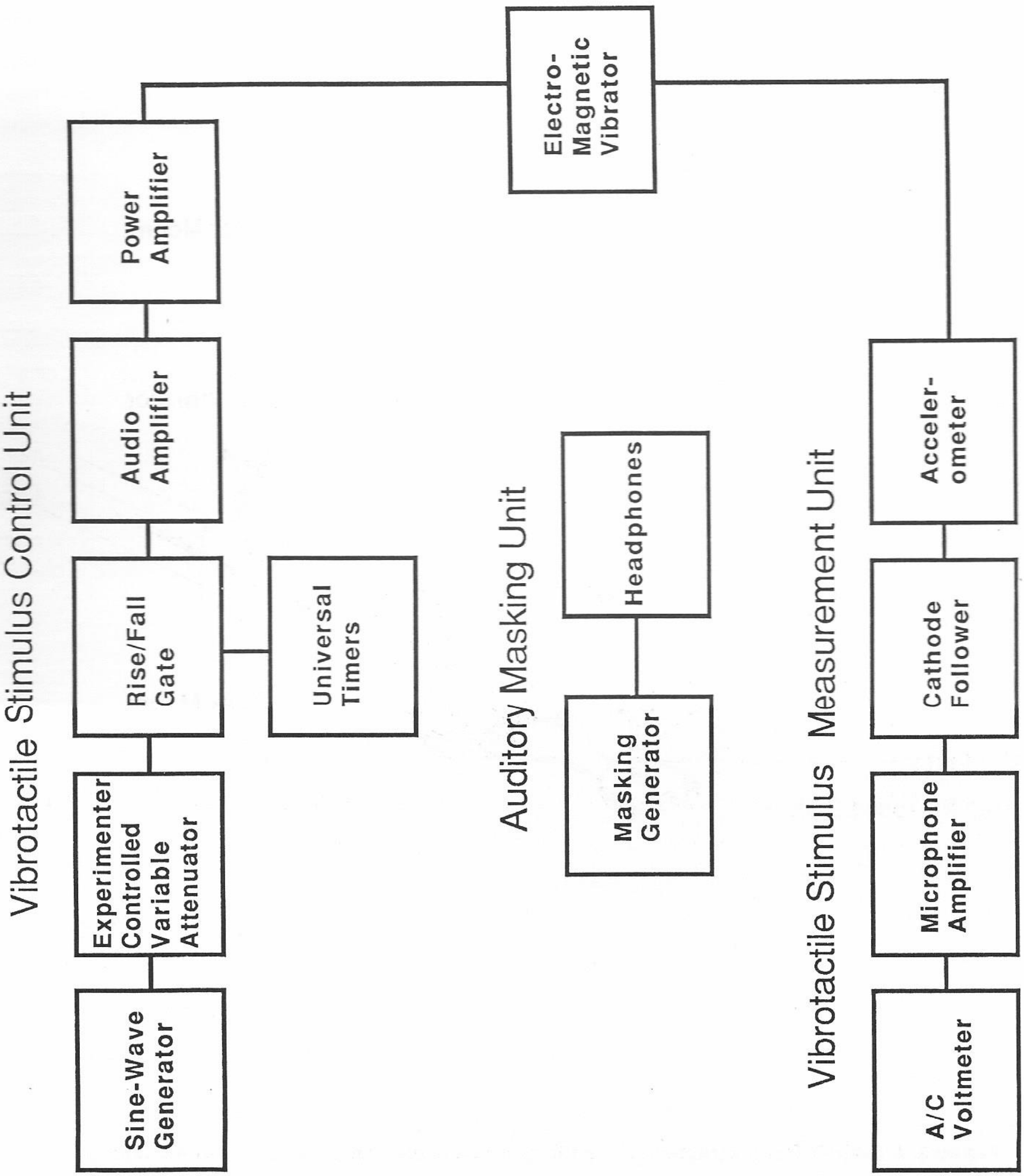
The vibrotactile stimulus measurement unit consists of an accelerometer which quantifies the up and down movements of the probe-contactor extension of the minivibrator, a cathode follower and microphone amplifier for increasing the signal coming from the accelerometer, and a voltmeter from which millivolt values representing probe-contactor movements can be read.

An auditory masking unit is included in the lingual vibrotactile instrumentation package in order to help mask auditory components that might be coming from the vibrating probe-contactor extension during signal application to the tongue. The auditory masking unit is comprised of a masking generator and TDH-49P headphones. The masking signal generated is a narrow band of noise centered around 250 Hz at 70 dB HL, bilaterally. A more detailed description of the vibrotactile equipment can be found in a review by Harris, Fucci, Petrosino, and Walace (1986).

Procedure

For testing of lingual vibrotactile thresholds of sensitivity, the standard procedure is as follows: A subject is seated in an adjustable chair and positioned so that the tongue can be placed against the bottom of a rigidly mounted plastic disk (Figure 2). The tongue is placed against the bottom of the rigidly mounted plastic disk only during threshold testing, and the subject is permitted to rest between stimulus presentations. A hole in the center of the disk provides access for the probe-contactor extension of the vibrator to the anterior midline section of the dorsum of the tongue.

Figure 1. Block Diagram of the Lingual Vibrotactile Instrumentation



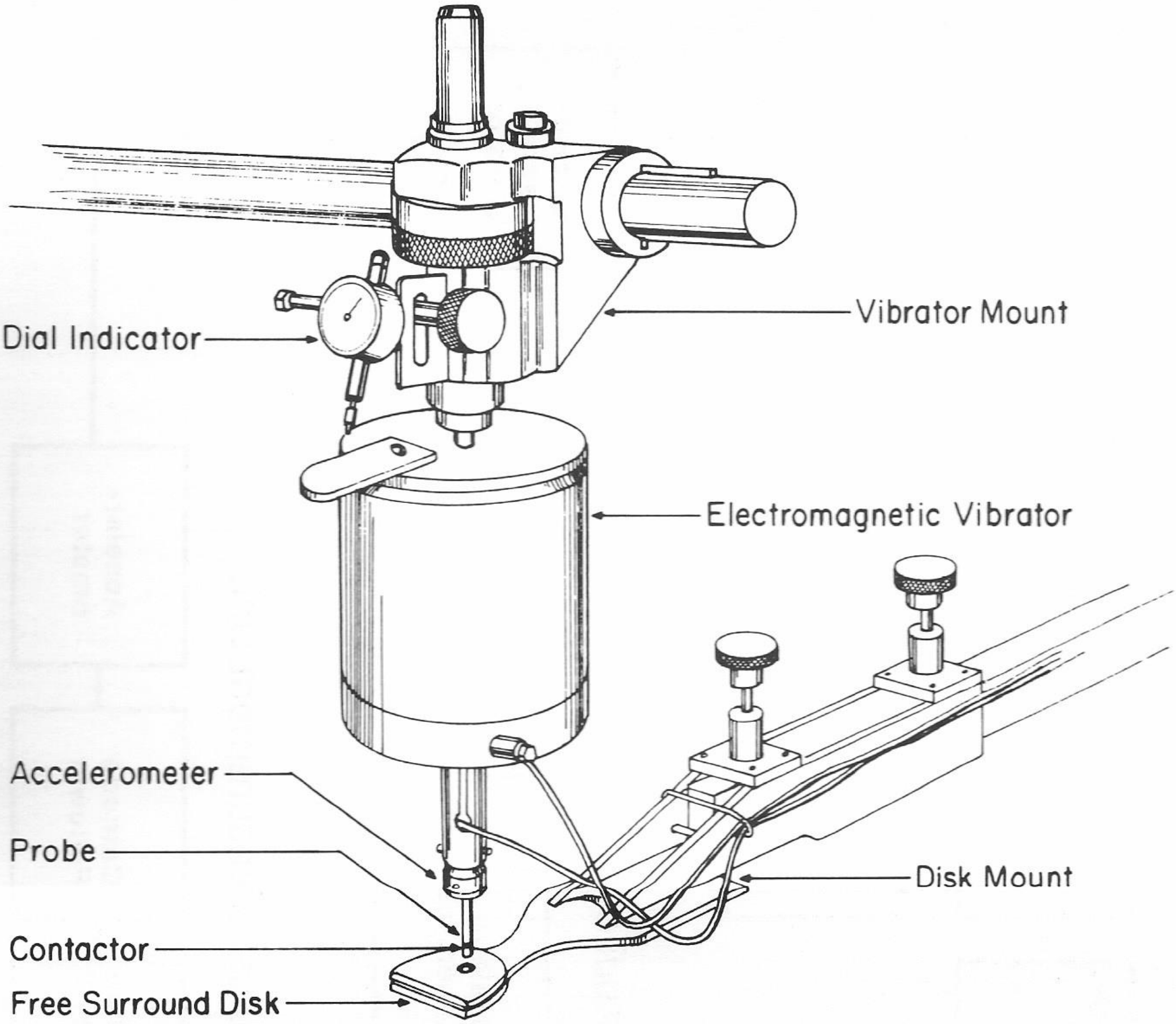


Figure 2. A Graphic Representation of the Vibrator Assembly Portion of the Instrumentation

The contactor on the end of the probe has an area of .128 cm², and there is a 1 mm gap between the contactor and the disk. The contactor area of .128 cm² is employed because it is small enough for the contactor to fit completely on the dorsal surface of the tongue. The TDH-49P headphones are placed over the subject's ears for binaural auditory masking of the vibrotactile stimulus being applied to the tongue.

An ascending method of limits is routinely employed for threshold testing. This method of threshold testing has been chosen over the forced-choice criterion-free method of threshold testing to minimize subject fatigue and sensory system adaptation (Petrosino & Fucci, 1983). Accepted lingual vibrotactile threshold of sensitivity is the mean of three successive readings within a 5 mV range (Telage & Fucci, 1974).

Application

For the most part, the lingual vibrotactile instrumentation described in this paper has been used for basic research purposes (Fucci, Petrosino, Harris, Randolph-Tyler, & Wagner, 1989; Petrosino, Fucci, Ellis, & Harris, 1989). A comprehensive study of speech impaired populations has not been undertaken because of the non-portability of the instrumentation as it is presently constructed, and the lack of significant numbers of speech impaired populations to be found within the rural geographic region where the instrumentation is presently located. Due to advances in electronics technology, a portable unit is now feasible given the availability of design and production funds.

The two primary types of speech impaired populations that have been studied are those comprised of individuals with disorders of articulation and fluency problems (Fucci, 1971, 1972; Fucci & Crary, 1979; Fucci, Petrosino, Gorman, & Harris, 1985; Fucci, Petrosino, Musto, & Townsend, 1984; Petrosino, Fucci, Gorman, & Harris, 1987).

In the case of disorders of articulation, it has been found that a certain percentage of individuals tested (25-30%) have shown lingual vibrotactile thresholds of sensitivity that are less than those found in normal speaking individuals. The age ranges represented are from 5 yr.-25 yr. The only safe conclusion to be drawn at this point in time is that certain individuals demonstrating articulation problems may be hard of feeling with regard to the sensory receptors found in the lingual dorsal surface which, according to traditional feedback theory, would be important to the articulatory aspects of speech production.

Individuals with fluency problems usually demonstrate normal lingual vibrotactile thresholds of sensitivity, but present different results for magnitude estimation scaling of stimuli presented above threshold of sensitivity. The individuals tested have usually been young adults, and they have shown more conservative scaling behavior than normal speaking young adults by using a more narrow range of numbers to estimate the suprathreshold stimuli presented to the dorsal surfaces of their tongues.

The clinical significance of the above reported findings are not clear at this time. A more broad based approach to the collection of clinical data is needed which will cover a wide range of speech impaired populations representing the full age spectrum. This undertaking will be possible through the development of portable vibrotactile instrumentation units which can be placed in public schools, hospitals, nursing homes, and other sites where large numbers of individuals with speech production problems can be tested.

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Address reprint requests to:
Donald Fucci, Ph.D.
School of Hearing & Speech Sciences
Ohio University
Athens, Ohio 45701