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Oral Form Discrimination and Tongue-Thrust Swallowing

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INTRODUCTION

The role of the musculature in the growth and development of the face and dental structures has received the attention of the dental profession for many years. Of particular interest is the part played by the muscles in the creation of certain dental malocclusions. One type of muscle deviation which has been assigned a role in the production of malocclusion is the so-called "tongue-thrust swallow." The purpose of this investigation is to evaluate the possibility that tongue-thrust swallowing may be the result of defects in oral sensory perception.

An area of confusion exists regarding what features distinguish a normal swallowing pattern from an abnormal swallowing pattern. Tongue-thrust swallowing commonly is described as differing from normal swallowing in the following ways: (1) protrusion of the tongue between the teeth during swallowing;³⁸ (2) lack of contraction of the masseter muscles with concomitant failure to close the teeth together during swallowing;^{13,29,38} and (3) facial grimace resulting from contraction of the perioral musculature, especially the mentalis and orbicularis oris muscles.²⁹ Nevertheless, contradictions to the above characteristics are numerous in the literature.^{9,13,18} Thus it seems that significant differences between tongue-thrust swallowers and normal swallowers are slight. There is probably no one subject who fits the stereotyped pattern of a tongue-thrust swallower and, as Blooner⁵ has so aptly stated, "The population of so-called tongue thrusters is probably a heterogeneous one."

The problem of definition of tongue-thrust swallowing is apparent in reports of the incidence of tongue-thrusting. This assessment may vary widely depending upon the criteria used by the investigator to differentiate normal and tongue-thrust swallowing. The percentage of tongue-thrusters reported among elementary school children has varied

from a low of 20 percent¹⁶ to a high of 82 percent.³ In a well controlled study, Fletcher, Casteel and Bradley⁷ have indicated that the incidence of tongue-thrust swallowing decreases with age. Tulley³² has supported this finding by observing that many tongue-thrusts disappeared by age eleven years.

Tongue-thrust swallowing holds great importance for dentists, particularly those involved in orthodontics. Abnormal swallowing has been held responsible for producing several different types of malocclusion, causing many of the relapses found following orthodontic treatment, inhibiting orthodontic tooth movement and warping of the bones in the facial complex. Indeed, the tendency appears to the orthodontist to assume abnormal tongue function as a factor in every adverse occurrence which he cannot otherwise explain.

Despite the fact that it has not been proved and in spite of other equally plausible etiological factors being operative, there are those who feel that tongue-thrust is the cause of open-bite malocclusions.³⁰ Other investigators are more cautious, stating that only some open-bites are the result of tongue-thrusting.^{30,37,38} Still others feel that the open-bite is the cause of the thrust in most instances.¹⁰ The fact that open-bite and tongue-thrust swallowing are associated cannot be disputed even though some tongue-thrusters never develop open-bites²⁹ and open-bite is not always an indication of the "perverted" swallow.²⁸

Several other dental problems have been associated with tongue-thrust swallowing. Investigators have reported: (1) bimaxillary or double protrusions;²⁸ (2) severe Angle Class III malocclusions;^{10,30} (3) constriction of the maxilla with concomitant cross-bites;²⁸ and (4) orthodontic relapse problems.²⁸

Since the equilibrium theory of tooth position was advanced in 1873 by Tomes,³¹ investigators have attempted to test the validity of this concept. Many studies have been conducted with various results being reported, but all agree that in the "normal" individual the tongue exerts more force against the lingual surfaces of the teeth than the lips and buccal musculature exert on the facial surfaces during normal activities over the period of a day. When muscle forces are unbalanced for normal subjects, Winders³⁷ has reported a much greater imbalance for thrusters. One group of investigators has stated that "Forces exerted upon the crown of the tooth by the surrounding soft tissue may be sufficient to cause tooth movement. . . . Differential forces . . . if applied over a considerable period of time can cause important changes in tooth position."³⁵ It is possible, therefore, that the tongue can and does move teeth. However, it is interesting to note that no correlation was found to exist between the axial inclination of maxillary and mandibular incisors and the levels of labial and lingual muscle pressures acting against those teeth.²⁵ Other investigators have shown that lingual pressures are not correlated to palatal width.^{2,38} In addition, Backlund² has found no correlation between the type of swallow and such factors as maxillo-mandibular apical base discrepancy, jaw height, overjet and incisor inclination. Hence, as Lines¹⁷ has stated, "It is impossible to evaluate forces generated by the tongue during deglutition in the proper perspective, since the intensity, duration, and frequency of all forces acting on the dentition are not known."

The etiology of tongue-thrust swallowing has been widely pursued by a number of investigators with the results largely inconclusive. No single trait or group of traits has been found to apply to all or even most tongue-thrust swallowers. Hoffman and Hoffman¹⁴ have noted that tongue thrust may be present in a number of conditions

including cerebral palsy, infantile perseveration, macroglossia, mongolism and cretinism. Other investigators have attributed tongue-thrust swallowing pattern to such varied factors as habits,⁹ physiological adaptation,^{2,10,16,27} maturation defects²⁷ and motor defects.²⁴

A final condition which has been offered as an explanation of tongue-thrust swallowing is the failure of some aspect of oral proprioception or sensory perception.^{5,29} Whitman³⁶ has reported the absence of a gag reflex in abnormal swallows. Kawamura¹⁵ has suggested that a special sensory feed-back system managing tongue tonus and movement probably exists, because of the fine and skillful movements the tongue is capable of performing.

Much of the research concerning sensory perception of the tongue has been done in fields concerned with other than tongue-thrust swallowing; however, these may bear some relation since all involve various functions of the tongue. Disruption of sensory feedback by anesthetization of oral structures has shown articulatory errors to increase significantly.²⁰ Two separate studies have recently reported disordered speech in persons demonstrating marked impairment of oral sensory function.^{6,19} Some cerebral palsied individuals seem to have defective oral sensory functions in addition to their defective oral motor function. When eating, these persons appear to be unaware of the presence of food in their mouths. They also tend to be unaware of the presence of saliva in their mouths, and, hence, tend to drool.²⁰

Storey²⁷ has noted that severing the vagus nerve produces a profound sensory loss with loss of the gag reflex and marked difficulty in swallowing. He further stated that surface anesthetization of the pharynx abolishes the ability to initiate voluntary swallowing. Such observations have prompted McDonald and Aungst²⁰ to speculate that the quality of oral sensory function may be related to the quality of oral motor proficiency. Further, they have stated that "There may well be a sub-group 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 ability."

Measurement of oral sensory perception is a challenge. Many methods for assessing sensory ability have been used including pattern recognition, kinesthetic pattern recognition, two-point discrimination, weight perception, tactile threshold determination, localization, texture discrimination and vibrotactile sensitivity. However, all have been limited in some aspect.

The ability to recognize the form of objects by means of the tactile sensory system provides the neurologist with diagnostic information that contributes to the overall assessment of sensorimotor functioning.⁸ Therefore, a test for oral stereognosis — the ability to recognize the form of objects placed in the mouth (presumably mediated by the oral tactile sensory system) — was developed by the Oral and Pharyngeal Development Section of the National Institute of Dental Research to permit assessment of stereognostic perceptions by oral mucosal surfaces.¹² After a review of studies in oral sensorimotor function, McDonald and Aungst²⁰ concluded that form identification in the mouth is more promising as a measure of oral sensory function than are other tests. Ringel, House, Burk, Dolinsky and Scott²³ have concluded that form identification can be a valuable tool in evaluating the functioning of the articulatory mechanism. It has been hypothesized that information from oral stereognosis studies may provide useful insights

into the sensory mechanisms which guide all oral motor functions.²²

Stereognosis is a complex form of sensory testing for it simultaneously measures several different sensory modalities and their cerebral integration. Wright³⁹ has written that stereognosis involves "... the most elaborate function subserved by the parietal cortex. It necessitates perfect reception of the impulses set up by the stimuli from the object."

In contrast to other measures of oral sensory discrimination, the ability to identify forms in the mouth appears to show a more delayed schedule of development, a significantly lower ultimate level of performance and a less highly developed discriminatory capacity compared to visual and manual perception.³⁴ Arndt and co-workers have found the mean oral stereognosis score for third grade children to be higher than the mean score for first grade children.¹ McDonald and Aungst²⁰ also have found a growth curve to exist with means for their test scores increasing with age until the mid-teens where a leveling of the curve occurred. They have proposed that the leveling of the curve coincided with the completion of growth of the oral and facial structures; whereas Arndt, et al.,¹ have stated that any increase in score after age eight probably reflects improved test taking skills and learning effects. Ringel, et al.,²³ also have noted an improvement in oral form discrimination with age and have stated that this improvement may have two major components: (1) psychological abilities — adults may have more interest in participating, may pay more attention to demands placed on them, and may be more capable of retaining sensory information for subsequent comparisons; and (2) physical abilities — adults may be better at stimulus exploration because of superior motor ability and because increased ratio of oral-cavity size to stimulus-form size favors more adequate manipulation.

Many investigations have been based on oral stereognosis performance, but results of these studies have varied widely depending on methodologies and criteria chosen by the investigators. Some results of these studies have been: (1) more difficulty with oral form recognition for articulatory-defective speakers than for normal speakers;^{21,23,34} (2) high correlation between oral stereognosis scores and chewing ability (0.81), drinking ability (0.75) and articulation ability (0.70);²⁶ (3) correlation between oral motor ability to assemble puzzles and stereognosis scores;¹⁷ (4) significant differences between stereognosis scores for neurologically impaired subjects as opposed to normals;¹¹ and (5) significant differences in oral stereognosis scores between deaf children who have learned to articulate clearly and those who are deficient in articulation skills.³³

Lines¹⁷ has found "Inferior oral sensory perception does not appear to be etiologically related to tongue-thrust swallowing..." His oral stereognosis study involved the use of an answer sheet from which the subject was to select visually a form matching the one that had been placed in his mouth. Best and Taylor⁴ have precluded the use of the visual system in their definition of stereognosis. Therefore, Lines' experiment and others similarly conducted are open to question since they have not measured oral sensory capacity by itself, but rather some aspect of inter-sensory matching.³⁴ The results depend on sensory systems other than those under test and rely upon absolute responses rather than on the subjects' discrimination functions.²¹

A second criticism that has been leveled at the traditional oral stereognosis tests is their failure to distinguish between decisions made at different levels of discrimination activity. Ringel, et al.²³ have observed that "It is not enough to believe that the severity

of an oral discrimination disability increases merely as the total error score increases; identification of the level of discrimination failure is crucial for understanding the sensory defect in question and its potential effect on organized motor activities . . . ”

In answer to the above criticisms, Ringel, Burk and Scott²¹ have introduced a new type of oral stereognosis test which they prefer to call an oral form discrimination test. To eliminate the visual sensory aspect, they use pairs of forms, presenting first one form then another, and require the subject to tell if the forms are the same or different. In assessing the level of discrimination failure, they compare the number of within-class errors (errors made when the pair of forms presented was of the same general shape) to the number of between-class errors (errors made when the pair of forms was of different general shape). This ratio of within-class errors to between-class errors has been shown to be an excellent indicator of the severity of articulation disorders.

The present study will attempt to ascertain if the quality of oral form discrimination of tongue-thrust swallows, as perceived by the use of Ringel's test, is significantly different from values attained by normal swallows. Oral sensory defect in persons with a tongue-thrust swallow should be apparent when test scores of the tongue-thrust group and the norm are compared if, indeed, sensory defects are factors in the etiology of tongue-thrust swallows.

METHODS AND MATERIALS

Subjects

Subjects selected for this investigation were patients either referred for tongue-thrust therapy to the Department of Communication Disorders of St. Louis University or registered in the Department of Orthodontics, Washington University School of Dentistry. All subjects were within the age range of 11 to 13 years inclusive. No effort was made to limit the subjects on the basis of race or sex. Some subjects were wearing various orthodontic appliances and others were not. Of those wearing appliances, none were wearing any form of tongue restraining or habit breaking appliance and none were wearing any appliance which covered the palate. All subjects were free from any apparent mental or neurologic disorder.

The experimental group was composed of 14 individuals, 9 males and 5 females, diagnosed as exhibiting a tongue-thrust swallowing pattern. Subjects were selected for inclusion in the experimental group only when all of the following factors were observed clinically: (1) presence of a type of malocclusion which has been attributed to tongue-thrust swallowing; (2) contraction of the facial muscles, particularly the mentalis and obicularis oris muscles, during swallowing; and (3) inability to swallow and/or protrusion of the tongue during the attempt to swallow while the lower lip was being held between the thumb and forefinger of the investigator.

The control group was composed of 11 individuals, 5 males and 6 females, with no past history of abnormal swallowing. Subjects included in this group exhibited none of the clinically observable factors used in selecting the experimental group. Because age has been shown to affect scores obtained on the test used, both age range and average age of the control group were held as close to those in the experimental group as possible.

Materials and Procedures

The experimental evaluation of each subject was carried out using a test of oral form discrimination as described by Ringle, et al.^{2,3} The task was to discriminate between paired forms placed in the subject's mouth in rapid succession. Throughout the test the subject was blindfolded and not allowed to touch the forms with his hands. The procedure was identical for all subjects.

The test items consisted of ten stimulus forms selected from the forms in the National Institute of Dental Research standard twenty-item oral stereognosis test.* (Figure 1) The dimensions of each item can be estimated from the scale in the figure. All forms had a handle attached perpendicularly to one of the flat surfaces at its center (Figure 1 — side view) for ease of manipulation by the investigator. The forms were made of a translucent, white, heat-resistant, inert plastic.

Figure 1. Forms used for the oral discrimination tasks.

The test session began with a brief interview in which the subject's parents were asked about his medical and dental history. The swallowing pattern of the subject was observed at this time in order to determine the unconscious swallowing pattern. Particular attention was paid to facial muscle contraction and tongue protrusion. The subject was then seated and his occlusion was examined and noted on the history and examination sheet. (Figure 2) Swallowing performance while the lower lip was being held by the investigator was then observed.

Following this brief clinical observation, the subject was handed an example of the test form (a circular form not used in the test but identical to those used in all aspects other than shape) to examine while the following instructions were read:

*Wilks Precision Instrument Co. Inc., 5706 Frederick Ave., Rockville, Maryland 20850.

NAME _____ AGE _____ SEX _____ ANGLE _____

ADDRESS _____ BIRTH DATE ____ / ____ / ____

PHONE _____

HISTORY:

Breast fed _____ Bottle fed _____
Thumb sucking _____ Mouth breathing _____
Tonsils and adenoids _____

SIGNIFICANT MEDICAL OR DENTAL HISTORY:

DESCRIPTION OF MALOCCLUSION:

NOTES:

Figure 2. History and examination sheet.

I have ten different plastic forms similar to the one you are holding. I am going to place these forms in your mouth. One form will be placed in your mouth and you will have five seconds to feel it with your tongue. That form will be removed and a second form will be placed in your mouth. This form may either be the same as the first or different. Again you will have five seconds to feel the form with your tongue. After the second form has been removed from your mouth, I will ask you if they were the same or different. There are 65 pairs of forms to be presented. The entire test will take about 45 minutes during which you will be blindfolded because I do not want you to see which forms are being placed in your mouth. There are no correct or incorrect answers to this test. Only your ability to tell if the forms are the same or different is being tested.

The subject was then asked if he had any questions and, if so, these were answered. At no time was he allowed to see the actual test forms or given any information regarding the proportion of occurrence of same and different pairs of stimuli.

The subject was then blindfolded and the test forms were prepared. Forms were placed in a pan containing five compartments — two forms in each compartment — to facilitate handling of the forms and allow easy retrieval of the particular form desired. The compartments in the pan were filled with a commercial mouthwash* to remove saliva from the forms and to give a similar taste to all forms. When the same form was presented in succession, it was returned to the pan and then placed back in the subject's mouth. This eliminated the possibility that the subject would know that the form was the same merely by taste or by the interval between withdrawal of the form and its subsequent remouthing. With the above arrangement, it was noted that less than five seconds elapsed between the removal of the first form in a pair and the placement of the second form.

Test stimuli were administered to all subjects in the order shown on the data sheet

*Lavoris, Vick Chemical Co., P.O. Box 606, Binghamton, New York 13902.

(Figure 3) beginning at number one and proceeding through number 55. Pairs one through ten were then presented a second time. The stimulus form appearing to the left in the perception column was always presented first in the pair. The subject's responses were noted by placing an "S" for "same" or a "D" for "different" in the response column of the data sheet. When the subject's response differed from the actual relationship of the two forms, the response was defined as an error.

Pair	Perception	Response	Pair	Perception	Response
1.	3, 7	D _____	28.	2, 8	D _____
2.	3, 6	D _____	29.	6, 6	S _____
3.	1, 2	D _____	30.	7, 8	D _____
4.	10, 10	S _____	31.	5, 9	D _____
5.	7, 10	D _____	32.	6, 7	D _____
6.	8, 10	D _____	33.	8, 8	S _____
7.	3, 5	D _____	34.	7, 9	D _____
8.	2, 10	D _____	35.	1, 4	D _____
9.	3, 9	D _____	36.	3, 8	D _____
10.	3, 10	D _____	37.	2, 7	D _____
11.	2, 4	D _____	38.	4, 9	D _____
12.	1, 7	D _____	39.	6, 10	D _____
13.	6, 9	D _____	40.	5, 5	S _____
14.	5, 10	D _____	41.	3, 3	S _____
15.	1, 5	D _____	42.	5, 8	D _____
16.	4, 4	S _____	43.	7, 7	S _____
17.	4, 5	D _____	44.	2, 6	D _____
18.	1, 3	D _____	45.	1, 6	D _____
19.	4, 8	D _____	46.	1, 1	S _____
20.	9, 10	D _____	47.	2, 9	D _____
21.	5, 7	D _____	48.	2, 3	D _____
22.	9, 9	S _____	49.	1, 10	D _____
23.	2, 2	S _____	50.	3, 4	D _____
24.	1, 8	D _____	51.	4, 10	D _____
25.	5, 6	D _____	52.	2, 5	D _____
26.	8, 9	D _____	53.	6, 8	D _____
27.	1, 9	D _____	54.	4, 6	D _____
			55.	4, 7	D _____
B _____ + W1 _____ + W2 _____ = TOTAL ERRORS _____			DISAGREEMENTS _____		

Figure 3. Data Sheet

Scoring

Each test was scored in the following manner:

- (1) All errors made on the first 55 pairs presented were marked and entered as TOTAL ERRORS.
- (2) All instances where the subject's response on the second presentation of pairs one through ten varied from his initial responses on these pairs were marked and entered as DISAGREEMENTS.

The total errors made were then subdivided as follows:

- (B) Errors which involved confusing forms of different general shape (triangular versus rectangular, oval versus viconcave, et cetera) were noted as BETWEEN-CLASS ERRORS.
- (W₁) Errors which involved confusing forms of the same general shape but which were different in some dimension (large rectangle versus small rectangle, large triangle versus small triangle, et cetera) were scored as WITHIN-CLASS₁ ERRORS.
- (W₂) Errors where the forms were the same, but the subject thought they were different, were scored as WITHIN-CLASS₂ ERRORS.

Scoring was then checked by totaling between-class, within-class₁ and within-class₂ errors and noting if this total equaled the total errors. It was decided to exclude from the study any subject who showed more than two "disagreements" as his responses could be considered unreliable.

Statistical Treatment of Data

Mean scores and standard deviations were determined for both groups of subjects for total errors, between-class errors, within-class₁ errors, within-class₂ errors, and total within-class errors. Statistical procedures were then applied to note differences between performances of the experimental and the control groups in each of the several error categories. Analysis was also made of the distribution of the errors between the several error categories.

RESULTS

The mean scores of the experimental (tongue-thrust) group were compared to the mean scores of the control group by use of Student's "t" test. The results of this comparison are shown in Table I. Differences significant at the 0.05 level were found to exist in both total error scores and between-class error scores with the experimental group exhibiting the larger number of errors. Other scores showed no significant differences between the two groups.

Table I. Comparison of control and experimental groups on the basis of mean error scores.

CATEGORY OF ERROR	EXPERIMENTAL GROUP (N=14)		CONTROL GROUP (N=11)		$\bar{X}-\bar{Y}$	't' Value	P Value
	Mean Errors ($\bar{X}$)	S.D.	Mean Errors ($\bar{Y}$)	S.D.			
TOTAL	10.30	6.1	6.18	2.0	4.12	2.14	0.05
BETWEEN-CLASS	5.50	4.8	1.64	2.0	3.86	2.47	0.05
TOTAL WITHIN-CLASS	4.79	1.9	4.55	1.2	0.24	0.36	N.S.
WITHIN-CLASS ₁	3.21	1.7	3.55	1.0	-0.34	0.58	N.S.
WITHIN-CLASS ₂	1.57	1.3	1.0	1.0	0.57	1.18	N.S.

The data presented in Table I is presented graphically in Figure 4. Mean error and standard deviation for both experimental and control groups are shown in each error category along with the representation of the maximum errors possible in that category. By far the greatest percentage of possible errors for both experimental and control groups were made in the within-class₁ category. Items of similar general shape but differing in size were judged to be the same 40 percent of the time by the experimental group and 44 percent of the time by the control group. The greatest difference between experimental and control groups was found in the between-class error category. Here the experimental group judged forms of different general shape to be the same 15 percent of the time while subjects in the control group made similar errors in only 4 percent of the instances.

Figure 4. Experimental and control group errors.

Ringel, et al.²³ have suggested that error distribution is an important factor in the application of this oral form discrimination test. Thus, to study the error distribution, a bar graph with each error category in the same location and showing errors in each category was prepared for both the experimental and the control groups. (Figure 5) While

Figure 5. Distribution of errors for both experimental and control group.

errors in the experimental group show a relatively smooth declining tendency when scanning the bars from left to right, no such tendency exists in the graph of the control group because of the low number of errors in the between-class category.

In order to determine if the experimental and control groups exhibited significant differences in the distribution of errors among the several categories (between-class, within-class₁, within-class₂, and total within class), a chi square analysis was employed. When the error distribution of the normal swallowers was used as the norm, a difference significant beyond the 0.01 level was noted in the proportion of between-class to within-class₁ errors, in the proportion of between-class to total within-class errors, and also in the proportion of between-class to within-class₁ to within-class₂ errors. No such differences were noted between error distributions of tongue-thrust swallowers and normal swallowers when between-class errors were compared to within-class₂ errors or when within-class₁ errors were compared to within-class₂ errors. Table II presents the results of this analysis.

DISTRIBUTION STUDIED	TOTAL ERRORS		X ² Value	P Value
	EXPERIMENTAL	CONTROL		
B	77	18	15.5	0.01
W ₁	45	39		
B	77	18	13.6	0.01
W ₁ +W ₂	67	50		
B	77	18	15.3	0.01
W ₁	45	39		
W ₂	22	11		
B	77	18	2.89	N.S.
W ₂	22	11		
W ₁	45	39	1.66	N.S.
W ₂	22	11		

Table II. Chi square analysis of distribution of errors.

DISCUSSION

This study was undertaken to evaluate one aspect of oral sensory perception — oral form discrimination — in persons who have a tongue-thrust swallowing pattern. Results of this study indicated that there may be a heretofore undetected oral sensory dysfunction in the tongue-thruster. This dysfunction has not been demonstrated previously because the tests used by other investigators have not been capable of evaluating this particular aspect of oral sensory perception.

Comparison of the mean error scores for the tongue-thrust group with those of the normal swallows showed that the thrusters made more total errors ($P = 0.05$) and more between-class errors ($P = 0.05$) than did the normal subjects. (Table I) In the other error categories, there was no significant difference between the two groups. Hence, the fact that total errors were higher for the experimental (tongue-thrust) group is almost entirely (93 percent) a reflection of the increased number of between-class errors made by that group.

Care must be exercised in interpreting differences in the mean scores reported here, since they are significant only to the 0.05 level of confidence. The sample size was small. To base conclusions on test results from only 25 subjects is impossible unless the data is so definitive that it statistically exceeds the 0.01 level of confidence.

The original data shows that only four subjects in the tongue-thrust group made more total errors than the highest number of errors made by any subject in the control group. The possibility exists that these individuals either did not understand the directions or did not make an effort while taking the test. Also noteworthy is the fact that five subjects classified as tongue-thrusters made fewer total errors than the average total errors for the control group. It thus becomes obvious that clinical application of the norms for total errors cannot be used as a criterion for diagnosing tongue-thrust swallowing. A larger study might alleviate some of the aforementioned problems.

By similar logic, the average number of errors made in the between-class category can not be held as diagnostic. Seven of the fourteen subjects in the tongue-thrust group made between-class error scores falling within one standard deviation of the mean error score for the control group. However, if only one subject (S.S.) were eliminated in computing the statistics for the control group, then only three tongue-thrusters would fall within one standard deviation of the control group's mean between-class error score. A more exhaustive study would almost certainly prove the mean error score on between-class errors to be highly significant.

Whereas the mean total error score and the mean between-class error score may or may not be important in distinguishing tongue-thrust swallowers from normal swallowers, the distribution of the errors appears to be highly important. Tongue-thrusters (experimental group) make proportionately more errors in the between-class category than do normal swallowers. (Table II) This difference in error distribution as determined by the chi square analysis is significant beyond the 0.01 level of confidence when between-class errors are compared with within-class₁ errors, with total within-class errors, or with both within-class₁ errors and within-class₂ errors.

While all forms used in the test varied both in size and shape, within-class decisions were defined such that they were primarily based upon size comparison, whereas between-class decisions were defined to be based primarily upon shape. It might be said that the normal swallower finds it far easier to distinguish between objects when they vary in shape than when size is the primary determinant. This appears to be the case for tongue-thrusters also, but to a lesser degree. While they make a smaller percentage of the total possible errors in the between-class category than in the total within-class category, this difference is not as pronounced as that found in normal swallowers.

Again clinical application of the values established could be questionable since four individuals in the experimental group would be classified as normal and one subject in the control group would be labeled a tongue-thruster by these standards. Although every effort was made to apply a strict definition of tongue-thrusting in the selection of the experimental group, it is possible that a more rigorous definition of tongue-thrust swallowing than that used in this study might alleviate this problem. However, care must be taken in formulating such a definition in order that clinical usefulness is not compromised by the scarcity of persons fitting the definition.

It is interesting to note that Ringel, et al.²³ obtained results quite similar to those in this study when studying persons with defective articulation. None of the subjects in this study were considered to have speech problems. Certainly, none spoke in a manner which was objectionable to the untrained ear. Whether the sensory-discrimination defect in persons with poor articulation is similar to that in persons with tongue-thrust swallowing patterns is open to question. Similarity of test scores cannot be construed as establishing a true relationship since the defects could occur at any point along the sensory-motor chain which is responsible for discrimination. The possibility does exist, however, that poor articulation and tongue-thrust swallowing are different manifestations of the same basic problem since both involve abnormal tongue placement.

One may ask whether sensory-discrimination abilities and tongue activity during swallowing exist in a cause-effect relationship. Since anatomic maturation and motor development are said to be important in establishing both form discrimination ability and a normal swallowing pattern, the cause-effect relationship is plausible. However, both

discrimination and swallowing behavior could be related to more general factors such as neurologic maturation and/or perceptual skill development.

If the cause-effect hypothesis is accepted, then sensory disturbances must be considered an etiologic entity for abnormal swallowing and therapy should consist of tongue training to compensate for the disturbed orosensory channels. Merely restricting the tongue by mechanical devices would have little beneficial effect. If, in fact, sensory discrimination ability and swallowing behavior are related to more general factors, then no therapy in use today would be entirely effective.

Evidence gathered in this study suggests that there is a difference between normal swallowers and tongue-thrust swallowers in oral form discrimination ability. This evidence may or may not be of importance from an applied point of view. Nevertheless, any theorizing about the process of swallowing should take into account the sensory mechanisms underlying the swallowing process.

SUMMARY AND CONCLUSIONS

The purpose of this investigation was to determine if oral form discrimination ability in subjects with a tongue-thrust swallowing pattern is different from that in subjects with a normal swallowing pattern.

Subjects were selected for the experimental (tongue-thrust) group only if they demonstrated all of the following characteristics: (1) a type of malocclusion attributable to tongue-thrust swallowing; (2) contraction of the facial muscles during swallowing; and (3) inability to swallow and/or protrusion of the tongue during the attempt to swallow while the lower lip was held by the investigator. Subjects selected for the control group demonstrated none of the above characteristics. All subjects were age 11 years through 13 years.

The test of oral form discrimination required the blindfolded subject to determine if paired geometric forms placed individually in his mouth were the same or different. Scoring was based on the number of errors made on the 55 pairs presented. Errors were categorized to indicate the type of discrimination being tested when the error was committed.

Statistical procedures were applied to note differences between the experimental and control groups in both mean error score and error distribution.

The following conclusions were derived from this investigation:

1. Total errors and errors made when the forms were of different general shape tend to be significantly greater ($P = 0.05$) in the tongue-thrust group than in the control group.
2. Error distribution for tongue-thrust swallowers tends to be significantly different ($P = 0.01$) from that found for normal swallowers. In tongue-thrusters, errors made where forms were of different general shape account for a much greater percentage of the total errors.
3. Oral form discrimination ability appears to be impaired in the tongue-thrust swallower.
4. Oral form discrimination ability in tongue-thrust swallowers is sufficiently different from that in normal swallowers to warrant further study.

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