Tongue Movements in Normal 2- to 8-Year-Old Children: Extended Profile of an Eating Assessment

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Key Words: eating assessment • deglutition • food, texture • oral-motor function

In this study tongue movements of 103 normal 5-, 6-, 7-, and 8-year-old children were measured and compared. The 5-year-olds were compared with children of an earlier study and data were combined for 2- to 8-year-old children.

Two different tongue positions were measured as three standard textures of food were presented: first, the position of the tongue as the food was 5 cm away from the lips, and second, the position of the tongue or other oral characteristics as the food was swallowed. For the anticipation of food a significant age-texture (p < .001) as well as an age-sex-texture interaction was noted (p < .035). For swallowing significant age (p < .0001), texture (p < .0001), and sex-age interactions (p < .0001) were found. Although food is anticipated in a similar fashion by both sexes, age and texture differences must be taken into account when swallowing is evaluated. A preliminary developmental curve for the two eating behaviors is presented for children 2 to 8 years old.

Feeding may be the most difficult aspect of a child's care if he or she has multiple handicaps, such as those associated with cerebral palsy, or Down's syndrome. Although treatment programs for the child with physical disabilities almost always deal with measures of motor performance of the trunk and limbs, eating, which also involves motor skills, is less frequently mentioned (Denhoff, 1981; Field, 1980; Simeonsson, Cooper, & Scheiner, 1982).

Of 27 studies reviewed by Simeonsson and colleagues (1982), none dealt directly with eating problems. This is surprising given the magnitude of the problem: Of a group of 100 children with developmental disabilities (cerebral palsy, Down's syndrome, multiple handicaps), 39% were described as having severe feeding problems (Denhoff, 1981). Similar figures are quoted by Palmar, Thompson, and Linscheid (1975).

Therapists have responded to the demands for intervention by developing specific feeding techniques (Gallender, 1980; Morris, 1978; Sleigh & Niman, 1984). Although there are descriptions of the clinical manifestations of various eating impairments (Morris, 1981; Ottenbacher, Hicks, Roark, & Swinea, 1983; Sleigh and Niman, 1984) as well as extensive treatment protocols describing how to deal with various problems (Morris, 1978), there have been few studies examining the effectiveness of some of these therapeutic regimens (Ottenbacher, Scoggins, & Wayland, 1981; Ottenbacher et al., 1983). To conduct good effectiveness studies, objective measures standardized for normal developmental function are required. With this information, therapists will have at their disposal reliable, objective measurements, enabling them to account for both the efficiency and efficacy of their treatment programs.

Therefore, our efforts over the past years have focused on the development of eating norms in young children. We have documented the gradual maturation of oral-motor behaviors during chewing and swallowing from 2 to 5 years of age (Gisel, 1988; Schweab, Niman, & Gisel, 1986a, 1986b; Schwartz, Niman, & Gisel, 1984a, 1984b). In the present study, we report on the ongoing maturation of eating skills in normal children 5 to 8 years old. We will describe tongue positions during the anticipation and swallowing of three standard textures of food utilizing data from earlier studies (Schwab et al., 1986b; Schwartz et al., 1984a). A preliminary curve of these two eating behaviors for children 2 to 8 years old will be presented.

Materials and Methods

Sample

The sample included 103 children: twenty were 5 years ± 2.8 months old (8 girls, 12 boys), 36 were 6
years ± 2.5 months old (20 girls, 16 boys), 26 were 7 years ± 2.2 months old (13 girls, 13 boys), and 21 were 8 years ± 2.7 months old (10 girls, 11 boys). These children were also part of a study on chewing development (Gisel, 1988) and oral stereognosis (Gisel & Schwob, in press-a, in press-b). Institutional consent was obtained through the McGill University Ethics Committee. The consent of parents and the children was obtained prior to testing. All children spoke French, and they were tested at two primary schools in Montreal, Quebec.

Procedure

Sessions took place between 9 AM and 11:30 AM in a well-lit classroom used only for testing. The children were seated on a chair with their feet flat on the floor, and the investigator sat in front of the child. Each child was observed once for 20 to 30 minutes.

Children were given the following foods: applesauce (pureed texture), graham cracker (solid texture), and raisins (viscous texture). The procedure for administering these foods has been described (Schwartz et al., 1984a). Tongue positions and swallowing activities were recorded: first, the tongue's position when the food was 5 cm away from the mouth; and second, activities as the food was swallowed. Briefly, four positions were described as follows: retracted 5 mm or more (from the mandibular ridge), behind teeth, on top of teeth, and on or beyond lower lip. Five activities were described as smooth swallowing (no visible contribution of the facial musculature to swallowing); tongue not observed, puckers in corners of mouth; tongue not observed, lips pursed; tongue on top of teeth; and tongue on or beyond lower lip. For details of definitions, see Schwartz et al. (1984a).

The data analysis was based upon a chi-square test of independence for frequency data done with the CAT MOD procedure in SAS (SAS Institute, Inc., 1985), which transforms the data into a linear model. Effects of age, sex, and texture (A, GC, R) were tested. A chi-square test was used to determine the comparability of data between the 5-year-old children tested by Schwartz et al. (1984a) and those of the present study. Intrarater reliability was tested on a group of 21 children by comparing the first five trials with the second five. Interrater reliability was measured on a different group of 21 children with two observers administering five trials to each child (see Schwartz et al., 1984a).

Results

Tongue Position as Food Is Presented

Table 1 shows the percentage scores for the effects of texture, sex, and age on tongue position and movement. The tongue was observed behind teeth most frequently (71.4%). Positions on top of teeth (13.1%), and retracted 5 mm or more (11.6%) were followed by on or beyond lower lip (3.9%). A similar order was observed among the four age groups (see Table 1). There was a small increase in the most mature response (behind teeth) and a decrease in retracted 5 mm or more responses with age. There was also a small decrease in the on top of teeth position and a small increase in the on or beyond lower lip category with increasing age. The distribution of the percentage scores for both sexes was similar to that reported for textures.

It was expected that there would be no differences in the anticipatory position of the tongue as foods with different textures were presented to boys and girls of different age groups (5, 6, 7, and 8 years). There were no significant age (χ² = 7.07, df = 15, p = .956), sex (χ² = 0, df = 5, p = 1) or texture (χ² = 12.74, df = 10, p = .239) effects. However, a significant age–texture interaction (χ² = 59.56, df = 30, p < .001), as well as an age–sex–texture interaction (χ² = 45.40, df = 30, p < .035), was noted.

Tongue Position and Movement Upon Swallowing

The predominant response during swallowing was puckering (71.9%) followed by a smooth movement (14.5%) and pursed lips (13.2%). The tongue was no longer observed on top of the teeth or beyond the lower lip in this age group. The order of swallowing responses evolved with 5- to 7-year-olds showing the

<table>
<thead>
<tr>
<th>Position</th>
<th>Food</th>
<th>Sex</th>
<th>Age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R1</td>
<td>GC</td>
<td>A</td>
</tr>
<tr>
<td>Retracted 5 mm or more</td>
<td>17.4</td>
<td>3.0</td>
<td>14.3</td>
</tr>
<tr>
<td>Behind teeth</td>
<td>60.4</td>
<td>94.2</td>
<td>59.7</td>
</tr>
<tr>
<td>On top of teeth</td>
<td>19.6</td>
<td>2.5</td>
<td>17.2</td>
</tr>
<tr>
<td>On or beyond lower lip</td>
<td>2.6</td>
<td>0.3</td>
<td>8.8</td>
</tr>
</tbody>
</table>

Note: Data represent percentage scores for columns. R1 = Raisin 1, GC = graham cracker, A = applesauce. Age-texture interaction: χ² = 59.56, df = 30, p < .001. Age-sex-texture interaction: χ² = 45.40, df = 30, p < .035.
order *puckers-pursed lips-smooth movement* but 8-year-olds showing the order *puckers-smooth movement-pursed lips*. The increase in smooth swallowing was quite sudden; it occurred between the ages of 7 and 8 years. The increase in puckering was much smaller; it occurred between the ages of 5 and 6 years. *The increase in smooth swallowing occurred simultaneously with the decrease in the pursing response.* It was also expected that there would be no differences in the swallowing movements as differently textured foods were presented to boys and girls and to the different age groups. A highly significant effect of age ($X^2 = 68.24, df = 15, p < .0001$) and texture ($X^2 = 70.35, df = 15, p < .0001$) but not sex ($X^2 = 10.24, df = 5, p < .07$) was noted. There was a significant age-sex interaction ($X^2 = 66.83, df = 15, p < .0001$).

To make further comparisons between younger (Schwaab et al., 1986a) and older age groups, the 5-year-old children of the study by Schwartz et al. (1984a) and this study were compared. The results of the two investigations differed on measures of anticipation ($X^2 = 19.46, df = 5, p < .002$) and swallowing of food ($X^2 = 109.53, df = 5, p < .0001$). Recognizing the need for the further study of reliability, the data of Schwaab et al. (1986a) and Schwartz et al. (1984a) were used to generate a preliminary developmental curve for anticipation and swallowing of food. Food textures were averaged for the purpose of illustration (see Figures 1, 2).

When anticipating food, the *behind teeth* response was the most frequent among all age groups. Two- and 3-year-old children had the highest frequency, which declined at 5 years, after which a small but consistent increase occurred up to 8 years. The *retracted* tongue position fluctuated between 4.4% and 13%, with the 4- to 7-year-old group showing the highest values. The *on top of teeth* response peaked at 5 years (18.5%) and declined thereafter to 10.6% at 8 years. An inverse configuration compared to the *behind teeth* response was noted. Although the *on or beyond lower lip* response showed some fluctuation (3.0–8.5%), it seemed to represent a fairly constant residual in normal children.

Figure 2 lists children's oral activities during the swallowing of food. Among the younger age group (2 to 4 years) open mouth and forward positions of the tongue (*on top of teeth, and on or beyond lower lip*) were quite common. These were not apparent in the 6-year-olds. The most mature position, where the circumoral musculature is no longer used in swallowing (*smooth swallowing*), was only observed in the older age group (5 to 8 years, see Table 2). An inverse relationship existed between puckering and pursing: Puckering decreased from 4 to 8 years whereas pursing increased during the same period. The two responses were the most common and indicated the gradual change from the extensive participation of the facial musculature to an absence of its visible use in about one quarter of the children at 8 years of age.

**Observer Reliability**

When intraindividual reliability was tested by comparing the first five trials to the second five administered by the same investigator, there were no differ-

**Figure 1**

Tongue Positions in Normal 2- to 8-Year-Old Children Anticipating the Intake of Food

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Note. Behaviors were recorded when the food was 5 cm away from the lips. Data represent frequency responses expressed as a percent of the total of four categories.
Figure 2
Tongue Positions or Movements in Normal 2- to 8-Year-Old Children Swallowing Food

<table>
<thead>
<tr>
<th>Percent Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smooth</td>
</tr>
<tr>
<td>Puckers</td>
</tr>
<tr>
<td>Pursing</td>
</tr>
<tr>
<td>Tongue on top of teeth</td>
</tr>
<tr>
<td>Tongue on / beyond lower lip</td>
</tr>
<tr>
<td>Jaw open</td>
</tr>
</tbody>
</table>

Note. Data represent frequency responses expressed as a percent of the total of seven categories. Data of the 2- to 4-year-old children from the study by Schwaab, Niman, and Gisel (1986b) and of the 4- to 5-year-old children from the study by Schwartz, Niman, and Gisel (1984a) were used with the authors' permission.

Discussion

Tongue Position as Food Is Presented

Throughout our studies, a significant relationship between age, sex, and texture in anticipation of food has been demonstrated (Schwartz et al. 1984a; present study). The gradually maturing skill is characterized by a resting position of the tongue on the floor of the mouth, opposed to the mandibular teeth. Although the very young (2- and 3-year-olds) seem to use it more frequently than the 5- and 6-year-olds, this may be due to the differential growth rates of the tongue and mandibular arch (Cohen, 1977). This idea is supported by the observation that the more forward position of "on top of teeth" peaks at 5 years indicating that the tongue may have increased in size before the increase of the mandibular structures.

Both Schwartz et al. (1984a) and I and my collaborators (Gisel et al., 1984) have shown differences in 4- and 5-year-old normal children and children with Down's syndrome for sex-position interactions, as well as a sex-age-texture interaction in the present study. Schwaab et al. (1986a) could not verify this finding in 2- to 4-year-old children. It seems, therefore, that sex alone does not contribute to the way in which children anticipate food.

The contribution of various food textures to tongue position and movement must remain a matter of concern. Viscous (raisin) and pureed textures (applesauce) are anticipated in the same manner; solid food (graham cracker) is not. This may be due to the nature of the task involved. Raisins and applesauce can be passively received, whereas the graham cracker has to be actively bitten off. A forward tongue position might result in biting the tongue, whereas retracting the tongue would not permit taking a bite. The large response of "on or beyond lower lip" for the pureed texture (applesauce), which does not call for a biting response, seems to further support the points mentioned. Thus, the solid texture may elicit a more mature response from the subject than the other textures. We have made similar observations in children with Down's syndrome (Gisel et al., 1984). These data are also consistent with our observation that optimal chewing time is achieved earlier with solid than with viscous and pureed textures (Gisel, 1988). This may have important therapeutic implications. Sleight and Niman (1984) described how infants with Down's syndrome chew normally when they are given solid foods (wafers, bread sticks, graham crackers) whereas with pureed foods, such as applesauce, they exhibit sucking behaviors. Our data support the clinical findings of Sleight and Niman even at the stage of food anticipation by showing differential responses to various food textures among normal children and children with Down's syndrome.
Significant age differences were noted in 5- to 8-year-olds during swallowing. This may be attributed to the marked increase in smooth responses from 7 to 8 years and the concomitant decrease in pursing responses. In contrast to the more mature pattern that was used when food of a solid texture was anticipated, the swallowing of the solid texture consistently appeared less mature than the swallowing of the viscous and pureed textures. This may have been due to a greater effort needed for swallowing relatively dry food as compared to the other relatively more moist foods. Differences with regard to texture would also seem very apparent in 2- to 4-year-olds and in the 5- to 8-year-olds of the present study, clear differences were demonstrated by Schwartz et al. (1984a) and children with Down's syndrome (Gisel et al., 1984). Swallowing was further characterized by a much broader spectrum of behaviors (7 categories) than the anticipation of food (4 categories). When looking at the entire developmental continuum, some major transitions can be discerned. Forward-tongue positions and open-jaw swallowing were used only by the 2- to 4-year-old group and disappeared completely after 5 years of age when patterns similar to those found in adults began to emerge. These patterns were characterized by the smooth appearance of the circumoral structures. When examining the reciprocal relationship of pursing and puckering, puckering appeared to level off at the age of 6 years and give way to the smooth responses, whereas pursing continued to decrease. Schwartz et al. (1984a) have suggested that puckering is a more mature response than pursing.

Interobserver reliabilities have been consistently high between investigators of the same study.

Tongue Position and Movement Upon Swallowing

Schwaab et al. (1986b) reported a 0.82 interrater reliability as did Schwartz et al. (1984a) for the anticipation of all foods. Reliability figures for swallowing are 0.70 in the Schwaab et al. study and 0.75 in the Schwartz et al. study. Data of the present study show that there were no differences between the results of two independent observers. We encountered some difficulties when we compared reliability data across studies. Thus, differences were observed between the 4-year-olds in the Schwaab et al. study (1986b) and the Schwartz et al. (1984a) study. Similarly, differences were observed between the 5-year-olds in the Schwartz et al. study (1984a) and the present study. Such differences may have occurred because the eating categories are interpreted somewhat differently when the test is administered, and they have been discussed by Schwaab et al. (1986a). Because therapists use clinical judgment when administering a clinically meaningful test, the idea of training therapists for the reliable administration of this test should be considered for the future. However, these findings should not detract from the importance of having a preliminary baseline (see Figures 1, 2) against which behaviors of children with eating impairments can be compared.

Summary

A consistent pattern of tongue positions and movement was observed in normal 2- to 8-year-old children anticipating the intake of food. The tongue was predominantly held in a resting position behind the teeth (68%-82%). Other categories in order of declining importance were tongue on top of teeth (8%-18%), retracted 5 mm or more (4%-13%), and on or beyond the lower lips (3%-8.5%). It was found that swallowing undergoes marked changes from open-mouth swallows and contraction of the circumoral musculature to smooth swallowing without any perceptible circumoral activity. Although age, sex, and texture play a role both in the anticipation and the swallowing of food, these three factors do not always
affect tongue position and movement as a sole factor but interact with each other in their effects on tongue position and movement. The developmental curves presented are based on an average of approximately 20 children in each age group. Details for the various food textures as well as the sexes need to be defined more precisely in a future study. Therefore, the curves should serve only as a general guideline for the practicing therapist in helping him or her compare the behavior of children with eating impairments with the normal behaviors presented here.

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References