Tongue Movements in Normal Preschool Children During Eating

(tongue position, eating assessment, food texture, swallowing)

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This study describes tongue movements of normal preschool children during eating, and is the first phase in a long-term project to develop a standardized eating assessment for children. It is hoped eventually to fill the need for an objective measurement tool in pediatric occupational therapy practice. The movements were monitored in 40 children; 20 were 4 years ± 1 month, and 20 were 5 years ± 1 month. Each group consisted of 10 boys and 10 girls.

Two different tongue positions were quantified: First, as food was presented to the child when the food was 5 cm from the lips; and second, as food was swallowed. Tongue position upon food presentation and upon swallowing was affected by age, sex, and type of food. Both responses showed maturational changes from 4 to 5 years. It is proposed that important maturational changes take place between 4 and 5 years of age, but that adult patterns of swallowing are attained later in development.

Children with eating problems are often referred to occupational therapists for evaluation and treatment. Such evaluations remain largely descriptive because of the lack of a standardized eating assessment scale. Without a base for comparison with normal development, the judgment about the severity of an eating problem remains mostly subjective. Reliable and valid methods are needed by the clinician to identify normal as well as abnormal oral-motor behavior. Our long-term goal is to develop a standardized eating assessment for infants and children. The purpose of this study is to report on the first phase of our project, which dealt with the assessment of normal tongue movements in 4- and 5-year-old children. Assessment procedures were developed and tongue movements were quantified under two conditions: tongue position upon presentation of food; and swallowing food. These movements undergo maturational changes that could be clearly demonstrated in these two age groups.

Tongue movements during swallowing of water and saliva have been studied (1-5). It appears that swallowing in infants and young children differs from swallowing in older children and adults. Proffit and co-workers (2,3) proposed that three transition phases occur between the ages of 2 and 5 years, and lead from...
infantile to adult swallowing. However, clinical studies indicate that children may be in transition to more adult-like patterns of swallowing beyond 5 years of age (6, 7). An infantile swallow is observed when the tongue protrudes until it contacts the lower lip. The jaws are parted and facial muscles actively contract during swallowing.

The transition phases described by Proffit and co-workers (2, 3) are similar to tongue-thrust swallowing described by other authors (1, 6, 7). Bell and Hale found that 82 percent of 5- and 6-year-old children swallowed with a forward tongue position (6). Hanson and co-workers reported 39 to 55 percent of the preschool children they studied swallowed with the tongue between the teeth but that the type of fluid in the mouth (i.e., saliva or water) affected tongue position upon swallowing (7).

Proffit’s model describing transition phases in swallowing is consistent with different growth rates of the tongue and face. During early growth, tongue position in the oral cavity depends upon the space available for it. Facial growth depends on the growth and action of the masticatory muscles and the teeth, and the growth of the maxilla and mandible. The face continues to grow for about 20 years (8).

Since tongue position appears to be influenced by the type of liquid swallowed (7), tongue movements were quantified in response to several solid foods with different textures.

Materials and Methods

Sample. Forty normal preschool children were studied—20 children aged 4 years ± 1 month, and 20 aged 5 years ± 1 month. Each age group consisted of 10 boys and 10 girls. Proffit and co-workers (2, 3) suggested that most children make the transition between infantile and adult swallowing between 2 and 5 years. Four- and 5-year-old children were chosen because a majority of them should demonstrate mature swallows.

Children excluded from the study were those with medically diagnosed neurological difficulties or mental retardation, patients receiving speech therapy, children with oral defects such as cleft palate or cleft lip, and children with one or more obviously decayed teeth. Only Caucasian children were included since it has been shown that oral structure measurements vary for different racial groups (9). Children were from middle to upper middle class homes.

All children attended preschool at least 2 half days per week and had normal speech sound acquisition as judged by their teachers. Written parental consent was obtained before observation of each child.

Procedures. Two different tongue positions during eating were observed. The first was tongue position as food was presented to the child. It was recorded when the spoon at the food was 5 cm away from the lips. Positions recorded were tongue behind teeth, on top of teeth, on or beyond the lower lip, or retracted 5 mm or more from the teeth. The second was tongue position upon swallowing the food. Originally, the child’s lips were to be spread by an investigator’s thumb and index finger if the tongue could not be viewed upon swallowing as indicated in the literature (6, 7). However, pilot trials indicated that this procedure might interfere with normal swallowing patterns. Therefore, only phenomena that were observed without touching the oral structures were recorded such as pursing of the lips or puckering. Puckering was defined as a dimpling of the cheeks near the corners of the mouth. The observation of the tongue on top of the teeth during swallowing was also noted.

Testing occurred between 9:00 and 11:30 a.m. Eating observations took place in a quiet room at the child’s school. The children were seated with their feet positioned flat on the floor or on a support. The investigator sat in front of the child in a small chair during the observation session. Each child was observed once for 15 to 20 minutes. Ten spoonfuls of applesauce (pureed food) presented on a long-handled baby spoon, 20 raisins (bite-size food), and 10 bites of graham cracker broken into quarter sections (bite-off food) were presented in random order. Unsweetened applesauce, raisins, and graham crackers were chosen because of their appeal to preschool children, expense, texture, and ease in storing between observation sessions.

Raisins were presented twice to the child. First, the raisin was placed behind the lower incisors (raisin I) ten times; second, the raisin was placed over the molars (raisin II) ten times. The raisin was placed five times either over the right or left molars in a random order. The graham cracker was presented to the child to bite off a piece of the cracker. Each tongue position was scored after the child had finished swallowing. One difficulty encountered was how to judge when the child had swallowed for the last time. The most
forward position of the oral musculature or tongue was scored, although the most forward position was not always the most common pattern used for swallowing.

Data analysis was based upon a Chi-square test of independence. A log-linear model was chosen (10) and executed via computer program BMDP-4F-multiway frequency tables analysis (11). Comparisons were made between sexes, ages, food types, and tongue positions. A z-test was used to compute post-hoc scores. An alpha level of .05 was regarded as significant.

The method used to compute reliability accounted for within subject and between observer variability. Reliability was tested on 27 children by comparing the first 5 to the second 5 trials administered by 1 observer. Comparisons were also made in 13 children between 2 observers when each administered 5 trials to any 1 child.

Results
Tongue Position as Food Is Presented.
Since food texture may influence tongue position (7), it was hypothesized that there will be no significant difference in the position of the tongue as differently textured foods will be presented.

Table 1 illustrates percentage scores for the effects of food on position. The tongue was observed most often “behind teeth” for all three foods, followed by the position “on top of teeth.” The tongue was “retracted 5 mm or more” 10.1 percent for total responses, whereas 9.6 percent of the total responses were observed “on top or beyond the lower lip.” The order of responses in “on or beyond the lower lip” and “retracted 5 mm or more” was the same for graham cracker (5.3 and 9.1%, respectively) and applesauce (11.6 and 13.7%, respectively), whereas the response order was reversed for raisin I (12.1 and 7.5%, respectively).

The effects of sex on position were significantly different ($p < .001$) for all tongue positions, indicating that strong sex differences exist in the way the tongue anticipates food (Table 1). The “behind teeth” position was observed most frequently in males and females. Females scored twice as many times as males in the “on top of teeth” position. Seven percent of the males and 12.9 percent of the females scored in the “on or beyond the lower lip” position. Therapists often consider this response abnormal. The tongue was retracted 5 mm or more—12.9 percent for males and 7.2 percent for females.

The effects of age on position were significantly different ($p < .003$ or less) except for the “on or beyond the lower lip” position ($p > .575$; see Table 1). Again, the “behind teeth” position was observed most frequently in 4 and 5 year olds, but 4 year olds scored less frequently (61.4%) than 5 year olds (65.5%). Five-year-old children scored more frequently in the “on top of teeth” position (20.8 vs 13.1%), and 3.5 times less often in the “retracted 5 mm or more” position than 4-year-old children. Both groups scored between 9 and 10 percent in the “on or beyond the lower lip” position.

The effects of food on position are illustrated in Table 2. Applesauce was significantly different from graham cracker and raisin I in every position at $p < .001$ and in the “on top of teeth” position at $p < .006$. The differences observed in the “on top of teeth” position appear to be caused by the differences in raisin I and applesauce since graham cracker was not different from raisin I ($p > 0.490$) or applesauce ($p > 0.078$). Raisin I was not different from applesauce in the “on top or beyond the lower lip” position ($p > .653$). However, all other food interactions were significantly different when the tongue was observed in the “on top or beyond the lower lip” position ($p < .001$). When the tongue was “retracted 5 mm or more,” raisin I was not different from graham cracker ($p > .110$).

All other food interactions were significant ($p < .001$).

Tongue Position upon Swallowing.
It was proposed that there would be no differences in tongue position upon swallowing differently textured foods. Scores for tongue position upon swallowing are illustrated in Table 3.

The most common response was “tongue not observed, lips are pursed” for all foods except raisin I where “tongue not observed, puckers in corners of the mouth” was the most common response. The “tongue on top of teeth” position was observed least frequently for all food types, whereas “puckers in corners of the mouth . . .” represented the intermediate response.

Among the effects of sex on position, 63 percent of the females scored in the “lips are pursed” position compared with only 42 percent of the males (Table 3). Males scored most frequently in “puckers in corners of the mouth,” 45.8 percent, whereas females scored 27.2 percent. The least observed response was “tongue on top of teeth.” Males scored more often in this position than females (12.2 vs 9.8%, respectively). All interactions were statistically significant at a level of at least $p < .008$.
Table 1
Tongue Position as Food Is Presented to Normal Preschool Children

<table>
<thead>
<tr>
<th>Position</th>
<th>Food*</th>
<th>Sex</th>
<th>Age</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RI</td>
<td>G</td>
<td>A</td>
<td>T</td>
</tr>
<tr>
<td>Behind Teeth</td>
<td>65.0</td>
<td>69.3</td>
<td>55.8</td>
<td>63.4</td>
</tr>
<tr>
<td>On Top of Teeth</td>
<td>15.4</td>
<td>16.3</td>
<td>18.9</td>
<td>15.9</td>
</tr>
<tr>
<td>On or Beyond the Lower Lip</td>
<td>12.1</td>
<td>5.3</td>
<td>11.5</td>
<td>9.6</td>
</tr>
<tr>
<td>Retracted 5 mm or More</td>
<td>7.5</td>
<td>9.1</td>
<td>13.7</td>
<td>10.1</td>
</tr>
</tbody>
</table>

Data represent percentage scores for columns.
* For statistics, see Table 2.
RI=raisin I, RII=raisin II, G=graham cracker, A=applesauce, T=total.
N=40; 20 males and 20 females.

In the effects of age and position both groups scored highest in the "lips and pursed" position (Table 3). However, the response was seen less often in 5 year olds than in 4 year olds (47.0 vs 59.0%, respectively). Puckers were observed less in 4 year olds than in 5 year olds (29.1 vs 43.0%), although it was originally suggested that there would be no difference in the frequency of "puckering in the corners of the mouth" between 4- and 5-year-old children. Puckering is thought to be more mature than pursed lips, because the frequency of the response increased nearly 50 percent from 4 to 5 years. The tongue was placed on top of teeth less often in 5 year olds than 4 year olds (10.0 vs 11.9%). All interactions between age and position were significant (p < 0.036 or less).

Analyses for the effects of food on position indicated that the type of food affected the "lips are pursed" position for all food com-

Table 2
p-Values Derived from a z-score for Effects of Various Foods on Tongue Position as Food Is Presented to Normal Preschool Children

<table>
<thead>
<tr>
<th>Food</th>
<th>Behind Teeth</th>
<th>On Top of Teeth</th>
<th>On Top or Beyond Lower Lip</th>
<th>Retracted 5 mm or More</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI &amp; G vs A</td>
<td>.001</td>
<td>.006</td>
<td>.001</td>
<td>.001</td>
</tr>
<tr>
<td>RI vs G</td>
<td>.011</td>
<td>.490</td>
<td>.001</td>
<td>.110</td>
</tr>
<tr>
<td>RI vs A</td>
<td>.001</td>
<td>.007</td>
<td>.653</td>
<td>.001</td>
</tr>
<tr>
<td>G vs A</td>
<td>.001</td>
<td>.078</td>
<td>.001</td>
<td>.001</td>
</tr>
</tbody>
</table>

RI=raisin I, G=graham cracker, A=applesauce.
Table 3
Effects of Position, Food, Sex, and Age on Tongue Position upon Swallowing in Normal Preschool Children

<table>
<thead>
<tr>
<th>Position</th>
<th>Food*</th>
<th>Sex</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tongue Not Observed, Lips pursed</td>
<td>RI RII G A T</td>
<td>Male Female p</td>
<td>4 Years 5 Years p</td>
</tr>
<tr>
<td>Tongue Not Observed, Puckers Observed in Corners of Mouth</td>
<td>45.3 39.0 28.6 31.4 36.1</td>
<td>45.8 27.2</td>
<td>.001 29.7 43.0</td>
</tr>
<tr>
<td>Tongue on Top of Teeth</td>
<td>12.5 11.1 13.0 7.6 11.0</td>
<td>12.2 9.8</td>
<td>.008 11.9 10.0</td>
</tr>
</tbody>
</table>

Data represent percentage scores for columns. See text for definitions of tongue positions.

* For statistics, see Table 4.

RI=raisin I, RII=raisin II, G=graham cracker, A=applesauce, T=total
N=40; 20 males and 20 females.

Table 4
p-Values Derived from a z-score for Effects of Various Foods on Tongue Position upon Swallowing in Normal Preschool Children*

<table>
<thead>
<tr>
<th>Food</th>
<th>Lips Pursed</th>
<th>Puckers in Corners of Mouth</th>
<th>Tongue on Top of Teeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI &amp; RII vs G &amp; A</td>
<td>.001</td>
<td>.001</td>
<td>.059</td>
</tr>
<tr>
<td>RI &amp; RII &amp; G vs A</td>
<td>.001</td>
<td>.001</td>
<td>.001</td>
</tr>
<tr>
<td>RI vs RII</td>
<td>.001</td>
<td>.001</td>
<td>.280</td>
</tr>
<tr>
<td>G vs A</td>
<td>.001</td>
<td>.119</td>
<td>.001</td>
</tr>
<tr>
<td>RI vs G</td>
<td>.001</td>
<td>.001</td>
<td>.704</td>
</tr>
<tr>
<td>RI vs A</td>
<td>.001</td>
<td>.001</td>
<td>.001</td>
</tr>
<tr>
<td>RII vs G</td>
<td>.001</td>
<td>.001</td>
<td>.144</td>
</tr>
<tr>
<td>RII vs A</td>
<td>.001</td>
<td>.001</td>
<td>.001</td>
</tr>
</tbody>
</table>

*See text for definitions of tongue positions.

bination combinations (p < .001; Table 4). Raisin responses were significantly different from each other in two of the three positions (p < 0.001). In the “puckers in corners of the mouth” position, the graham cracker versus applesauce effect was not significant (p > 0.119). All other food interactions in this category were statistically significant (p < .001). Food texture greatly affected “tongue on top of teeth” responses. Applesauce, a pureed food, was significantly different from raisin I, raisin II, and graham cracker (p < .001), which require chewing. However, raisin I, raisin II, and graham cracker were not significantly different from one another. This suggests that it is not as easy to swallow pureed food with an open mouth as it might be to swallow foods that require more chewing.

Observer Reliability. Reliability was computed for one observer comparing the first five trials to the second five and between two independent observers over five
trials each. The first procedure was necessary to demonstrate that children responded consistently over ten trials. Since the observer sat directly in front of the child, it was not possible for two observers to make observations from the same viewpoint. Therefore, reliability between two observers was established with each observer administering five of the total of ten trials for each food.

For “tongue position as food is presented,” the reliability of one observer for the average of all foods was 0.68 in 4-year-old and 0.69 in 5-year-old children. For “tongue position upon swallow,” the reliability of one observer for the average of all food texture was 0.54 for 4-year-old and 0.53 for 5-year-old children. For “tongue position as food is presented,” the percentage of agreement of two observers was 0.72 and 0.91 in 4 and 5 year olds, respectively, and for “tongue position upon swallow,” 0.78 and 0.72 in 4- and 5-year-old children, respectively. These figures clearly indicate good agreement between two independent observers but point out the variable nature of oral movement in normal children.

Discussion
It was expected that 4- and 5-year-old children would demonstrate mature swallows based on earlier studies (2,3) that described a transition from infantile to adult swallows between 2 and 5 years of age. However, developmental changes occurred in the tongue position upon swallowing as measured by the number of “puckers in corners of the mouth.” They increased about 50 percent from 4 to 5 years. Responses in “lips are pursed” and “tongue on top of teeth” decreased from 4 to 5 years. It is suggested that “puckers in corners of the mouth” was the most mature response among the responses recorded. The “tongue on top of the teeth” position was viewed as the most immature response because the lips were not closed upon swallowing. Pursing required active participation of the oral-facial muscles to close the lips. The child may use this position to prevent food from dripping out of the mouth if the tongue is in a low and forward position during swallowing.

Children who responded with “tongue on top of teeth” showed a slightly more mature response than the infantile swallow described by Proffit and co-workers (2). The swallow was more comparable to the first transition phase where the tongue lies low in the oral cavity. It extends between the teeth anteriorly and laterally. Comparisons between Proffit’s work and this study are difficult after the first transition phase because the authors provide no information about the movements of the oral-facial muscles as they relate to tongue movements. It is proposed, however, that pursed lips and puckers in the corners of the mouth are indicative of the second and third transition swallows, respectively. During the second transition phase, the jaw closes upon swallowing so that the posterior teeth make contact or are in close apposition. Lateral pressure on the palate increases as the tongue tip moves forward between the incisors. In the third transition phase, the teeth are in close contact. The tongue tip elevates to the maxillary incisors, and the sides of the tongue rest higher in the mouth (3). It is further proposed that an adult swallow is characterized by absence of contraction of the oral-facial muscles. Such swallows were not observed in any children in this study. It is suggested that older children need to be studied to determine when the final transition to adult swallowing occurs in the oral-facial musculature.

It was hypothesized that there would be no differences in the position of the tongue as differently textured foods would be presented. This hypothesis was rejected for all four positions.

The “behind teeth” response was observed most frequently, and the age by position analysis indicated that it seemed to be a more mature response than the other responses. It is proposed that, as 4-year-old children mature, the tongue is placed more forward in the mouth in anticipation of the food.

Males and females mature at different rates, with males showing a greater percentage of mature responses. However, summary analyses suggested that there was an interaction among sex, age, food, and position, and it would seem premature to attribute greater significance to sex than any other variable.

The type of food presented when testing children must be considered. Foods that require chewing cannot be regarded as a single category. The two types used in this study were “bite-off” food (graham cracker) and “bite-size” food (raisin). Because significant differences were observed between bite-off and bite-size food, it is suggested that they be regarded as separate food types with the implication that therapists should not generalize observational findings from one food type to the next. Further studies need
to be conducted to understand fully the influence of different textures of food upon tongue responses. Based upon the differences between these two types of food that require chewing, results of the pureed food (applesauce) must be regarded as preliminary until tongue responses to different types of soft textured foods have been studied.

This study shows that children distinguish between different types of food before it enters the mouth. One can only speculate about the possible control of this phenomenon. Learning might be involved. The tongue may be positioned in the most effective way to anticipate a specific food. Eagerness in anticipation of a preferred food may be expressed. The time-space component of this task may play a role. The child must be able to judge the distance and rate of approach of the food as it is brought toward the mouth as well as judge where the tongue is in relation to the food so that the tongue can effectively move it. It would appear ineffective to have the tongue on or beyond the lower lip when anticipating biting into a cracker, but 10 percent of the children held this position. However, none of the children bit into the cracker with the tongue over the teeth, indicating that they can correct their tongue position given tactile cues even though they may have misjudged visual and spatial clues. Further study is needed to determine whether these relations change when the child feeds himself or herself instead of being fed by another person. Because of the need to establish standardized procedures for the assessment, self-feeding was considered inappropriate at this time.

The current study represents the first phase in the development of a standardized feeding assessment with the aim to put Occupational Therapy Practice on a more objective basis. Studies with a group of children with Down's syndrome are already in progress and have demonstrated good sensitivity of the tool to discriminate between healthy and abnormal samples.

Summary

Tongue position upon food presentation and upon swallowing was affected by the age and sex of the child as well as by the food texture. Both responses underwent maturational changes in children from 4 to 5 years of age. "Tongue behind teeth" appeared to be a more mature position than food was presented from any other position studied. It was proposed that "puckers in corners of the mouth" upon swallowing was the most mature response observed in the children of this study. When the food was the same, such as raisins, but presented in different ways, different responses were observed upon swallowing. Therefore, the manner of food presentation must be considered when evaluating 4- and 5-year-old children.

The procedures developed for this study provided a more rigorous approach to eating assessment than is currently found in clinical settings. The type of food and the number of trials were specified. Although variability was great from one response to the next, there was adequate consistency within and among subjects if a sufficient number of trials was observed. It is suggested that examining isolated points (i.e., one swallow) is not appropriate for an estimate of a child's eating performance.

Acknowledgments

The authors thank W. Donald Gay, D.D.S.; Matt McGue, Ph.D.; Marilyn Brach, speech pathologist; and Loren Lange, OTR, for their unique contributions to this work.

Statistical analysis was supported through the Department of Biostatistics Grant #11541, Washington University, St. Louis, Missouri.

REFERENCES