Research Note

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Donald Fucci (*Ohio University*)

Linda Petrosino

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Oral Vibrotactile Assessment Procedures: Modifications

Donald Fucci, Ph.D.

Ohio University
Athens, Ohio 45701

Linda Petrosino, Ph.D.

Bowling Green State University
Bowling Green, Ohio 43403

An ongoing process to develop oral vibrotactile instrumentation that can be standardized and used in practical assessment of the oral tactile sensory system was reported in *The International Journal of Orofacial Myology* in March, 1990, by Fucci, Petrosino, and Harris. The material presented in the present article reflects the current research and future direction that the development of this instrumentation is taking. Potential benefits of this instrumentation for individuals working in the area of orofacial myofunctional disorders are suggested.

The present manuscript is a continuation of one reported in *The International Journal of Orofacial Myology* in March, 1990, by Fucci, Petrosino, and Harris. It reflects the current research and future direction that the ongoing development of oral vibrotactile instrumentation is taking.

The importance of the oral somesthetic system in speech production has been recognized since the application of servo theory to speech production (Fairbanks, 1954; Mysak, 1966). Early procedures for tactile assessments of the oral structures, particularly the tongue, have included the use of nylon filaments, electrical stimulation, two-point discrimination, texture discrimination and oral stereognosis (Grossman, Hattis, & Ringel, 1965; Ringel & Ewanowski, 1965; Ringel & Fletcher, 1967; Paine, 1967). These procedures limited oral tactile assessment to gross discriminations and yielded subjective judgments of stimulus threshold.

Over the past 25 years, controlled assessment of oral sensation and perception has been possible through the development and use of vibrotactile instrumentation (Fucci, 1972). Vibrotactile instrumentation employs vibration as the stimulus mode and has allowed for experimenter control over the stimulus employed in the oral sensory evaluation procedure. Vibration is a form of stimulation which has all of the advantages of the

procedures indicated above. It further permits careful control over the important stimulus parameters of frequency, intensity, and time (Verrillo; 1962).

A block diagram of oral vibrotactile instrumentation is shown in Figure 1. The essential components of this instrumentation consist of a vibrotactile stimulus control unit which 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 is usually set at a frequency of 250 Hz which is the frequency to which the tongue responds with greatest efficiency (Verrillo, 1962). The signal is pulsed (500 msec. on and 500 msec. off) for the reduction of lingual receptor fatigue, and a rise/fall time of 50-100 msec. is used to provide 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 the probe-contactor movements can be read.

An auditory masking unit is included in the instrumentation package in order to mask the auditory signal generated from the vibrating probe-contactor extension during the testing procedure. The masking signal generated is a narrow band of noise centered around 250 Hz at 70 dB HL, bilaterally (Fucci, Petrosino, & Harris, 1990).

Figure 1 Block Diagram of Oral Vibrotactile Instrumentation

During the testing procedure, the 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 located directly in front of the lips. The tongue is placed against the bottom of the rigidly mounted plastic disk during 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. The contactor itself is small

enough to fit completely on the lingual surface. At the same time, headphones are placed over the subject's ears for binaural masking of the vibrotactile stimulus.

The application of this instrumentation allows the experimenter to utilize various psychophysical methodologies and procedures. One area of focus over the last few years in oral vibrotactile research has been the continued modification of procedural aspects of testing in order to increase subject comfort, increase accuracy of results and achieve acceptable levels of

standardization for routine clinical as well as research usage.

MODIFICATIONS

The method of limits has been the most frequently used technique for determining most sensory system thresholds and has been adopted as the standard method for obtaining oral vibrotactile thresholds. In this method, stimulation begins below an individual's threshold of response and continues until there is a response. It has been determined that subject fatigue and sensory system adaptation is greatly reduced through the use of this method over others. In oral vibrotactile testing, it has also been determined that with the method of limits, subjects tend to provide their lowest and most consistent thresholds of sensitivity (Hall, Fucci, & Arnst, 1972; Petrosino, & Fucci, 1983).

Although the investigation of sensitivity through threshold testing provides valuable information about the senses, it does not in itself provide the full picture of a sensory system. Psychophysical scaling of sensory attributes is necessary to complete the picture, since sensation changes do not have a one-to-one relationship with changes in the stimulus. As such, psychophysical relationships (magnitude functions) can be determined to provide more complete information of the sensory system under study. One such procedure that has successfully been used in the oral tactile sensory system assessment is the method of magnitude estimation (Stevens, 1964). Magnitude estimation allows the subject to make direct numerical estimations of the sensory magnitude of the stimulus being presented. Most researchers working with vibration have employed a three-trial method of vibrotactile suprathreshold magnitude scaling. The three-trial method requires subjects to scale a series of eight or more suprathreshold intensities three different times. The results of the first trial are considered practice and are discarded. The means of the second and third trials are considered the subjects' subjective numerical responses to the suprathreshold intensities (Verrillo, 1962; Verrillo, Fraioli, & Smith, 1969). Because vibrotactile research was originally performed on the hand, the three-trial method worked well due to the fact that the skin on the hand is non-mucosal. The vibrator probe-contactor could rest on the structure as long as was necessary to obtain three trials, with minimal adaptation and fatigue occurring to that structure. The tongue has a mucosal surface which dries out very quickly. It constantly has to be retracted back into the mouth between stimulus presentations. The tongue also has to be extended from the mouth to fit under the probe-contactor of the vibrator, resulting in early fatigue both from the need to extend the tongue and the drying effect that naturally occurs. It has been found that for lingual vibrotactile magnitude scaling a

single-trial of suprathreshold stimulus intensity presentations provides the same results as are obtained with the original three-trial method. Subjects are able to manage a single trial situation with minimal fatigue and discomfort to the lingual surface (Telage & Fucci, 1974; Petrosino, Fucci, & Harris, 1985).

Lingual vibrotactile magnitude-estimation scaling has routinely employed eight suprathreshold intensities (6, 10, 16, 20, 26, 30, 36, and 40 dB SL) (Fucci, Petrosino, Underwood, & Clark, 1992). In a recent study, it was discovered that a more limited set of suprathreshold intensities (four instead of eight) provided similar results on a group of young adults who acted as their own controls (Fucci, Petrosino, Harris, & Banks, 1994). During the first scaling task of the study, all subjects provided subjective numerical responses to the usual eight suprathreshold intensity levels. During the second scaling task of the study, all subjects provided subjective numerical responses to four suprathreshold intensity levels (6, 15, 26, and 36 dB SL). As long as the four intensity levels approximated the same intensity range as the eight intensity levels, suprathreshold scaling results were statistically the same. Given this situation, lingual vibrotactile testing could be made much more comfortable for subjects because they would not have to hold the tongue in test position for extended periods. Consequently, the whole testing situation could be condensed. More subjects could be tested in a shorter time, older and younger subjects could be tested with greater ease, and difficult to test subjects would be likely to provide more stable results.

Oral vibrotactile testing procedure has required a probe-contactor adjustment to each individual's lingual surface. This practice was established to insure that probe-contactor depth was exactly the same for each subject (Verrillo, 1962). Recently, a fixed probe-contactor position has been instituted that is used across all subjects. The setting of a fixed position for all subjects has cut test time considerably and has reduced the subject fatigue factor. Preliminary testing using a fixed probe contactor position has shown that any difference in test results for lingual threshold or suprathreshold testing is statistically negligible and acceptable for routine testing purposes (Fucci, Petrosino, & Underwood, 1993). Standardization of this portion of the adjustment set-up procedure has enabled more data collection on younger children and difficult to test populations who do not tolerate long periods in most types of testing situations (Fucci, Petrosino, Underwood, & Clark, 1992).

The effects of stimulus duration and stimulus intensity level on lingual vibrotactile thresholds has recently been studied. A vibratory stimulus was presented to the tongue for durations of 5 and 15 seconds at eight different suprathreshold intensity levels. It was determined that the time required for thresholds to return to baseline thresholds of sensitivity increased as the stimulus

duration or stimulus intensity was increased (Fucci, Ellis, & Petrosino, 1993). The shorter the stimulus the less likelihood of a threshold shift that could have an effect on suprathreshold responses. If stimulus duration is too short, however, suprathreshold scaling cannot be accomplished with any reliability on the tongue. All of the above findings involve the necessary considerations for the development of routine lingual vibrotactile testing procedures.

At present, the oral vibrotactile instrumentation described above is non-portable. This is a serious problem because the instrumentation is located in a rural geographic location where large populations of subjects of varying types and conditions are not available (Fucci, Petrosino, & Harris, 1990). A serious attempt is presently underway to build a portable unit. A prototype has been constructed which can be mounted on a desk as opposed to being bolted to the floor. With appropriate weights and clamps, aberrant vibrations to the tongue are controllable, but not completely isolated as is the case with the non portable research unit.

Simultaneously, an electronics package is being developed which will also be of a more portable nature. The electronics package that drives the non-portable unit is mounted in a floor rack. Similar electronics packages are becoming available that are miniaturized enough to be placed in suitcases that will fit in the trunk of a car along with the portable vibrotactile unit itself. Much more development and testing will be required before the portable unit will demonstrate the convenience of set-up and reliability presently shown in most portable clinical audiometers and other auditory measuring devices.

The use of vibrotactile instrumentation to perform both threshold and suprathreshold testing has added significantly to the knowledge of the oral tactile sensory system. However, it is only with the continued goal toward the collection of large data bases and continued standardization of procedures that practical application can finally be accomplished. Once practical application is achieved, the oral vibrotactile instrumentation will become a direct aid to oral facial or myologists, speech/language pathologists, physical therapists, occupational therapists, dental hygienists, and others concerned with rehabilitation of the orofacial region.

Correct tongue position, for example, is critical to proper oral facial development. Tongue position relates directly to sensory feedback which, if not functioning properly, can lead to tongue thrusting, a low position of the tongue within the oral cavity than is normal, inappropriate swallowing behaviors, and poor speech production (Kellum, 1993). Similarly, proper lip function also is dependent on the sensory feedback mechanisms located within those structures. If oral myofunctional therapists could ascertain the exact conditions of the tactile sensory mechanisms within and around the oral

cavity, appropriate compensation for sensory deficits could become an early part of a myofunctional therapy program. For example, a client showing an oral tactile sensory deficit could be taught to compensate through visual cueing. Pictures of the oral cavity could be used to show proper tongue position for the production of a particular speech sound, or for the various phases of swallowing. Mirrors could also be employed in visual cueing as a way for the client to see appropriate lip postures and tongue tip locations needed in speech therapy, dysphagia therapy, and tongue thrust rehabilitation. Auditory training is another possible means for clients to overcome oral sensory deficits once they are diagnosed. In speech therapy the ear is the major input device to articulation therapy, especially for those speech sounds requiring tongue positions that are not externally visible (Van Riper & Emerick, 1990; Shames, Wiig, and Secord, 1994). Modifications of oral vibrotactile instrumentation and procedural changes that will allow this instrumentation to become an effective diagnostic tool are continuing at this time.

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Address correspondence to;
Dr. Donald Fucci
Lindley Hall 219
School of Hearing and Speech Sciences
Ohio University
Athens, Ohio 45701