1971

Oral stereognosis and two-point discrimination ability of anterior tongue thrusters and normal swallowers

Lawrence Jay Friedman
University of the Pacific

ORAL STEREOGNOSIS AND TWO-POINT DISCRIMINATION ABILITY OF ANTERIOR TONGUE THRUSTERS AND NORMAL SWALLOWERS

A Thesis

Presented to

the Division of Communication Sciences

University of the Pacific

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

by

Lawrence Jay Friedman

March 1971

This thesis, written and submitted by

LAWRENCE JAY FRIEDMAN ,

is approved for recommendation to the

Graduate Council, University of the Pacific.

Department Chairman or Dean:

Kenneth L Perrin

Thesis Committee:

Kenneth L Perrin , Chairman

Dated MARCH 17, 1971

ACKNOWLEDGMENTS

The author wishes to express his thanks to all those who gave support and guidance in carrying out this research and in writing this thesis.

I wish to express deep appreciation to Dr. Kenneth L. Perrin, Chairman of the Supervisory Committee. Due to his encouragement, assistance, and generous giving of time, this project was brought to completion.

To each of my committee members, Dr. Roy J. Timmons and Dr. M. Darril Opdahl, I give thanks for their guidance.

To Dr. Marvin Hanson, Dr. Robert L. Ringel, Dr. Gerald N. McCall, Mr. Melvin Cohen and Mr. Jeffery Feinstein, I am grateful for their assistance.

To the subjects of this study I give thanks and appreciation for their time and cooperation.

To my wife, Carol, who spent many nights wondering why her husband must go to school again tonight, I express my eternal love and appreciation.

TABLE OF CONTENTS

Chapter Page

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Speech pathologists and dental specialists have observed the swallowing patterns of patients for many years. Their observations have determined that there is a normal swallow pattern, in which the tongue moves to the back of the mouth during swallow; and an abnormal swallow, in which the tongue moves to the front or side of the mouth during swallow.

Some people with abnormal swallowing patterns thrust the tongue either forward or sideways in the mouth, making contact with the anterior and/or lateral teeth. This deviant swallow has been termed "tongue thrust".

Tongue thrust has been the concern of orthodontists and pediodontists because of the harmful effects it has been reported to have upon the teeth.

In 1918, A.P. Rogers wrote the first article on the imbalance of the muscle forces between the tongue, lips and cheeks, as a cause of orthodontic relapse (35). Intense interest in the problem did not occur however, until a series of articles were published by Straub in 1960, 1961, and 1962 (41, 42, 43). Since Straub's articles were published, there has been a rapid increase in the number of articles on the subject.

Various articles on tongue thrust have related the deviant swallow pattern to dental malocclusions, speech defects and facial musculature imbalances (10,18,22). However, there have been numerous controversies related to terminology (4), etiology (2,22,43,45), incidence (12), diagnosis (22), specialists to be involved, treatment procedures (4,22,44), and in some cases, whether tongue thrust actually exists as a clinical problem.

Of special interest to the speech pathologist is the treatment process. This process involves training the patient to reposition the tongue inside of the oral cavity to effect a normal swallow. Inherent in the repositioning of the tongue is the usage of a tactile-kinesthetic approach. If, however, the patient is not able to discriminate where in the oral cavity the tongue is, therapy could be unsuccessful. Little is known about the sensory system of the tongue thrusters.

In a review of the literature only one study has been found which deals with the sensory system of tongue thrusters. Silcox reported in 1969 (38), that when a group of subjects were asked to identify geometric forms with their tongues, no significant differences were found between the scores of the normal subjects and the tongue thrusters.

Perhaps some of the reasons for the lack of significant difference in Silcox's study were that the thirteen to sixteen year old age group used, comprises only 28% of the tongue thrust population, according to Fletcher, Casteel

and Bradley (12); and that the subjects were allowed an unlimited amount of time to identify the forms.

Further examination of oral sensation in younger tongue thrusters and in which the time factor is controlled seems warranted. Also, two-point discrimination ability of tongue thrusters has yet to be examined. Such a study appears warranted in an effort to gain further insight into oral sensation in tongue thrusters.

Statement of the Problem

The present study was designed to determine whether differences exist between frontal tongue thrusters and normal swallowers on tasks of oral stereognosis and two-point discrimination.

Questions to be Examined

The first three questions which this study examined are similar to those which were examined by Silcox (38). The latter three have not been previously reported.

1. Do differences exist between the oral stereognostic ability of normal swallowers and tongue thrusters?

2. Do differences exist in oral stereognostic ability between different age levels within the tongue thrust population?

3. Do differences exist in the oral stereognostic ability between male and female subjects in the tongue thrust and normal groups?

4. Do differences exist in the two-point discrimination task scores between the tongue thrusters and normal

swallow groups?

5. Do differences exist between two-point discrimination ability and oral stereognostic ability of tongue thrust and normal swallow groups?

6. Do differences exist in the placement of the oral stereognostic forms between the tongue thrust and the normal swallow groups?

Definition of Terms

Because of the diversity of terminology that is present in the literature relative to tongue sensation and control, the following definitions presented in the literature will be used for the purpose of this study:

Tongue Thrust. Tongue thrust, according to Silcox, is "present if the tongue presses against or pushes between the maxillary and/or mandibular teeth during swallow. Tongue thrust is anterior if the tongue presses against or between the incisors and cuspids; and it is lateral if contact is made with the left or right premolars during swallow" (38, p.9).

Oral Stereognosis. Oral stereognosis, says Woodford, "can be defined in its present usage as the faculty of perceiving three-dimensional qualities (shapes) of objects examined orally and of identifying them, while any inability to perform this task represents astereognosis, regardless of where the defect lies, or whether it is organic or functional" (46, pp.15-16).

Two-Point Discrimination. Ringel says that two-point

discrimination is "the ability of an individual to distinguish the minimum separation of two punctiform stimuli that can be discriminated as two separate stimuli" (32, p.310).

CHAPTER II

REVIEW OF THE LITERATURE

This chapter (1) presents information on the neural innervation of the tongue, (2) reviews the differences between tongue thrust and normal swallow, (3) reviews the types of tongue thrust, (4) presents information on oral stereognosis and two-point discrimination, and (5) presents information on the relationship of oral stereognosis and two-point discrimination to various disorders.

SWALLOW

Oral Innervation

Grossman and Hattis say that "the tongue has been described as the surface which is best provided with sensory nerve fibers for the entire body and that the frequency of sensory terminations is greatest in the anterior region of the tongue" (15, p.39). They go on to say that "the receptors observed in the mucosa of the tongue are, in general, similar to those of the palate and gingiva, with the exception of additional receptors which are present in the lingual surface" (15, p.39).

Smith (41) presents a description of the sensory nerve supply in detail. He says that:

> The sensory nerve supply of the oral cavity is derived from the lingual branch of the trigeminal nerve,

which ends in the anterior portion and sides of the tongue. This nerve carries the sensations from the anterior two-thirds of the tongue. Fibers of the glossopharyngeal nerve go to the mucous membrane at the base and sides of the tongue for the sense of taste and cutaneous stimulation. The superior laryngeal nerve has branches at the root of the tongue near the epiglottis. The motor nerve of the tongue is the hypoglossal nerve.

The trigeminal nerve receives tactile impulses in the tongue mainly through stimulation of Meissner's corpuscles, which are large, oval-shaped bodies within a thin tissue capsule. Each capsule receives several nerve fibers which are devoid of myelin fibers and coil into a spiral complex network. Impulses are carried over the branch of the trigeminal nerve to the main sensory nucleus located at the pons. Axions are sent to the opposite side where they form two tracks of the trigeminal lemnisci. These terminate in the arcunate nucleus of the thalmus. Finally the cells end at the post central gyrus of the cerebrum.

The trigeminal nerve has three main roots; a large sensory root, a mesencephalic root and a small motor root. The large sensory root goes to the cutaneous tissue of the face and supplies the mucous membrane of the mouth, nose and cornea. It carries impulses of light touch, tactile discrimination, sense of position and passive pressure movement of the tongue and oral cavity. The mesencephalic root carries impulses which govern the positioning of tongue and jaw. (41, p.7)

Normal Swallow

There is a distinction between the deglutition of a baby swallowing liquid and that of a child who is swallowing solid and semi-solid foods. The baby's instinctive and rhythmic peristaltic-like muscle activity steers the liquid back into the pharynx. The liquid is then directed through the pharynx by the pharyngeal constrictors past the epiglottis into the esophagus. Once in the esophagus, it continues by peristaltic action and gravity into the stomach.

As the alteration in foods occurs and the eruption of teeth takes place, a modification of the swallowing act occurs. One of the most complete studies of adult swallowing has been done by Ardan and Kemp(3), but by combining data

from several authors (2,8,36,44), a pattern of normal swallow can be given in greater detail.

The normal adult swallowing act can be divided into three stages.

The first stage is both "voluntary and conscious during which the food is collected in a bolus and carried to the isthmus of the fauces" (44, p.91). The teeth are firmly occluded. The food is then gathered onto the tongue tip and by action of the lingual muscles is rolled towards the dorsum of the tongue. The hyoglossal muscles pull the root of the tongue downward. The root of the tongue then rotates through an arc of a circle having the hyoid bone as its center (8). The mylohyoid, glossopalatini and the styloglossus contract, pressing the tongue against the hard palate.

The dorsal surface of the tongue is "in contact with the hard and soft palate, exerting its pressure against them in an upward and lateral direction. Its tip and edges do not protrude between the teeth at any point. The tip of the tongue does not come forward any further than the lingual gingival third of the maxillary incisors" (21, p.649).

The action of the tensor veli palatini causes the soft palate to tense and in effect lengthens the hard palate. This creates an added base against which the tongue can move (14).

A wave of contraction then occurs starting at or near the tip of the tongue, which is resting against the

lower anterior teeth, and the front portion of the hard palate, and spreads backward. During this action, a seal between the tongue and palate is maintained (44).

At the same time, the hyoid bone is carried upward and forward so that it becomes buried in the base of the tongue. The diagastric, stylohyoid, and the geniohyoid muscles are involved in this action (44).

Stage two is brief and occupied with guiding the food through the pharynx. As the bolus passes from the oral cavity into the upper end of the esophagus through the oral and laryngeal portion of the pharynx, there are four openings that must be closed to prevent material from entering them. They are: first, the nasopharynx; second and third, the Eustachian tubes; and fourth, the glottis (44). The nasopharynx is closed off by the approximation of the palatopharyngeus muscles. The salphingopharyngeus muscles close off the pharyngeal orifices of the Eustachian tubes. Movement of the arytenoid cartilages medially causes the glottis to be closed. As the pharynx descends with the contraction of the infrahyoid muscles, the bolus is carried downward into the esophagus.

The third stage of deglutition is a peristaltic wave which passes down the esophagus to the cardiac sphincter of the stomach. This third stage of swallow has been mentioned only briefly because it is a reflexive action.

The entire time for the preceeding action to occur is extremely short. The initial stages of the swallowing act

are in the magnitude of one or two seconds making recognition of swallow by observation and palpation highly critical.

Tongue Thrust

Humphrey (19) in a study of fetal reflexes has observed what appears to be a sucking response at about 8.5 weeks menstral age. This develops into a swallow reflex which is the result of neural pathways becoming functional and allowing the responses to occur. This swallow reflex, referred to as the infantile swallow pattern, is manifested in the nursing instinct as the tongue darts forward to obtain milk from the mothers breast (24). This nursing instinct is one of the best developed of all infantile movement.

This infantile swallow pattern if retained past the change from soft to hard foods becomes an oro-facial muscle imbalance, which has been termed "tongue thrust". Other terms which have been employed are; atypical swallow, perverted swallow, reverse swallow, visceral swallow and endogenous tongue thrust.

Tongue thrust is present if the tongue presses against or pushes between the maxillary and/or mandibular teeth during swallow. A review of the normal swallow gives a basis from which to judge abnormal swallow.

In the abnormal swallow habit, according to Straub (41), the muscles of mastication are not used in bringing the jaws tightly together. First, the tongue is thrust forward between the teeth, and then the muscles of mastication bring the jaws together until the upper and lower teeth

contact the tongue. The orbicularis oris and other facial muscles of expression, especially the mentalis, enter the act by tensing to help force the bolus of material back into the pharynx. In many cases, the patient blows air forward and builds up a positive pressure instead of a negative pressure in the anterior portion of the oral cavity.

There is also a tendency to move the head forward in an effort to move the bolus or saliva back into the pharynx. This accompanied by contraction of the muscles of expression is so intense that patients may have a strained expression about the face and throat. In older patients a change in facial contour has also been noted (41). The variation in forces between the thrust and other muscle pressure imbalances has been suggested as one cause of malocclusion.

Tongue thrust has been termed "anterior" if the tongue presses against or between the incisors and cuspids; and "lateral" if contact is made with the left or right premolars and molars during swallow.

Bell and Hale (7) examined 353 children, aged five and six years of age, and found that 82% exhibited a swallow which could be classified as a tongue thrust. Ward (45) found that 74.3% of a group of first, second, and third graders possessed a tongue thrust pattern.Fletcher, Casteel and Bradley (12), found that the incidence of tongue thrust swallow numerically decreased with an increase in age. If the tongue thrust exists normally at birth as has been suggested by Lewis (24), then what factors are responsible for the

retention of the infantile swallow habit after 18 years of age.

Considerable controversy with respect to occurance of the tongue thrust pattern of oral activity has been focused upon its etiology.

Bottle feeding has been discussed as a cause of tongue thrust by a variety of authors. Straub (41) and Picard (31) both suggest that the abnormal swallowing habit seems to be the direct result of improper bottle feeding. Straub believes that for one to appreciate why bottle feeding causes the tongue thrust, one must understand the differences in the mechanics of breast and bottle feeding. He says, "In breast feeding, the tongue is free in the mouth to place itself properly to take care of the normal act of deglutition, since the milk does not run freely but must be sucked out with pressure. When a mouthful of milk is obtained, the source of supply is shut off and the baby uses the normal tongue action for deglutition" (41, p.421).

In bottle feeding, Straub says (41), "the nipple is very long and reaches partially into the throat. To make sure that the infant gets sufficient milk, several large holes are usually placed in the nipple. When the infant attempts to suck vigorously, the milk comes so fast that he will either regurgitate and choke or spill milk out at the sides of his mouth. This teaches the baby to shove his tongue forward, maintain the tip in that position, and swallow the milk with the back portion of the tongue abnormally,

while the tip of the tongue is receiving a new supply of milk" (41, p.421).

The "Nuk Sauger Preventive Orthodontic Program" of artificial infant feeding published by the Rocky Mountain Metal Products Company, has indicated that the typical artificial nipples produced by most companies, are not designed to be an accurate facsimile to the breast of the mother (29).

Thumbsucking has also been advanced as a cause of the tongue thrust problem, however, doubt has been expressed by some investigators as to whether a cause or effect relationship exists between the two (2,41). If the thumbsucking has created an open space, then frequently the tongue assumes this space as a habitual resting place instead of its usual place of rest.

Rogers (35) and Andrews (2) believe that tongue thrust developes when the tongue thrusts into the space created by the loss of the decidous incisors. By the time that the permanent teeth erupt the tongue thrusting has become a habit.

Andrews (2) states that "if the tonsils become infected and remain so for a period of time, it is painful to swallow and the tongue is forced to assume a more anterior position". If this reflex continues for a period of time it may establish new neural muscular pathways which continue to control the swallowing even after the tonsils are no longer sore. Andrews also believes that macroglossia of the

tongue is another cause for the tongue thrust pattern.

Leech (23) in examining a group of 500 patients at an upper respiratory research clinic, found that 43% of the patients manifested an atypical swallow pattern.

Lack of physiological maturation of the swallow pattern is also listed as a cause of tongue thrust. Becker (6, pp.8-9) says that "some children never learn to perform the normal 'teeth together' swallow as when eating tougher foods. They continually swallow in the way that the normal child reserves for soft foods."

Heredity has also been suggested as a cause based on not only structural similarities but also on the similarity in swallowing patterns which are exhibited.

Barrett (4) however, believes that malocclusion is the possible cause of tongue thrust and not visa versa. The malocclusion, states Jann (20) on the basis of clinical observation of young children, is etiologically significant in the development of not only a tongue thrust but also an accompanying speech defect.

Controversy also exists over the diagnostic methods which should be employed to check for abnormal swallow. Of the five methods which have been used, four are objective and one is clinical.

The clinical technique consists of first having the patient swallow water while checking for masseter muscle action. These muscles should contract during normal swallow. Also observation of the perioral muscles during swallow is

important as any contraction of these muscles would indicate an abnormal swallow. The final step is to use the thumb and forefinger to break the labial seal and observe where the tongue is at the moment of swallow (11).

The entire time for the swallow act to occur is extremely short. The initial stages of the swallowing act is in the magnitude of one or two seconds. The recognition and diagnosis of an abnormal swallow by observation and palpation is susceptible to criticism.

SENSATION AND PERCEPTION

Adults do not use their mouths for exploratory haptic touching as the infant seems to do. Putting things in the mouth is not a socially accepted habit after a certain age. "nevertheless, this organ retains the ability to discriminate the shape, size and solid geometry of objects without seeing them" (13, p.135).

Oral sensory experience is distinctive in its continuity. Bosma states (9, p.98), "the sensory-elicited oral motion effecting the opposition experience in the tongue, lips and palate is the essential mechanism of the infant suckle and oral positional mechanism". Sucking has been elicited by stimulation about the mouth of the human fetus as early as 24 weeks of menstral age (19).

Even though oral sensation is active early in the fetus, it becomes secondary to other activity in the body. Bosma states (9, p.106) that "the strongly crying infant's

oral area is insensitive to stimulation, but he may be calmed by enforced swallow, as of water delivered to the pharynx via nose or mouth". Another type of insensitivity reported by Bosma was "the infant in established suckle ... is more tolerant of peripheral pain" (9, p.107).

"In this developmental prospective, the crudely performing mouth of the infant is awaiting the development of sensory cues to discriminate actions" (9, p.109). The oral sensation of the infant is further complicated by the fact that in the oral region there is a close relationship between sensory and motor function.

The mouth is an active perceptual system which anatomically includes a set of overlapping parts; the jaws, lips, teeth, tongue, palate and throat (13). Shelton, Arndt and Hetherington (37) state that stereognosis is intersensory involving more than one sensory organ. Paine (30, p.151) states that "such sensations as touch, deep pressure and two-point discrimination are essential to the ability to pass tests for stereognosis". However, Shelton, Arndt and Hetherington (37) suggest that it is not at all well established how persons perceive intraoral sense of position and movement.

ORAL STEREOGNOSIS

Woodford states that "oral stereognosis is the faculty of perceiving three-dimensional qualities (shape) of objects examined orallly and of identifying them" (46, pp.15-16). In any discussion of shape, form and size, there

is a constancy developed which "is the tendency for object properties to remain uniform and unchanged in spite of the conditions under which they are observed" (5, p.172).

Questions have been raised about the testing of oral stereognosis in that the test may include stimulations which are secondary to stereognosis. The mouth consists of overlapping parts which function as a whole unit, and all play a part in discrimination and sensation. Shelton, Arndt and Hetherington (37) and Ringle (33) agree that there can be intersensory involvement in the oral perception process. It would follow then that "oral stereognosis is a test of general abilities" (27, p.219).

A variety of tests of oral stereognosis have been developed. Grossman (16) using ten geometric forms tested oral stereognostic ability in normal and neurologically impaired subjects and found that the anterior lingual surfaces of the tongue are of primary importance for oral discrimination. Smith (40) used 15 forms to test oral stereognostic ability in twenty-five speech defective children. His results indicated that his forms were easy to identify and more difficult forms needed to be added to the test.

Mihacs (27) presented a twenty-five item test to twenty college students who had their hard palate covered with wax. He found that covering the palate had no effect on the form identification task.

Shelton, Arndt and Hetherington (37) developed a test

that was comprised of thirty-five forms with handles attached. After administering the forms to first grade, third grade and graduate students, they found that there is an increase in mean correct response with increased age.

Ringle is quoted by Silcox (38) of being critical of having handles on the forms because he believes this impedes the manipulation of the forms. No other source has been found in a review of the literature which concurred with this opinion.

The National Institute of Dental Research has produced a set of twenty forms, which have come to be known as the standard NIDR 20 set. The set is produced in two ways. One has a handle and the other does not. The same forms are available in a larger size than the standard.

Different sizes of forms have been tested and it has been found that the number of correct responses increases with an increase in the size of the forms (28).

TWO-POINT DISCRIMINATION

Early theorists hypothesized that the area served by a single neuron and the space between the adjacent neuron provided the neurophysiological basis or "two-point" perceptions. Present evidence, however, supports a more dynamic view of such perceptions. Spacial discrimination involves the interaction of such factors as the size and density of innervation of the receptive field, the intensity and location of the stimulus, and the effects of afferent inhibition

of areas surrounding the site of stimulation (32).

Ringle and Ewanowski (32) using an oral esthesiometer attempted to devise a test to provide procedures and normative data on the evaluation of two-point discrimination capacities of selected oral structures. The esthesiometer contains probe points which could be weighted so that under free movement, they would fall with a calibrated amount of force and strike the desired surface. The subject would then push a button, lighting a light, thereby indicating contact had been made and how many points had been felt. Using twenty-five university students, they found that two-point discrimination decreases in a front-to-back of the mouth relationship. Ringle and Ewanowski also reported a mean value of 2 mm for threshold on a two-point oral discrimination task (32).

McCall (25) attempted to provide further measures of the oral-sensory mechanism. He received mean values of 1.7 mm for normal subjects.

Present research evidence demonstrates that the normal two-point limen for the tongue tip is between 1 and 2 mm, however, further research is indicated for other tongue areas (25).

RELATIONSHIP OF ORAL STEREOGNOSIS AND TWO-POINT DISCRIMINATION TO VARIOUS DISORDERS

Solomon (27) and Class (28), in work done with athetoid children and adults, found that there was a marked relationship between oral stereognostic ability and chewing,

drinking and articulatory proficiency. There was also a tendency for poor performance on the motor tests to be associated with poor performance on the sensory tests. No difference in the two-point discrimination ability of athetoid children has been noted (26).

Ringle (34) administered an oral stereognostic test to sixty children with "functional" disorders of articulation. He found that the subjects without speech defects did better and that as the number of articulation errors increased so did the number of errors on the test. Ringle concludes that this test, which purports to be a test of oral sensation, differentiated between defective speakers and individuals without speech defects.

Moser, LaGourge and Class (28) found that stutterers made more errors on an oral stereognostic task than did persons who did not stutter, or had an articulation disorder.

Shelton, reported Silcox (38), found that cleft palate individuals "perform similarily to normal speakers and that there is no trend of responses between different classes of clefts". Shelton also found that deaf and blind subjects differed little in oral form recognition.

Silcox (38) studying the relationship in oral stereognostic ability in a tongue thrust group, found no differences between the tongue thrusters and the subjects with a normal swallow pattern.

In conclusion, the research on oral stereognosis and two-point discrimination has been well summarized by McDonald

and Aungst (27, p.219):

1. As a measure of oral sensory function, form identification in the mouth and two-point discrimination seem to be more promising than weight perception, localization or texture discrimination.

2. Oral stereognosis is a general ability.

3. The tongue appears to be the most sensitive of the oral structures in identifying forms.

4. It does not appear possible to improve oral identification of forms through practice in manual tracing of the forms, tactile experience with the forms or visual inspection of the forms.

5. There may well be a subgroup of persons with defective oral motor function such as poor articulation or poorly developed chewing, sucking, and swallowing, whose motor dysfunction is associated with defective oral sensory abilities.

CHAPTER III

PROCEDURE

The present study was designed to determine whether there was a difference between the oral stereognostic and two-point discrimination ability of anterior tongue thrusters and normal swallowers.

Subjects

Seventy-four subjects, ages nine to twelve years old, were evaluated for possible inclusion in the study. According to Fletcher, Casteel and Bradley (12), this age group comprises 37% of the tongue thrust population.

To be included in the final research population, subjects had to meet the following criteria; demonstrate no articulation defect and have no oral-facial anomaly. Subjects in the experimental population had to demonstrate an anterior tongue thrust.

To determine if the subjects met the above criteria, all subjects were given an articulation test, which required them to read a paragraph containing English speech sounds. Moser, LaGourge and Class (28) have reported that articulatory disorders do not affect responses on an oral sensation task, but McDonald and Aungst (27) found that subjects with articulatory disorders did not do as well as normal speakers on the same task. Because of this controversy, it was determined that individuals with any misarticulations would be

excluded from the study. The examiner performed an oral peripheral examination on all subjects to rule out the possibility of an oral-facial anomaly.

To determine if the subject was a tongue thruster, a clinical procedure consisting of having the subject swallow water was used. During the swallow, the masseter muscle action was observed, as these muscles should contract during normal swallow. Also, contraction of the perioral muscles was noted, since any contraction of these muscles might indicate an abnormal swallow. The final step was the use of the thumb and forefinger to break the labial seal and observe the location of the tongue at the moment of swallow (11). For the subject to qualify as a tongue thruster for this study, the tongue had to make contact with or be anterior of the central incisors. This procedure was performed twice, by two examiners, and both examiners had to agree on the tongue thrust diagnosis.

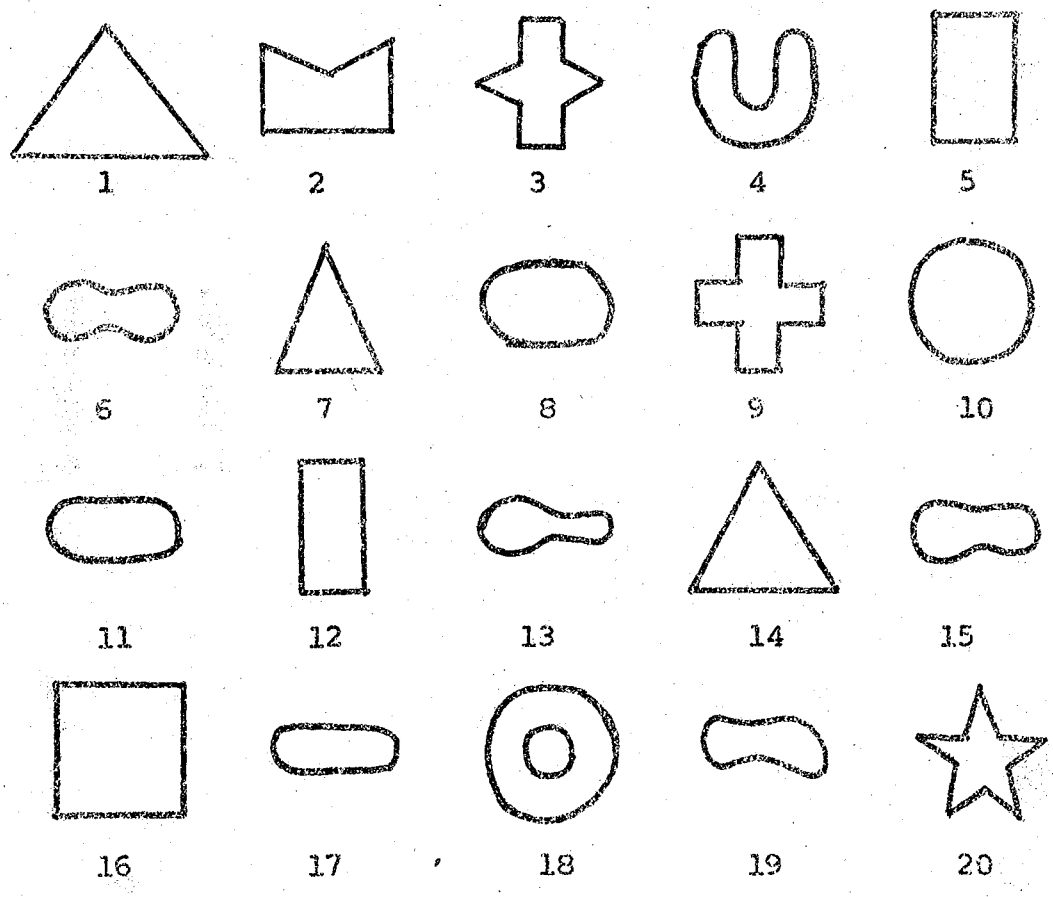
Sixty subjects comprised the final research population with an age range of nine to twelve years and with a mean age of 10.3 years. Thirty of these were normal and thirty were tongue thrusters. Half of the subjects were male and half were female. Fourteen of the original seventy-four subjects were excluded because of articulation defects.

Oral Stereognostic Evaluation Procedure

Twenty forms were used in the study. The forms were made of 1/4 inch thick plexiglass attached to 5 inch stainless steel handles (Figure I). The handles were calibrated in

FIGURE I

ORAL STEREOGNOSTIC TEST FORMS



five 1 cm increments from the form end of the handle.

The selection of the form designs were based on forms described by Shelton, Arndt and Hetherington (37) and developed by the National Institute of Dental Research.

In administering the test, each subject was seated at a table with the form selection chart, and was given the following instructions:

> We would like you to help us find out if boys and girls can match a form with a picture, not by looking at them, but by feeling the forms with your tongue.
>
> We'll ask you to close your eyes, and open your mouth, and I will put one of these forms from this bag into your mouth. After the form is in your mouth, open your eyes, but keep your mouth closed. Move the form around on your tongue, and see if you can discover which picture matches the form you have in your mouth. When you know which one it is, point to the picture on the chart in front of you. You will have only 15 seconds to make a decision, so as soon as you know which is the form you have in your mouth, point to the picture matching it. Then close your eyes, and I'll take out that form, and put in another one.
>
> Remember, this game is to see if you can tell, without looking, what is in your mouth. So remember, keep your eyes closed, except when you have a form in your mouth, and your mouth is closed. You have only a short time, so decide as quickly as possible. If you're not sure which picture matches the form, take a guess. If you're ready, we'll begin. Do you have any questions?

With the instructions completed, the first form was placed in the subjects mouth. Care was taken to shield the form from view by using the tester's hand. Using the handle, the subject manipulated the form for 15 seconds, and pointed to the picture they thought matched the form. At this time, the depth to which the form was inserted into the mouth was also determined, using the calibration on the handles of the forms. This procedure was followed for all

20 forms. At no point during the test was the subject given any indication as to the accuracy of his response.

Two identical sets of forms were used, allowing one set to be sterilized while the other set was being used. Following the oral stereognostic test, the test for two-point discrimination was administered.

Two-Point Discrimination Procedure

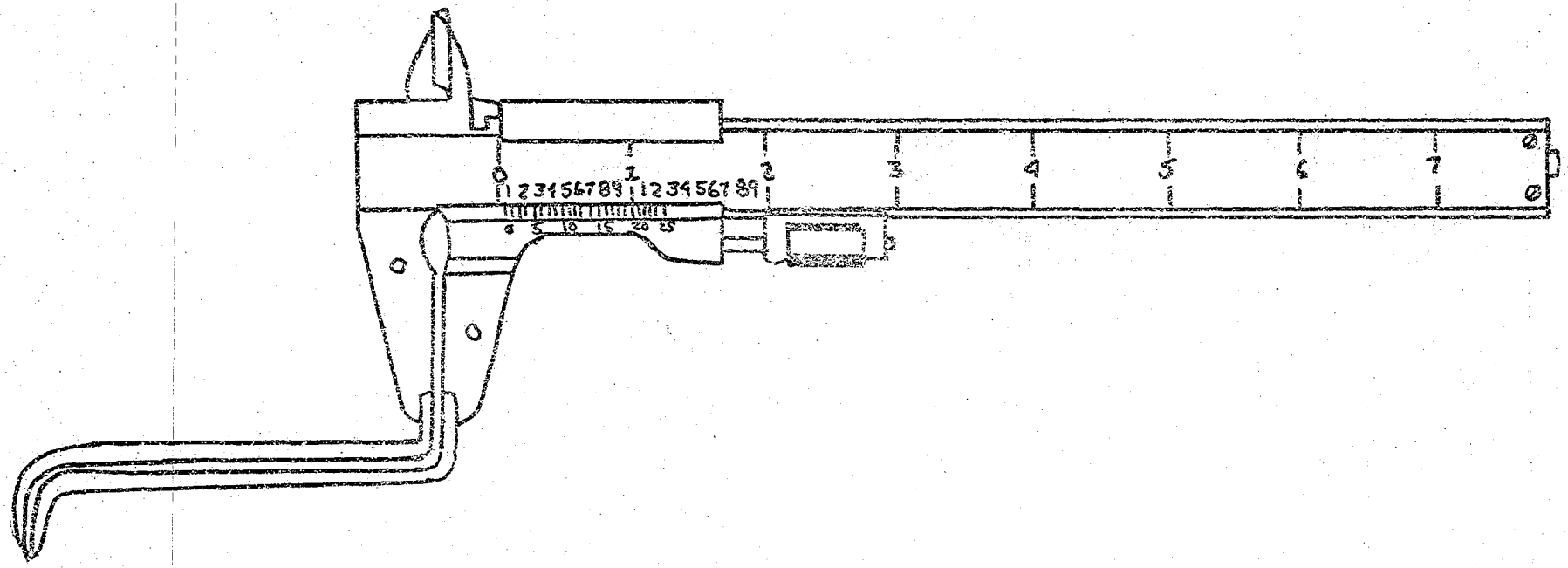
The psychophysical "method of minimal change" described by McCall (26) was used in the administration of this test. This procedure involves the establishment of ascending and descending thresholds. An ascending threshold is established by gradually moving the two points apart until the subject is able to perceive two points. A descending threshold is obtained by decreasing the distance between the two points until the subject perceives them as one distinct point.

To obtain two points which could be moved apart and back together again, a pair of vernier calipers (Figure II) were modified by welding two stainless steel rods to the ends. The rods extended approximately three inches out in front of the caliper. The ends of the rods were turned down and bent so that they were approximated when the calipers were closed. The tips of the rods were filed to points of less than 1 mm in diameter, but the sharpness did not obtain that of a pinpoint.

Before presenting the task to the subject, the following instructions were given:

FIGURE II

CALIPERS FOR TEST OF TWO-POINT DISCRIMINATION ABILITY



> We would like you to help us find out if boys and girls can tell whether they are feeling one or two points touching their tongue.
>
> We'll ask you to close your eyes and open your mouth and I will touch your tongue with this pointer. When I take it out of your mouth, I want you to hold up one finger if you felt one point, and two fingers if you felt two points. We'll do this several times, and each time I want you to tell me how many points you felt.
>
> Remember, this game is to see if you can tell how many points are touching your tongue. If you're not sure, please guess. If you're ready, we'll begin. Do you have any questions?

With the instructions completed, the subjects tongue was touched with the calipers until the subject reported the change from one to two points. The amount of incremental change was then recorded for each subject, until his threshold was determined.

Method of Analysis

Two-tailed *t*-tests of significance were computed to test the following questions: (1) Do differences exist between the oral stereognostic ability of normal swallowers and tongue thrusters?, (2) Do differences exist in oral stereognostic ability between different age levels within the tongue thrust population?, (3) Do differences exist in the oral stereognostic ability between male and female subjects in the tongue thrust and normal groups? and (4) Do differences exist in the two-point discrimination task scores between the tongue thrusters and normal swallow groups?

Two-tailed *t*-tests were selected because of the non-directionality of the data to be analyzed. A level of .01 was selected as the acceptable level of significance.

The Spearman Rank Correlation Coefficient was

computed for Question Five. This inquired into the relationship between two-point discrimination and oral stereognostic ability of normal and tongue thrust swallowers.

Data for Question Six, which dealt with the placement of the forms in the mouths of the tongue thrust and normal subjects was analyzed by computation of a Chi Square distribution.

CHAPTER IV

RESULTS AND INTERPRETATION

The purpose of this study was to determine whether there was a difference between oral stereognostic and two-point discrimination ability of persons with a tongue thrust swallow pattern and persons who have a normal swallow pattern.

Seventy-four subjects were originally screened for the study. Fourteen were eliminated because they did not meet the criterion of no articulation errors. The remaining 60 subjects were in an age range of nine to twelve years with a mean age of 10.3 years. Half of these subjects had a tongue thrust swallow pattern and the other half had a normal swallow. Also, half of the subjects in each group were male and the other half female.

Oral Stereognosis

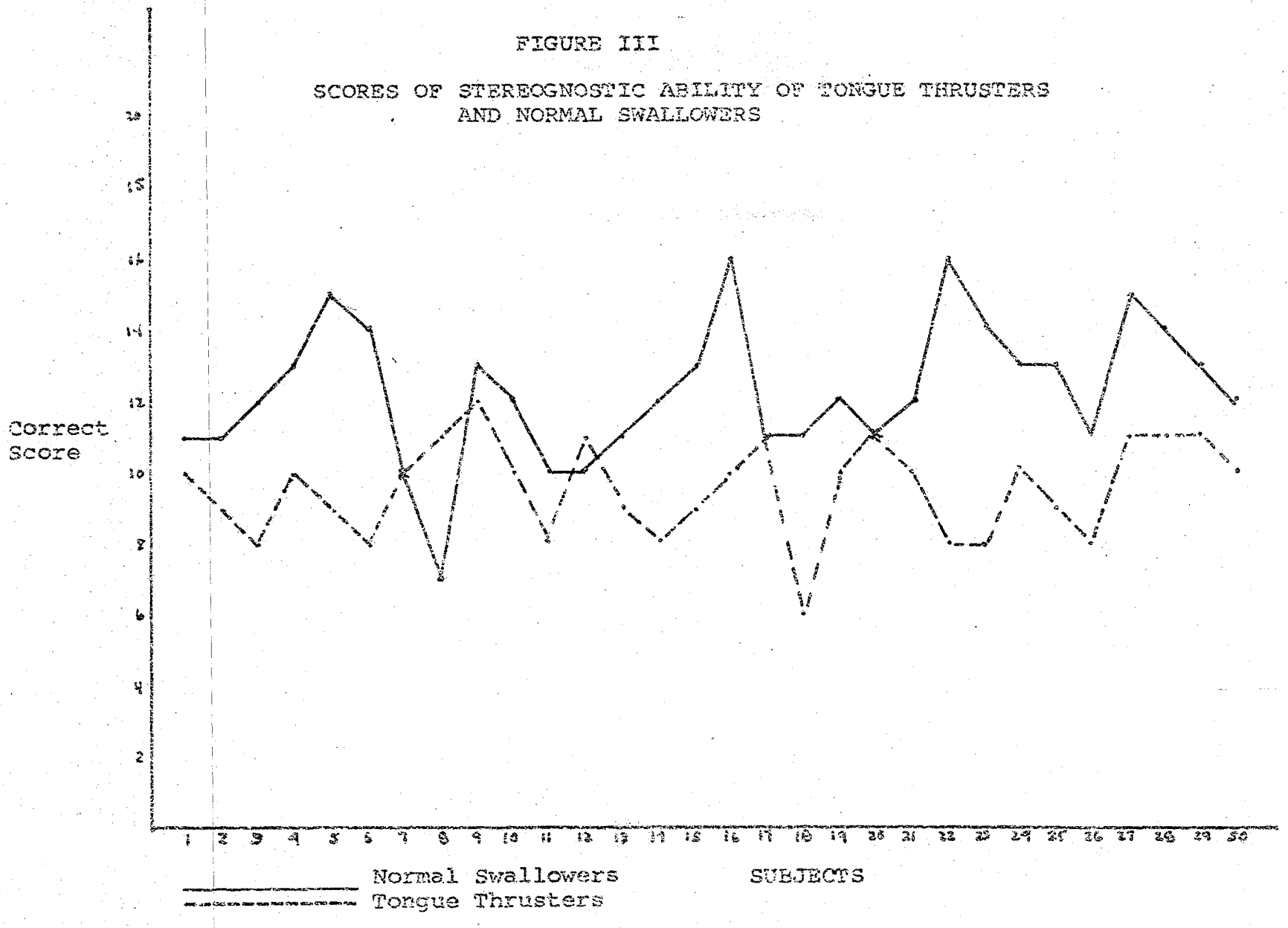
Figure III presents the subject's response scores on the test of oral stereognosis.

The mean correct response on the oral stereognostic task for the normal swallowers was 12.27 and for the tongue thrusters 9.52. The scores for the normal swallow group had a range of 7 to 16 while the scores for the tongue thrusters ranged from 6 to 12 correct responses. A *t*-score of 6.21 (df=58) was obtained. The results of this test were significant at the .01 level of confidence.

These results seem to indicate that the control sub-

FIGURE III

SCORES OF STEREOGNOSTIC ABILITY OF TONGUE THRUSTERS AND NORMAL SWALLOWERS



jects were better able to identify forms orally than were the tongue thrust subjects. This finding is different than that obtained by Silcox (38) who found no significant differences between his groups. Some reasons for this difference might be due to the restrictions on the amount of time which the tongue thrusters in the current population had in comparison to the amount of time Silcox gave his groups. If a sensory deficit is present it could take the tongue thrusters longer to make the discriminations. By giving the tongue thrusters an unlimited amount of time, as Silcox did, they may have been able to make the necessary discriminations.

Another factor that must be considered is the different age groups which were employed. Silcox's research population consisted of 13 to 16 year olds while the present population was 9 to 12 year olds, therefore the same degree of maturation may not have taken place. The amount of tongue thrusters represented by the younger age group, as well as the possibility of the problem being more pronounced in this group, might further account for some of the differences.

Finally, another factor which might account for the difference is the increased amount of subjects utilized in this study. Thirty tongue thrust subjects were employed as compared to nineteen tongue thrusters in Silcox's study. A larger number of subjects, presents the researcher with a more diverse population and one which may be more representative of the whole.

The second question inquired if there would be a

difference between different age levels in the tongue thrust population. Figure IV presents a display of the groups mean scores.

The computed mean scores by age level for the group of tongue thrusters and the normal swallowers were similar with only slight differences between them. No significant differences were found when testing the oral stereognostic ability between nine, ten, eleven and twelve year old tongue thrusters and normal swallowers.

Sensory acuity does not appear to be related to age level. This would suggest that oral stereognostic ability is not developmentally linked, at least within the population studied. This is in opposition to the findings of Shelton, Arndt and Hetherington (37), who using first grade, third grade and college students, found an increase in scores with an increase in age. The difference may be due to the greater age range which they utilized in their study.

Question Number 3 asked if differences exist in the oral stereognostic ability of different groups when classified by sex. Figure V presents the subjects scores for both male and female normal swallowers versus male and female tongue thrusters.

The mean correct response score was 12.67 for the male normal swallowers and 11.87 for the females. The mean correct response for the male tongue thrusters was 9.47 while the female tongue thrusters had a mean correct score of 9.60. A t-test score of 1.09 (df=28) was obtained for the normal

FIGURE IV

STEREOGNOSTIC ABILITY BETWEEN GROUPS OF TONGUE THRUSTERS AT DIFFERENT AGE LEVELS

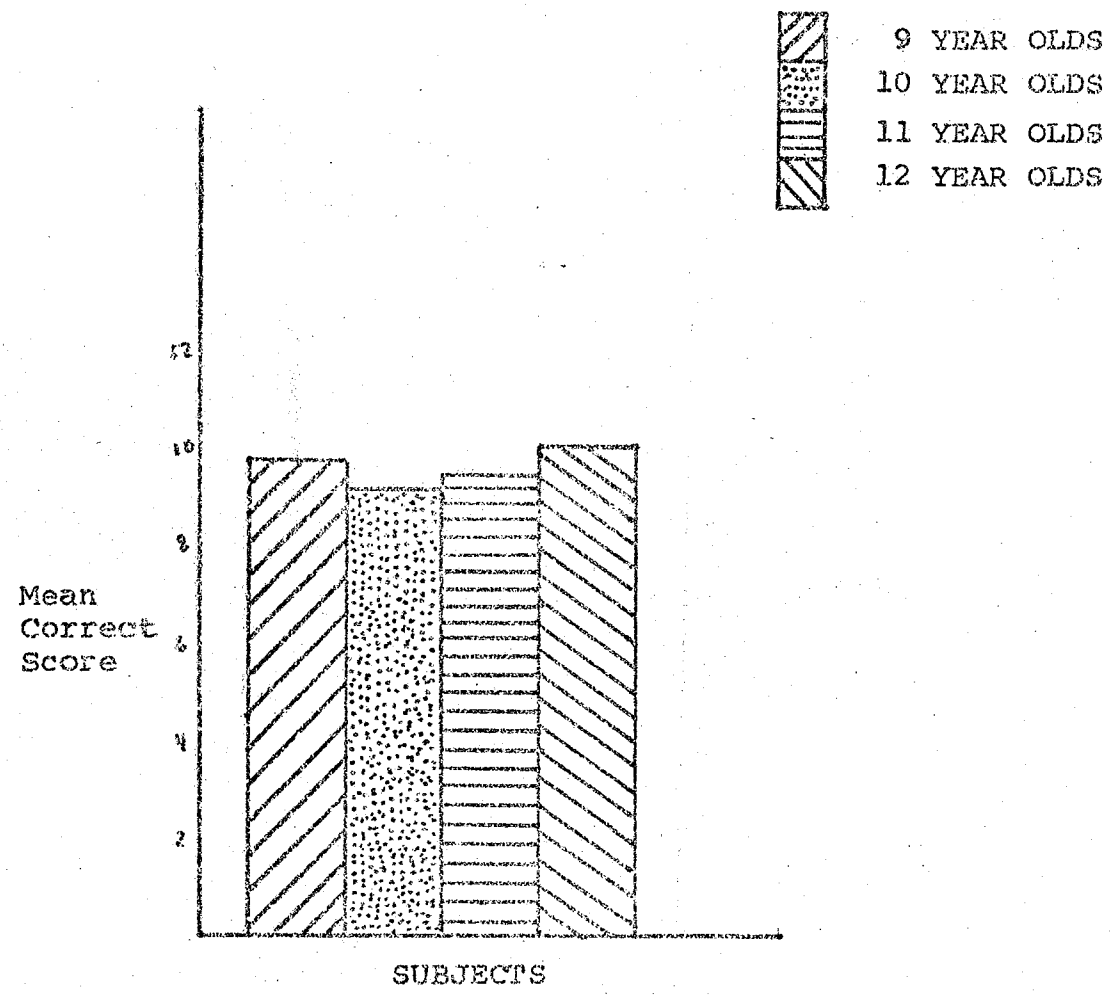
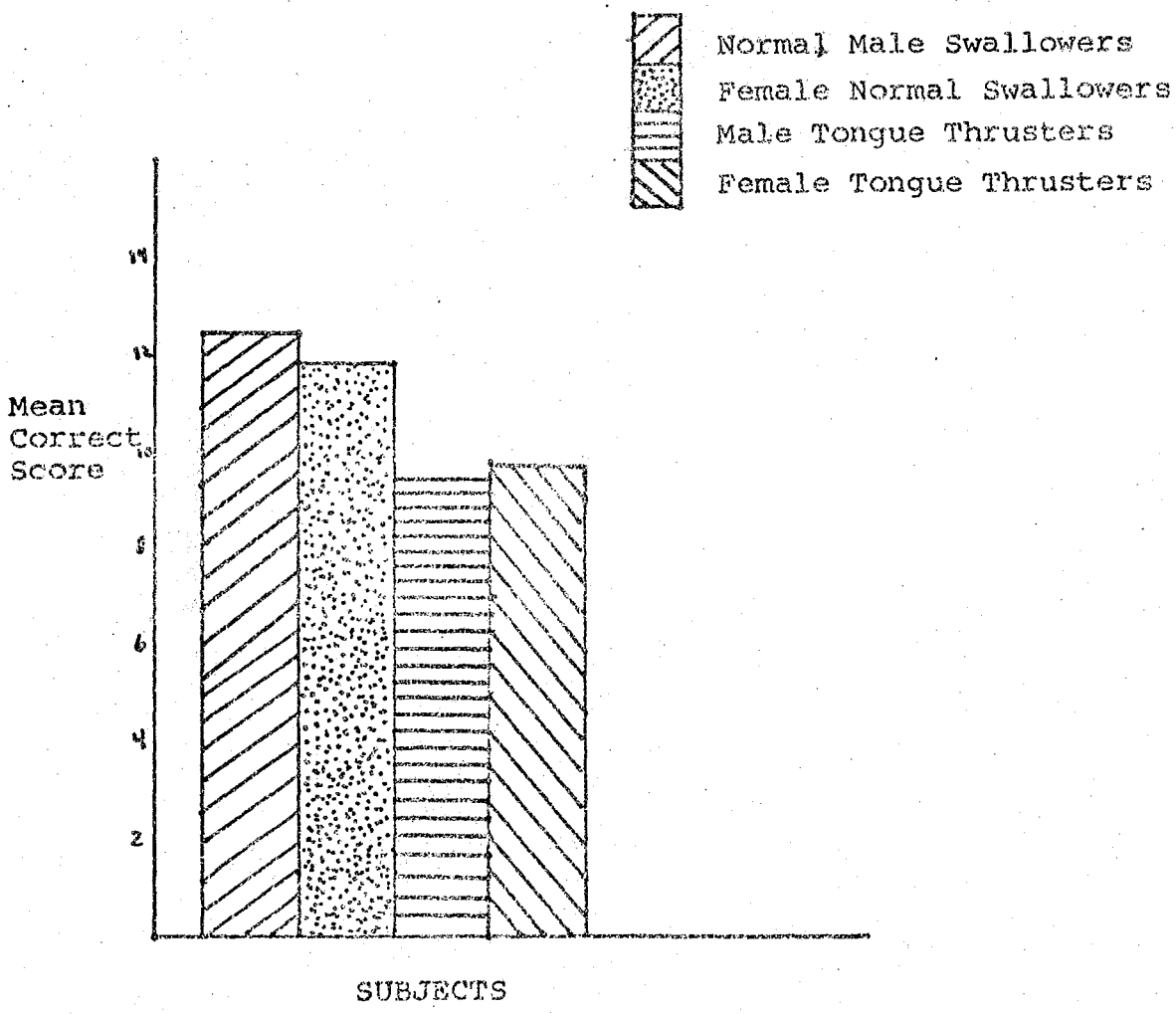


FIGURE V

STEREOGNOSTIC ABILITY OF MALE AND FEMALE NORMALS VERSUS MALE AND FEMALE TONGUE THRUSTERS



swallowers and one of 0.24 (df=28) for the tongue thrusters, was computed. Neither of these t-scores are significant. Therefore, it might be concluded that oral stereognostic ability was not related to sex within groups.

When females were compared between groups, the results were quite different. A mean correct response for the female tongue thrusters was 9.60 and for the female normals 11.87. The computed t-score was 5.49 (df=28) which is significant at the .01 level of confidence. Normal male subjects had a mean correct response of 12.67 compared to 9.47 for the male tongue thrusters. The computed t-score of 13.53 (df=28) was significant at the .001 level of confidence. There is a significant difference in oral stereognostic ability when compared by sex between groups.

These results seem to indicate that the sensory ability of the normals, both males and females, is better than that of the oral stereognostic ability of tongue thrusters. This data correlates well to the results of the first question, indicating that the normal subjects are better able to identify forms than the tongue thrust subjects.

It is also interesting to note than in an examination of the scores for the normal subjects, we find that subjects 26 and 38, both males, attained the highest score while subject 8, a female, attained the lowest score for the normal group on the oral stereognostic task. In examining the scores for the tongue thrust group, we find similar results. Subject 19, a male, attained the highest score while subject

42, a female, attained the lowest score for the tongue thrusters. This could indicate that the male subjects have a better developed sensory ability than the female subjects.

Two-Point Discrimination

To determine if there would be a difference in the two-point discrimination ability between tongue thrusters and normal swallowers, a t-test of the mean correct responses was computed. Figure VI presents the subjects scores.

It can be seen from the graph that the tongue thrusters scores ranged from 1.0 to 2.6 mm while the normals scores ranged from 1.0 to 1.8 mm. This range is similar to that found by other researchers who reported the normal range of 1.0 to 2.0 mm on this task (1).

The mean response for the normal swallowers was 1.20 and for the tongue thrusters 1.53. A t-score of 0.87 (df=58) was computed. The results of this test were not significant.

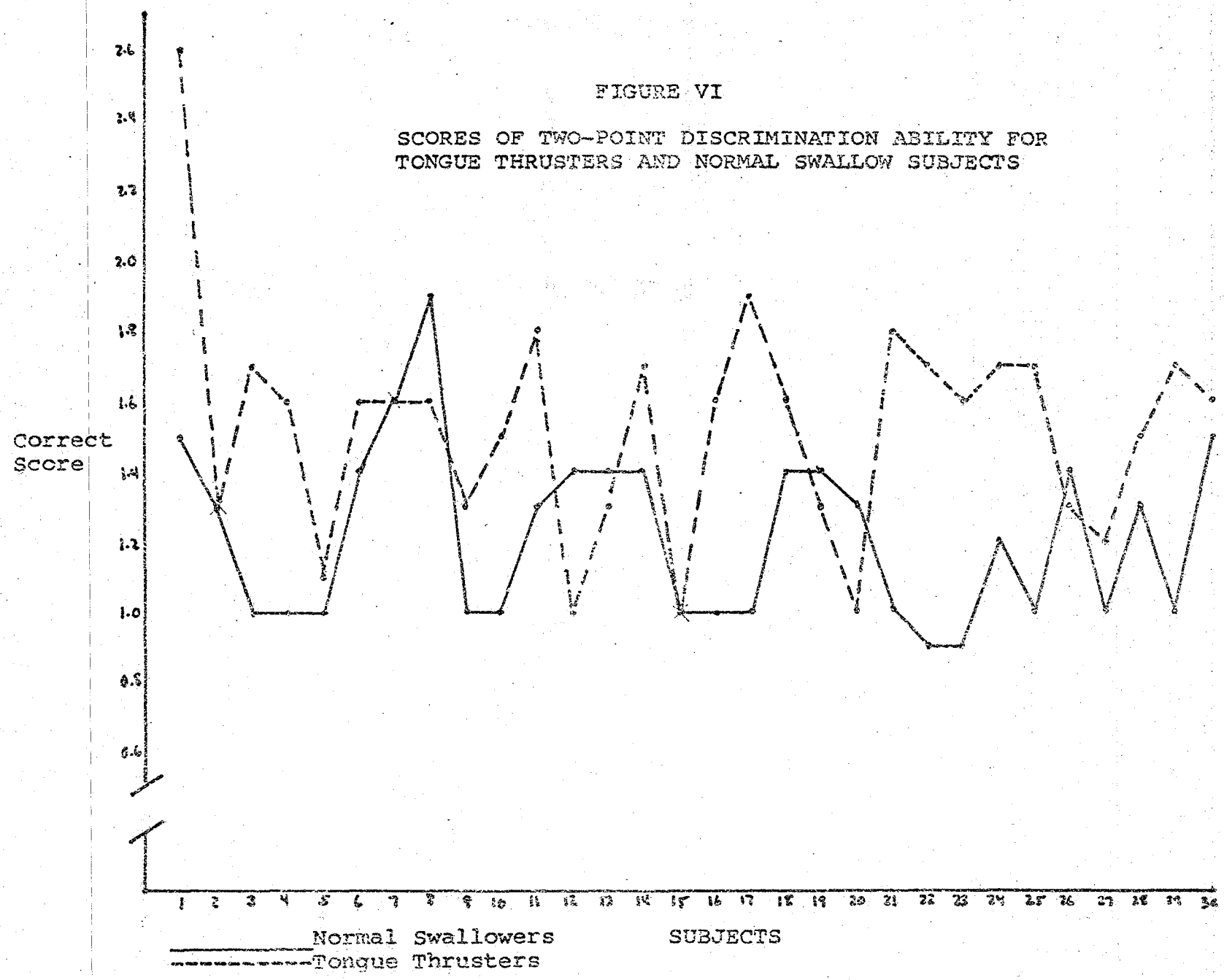
From this it might be concluded that two-point discrimination, which is the "ability to distinguish the minimum separation of two punctiform stimuli that can be discriminated as two separate stimuli" (32, p.310), is apparently not appropriate for examining differences between tongue thrusters and normals while oral stereognosis being a general task might indicate general overall sensory differences.

Two-Point Discrimination and Oral Stereognosis

Question Number 5 examined the relationship between two-point discrimination and oral stereognostic ability of

FIGURE VI

SCORES OF TWO-POINT DISCRIMINATION ABILITY FOR TONGUE THRUSTERS AND NORMAL SWALLOW SUBJECTS



tongue thrusters and normal swallowers.

Spearman Rank Correlations were computed for the normal group and for the tongue thrust group. These resulted in r_s values of 0.147 and -0.998 respectively. This seems to indicate that there is no relationship between the normal swallowers ability to recognize objects orally and to distinguish points on his tongue, while there is a negative relationship for the tongue thrust group which means they did better on the recognition of objects than on the recognition of points on the tongue. It might therefore be concluded that the two measures are measuring entirely different things.

Oral stereognosis measures an individuals ability to discriminate stimuli with a wide range of neural stimulation occuring while two-point discrimination presumable involves only individual neurons. Therefore, an individuals ability to perform on one task may not be related to his ability to perform on the other task.

Two different areas of the tongue are used in these tasks. In a test of oral stereognostic ability, the subject can use the entire tongue, but in two-point discrimination only the tongue tip is utilized. Furthermore, oral stereognosis is an active task involving object manipulation while two-point discrimination is a passive task and no manipulation is involved.

Placement of the Forms

Question Number 6 dealt with the placement of the forms on the tongue. Analysis by a Chi Square distribution

resulted in a X^2 value of 26.66 (df=2). This was significant beyond the .005 level of confidence. This indicated that both groups tended to show the same placement of the forms, with 2.0 cm being the predominant choice for placement within both groups. It might therefore be said, that tongue thrusters and normals in attempting identification of the forms used similar areas of the tongue. This might be due to a possible comfort factor and also due to the tongue tip being used for recognition purposes. This would agree with Ringles study (32) in the tongue tip being the most sensitive area for recognition purposes.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to (1) determine if differences exist between the oral stereognostic ability of normal swallowers and tongue thrusters. (2) To determine if differences exist in oral stereognostic ability between different age levels within the tongue thrust population. (3) To determine if differences exist in the oral stereognostic ability between male and female subjects in the tongue thrust and normal swallow groups. (4) To determine if differences exist in the two-point discrimination task scores between the tongue thrusters and the normal swallow groups. (5) To determine if differences exist between two-point discrimination ability and oral stereognostic ability of tongue thrusters and normal swallowers, and (6) to determine if differences exist in the placement of the oral stereognostic forms between the tongue thrust and normal swallow groups.

The subjects chosen were thirty tongue thrust swallowers and thirty normal swallowers who were matched for age and sex. The age range of the subjects was from nine to twelve years with a mean age of the subjects being 10.3 years.

The subjects were students of the Stockton Unified

School District, California. They had normal speech and were judged as being either a tongue thrusters or a normal swallower based on two-judge agreement.

The test of oral stereognosis that was administered to these sixty subjects was a variation of the Shelton, Arndt and Hetherington test (37). The test items were twenty 1/4 inch plexiglass forms on 5 inch stainless steel handles. The forms were sterilized and placed in the subjects mouth, one at a time, using the testers hand as a shield. The subject was allowed to manipulate each form for 15 seconds. This time factor was selected based on a pilot study as the minimum amount of time necessary for discrimination. After manipulating each form, the subject pointed to a chart in front of him which contained pictures of the forms in their mouth.

The test of two-point discrimination that was administered to the sixty subjects was a variation of the McCall test (26). The subjects tongue was touched with a calipers that had been modified for the test, by the addition of a 3 inch stainless steel rod to the ends of the calipers. The distance between the points were increased and decreased until the subject reported a threshold change from one to two points.

Conclusions

The results, under the conditions imposed by this investigation, revealed the following conclusions:

(1) There was a significant difference in oral ster-

eognostic ability and tongue thrust, as measured. From this it might be concluded that normal subjects have a better sensory perception than tongue thrust subjects on this task. This is in opposition to Silcox (38) who found no differences between his groups.

(2) There was no significant difference in oral stereognostic ability between nine, ten, eleven and twelve year old groups of tongue thrusters and normal swallowers. This might indicate that oral stereognostic ability was not developmentally linked, at least for these age groups. This was in opposition to the findings of Shelton, Arndt and Hetherington (37) who found an increase in score with an increase in age, at least for first grade, third grade and graduate students.

(3) No significant difference was found when oral stereognostic ability was compared for sexes within groups. There was however, a significant difference when compared between groups. It might be concluded that the sensory perception of normal swallowers is better regardless of sex than that demonstrated by tongue thrusters.

(4) Tongue thrusters and normal swallowers did not perform significantly different on the two-point discrimination task. From this it might be concluded that two-point discrimination is not an appropriate task for determining differences between tongue thrusters and normals, while oral stereognosis being a general task might indicate general overall sensory differences.

(5) Both groups tended to show the same placement for the forms, with 2.0 cm being the predominant choice for placement within both groups. Thus tongue thrusters and normals used similar areas of the tongue.

From data accumulated in the study, it might be indicated that due to the lack of sensory acuity evidenced in the tongue thrust population, there exists a deficit in monitoring of tactile-kinesthetic sensation. From this, one might assume that increased tactile stimulation is warranted for tongue thrust therapy.

Recommendations

Several recommendations can be made as a result of the study. A general recommendation is that there is a need for more study of oral stereognosis and its relationship to tongue thrust. Normative data needs to be established in an attempt to understand any deviation which might occur.

It is recommended that further study on the placement of the forms be attempted. Concurrent with this should be a study of placement of the forms and the size of the oral cavity.

Finally, it is recommended that the oral stereognostic forms be classified according to classes of shapes and that the kinds of responses made by normal swallowers and tongue thrusters be compared.

BIBLIOGRAPHY

1. American Speech and Hearing Association. Speech and the Dentofacial Complex: The State of the Art. ASHA Report Number 5, October 1970.

2. Andrews, R.G., "Tongue Thrusting." Journal Southern California State Dental Association, 28, 47-53, 1960.

3. Ardan, T.M., and Kemp, F.H., "A Radiographic Study of the Movements of the Tongue in Swallowing." The Dental Practitioner, 5, 252-263, 1955.

4. Barrett, R.H., "One Approach to Deviant Swallowing." American Journal of Orthodontics, 47, 726-736, October 1961.

5. Bartley, H.S., Principles of Perception. New York: Harper Brothers, 1958.

6. Becker, Barry M., "Etiological Study of Abnormal Swallowing." Unpublished Master's Thesis, The Ohio State University, 1961.

7. Bell, D., and Hale, A., "Observation of Tongue Thrust Swallow in Preschool Children." Journal of Speech and Hearing Disorders, 28, 195-197, 1963.

8. Best, C.H., and Taylor, N.B., The Physiological Basis of Medical Practice, A Textbook of Applied Physiology, 6th edition. Baltimore: Williams and Wilkins Co., 1955.

9. Bosma, J.F. (ed.), A Symposium on Oral Sensation and Perception. Springfield, Illinois: Charles C. Thomas, 1967.

10. Brodie, A., "Consideration of Musculature in Diagnosis, Treatment and Retention." American Journal of Orthodontics, 38, 828-835, 1952.

11. Elcan, P.D., "Abnormal Deglutition: Diagnosis and Treatment." Journal of Dentistry for Children, 30, 256-259, 1963.

12. Fletcher, S.G., Casteel, R.L., and Bradley, D.P., "Tongue Thrust Swallow, Speech Articulation and Age." Journal of Speech and Hearing Disorders, 26, 201-208, 1961.

13. Gibson, J.J., "The Mouth as an Organ for Laying Hold on the Environment." Symposium on Oral Sensation and Perception. J. F. Bosma (ed.). Springfield, Illinois: Charles C. Thomas, 1967.

14. Green, R.I., "Speech Defects: Radiology of Speech Defects." Radiography, 27, 331-338, 1961.

15. Grossman, R.C., "Methods of Determining Oral Tactile Experience." Symposium on Oral Sensation and Perception. J.F.Bosma (ed.). Springfield, Illinois: Charles C. Thomas, 1967.

16. _____ and Hattis, B.C., "Oral Mucosal Sensory Innervation and Sensory Experience." Symposium on Oral Sensation and Perception. J.F.Bosma (ed.). Springfield, Illinois: Charles C. Thomas, 1967.

17. Hahn, E., and Sloan, R.F., "Problems in Tongue Behavior in Children." Journal Southern California State Dental Association, 34, 316-327, July, 1966.

18. Heath, J.R., "Table Demonstration: Some Dental Deformities Caused by Abnormal Orofacial Muscular Behavior Patterns." Dental Magazine and Oral Topics, 72-73, 172-173, 1954/1956.

19. Humphrey, T.J., "Some Correlations Between the Appearance of Human Fetel Reflexes and the Development of the Nervous System." Progress in Brain Research, 4, 93-135, 1964.

20. Jann, H.W., "Tongue Thrusting as a Frequent Unrecognized Cause of Malocclusion and Speech Defects." The New York State Dental Journal, 26, 72-81, 1960.

21. Kydd, W.L., "Maximum Forces Exerted on the Dentition by the Perioral and Lingual Musculature." The Journal of the American Dental Association, 55, 646-651, 1957.

22. Larr, A.L., Tongue Thrust and Speech Correction. San Francisco: Fearon Publishers, 1962.

23. Leech, H.L., "A Clinical Analysis of Orofacial Morphology." Dental Practitioner, 10,57-68, 1958.

24. Lewis, J.A., and Counihan, R., "Tongue Thrust in Infancy." Journal of Speech and Hearing Disorders, 280-282, 1964.

25. McCall, G.N., "The Assessment of Lingual Tactile Sensation and Perception." Journal of Speech and Hearing Disorders, 34, 151-156, 1969.

26. _____. "Study of Certain Somesthetic Sensibilities in a Selected Group of Athetoid and Spastic Quadriplegic Persons." Unpublished Doctoral Dissertation, North-Western University, 1964.

27. McDonald, E.T., and Aungst, L.F., "Studies in Sensori-Motor Function." Symposium on Oral Sensation and Perception. J.F.Bosma (ed.). Springfield, Illinois: Charles C. Thomas, 202-220, 1967.

28. Moser, H., LaGourge, J.R., and Class, L.W., "Studies of Oral Stereognosis in Normal, Blind and Deaf Subjects." Symposium on Oral Sensation and Perception. J.F.Bosma (ed.). Springfield, Illinois: Charles C. Thomas, 244-286, 1967.

29. "Nuk Sauger Preventive Orthodontic Program," Bulletin of Product Research. Denver, Colorado, Rocky Mountain Metal Products Co., 1961.

30. Paine, R.S., "Manual Stereognosis." Symposium on Oral Sensation and Perception. J.F.Bosma (ed.). Springfield, Illinois: Charles C. Thomas, 149-158, 1967.

31. Picard, P.J., "Bottle Feeding as Preventive Orthodontics." The Journal of California State Dental Association and the Nevada State Dental Society, 35, 90-95, 1959.

32. Ringle, R.L., and Ewanowski, S.J., "Oral Region Two-Point Discrimination in Normal and Myopathic Subjects." Second Symposium on Oral Sensation and Perception, J.F.Bosma (ed.). Springfield, Illinois: Charles C. Thomas, 309-322, 1970.

33. _____, Saxman, J.H., and Brooks, A.R., "Oral Perception: Mandibular Kinesthesia." Journal of Speech and Hearing Research, 10, 637-641, 1967.

34. _____, and others, "Some Relations Between Orosensory Discrimination and Articulatory Aspects of Speech Production." Journal of Speech and Hearing Disorders, 35, 3-11, 1970.

35. Rogers, A.P., "Muscle Training and Its Relation to Orthodontia." International Journal of Orthodontia, 4, 555, 1918.

36. Shelton, R.L., Bosma, J.F., and Sheets, B.V., "Tongue, Hyoid, and Larynx Displacement in Swallow and Phonation." Journal of Applied Physiology, 15, 283-288, 1960.

37. _____, Arndt, W.B., and Hetherington, J.J., "Testing Oral Stereognosis." Symposium on Oral Sensation and Perception. J.F.Bosma (ed.). Springfield, Illinois: Charles C. Thomas, 221-243, 1967.

38. Silcox, Bud L., "Oral Stereognosis in Tongue Thrust." Unpublished Doctoral Dissertation, University of Utah, Salt Lake City, Utah, 1969.

39. Sloan, R.F., and others., "The Application of Cephalometrics to Cineflurography." The American Journal of Roentgenology, Radium Therapy and Nuclear Medicine, 92, 977-985, 1964B.

40. Smith, Robert M., "Stereognostic Perceptions Within the Mouths of Children with Speech Problems." Unpublished Master's Thesis, Pennsylvania State University, 1964.

41. Straub, W.J., "Malfunction of the Tongue: Part I." American Journal of Orthodontics, 46, 404-424, 1960.

42. _____. "Malfunction of the Tongue: Part II." American Journal of Orthodontics, 47, 596-617, 1961.

43. _____. "Malfunction of the Tongue: Part III." American Journal of Orthodontics, 48, 486-502, 1962.

44. Truesdell, B., and Truesdell, F.B., "Deglutition: With Special Reference to Normal Function and the Diagnosis, Analysis and Correction of Abnormalities." The Angle Orthodontist, 7, 90-99, 1937.

45. Ward, M.M., and others., "Articulation Variations Associated with Visceral Swallowing and Malocclusions." Journal of Speech and Hearing Disorders, 26, 334-341, 1961.

46. Woodford, L.D., "Oral Stereognosis." Unpublished Master of Science in Orthodontics Thesis, University of Illinois at the Medical Center, Chicago, 1964.

APPENDIX A

Subjects by Group, Number, Age, Sex and Oral Stereognostic Correct Score

NORMAL SWALLOW SUBJECTS

Student Number	Age	Sex	Correct Score
1	9	M	11
2	9	M	11
3	9	M	12
4	9	M	13
9	9	M	13
21	10	M	10
23	10	M	11
26	10	M	16
35	11	M	12
37	11	M	12
38	11	M	16
39	11	M	14
49	12	M	13
52	12	M	14
54	12	M	12
5	9	F	15
6	9	F	14
7	9	F	10
8	9	F	7
10	9	F	12
22	10	F	10
24	10	F	12
25	10	F	13
33	11	F	11
34	11	F	11
36	11	F	11
40	11	F	13
50	12	F	11
51	12	F	15
53	12	F	13

TONGUE THRUST SUBJECTS

Student Number	Age	Sex	Correct Score
11	9	M	10
12	9	M	9
13	9	M	8
14	9	M	10
19	9	M	12
27	10	M	8
29	10	M	9
32	10	M	10
43	11	M	10
45	11	M	10
46	11	M	8
47	11	M	8
55	12	M	9
58	12	M	11
60	12	M	10
15	9	F	9
16	9	F	8
17	9	F	10
18	9	F	11
20	9	F	10
28	10	F	11
30	10	F	8
31	10	F	9
41	11	F	11
42	11	F	6
44	11	F	11
48	11	F	10
56	12	F	8
57	12	F	11
59	12	F	11

APPENDIX B

Subjects by Group, Number, Age, Sex and Two-Point Discrimination Score

NORMAL SWALLOW SUBJECTS

Student Number	Age	Sex	Correct Score
1	9	M	1.5
2	9	M	1.3
3	9	M	1.0
4	9	M	1.0
9	9	M	1.0
21	10	M	1.3
23	10	M	1.4
26	10	M	1.0
35	11	M	1.4
37	11	M	1.0
38	11	M	0.9
39	11	M	0.9
49	12	M	1.0
52	12	M	1.3
54	12	M	1.5
5	9	F	1.0
6	9	F	1.4
7	9	F	1.6
8	9	F	1.9
10	9	F	1.0
22	10	F	1.4
24	10	F	1.4
25	10	F	1.0
33	11	F	1.0
34	11	F	1.4
36	11	F	1.3
40	11	F	1.2
50	12	F	1.4
51	12	F	1.0
53	12	F	1.0

TONGUE THRUST SUBJECTS

Student Number	Age	Sex	Correct Score
11	9	M	2.6
12	9	M	1.3
13	9	M	1.7
14	9	M	1.6
19	9	M	1.3
27	10	M	1.8
29	10	M	1.3
32	10	M	1.6
43	11	M	1.3
45	11	M	1.8
46	11	M	1.7
47	11	M	1.6
55	12	M	1.7
58	12	M	1.5
60	12	M	1.6
15	9	F	1.1
16	9	F	1.6
17	9	F	1.6
18	9	F	1.6
20	9	F	1.5
28	10	F	1.0
30	10	F	1.7
31	10	F	1.0
41	11	F	1.9
42	11	F	1.6
44	11	F	1.0
48	11	F	1.7
56	12	F	1.3
57	12	F	1.2
59	12	F	1.7