Research Article

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Elnita Ostrom Stanley (*Stephen F. Austin University*)

Dale J. Lundeen (*Northwestern University*)

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Tongue Thrust in Breast-Fed and Bottle-Fed School Children: A Cross-Cultural Investigation

by

Elnita Ostrom Stanley, Ed. D.,
Professor, Department of Counseling
and Special Educational Programs
Stephen F. Austin State University
Nacogdoches, Texas

and

Dale J. Lundeen, Ph. D.,
Professor of
Speech/Language Pathology
University of Northern Colorado
Greeley, Colorado

Abstract

To investigate the frequency of tongue-thrust swallowing in a breast-fed population and in a bottle-fed population, 110 Navajo and 149 non-Indian children within the 7- to 13-year age range were individually tested. Frequency of tongue-thrust swallowing was 65% in the breast-fed (Navajo) sample and 81% in the predominantly bottle-fed (non-Indian) sample. This difference was statistically significant.

On the basis of a parent questionnaire, two subgroups were formed from the predominantly bottle-fed (non-Indian) sample. They were composed of a) 59 totally bottle-fed non-Indian children and b) 31 non-Indian children who had been breast-fed four months or longer. No statistical difference in terms of tongue-thrust swallowing was found between the two subgroups. However, a statistical difference was found when each of the two subgroups was compared separately with the breast-fed Indian sample. Statistically more tongue-thrust swallowing existed in a totally bottle-fed group and in a group which had been breast-fed from four to twelve months than in the Navajo group which had been breast-fed from 18 to 36 months. The relationship between method of feeding in infancy and undue prolongation of tongue-thrust swallowing clearly merits further investigation.

The data for this study were gathered in 1972; the results were reanalyzed statistically in 1979. The findings have heretofore been unpublished.

Investigation of Manner of Infant Feeding and Tongue-Thrust Swallowing

Tongue thrusting has been shown to be an infantile swallowing reflex which is normally present at birth (Lewis and Counihan, 1965). As the baby develops, the tongue-protrusion type of swallowing reflex is usually extinguished and a more mature swallowing pattern emerges (Mysak, 1968). This sequence of events fails to occur in many individuals, however, and tongue-thrust swallowing is retained long after the infantile reflexive period.

A number of explanations have been offered concerning the tongue-thrust behavior which is seen in later life. Moyers (1969 and 1971) identified two kinds of later tongue thrust: 1) a retained unconditioned, congenital reflex, such as the infantile tongue-thrust swallow or the extensor-thrust of the cerebral-palsied child and 2) a conditioned reflex such as a learned "tooth-apart" swallow due to an inflamed pharynx, etc. Among other explanations are the possibilities that swallow patterns change as a function of growth and development (Subtelny et al., 1964) and the tongue thrust may be seen during periods in which the tongue is disproportionately large for its environment (Hoffman and Hoffman, 1965). There may be a series of transitional stages between infantile and adult swallowing behavior. For reasons as yet unknown, the swallow pattern may be arrested at a less-than-mature level (Proffit and Norton, 1970).

A relationship between improper bottle feeding and tongue-thrust

swallowing has long been predicated (Larr, 1962; Picard, 1959; Straub, 1960), although in recent years the importance of the relationship has been doubted (Hanson and Cohen, 1973; Barrett and Hanson, 1978; Cole and Cole, 1979). In the sixties, the general consensus of opinion held that tongue thrust is produced by a lack of physiologically normal feeding movements during bottle feeding (Carrell, 1968). Straub (1960) asserted that the conventional bottle nipple is too long and reaches partially into the baby's throat or soft-tissue area. The baby usually has to handle a free flow of milk from a large hole in the nipple. To prevent strangling, the tongue is thrust forward against the nipple. The front of the tongue then extends over the lower gum pads forming a tight seal with the lower lip. The tongue-thrust swallow was said to be maintained through the necessity of managing the rapid flow of milk (Larr, 1962; Picard, 1959).

The retention of tongue thrust beyond the infantile reflexive period has been shown to have profound implications. Muscle differentiation and localized actions cannot appear until primitive reflexes are partially or totally suppressed (Humphrey, 1971; Crickmay, 1966). The retention of the tongue-thrust reflex may, therefore, be associated with a lack of facial muscle differentiation and of fine motor movement. Inadequate lingual coordination and movement may interfere with the normal saliva-cleansing action of the tongue (Weiss, 1969; Nuk Sauger, 1970), and, indeed, tongue thrusters have been found to have

nearly twice as many carious teeth as non-thrusters (Lundeen et al., 1974). Tongue pressures associated with thrust are strong and place unusual stress on the facial structures, which may result in a severely contracted maxilla, protruding upper teeth, and an open-bite relationship (Straub, 1960). Tongue thrust may also be responsible for the high incidence of orthodontic relapse (Howland, 1979) and many persistent articulatory disorders (Weiss, 1969). Hence, orthodontic treatment may be given concurrently with oral myofunctional therapy (Howland, 1979).

Purpose of the Study

The purpose of this study was to test the theory that tongue thrusting is associated with bottle feeding. Other possibly related variables were observed, but this report deals only with tongue thrust and infant feeding and sucking habits. Most previous investigations of the bottle-feeding theory have been in populations from orthodontic (Straub, 1960), upper-respiratory (Leech, 1958), and other clinical situations (Garliner, 1971), or in populations of school children which included a relatively small number of totally breast-fed subjects (Ward et al., 1961; Lay, 1964; Hanson and Cohen, 1973). At least one reportedly well-done study was not submitted to statistical analysis (Najera, cited in Barrett and Hanson, 1978).

To determine the possible influence of breast feeding, this study investigated swallowing behavior in two samples of school children, one of which had been breast-fed in infancy, and the other of which had predominantly been bottle-fed. Neither the breast-fed nor the bottle-fed samples were selected from a clinical population.

The Samples

Sampling procedure. The breast-fed sample was composed of Navajo children from the Bureau of Indian Affairs School in Crownpoint, New Mexico. Ward et al. (1961) proposed a need for investigating tongue-thrust behavior in "... children in other cultures where infantile and early feeding is dramatically different from ours ..." (p. 339). The large sample of Navajo children selected for this study exhibited the qualifications of "a different culture" and a history and

tradition of breast-feeding during infancy. The predominantly bottle-fed sample was composed of non-Indian children from the Laboratory School at the University of Northern Colorado in Greeley, Colorado.

A modification of stratified random sampling procedure was used. A number from a table of random numbers (Glass and Stanley, 1970) was assigned to each child enrolled in grades one through eight. Ten children of each sex were selected from each of the eight grade levels in both schools, yielding a total of 160 subjects from each school. Ages ranged from 6 to 17 years for the Navajo children and from 6 to 14 years for the non-Indian children. To equalize the age ranges within both groups, upper and lower age-range subjects were dropped, and only those within the 7- to 13-year range were considered. The final samples included 110 breast-fed Navajo children and 149 predominantly bottle-fed non-Indian children.

Navajo breast-fed sample. Medical records confirmed that 71 of the Navajo children had been born in the Public Health Service (P.H.S.) Hospital in Crownpoint. Of these, 93% had been breast-fed, and 7% had been given formula at birth for medical reasons. Hospital personnel stated that these percentages probably hold true for this entire population of children and that, due to scarce refrigeration, those who had been given formula probably resumed breast-feeding following discharge from the hospital. For this reason, the Navajo sample is considered to be almost entirely breast-fed and will be called "breast-fed" in this study. P.H.S. nurses in Crownpoint reported age of weaning for these children as a range from 18 to 36 months; the prolonged nursing was due partly to tradition and also to a need for sanitary nutrition in the presence of a severe drought (Young, 1967).

According to the P.H.S. nurses, much of the liquid diet in early childhood consisted of soda pop, another source of sterilized liquid. Rather than pacifiers, the infants usually chewed on mutton bones during the teething period. Kluckhohn and Leighton (1962) described changes which had occurred in the Navajo diet over the years and stated that strictly

native dishes were usually reserved for ceremonial occasions. Coffee or tea was usually served at every meal, even to small children. Staples consisted of wheat bread and of meat, usually mutton or goat flesh, which were not always plentiful. To compensate for a deficiency in green vegetables, all non-boney portions of an animal, including the internal organs, were eaten.

Non-Indian predominantly bottle-fed sample. The Laboratory School in Greeley, Colorado, from which the non-Indian predominantly bottle-fed sample was drawn, admits children on a "first-come, first served" basis; however, the sexes are equated, and children come from diverse socioeconomic backgrounds. All major minorities are represented. Some Chicano, but no black, children were drawn in this random sample.

A questionnaire was sent to the parents of the 160 Laboratory School children. There were 127 returns, with 122 representing the 7- to 13-year age range and yielding the following information concerning method of infant feeding in the non-Indian children:

Totally bottle-fed: N=59
Bottle-fed with from 1 week to
3 months of breast-feeding: N=32

Combined N=91 (75%)
Breast-fed (with supplemental
bottle feedings) from 4 to 12
months: N=28
Totally breast-fed for a
duration of 6 to 12 months: N= 3

Combined N=31 (25%)

For the main problem of this study, the non-Indian children were considered altogether as a "predominantly bottle-fed sample." In subsequent problems, the totally bottle-fed children and the children who had been breast-fed four months or longer were considered as separate groups.

Definition of Terms

Breast-fed sample. For this study, the term "breast-fed sample" refers to a group of Indian children, of whom probably more than 95% were breast-fed until they were from 18 to 36 months of age.

Predominantly bottle-fed sample. The term "predominantly bottle-fed sample" refers to a group of non-Indian

children, of whom approximately 75% were either totally bottle-fed in infancy or were breast-fed with supplemental bottle-feeding for three or less months and then bottle-fed.

Non-Indian bottle-fed subgroup. The term "non-Indian bottle-fed subgroup" refers to 59 children from the predominantly bottle-fed sample, who were known to have been totally bottle-fed in infancy.

Non-Indian breast-fed subgroup. The "non-Indian breast-fed subgroup" denotes 31 children from the predominantly bottle-fed sample who were breast-fed at least two-thirds of their daily milk feedings until they were from four to twelve months of age. This definition was based on an earlier investigation of tongue thrust by Ward et al. (1961), who found that 46, or 12.8%, of 358 primary-grade school children of "average socio-economic background" (p. 335), had been breast-fed. For those children, breast-feeding had usually been supplemented by bottle-feeding and had ceased by three months in most instances.

Assumptions

In the process of the study, the following assumptions were made:

1) The modification of stratified random sampling procedure was a sufficient control for within-group differences due to possible variations in nutrition, child-rearing practices, and the emotional, physical, and intellectual make-up of the subjects. These variables are difficult to control when comparing groups from different cultures, placing a greater burden on the interpretation of intergroup results.

2) There was no genetic difference which would predispose either of the samples toward a certain manner of swallowing.

Procedure

Tongue-thrust examination. All observations were made by one examiner. Each subject was told that the examiner wished to "watch the way you swallow" (Fletcher et al., 1961, p. 203) and was asked to swallow five times. Where necessary, the subject was requested to chew "... in order to stimulate salivary action as an aid to swallowing and as a means of dissipating tension in the orofacial area" (Ronson, 1965, p. 319). The

examiner's thumb was placed over the child's lower lip, and the forefinger was extended to palpate the masseter. As the child swallowed, the examiner pressed the lower-lip down with her thumb.

Hanson and Cohen (1973) evaluated tongue thrust

... according to two definitions: 1) a liberal definition (the tongue contacts the lingual surface of the anterior teeth) and 2) a conservative definition (the tongue protrudes between the upper and lower teeth) (p. 73).

The tongue-thrust criteria for the study described in this paper resembled those of Hanson and Cohen's liberal definition. A judgment of tongue-thrust swallow was made 1) if during any phase of the swallow, including the preparatory swallow phase, the tongue was observed to be pressing against the teeth or protruding through the teeth, either anteriorly or laterally; or 2) if the labial seal could not be broken, even with digital pressure. The subject was judged a tongue thruster if three out of five swallows were tongue-thrust swallows.

Reliability. To determine investigator reliability, six per cent of the subjects, 10 from each sample, were re-examined by another speech pathologist. The results revealed 100% examiner agreement on the judgment of tongue-thrust swallowing.

Treatment of the data. The main problem in this research was to determine if a difference existed in the prevalence of tongue-thrust swallowing in two independent samples: a sample which had been breast-fed from 18 to 36 months and a predominantly bottle-fed sample. Later, on the basis of information from a parent questionnaire, two subgroups were formed from portions of the predominantly bottle-fed non-Indian sample, as follows: a) non-Indian totally bottle-fed subjects, $N=59$, and b) non-Indian children who had been breast-fed from 4 to 12 months, $N=31$. These two non-Indian subgroups were compared with each other (Subproblem A), and each subgroup was compared in separate statistical tests with the breast-fed Navajo sample (Subproblems B and C) in terms of the prevalence of tongue-thrust swallowing.

Statistical operation. In each

comparison, the data were submitted to a test for the significance of the difference between two independent proportions (Ferguson, 1966). The observed difference between the proportions was divided by the estimate of the standard error of the difference, and a z score was obtained. Each value of z was interpreted as a deviate of the unit normal curve. As is usual in two-tailed tests, values of 1.96 and 2.58 were required for significance at the 5 and 1 per cent levels of confidence, respectively.

Results

The results of the statistical tests for all the problems are shown in Table One.

Main problem: Is there a difference in a Navajo breast-fed sample, duration of 18-36 months, and in a non-Indian predominantly bottle-fed sample in terms of the prevalence of tongue-thrust swallowing? As shown in Table One, a z score of 2.87 was obtained and was found to be significant at the .01 level of confidence. Accordingly, the null hypothesis that there is no difference between a breast-fed group and a predominantly bottle-fed group in the prevalence of tongue thrusting was rejected. These data support the interpretation that the prevalence of tongue-thrust swallowing was greater in a predominantly bottle-fed population than in a breast-fed population (duration 18 to 36 months).

The duration of breast-feeding from 18 to 36 months takes on greater import in light of the following subproblems.

Subproblem A: Is there a difference in the prevalence of tongue thrust between a non-Indian breast-fed subgroup, duration of 4-12 months, and a non-Indian totally bottle-fed subgroup? The 31 non-Indian children who had been breast-fed for a duration of from 4 to 12 months were compared with the 59 totally bottle-fed non-Indian children in terms of the prevalence of tongue thrust. In this comparison, 84% of the breast-fed children were tongue thrusters and 93% of the bottle-fed children were tongue thrusters. The z value of 1.40 was non-significant, indicating that the difference between the two groups could have been due to chance. Therefore, breast-feeding for a

duration of from four to twelve months would seem to have no appreciable beneficial effect on the development of a mature swallowing pattern.

TABLE ONE

COMPARISONS OF PREVALENCE OF TONGUE THRUST IN BREAST-FED AND BOTTLE-FED CHILDREN

AGES 7 TO 13 YEARS

Samples being compared	No. of tongue thrusters	Proportion of tongue thrusters	$s_{p_1p_2}^*$	z^{**}	Probability level for two-tailed test
MAIN PROBLEM					
Breast-fed Navajo sample, N = 110	72	.65	.0548	2.87	.004 (significant difference)
Predominantly bottle-fed non-Indian sample, N = 149	121	.81			
SUBPROBLEM A					
Breast-fed non-Indian subgroup, N = 31	26	.84	.0666	1.40	.16 (non-significant)
Bottle-fed non-Indian subgroup, N = 59	55	.93			
SUBPROBLEM B					
Breast-fed Navajo sample, N = 110	72	.65	.0697	3.98	.0026 (significant difference)
Bottle-fed non-Indian subgroup, N = 59	55	.93			
SUBPROBLEM C					
Breast-fed Navajo sample, N = 110	72	.65	.0937	1.97	.05 (significant difference)
Breast-fed non-Indian subgroup, N = 31	26	.84			

*Standard error of the difference between two proportions based on independent samples.

**A z value of 1.96 is required for significance at the .05 level, and a z value of 2.58 is required for significance at the .01 level of confidence.

Subproblem B: Is there a difference in the prevalence of tongue thrust between an Indian breast-fed sample, duration 18-36 months, and a non-Indian totally bottle-fed subgroup? The 110 Navajo children who had been breast-fed for a duration of 18 to 36 months were compared with the 59 totally bottle-fed non-Indian subjects. Tongue thrusting was found in 65% of the breast-fed children and 93% of the bottle-fed children. The obtained z value of 3.98 was highly significant at the .01 level of confidence; there were significantly fewer tongue thrusters in the group which had been breast-fed for a duration of from 18 to 36 months.

Subproblem C: Is there a difference in the prevalence of tongue-thrust swallowing between two breast-fed groups, an Indian sample, breast-fed a duration of 18-36 months, and a non-Indian sample, breast-fed a duration of 4-12 months? The 110 Navajo children who had been breast-fed until they were from 18 to 36 months of age were compared with the 31 non-Indian children who had been breast-fed until they were from 4 to 12 months of age in terms of the prevalence of tongue-thrust swallowing. Table One shows that 65% tongue thrusting was found in the breast-fed 18-36 months Indian sample and that 84% tongue thrusting was found in the breast-fed 4-12 months non-Indian subgroup. A z value of 1.97 was obtained. The difference was found to be statistically significant at the .05 level of confidence. There were significantly fewer tongue-thrusting children in the group which had been breast-fed from 18 to 36 months; so it is possible that the longer term of breast-feeding contributed to the difference.

Age trends in maturation of swallowing behavior. Figure 1 gives the percentage of tongue thrust at each age level for the two large samples of the main problem, the predominantly bottle-fed non-Indian sample and the long-term breast-fed Navajo sample. As is shown, in each sample at each age level, tongue thrust was the prevalent method of swallowing with the exception of the eight-year-old Navajo group, in which tongue thrust was seen in 50% of the subjects.

The tongue-thrust frequency at the various age levels resulted in a similarly fluctuating line for each of the

Bottle-Fed Group (N = 149)

n = 26 18 20 19 17 24 25

Breast-Fed Group (N = 110)

n = 20 12 19 9 7 18 26

two groups. Both samples show more tongue thrusting at age 7, less at age 8, more at age 9, less at age 10, more at age 11, and less at age 12. The only deviation from the pattern occurred at age 13 where there was a decrease in tongue thrust among the Navajos and an increase among the non-Indian children. Even though the lines fluctuate, there is a gradual overall reduction in tongue thrust from ages seven through 13.

The questionnaire study concerning non-Indian children. Study of the 117 complete returns from parents of the non-Indian children revealed that the mean duration of breast-feeding was 2.2 months, and the mean duration of bottle-feeding was 11.5 months. The mean age at introduction of solid foods was 7.8 weeks. The mean duration for thumb and/or finger sucking was 24.4 months, but the standard deviation was 66.7 months. The mean duration for pacifier sucking was 1.9 months, and the standard deviation was 5.6. The mean duration for blanket or other cloth sucking was .1 month with a standard deviation of .8; the mean duration of lip or tongue sucking was 2.2 months with a standard deviation of 10. Dental recommendations for orthodontic treatment had been made for 20% of the subjects.

The above, together with two other variables (i.e., mean duration of all the sucking habits and whether or not the individual had been breast-fed during his first four months of life) were analyzed in a multiple-linear regression model to determine if significant relationships existed with tongue-thrust swallowing. The entire group of variables accounted for only 8.33% of the variance, and the entire model proved statistically insignificant. Each variable was omitted from the full model and submitted to an F test, but no statistical significance was found. Not one of the variables tested could serve as a predictor of tongue-thrust swallowing in the non-Indian children.

DISCUSSION

While it cannot be stated with certainty that the longer-term of breast-feeding made the difference in these results, the findings do raise the possibility that long-term breast-feeding may be beneficial in the development of mature swallowing behavior. At the very least, there must be some feature or features in the infant-feeding or child-rearing practices of the Navajos that contribute to more mature swallowing and that may be adopted by the non-Indian culture as an aid to the oro-facial muscular development of its children.

Controversy Concerning Bottle-Feeding Theory

Much controversy exists concerning the cause of persistent tongue-thrust swallowing (Weinberg, 1970; Barrett and Hanson, 1978) and, in spite of thirty years of intensive study, the answers are still elusive. Straub (1960), Picard (1959), Garliner (1971), and others have attributed either the cause or the undue persistence of tongue thrust to improper feeding methods in infancy. However, in the last decade the relationship between bottle-feeding and tongue thrust has been seriously questioned by many writers (Barrett and Hanson, 1978; Cole and Cole, 1979; etc.).

Many etiological investigations have found no significant relationship between manner of feeding and tongue thrust (Leech, 1958; Subtelny, 1965; Ward et. al., 1961; Hanson and Cohen, 1973). The portion of this study which involved only the non-Indian groups (Subproblem A) supports those results; no significant difference in swallowing behavior was found between the totally bottle-fed and the short-term breast-fed children in the non-Indian sample (although there was a higher percentage of tongue thrusters in the bottle-fed group).

In non-Indian groups, therefore, a school child's chances of being identified as a tongue thruster seem to be about the same whether he has been bottle-fed in infancy or breast-fed for a duration of up to 12 months of age. Further, as results from the analysis of the questionnaire data revealed, such variables as duration of breast-feeding up to twelve months, duration of bottle-feeding, age at introduction to solid foods, and duration of various sucking habits (digital, pacifier, tongue or lip, blanket or other cloth) could not serve as predictors of tongue-thrust swallowing for the non-Indian children.

Less Tongue Thrusting in the Navajo Sample

Perhaps the most important finding in this study was that, while there was no significant difference in the percentage of tongue-thrust swallowing between the non-Indian groups which had either been bottle-fed or breast-fed for a relatively short duration, there was a significant difference in swallowing behavior each time a non-Indian group,

whether bottle-fed or breast-fed, was compared with the long-term breast-fed Navajo group. In all three of the cross-cultural comparisons, the weight of the evidence was in favor of the Navajo children (breast-fed 18 to 36 months), for they demonstrated significantly less tongue thrusting.

These results raise a question about the optimum duration of breast-feeding in order for the benefits to show. Perhaps four to twelve months is not a sufficient length of time for the facial musculature to gain maximum benefits from the more vigorous activity required in breast-feeding. Clearly there was a difference in the swallowing behavior of the children of the two cultures. The difference may have been related to the extended nursing period, per se, or to some feature related to the long-term breast-feeding, or to some other crucial feature in the early feeding and child-rearing practices of the Navajo.

Possible Factors in Swallow Maturation of the Navajo Sample

The findings of this study indicate that some factor or factors in the Navajo culture, probably related to the long-term breast-feeding, enhance a child's chances of developing mature swallowing behavior; whereas the absence of the factor or factors in the non-Indian culture impedes the child's chances of gaining maturity of the swallowing mechanism. Let us examine some of the possibilities.

Long-term vigorous use of the oral musculature. The variable for which we are searching is probably not in the breast-feeding, per se, but, rather, in the energetic oral exercise associated with it. According to Picard (1959), the naturally nursing infant expends about sixty times more energy than that used by the bottle-feeding baby and makes two times as many strenuous milking motions. Perhaps twelve or less months is simply not long enough to engage in this strenuous exercise. Perhaps the young child needs two or three years of practice in vigorous milk-pumping activity in order to develop the orofacial structure and neuromuscular coordination required in mature swallowing behavior.

Emotional and sensory-motor benefits associated with nursing. Although Guthrie (1967) reported that psychologists have been unable to elucidate

consistent differences in personality between bottle- and breast-fed youngsters, she and others (Breckenridge and Vincent, 1965; La Leche League International, 1963) have cited emotional benefits associated with natural nursing. Mysak (1968) implied that afferent stimulation during feeding and handling encourages neuromuscular development.

Here, then, are two other possible variables for our consideration. Do emotional well-being and prolonged rich tactile stimulation during breast-feeding contribute to earlier swallowing maturation?

Age at introduction of solid foods. Guthrie (1967) cautioned against any efforts to force infants to handle solid foods while the retrusive reflex, present until three months of age, is active and before the development of the ability to move food from the tongue tip to the throat.

From the questionnaire information of this study, it was determined that the mean age at which the non-Indian children were introduced to solid foods was under two months (7.76 weeks). The age for the Navajo children's introduction to solid foods was not determined. Four to six months would seem to be the logical age for the introduction of a wider variety of foods. Introduction before the digestive system is sufficiently mature may impede the child's neuromotor development (Guthrie, 1967; La Leche League International, 1963) and delay the acquisition of fine-motor skills, such as mature swallowing activity.

The foregoing has been a review of some of the factors which may be related directly or indirectly to long-term breast-feeding and which may contribute to the maturation of the swallowing mechanism. Let us now direct our attention to the prevalence of tongue thrust found in this study.

Prevalence of Tongue Thrust

Although this investigation indicated a statistically significant relationship between long-term breast-feeding (18 to 36 months) and mature swallowing behavior, a cause and effect relationship was not supported. A high prevalence of tongue thrust was found at every age level in both the long-term breast-fed and the predominantly bottle-fed samples. Also, even though this study assumed no pertinent

PREVALENCE OF TONGUE THRUST IN VARIOUS STUDIES

AGE:	4 yrs.	5-6 yrs.	6 yrs.	7 yrs.	8 yrs.	9 yrs.	10 yrs.	11 yrs.	12 yrs.	13 yrs.
INVESTIGATION:	N %	N %	N %	N %	N %	N %	N %	N %	N %	N %
Present:										
Navajo Long-Term Breast-Fed Group				20 75	12 50	19 74	9 67	7 71	18 67	26 58
Non-Indian Predominantly Bottle-Fed Group				26 89	18 72	20 90	19 84	17 88	24 71	25 76
Jann et al., 1964			1st Gr.	2nd Gr.	3rd Gr.	4th Gr.	5th Gr.			
Group 1			95 63	95 61	95 76					
Group 2				94 82	94 77	94 84				
Group 3					92 75	92 74	92 71			
Ward et al., 1961			120 66	122 79	116 79					
Bell and Hale, 1963		353 82								
Hanson and Cohen, 1973	4.9 yrs.	5.8 yrs.	6.7 yrs.	7.5 yrs.	8.2 yrs.					
Liberal Definition	178 87	178 79	178 79	178 73	178 71					
Conservative Definition	178 58	178 44	178 52	178 35	178 35					

genetic oro-facial difference between the Indian and non-Indian children, there is a possibility that the difference in the prevalence of tongue thrust between the two groups may have been due to some genetic factor. These writers have, however, read nothing in the available literature to lend credibility to the idea.

While the prevalence of tongue thrust in this study is relatively high, Table Two reveals that the age-level percentages are similar to those from other investigations in which tongue-thrust criteria resembled the liberal definition (stated previously) advanced by Hanson and Cohen (1973). Furthermore, comparison between the Indian and non-Indian samples remains valid because judgment of type of swallowing behavior was reliably made by one examiner according to one set of criteria, and the children were randomly selected.

In addition to the results of the present investigation, Table Two shows the tongue-thrust findings from Jann et al. (1964) who observed each of three groups of school children over a three-year period, from Ward et al. (1961) who found tongue-thrust swallowing in 75% of 358 primary-grade children, from Bell and Hale (1963) who found tongue thrusting in 82% of 353 five- and six-year-old children, and from Hanson and Cohen (1973) who reported tongue thrust according to both a liberal and a conservative definition in a longitudinal investigation of 178 children at five different age levels. In the liberal portion of the Hanson and Cohen study and in all the other investigations shown, with the exception of the eight-year-old Navajo group, immature swallowing behavior was the pattern of the majority. (Fifty per cent tongue-thrust swallowing was exhibited in the eight-year-old Navajo children.) Even Hanson and Cohen's (1973) conservative study found tongue thrust the pattern of the majority at the 4.9- and the 6.7-year levels with large numbers of children demonstrating tongue thrust at the other three age levels. The percentage figures shown in Table Two support the notion that the tongue-thrust manner of swallowing is associated with the developmental and growth factors of late childhood and early adolescence.

Possible Sources of Variation in Prevalence Studies

Differences in definition of tongue thrust. Over the years there has been a remarkable variation in tongue-thrust prevalence among the many investigations in school children. Differences in the criteria selected to define tongue thrust probably account for much of the discrepancy. Hanson and Hanson (1975) verbalized the problem: "Un-standardized definitions of tongue thrust make it difficult for incidence studies to completely agree with one another" (p. 22).

In addition to the forward thrusting of the tongue, contraction or relaxation of the facial muscles of expression and of mastication were considered in the tongue-thrust, or visceral, swallowing examinations in some studies (Ward et al., 1961; Jann et al., 1964). Because of contradictory findings (Subtelny et al., 1964; Weiss, 1969; Weinberg, 1970), these related orofacial factors were observed and recorded, but not considered in the judgment of tongue thrust in our investigation. According to Barrett and Hanson (1978), "... the inclusion of the presence or absence of molar occlusion, facial grimaces, or abnormal chewing habits, as a necessary part of the 'syndrome' of tongue thrust, is not warranted" (p. 137).

Hanson and Cohen's (1973) presentation of two definitions helps explain much of the broad variation in frequency of tongue thrust among the various studies. A swallow was judged tongue thrust in our investigation if the tongue pressed against or protruded through the teeth, either anteriorly or laterally (resembling the liberal definition), if the labial seal could not be broken, and if at least three of five swallows were tongue thrust.

Subtelny and Subtelny (1973) stated that lingual contact with the maxillary incisors was characteristic of the typical swallow. Barrett and Hanson stated that "... the only consistent aspect of tongue-thrust behavior is the thrusting of the tongue" (1978, p. 135). They contended that

The mere contact between the tongue tip and a portion of one or more of the anterior teeth during swallowing does not necessarily indicate tongue thrust. When there is significant pressure by the tip or blade of the tongue against a major portion of the area of an incisor,

cuspid, or premolar, then the diagnosis of tongue thrust is warranted (1978, p. 187).

Following the lead taken by Hanson and Cohen (1973), research should continue until a clear and universal definition of tongue thrust is adopted.

Differences in the diagnostic examination. Methods of examining for tongue thrust have ranged from cine-fluorographic observation of the tongue in action, use of strain gauges on the tongue to measure the force exerted during swallowing, use of ultraviolet light to view the oral cavity following an application of sodium fluorescein suspended in Orabase on the anterior tongue, to the clinician's manually separating the patient's lips during swallowing (Cole and Cole, 1979). It is quite likely that such a range of diagnostic procedures would yield differing prevalence figures.

Perhaps the most common practice in testing for tongue thrust is the parting of the subject's lips by the clinician at the height of the swallow, as was done in our investigation. Through cinefluorographic research, Cole and Cole (1979) found that many 7- to 9-year-old subjects, who had been previously identified as non-tongue thrusters, thrust only when their lips were parted by the clinician.

Unfortunately at this time, no technique other than the lip-parting one seems both plausible and readily available for purposes of testing large numbers of children. Electrodes on the tongue may induce deviate swallowing, and cinefluorography is accompanied by possible radiation hazards (Cole and Cole, 1979). Alternate testing methods need to be explored, however; findings from the various investigations may be accurately compared only when uniform diagnostic methods are followed.

Developmental trends in patterns of swallow. According to Mason and Proffit (1974), "Variability appears to be a primary attribute of school-age swallowing patterns" (p. 128). A quick visual perusal of Figure 1 suggests some pattern in the variability found in this investigation. Both samples showed more tongue thrusting at ages 7, 9, and 11, with less thrusting occurring at ages 8, 10, and 12. Both samples appeared to follow a similar, and perhaps predictable, course, with a

gradual overall reduction in age from seven through 13 years.

Little support can be found in the literature for the sharp decrease in tongue thrust at age eight. The finding may have been an artifact; however, it occurred in both the Navajo and the non-Indian samples. Of the studies shown in Table 2, Group 2 of the study by Jann et al. (1964) demonstrated a moderate decrease in percentage of tongue-thrust swallowing at age eight, and the liberal-definition study of Hanson and Cohen (1973) showed a slight decrease at that age.

Transient fluctuations in swallowing behavior may be associated with mixed dentition (Barrett and Hanson, 1978). Jann et al. (1964) reported finding tongue thrust in some children who had demonstrated mature swallowing the year previously. In their longitudinal study, Hanson and Cohen (1973) found that some children who swallowed normally at 4 years 9 months were tongue thrusting at age 8 years 2 months, and vice versa. In a follow-up study of those same children, Hanson and Hanson (1975) found 15.2% more of the children tongue thrusting at age 12 than were thrusting at age 8. They noted that a number of the 12-year-olds had missing, or partially erupted, molars. Our investigation found one per cent fewer children tongue thrusting at age 12 than at age 8 in the non-Indian group; however, our findings in the Navajo group support those of Hanson and Hanson. Seventeen per cent more Navajo children were tongue-thrusting at age 12 than at age 8.

Hoffman and Hoffman (1965) advocated that a developmental type of tongue thrust emerges during late childhood. They believed that tongue muscle function is closely related to the size of the tongue's environment. In observing older children, they noted that the space provided for the tongue varies from one growth period to another. The mouth cavity offers less room for the tongue during the eighth to the tenth, or possibly the twelfth, year. The child must house adult-sized teeth in his yet child-sized jaws and also put up with adenoids which are at a peak of growth. The tongue, being too large for the cavity, tends to expand anteriorly (anteriorly rather than posteriorly in order to maintain

the patency of the pharyngeal airway). This forward expansion may precipitate tongue-thrust swallowing during the periods in which our data showed an increase in that pattern of swallow (especially at ages 9 and 11).

The final growth of the facial skeleton is said to begin at about age 10 and continue to age 20 or 25 (Zemlin, 1968). The decrease in tongue thrust which was shown from ages 11 to 12 may be associated with the downward and forward displacement of the mandible during the final facial growth period. The oral environment simply may have more room to accommodate the tongue and to achieve a more normal swallow function during those years.

Worms et al. (1971) presented the possibility that the swallowing reflex may mature somewhere around the tenth to the twelfth year and that this maturation may be associated with spontaneous correction of dental malocclusions. These researchers studied open-bite malocclusion in 1,408 Navajo children and youth and reported their findings according to five age brackets: ages 7 to 9, 10 to 12, 13 to 15, 16 to 18, and 19 to 21. With considerable variation in frequency of open-bite among the age groups, they found that open-bite malocclusions "... represent, at least in part, a dynamic condition subject to change" and "... that many open-bites disappeared spontaneously" (p. 592). They found a large decrease in the frequency of open-bite in the 10- to 12-year age bracket, which may bear some relationship to our finding of a decrease in the frequency of tongue thrust at ages 10 and 12. The authors stated,

The maturation of the swallowing reflex, transition from the mixed dentition to the permanent dentition, and skeletal growth probably contribute to this self-correction at 10 to 12 years.

The maturation of the swallowing reflex has previously been noted. That swallowing patterns are variable is self-evident, but consistent judgment and evaluation of tongue-thrust, reverse swallow, etc. have often proved futile. Suffice it to say that the potential for changes exists and these changes could contribute to the correction of open-bites (Worms et al., 1971, pp. 593-4).

Dr. Marvin Hanson (1975) cautioned against the use of non-longitudinal data in making inferences about a decline in

the incidence of open-bite. He said, "Only in a longitudinal study, wherein the same children are seen from year to year, can valid statements be made concerning changes in malocclusion" (1975, p. 108). This caution would seem to extend to the interpretation of non-longitudinal data concerning tongue thrust. In viewing the declines and increases in tongue thrust at the various age levels, it must be borne in mind that the data for each age level represent the test results from a different group of children. We may wonder if the fluctuating lines represent some spontaneous correction of tongue thrust at one age and spontaneous resumption of thrusting behavior at another, but, since each child was tested one time at one age period, we may only surmise.

Fluctuations in the age-level prevalence figures found in all the above studies, however, suggest that the maturation of the swallowing reflex is a slow process which involves many stages in the growth of the individual. This developmental course seems to be associated with what is frequently referred to as the "transitional swallowing" period.

Transitional swallowing patterns. The larger numbers of tongue thrusters yielded by the criteria of the liberal definition may include many children who are actually in a transitional swallowing period. Proffit and Norton (1970) noted that the existence of transitional types of swallows had been presumed but had not been documented. They stated that the classic descriptions for mature swallowing are not correct for the normal infant, and that many adults do not swallow in the classic manner. On the basis of lingual pressure studies, they suggested the possibility of a series of transitional swallows. Many individuals may fail to progress through all the transitional stages between infantile and adult swallowing behavior. Fletcher (1970) stated that the swallow may remain at a less-than-mature level if the geometric configuration of the tongue or mouth fails to change and, thus, fails to provide the new sensory cues necessary to a more mature swallow pattern.

Cole and Cole (1979) suggested that the transitional period may last from the second until the seventh or eighth

year of life. They said that the tongue gradually assumes a slightly more posterior position during that age period due to the enlargement of the oral cavity and "... the gradual recession of the oropharyngeal lymphoid tissue" (p. 3). Our study seemed to show, however, that the transitional period lasted much longer than the eighth year.

In both of our samples, the Navajo and the non-Indian, there were fluctuations in percentage of tongue thrust at each year from the seventh to the thirteenth. We, therefore, feel that the period of transitional swallowing may last at least until puberty. As just noted, Hoffman and Hoffman (1965) suggested the eighth to possibly the twelfth year as the peak period for adenoid growth. Zemlin (1968) gave nine to ten as the peak years for adenoid expansion and stated that after that age the tissue slowly atrophies but is still greatly enlarged into the teens. He said that complete atrophy has usually occurred by adulthood. It may, then, be that the transitional period lasts until sometime during the teen years when the pharyngeal tonsil has receded sufficiently to allow for a more posterior positioning of the tongue and after other growth factors have been accomplished. "Possibly by the age of 14, the transitional period will have terminated," speculated Hanson and Hanson (1975, p. 27), "but then again perhaps not until much later."

Developmental-transitional aspects seem to account for a portion, but certainly not all, of prolonged tongue-thrust swallowing. Perhaps we are actually seeking to identify two populations of tongue thrusters, one in which the tongue thrust is a negative, deleterious type of behavior which contributes to dental malocclusion and to possible defective articulation. In the other population, tongue thrusting may not be a negative behavior, but a positive, transitory factor in the course of normal development. The tongue-thrusting children found in both the Navajo and the non-Indian groups in this investigation may have included a number of individuals at each age level who were exhibiting positive developmental variations in swallowing behavior. Others in each sample probably demonstrated a nega-

tive type of thrust.

Even though significantly less tongue thrusting was found in the long-term breast-fed Navajo group, the prevalence of tongue thrust in that group was 65 per cent. While some of the children may have exhibited transitional swallowing, two variables seem related to other-than-developmental thrusting among the Navajo children.

Variables Associated with the Prevalence of Tongue Thrust in the Navajo Sample

In addition to the normal developmental aspects just noted, some factors which may have prolonged tongue thrusting in many Navajo children seem to have differed from those which were operative in the non-Indian children. Many of the Navajo children who were tested in this investigation had suffered from a food shortage due to a severe drought in their preschool years. Refrigeration had been scarce, and, following weaning, soda pop had been a strong feature in the diet. According to Public Health Service staff members in the area, the poor nutrition had often resulted in the early loss of deciduous teeth, which precipitated malocclusion. According to Weber, "Most primary teeth lost prematurely are victims of dental caries ..." (1979, p. 10). He explained that early loss of teeth results in space problems due to crowding of the dentition. Tongue thrust may have been maintained by malocclusion in some of the Navajo children. Subtelny and Subtelny (1962) suggested that deviate muscle function may result as an adaptive pattern associated with malposed oral structures.

Another source of tongue thrust in the Navajo children may have been related to upper-respiratory disease, which was reported to have been quite prevalent among them. Moyers (1971) held that a "tooth-apart" swallow could be learned as a result of chronic pharyngitis or respiratory infections. Pain from chronic sore throat and upper respiratory infection may induce the sufferer to position his tongue anteriorly, an unfavorable posture for mature swallowing behavior. A tongue-thrust type of swallow, therefore, may be learned or maintained by this interaction of events.

In this study, tongue-thrust swallowing was investigated in breast-fed

and bottle-fed school children from two different cultural groups. Following is a list of conclusions which may be drawn from the statistical and interpretative treatment of the data.

CONCLUSIONS

The following conclusions are suggested by the findings. The interpretation of these conclusions should be limited to subjects who meet the characteristics of those who participated in this investigation and the methods used in testing them.

1. The frequency of tongue-thrust swallowing in a bottle-fed population was statistically greater than that within a breast-fed population from another culture. A cause and effect relationship between tongue thrust and bottle-feeding was not determined since other related factors may contribute to the difference and also since the incidence of tongue thrust in both groups was high.
2. This investigation supports the findings from other studies that there is no difference between bottle-fed and breast-fed children in the incidence of tongue-thrust swallowing when all of the children being compared come from the so-called "modern American society" and when the breast-fed subjects were nursed for a relatively short period (from about four to about twelve months).
3. Long-term breast-feeding may be beneficial in the maturation of the swallowing reflex. Because significantly less tongue thrusting was found in a Navajo group which had been breast-fed in infancy for a term of from 18 to 36 months than in a non-Indian group which had been breast-fed for a shorter term of 4 to 12 months, it is felt that longer-term sucking at the breast may be required before breast-feeding stimulates statistically significant differences in terms of swallowing behavior.
4. The incidence of tongue thrust seems to follow an age-related pattern. As shown in Figure One, both the Navajo breast-fed and the non-Indian predominantly bottle-fed samples showed similar decreases at age 8, increases at age 9, decreases at age 10, increases at age 11, and decreases at age 12.

These fluctuations, found in both groups, seem to be more than coincidence and suggest that some tongue-thrust swallowing may follow a predictable, developmental course related to changes in the oral structures and in the size of the oral cavity at various growth stages.

RECOMMENDATIONS FOR FUTURE RESEARCH

1. The effects of long-term breast-feeding and long-term vigorous exercise of the oral mechanism need further observation.
2. The swallowing reflex needs to be investigated in many other cultures to try to determine what maturational influences may exist. Differences in early child-rearing and child-feeding practices, including age at introduction of solid foods, require further study.
3. Possible transitional stages between an infantile tongue-thrust swallow and mature swallowing function need to be identified. Such identification should provide definite implications for therapy

or orthodontic treatment, or for the optimum time to begin the treatment.

4. A replication of this study, using both the conservative and liberal definitions of tongue thrust developed by Hanson and Cohen (1973), would yield helpful information. Those who are exhibiting a transitory, growth-related transitional tongue-thrust swallow may be discriminated from those whose tongue thrusting has negative, injurious effects.
5. There is a need for identification of readiness skills and growth factors which must be accomplished before the swallowing reflex can mature. Critical periods in the swallow maturation process, if any, need to be identified. Maturation of other neuromuscular systems needs to be studied to determine possible parallels with, and influences on, the maturation of the swallowing mechanism.
6. Efforts should be made to establish a uniform definition of harmful, non-developmental tongue thrust so that all investigators will be

looking for the same phenomena and so that appropriate treatment may be prescribed.

7. Diagnostic methods need to be standardized for purposes of study and of readily comparing information with other investigations. Standardized diagnostic procedures will ensure a frame of reference among referring professionals.
8. Samples of older adolescents and adults need to be studied to determine the age at which tongue thrust levels off, and the age beyond which we may expect tongue thrust to discontinue yielding to maturational forces. In this respect, more longitudinal studies need to be carried out.
9. Possible relationships between the emotional state and maturation of the swallowing reflex need further study. Effects of holding the child, emotional gratification from the close association between mother and child over a two or three-year period, and other benefits derived from breast-feeding need further investigation.

BIBLIOGRAPHY

- Barrett, R.H., and Hanson, M.L., *Oral Myofunctional Disorders*. Saint Louis: The C.V. Mosby Co., 1978.
- Bell, D., and Hale, A., Observations of tongue-thrust swallow in preschool children, *J. Speech Hear. Disord.*, 28:195-197, 1963.
- Breckenridge, M.E., and Vincent, E.L., *Child Development*. Philadelphia: W.B. Saunders Co., 1965.
- Carrell, J.A., *Disorders of Articulation*. Englewood Cliffs, N.J.: Prentice-Hall, 1968.
- Cole, R.M., and Cole, J.E., Myofunctional therapy in tongue-thrust swallowing and related problems. In J.W. Clark (Ed.), *Clinical Dentistry*, Volume 2. New York: Harper & Row, Publishers, 1979.
- Crickmay, M.C., *Speech Therapy and the Bobath Approach to Cerebral Palsy*. Springfield, Ill.: Charles C. Thomas, 1970.
- Ferguson, G.A., *Statistical Analysis in Psychology and Education*. New York: McGraw-Hill, 1966.
- Fletcher, S.G., Casteel, R.L., and Bradley, D.P., Tongue-thrust swallow, speech articulation, and age. *J. Speech Hear. Disord.*, 26:201-208, 1961.
- Fletcher, S.G., Processes and maturation of mastication and deglutition. *ASHA Reports*, 5:92-105, 1970.
- Garliner, D., *Myofunctional Therapy in Dental Practice*. Brooklyn, N.Y.: Bartel Dental Book Co., Inc., 1971.
- Glass, G.V., and Stanley, J.C., *Statistical Methods in Education and Psychology*. Englewood Cliffs, N.J.: Prentice-Hall, 1970.
- Guthrie, H.A., *Introductory Nutrition*. Saint Louis: The C.V. Mosby Co., 1967.
- Hanson, M.L., Tongue thrust: Another look at the evidence Part I. *IJOM*, 1(3):105-113, 1975.
- Hanson, M.L., and Cohen, M.S., Effects of form and function on swallowing and the developing dentition. *Am. J. Orthod.*, 64:63-81, 1973.
- Hanson, T.E., and Hanson, M.L., A follow-up study of a longitudinal research on malocclusions and tongue thrust. *Intern. J. Oral Myology*, 1:21-28, 1975.
- Hoffman, J.A., and Hoffman, R.L., Tongue thrust and deglutition: Some anatomical, physiological, and neurological considerations. *J. Speech Hear. Disord.*, 30:105-120, 1965.
- Howland, J.P., The winning team: orthodontics and myofunctional therapy. *Intern. J. Oral Myology*, 5(3):13-14, 1979.
- Humphrey, T., Human prenatal activity sequences in the facial region and their relationship to postnatal development. *ASHA Reports*, 6:19-37, 1971.
- Jann, G.R., Ward, M.N., and Jann, H.W., A longitudinal study of articulation, deglutition, and malocclusion. *J. Speech Hear. Disord.*, 29:424-435, 1964.
- Kluckhohn, C., and Leighton, D., *The Navajo*. Garden City, N.Y.: Doubleday, 1962.
- La Leche League, *The Womanly Art of Breastfeeding*. Franklin Park, Ill.: La Leche League International, 1963.
- Larr, A.L., *Tongue Thrust and Speech Correction*. San Francisco: Fearon, 1962.
- Lay, T.N., Investigation of atypical swallowing patterns among children

- in kindergarten through eighth grade. *Dissertation Abstracts*, 25: 4303, 1964.
- Leech, H.L., A clinical analysis of orofacial morphology and behavior of 500 patients attending an upper respiratory research clinic. *Dent. Pract.*, 9:57-68, 1958.
- Lewis, J.A., and Counihan, R.F., Tongue thrust in infancy. *J. Speech Hear. Disord.*, 30: 280-282, 1965.
- Lundeen, D.J., Kurtz, D.D., and Stanley, E.O., Clinical study of dental caries and tongue thrust. *J. Amer. Dent. Assn.*, 88: 1018-1020, 1974.
- Mason, R.M., and Proffit, W.R., The tongue-thrust controversy: Background and recommendations. *J. Speech Hear. Disord.*, 39:115-132, 1974.
- Moyers, R.E., Dental contributions to occlusion. *Dent. Clinics North Amer.*, 13:524-535, 1969.
- Moyers, R.E., Postnatal development of the orofacial musculature. *ASHA Reports*, 6:38-47, 1971.
- Mysak, E.D., *Neuroevolutional Approach to Cerebral Palsy and Speech*. New York: Teachers College Press, 1968.
- Nuk Sauger Functional Preventive Orthodontic Program. Denver, Colo.: Rocky Mountain Dental Products, 1970.
- Picard, P.J., Bottle feeding and preventive orthodontics. *J. Calif. State Dent. Assn. and the Nevada State Dent. Society*, 35:90-95, 1959.
- Proffit, W.R., and Norton, L.A., Influences of tongue activity during speech and swallowing. *ASHA Reports*, 5:106-115, 1970.
- Ronson, I., Incidence of visceral swallow among lispsers. *J. Speech Hear. Disord.*, 30:318-324, 1965.
- Subtelny, J.D., Mestre, J.C., and Subtelny, J.D., Comparative study of normal and defective articulation of /s/ as related to malocclusion and deglutition. *J. Speech Hear. Disord.*, 29:269-285, 1964.
- Subtelny, J.D., Examination of current philosophies associated with swallowing behavior. *Am. J. Orthod.*, 51:161-182, 1965.
- Subtelny, J.D. and Subtelny, J.D., Malocclusion, speech, and deglutition. *Am. J. Orthod.*, 48:685-697, 1962.
- Subtelny, J.D. and Subtelny, J.D., Oral Habits — studies in form, function, and therapy. *Angle Orthod.*, 43:349-383, 1973.
- Straub, W.J., Malfunction of the tongue, Part I: The abnormal swallowing habit: Its cause, effects, and results in relation to orthodontic treatment and speech therapy. *Am. J. Orthod.*, 46:404-424, 1960.
- Ward, M., Minst, M., Daniel, H., Jann, G.R., and Jann, H.W., Articulation variations associated with visceral swallowing and malocclusion. *J. Speech Hear. Disord.*, 26:334-341, 1961.
- Weber, F.N., Preventive and interceptive orthodontics. In J.W. Clark (Ed.), *Clinical Dentistry*, Volume 2. New York: Harper & Row, Publishers, 1979.
- Weinberg, B., Deglutition: A review of selected topics. *ASHA Reports*, 5: 116-130, 1970.
- Weiss, C.E., Orofacial musculature imbalance and associated symptoms. *Brit. J. Disord. Communication*, 4: 140-145, 1969.
- Worms, F.W., Meskin, L.H., and Isaacson, R.J., Open-bite. *Am. J. Orthod.*, 59:589-595, 1971.
- Young, R.W., *English as a Second Language for Navajos*. Albuquerque: Navajo Area Office, Bureau of Indian Affairs, 1967.
- Zemlin, W.R., *Speech and Hearing Science*. Englewood Cliffs, N.J.: Prentice-Hall, 1968.