Lateralization of Tongue Movements During Eating in Children 2 to 5 Years Old

(assessment, eating; child development; mouth)

Erika G. Gisel, Lynn Schwaab, Loren Lange-Stemmler, Carol W. Niman, Jeannette L. Schwartz

Normative data on skills of the tongue used in eating are presented. Normal children 2 to 5 years old were studied regarding their preference of placing food either on the right or left side when eating, and they were compared with age-matched Down's syndrome children. In addition, the ability to move food from the right to the left side of the mouth was studied.

Normal children underwent a transition from predominantly placing food on the right side at 2 years of age to predominantly placing it on the left side at 4 years of age. Among Down's syndrome children females preferred the right side, and males preferred the left side. The ability to move food from right to left (lateralizing) undergoes a developmental progression from tilting the head to rolling, followed by slow and eventually by smooth movement from one side to the other. Only 15% of the 5-year-olds were able to move food smoothly from side to side. These data provide a baseline against which children with eating problems can be compared.

Oral motor patterns of infants undergo rapid changes during the first two years of life and appear to adapt to the feeding needs of the growing organism. Thus, antero-posterior movements of the tongue predominate during the early months of life when sucking is the main mode of nutrient ingestion (1). The increasing ability of the tongue becomes evident in the change from sucking to more discrete movements during eating.

Munching, an up-and-down movement of the jaw, enables the child to make the transition from liquid to soft foods, such as cooked fruits or foods, which dissolve in the mouth when mixed with saliva. During infancy, tongue, lower lip, and mandible move together as a unit during eating and swallowing (2). A mature pattern of chewing is achieved gradually; it is characterized by increased mobility and independence of the tongue from the other oral structures (2).

Tongue and jaw movements during chewing have been described (3-6). The work done by Schwaab (7) and Schwartz and associates (3, 4) illustrates that important transitions of chewing and swallowing occur between 2 and 3 years of age and again between 4 and 5 years of age. These changes enable the child to chew efficiently an increasing variety of food textures.

Lateral movements of the tongue are of major importance in increasing the efficiency of chewing. They consist first of a gross rolling type of movement, the on-
set of which has been reported at around 5 months of age (8). Later-
ализation progresses from place-
ment of food over molars, and re-
taining it there for chewing, to the
ability to move food from the cen-
tral incisors to either side of the
mouth. The most mature pattern
is the movement of food from one
side of the mouth to the other (8).

Although the development of
tongue lateralization is known, the
exact temporal progression of
these patterns has not been de-
scribed. It is also not known
whether different food textures in-
fluence the development of lateral
tongue movements.

Therefore, the lateralization of
tongue movements was studied in
three groups of children 2 to 5
years old. The purpose of this
study was to describe the develop-
ment of tongue lateralization and
to compare findings on normal
children with findings on a group
of age-matched Down’s syndrome
children. Such information will
provide the clinician with a base-
line for effective patient assessment
and treatment planning.

Material and Methods

Sample

A total of 122 children was stud-
ied over three years. A group of
twenty 4-year-olds (10 males, 10
females) and twenty 5-year-olds
was studied in 1981 (9). Twenty-
six Down’s syndrome children (14
males, 12 females) were studied in
1982 (10). Fourteen were 4 years
old, and 12 were 5 years old. Sev-
enteen 2-year-olds (9 males, 8 fe-
nales), nineteen 3-year-olds (9
males, 10 females), and twenty 4-
year-olds (10 males, 10 females)
were studied in 1983 (7). All sub-
jects selected were of the same race
(Caucasian), because the oral struc-
ture measurements vary for differ-
ent racial groups (11). Among the
normal 2- to 5-year-olds, children
were excluded if they had medi-
cally diagnosed neurologic prob-
lems or mental retardation, oral
defects such as cleft palate or cleft
lip, one or more obviously decayed
teeth, or speech defects. Among
the Down’s syndrome group, chil-

dren with obviously decayed teeth
or periodontal disease were not in-
cluded. Five had congenitally miss-
ing teeth; all the others had full
primary dentition. One child had a
repaired cleft palate. All children
were from middle to upper middle
class homes. Children were re-
cruited from day-care centers,
nursery schools, the Special School
District of Greater St. Louis, and
through private contacts.

Procedures

Two tongue positions during
eating were observed. In the first
the tongue moved food after a bite
of graham cracker was taken or

When a raisin (raisin 1) was placed
behind the lower incisors. The fol-
lowing categories of movement
were recorded: right molar, left mo-
lar, and other. The other category
consisted of right/left canines or of
holding food over the left and right
equally.

In the second position the
tongue moved the food from one
side of the mouth to the other on
command. The raisin was placed in
random order either on the right
or the left molars (raisin 2). The
investigator tapped the child on the
opposite cheek and said, “Move the
raisin to this side.” The following
categories were recorded: smoothly,
side to side; slowly, side to side; rolls
tongue, side to side; does not move
food; tilts head; uses fingers; and
other. Ten raisins were used with
each of the normal children, and
six were used with each Down’s
syndrome child.

Testing occurred between 9 AM
and 11:30 AM. Eating observa-
tions took place in a quiet room at the

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right molar</td>
<td>51.2</td>
<td>49.7</td>
<td>38.0</td>
<td>38.6</td>
</tr>
<tr>
<td>Left molar</td>
<td>45.1</td>
<td>49.2</td>
<td>59.8</td>
<td>61.4</td>
</tr>
<tr>
<td>Other‡</td>
<td>3.7</td>
<td>1.1</td>
<td>2.2</td>
<td>—</td>
</tr>
</tbody>
</table>

Data represent percentages for columns: N = 56; 28 males, 28 females.
* Graham crackers and raisins.
† Data from Schwartz (9) with permission; N = 40; 20 males, 20 females.
‡ Right/left, canines; right/left, equally.
child's school, at the day-care center, or in the child's home. Procedures were the same as described previously (3, 4, 12, 13). Briefly, the investigator and the child sat facing each other. The investigator presented 10 bites of graham cracker broken into quarter sections and 20 raisins to normal children in random order. Only 6 bites and 12 raisins were presented to Down's syndrome children because their attention span and their endurance are lower than the attention span and the endurance of normal children. Each child was observed once for 15 to 20 minutes.

Data analysis was based on a $X^2$ test of independence. A log-linear model was chosen (14) and executed via a computer program BMDP-4F-multiplication tables analysis (15). The method used to compare reliability accounted for within-subject and between-observer variability. Intraclass correlations were computed by using the method of Ebel (16).

Results

The following three research questions were addressed:

1. Do children 2 and 3 years old and 4 and 5 year-olds have a preferred side for the initial movement of food in the mouth?

2. Are preferences for placing food in the mouth the same for normal children as for children with Down's syndrome?

3. What are the tongue movements of children moving a raisin from one side of the mouth to the other?

The following hypothesis was tested: There is no difference in the preferred chewing side between 2- and 3-year-olds and 4- and 5-year-olds.

<table>
<thead>
<tr>
<th>Investigator 1</th>
<th>Investigator 2</th>
<th>$X^2$</th>
<th>df</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raisin 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right molar</td>
<td>42.5</td>
<td>46.0</td>
<td>0.4</td>
<td>1</td>
</tr>
<tr>
<td>Left molar</td>
<td>57.5</td>
<td>54.0</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Graham cracker</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right molar</td>
<td>35.1</td>
<td>39.0</td>
<td>0.36</td>
<td>1</td>
</tr>
<tr>
<td>Left molar</td>
<td>64.9</td>
<td>61.0</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

Data represent percentages for columns.

Investigator 1: $N = 56$; 28 males, 28 females; data from Schwaab (7) with permission.

Investigator 2: $N = 40$; 20 males, 20 females; data from Schwartz (9) with permission.

Where the Tongue First Moves the Food

A shift from right-side to left-side preference was noted from 2 to 5 years of age (see Table 1). Thus, 51.2% of all 2-year-olds placed food on the right side, whereas only 38% of the 4-year-olds chose the right side. Forty-five percent of the 2-year-olds placed food on the left side, whereas 60% of the 4-year-olds chose the left side. Right and left were equally distributed (50% vs. 50%) at 3 years of age. The left-side preference persisted at 5 years of age (i.e., 61.4% vs. 38.6%).

To determine whether the 2- and 3-year-old children of Investigator 1 differed from the 4- and 5-year-old group of Investigator 2, the 4-year-old groups of Schwaab (7) and Schwartz (9) were compared (see Table 2). No significant differences were found in the initial tongue placement of raisin 1 ($p = 0.53$) and graham cracker ($p = 0.55$). Thus, the data of the two authors were comparable. The younger group was then compared with the older group (see Table 3). No differences in tongue place-

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>2</th>
<th>3</th>
<th>(n)</th>
<th>4</th>
<th>5†</th>
<th>(n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raisin 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right molar</td>
<td>49.0</td>
<td>39.2</td>
<td>(36)</td>
<td>46.2</td>
<td>37.8</td>
<td>(40)</td>
</tr>
<tr>
<td>Left molar</td>
<td>51.0</td>
<td>60.8</td>
<td>(36)</td>
<td>53.8</td>
<td>62.2</td>
<td>(40)</td>
</tr>
<tr>
<td>Graham cracker</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right molar</td>
<td>57.1</td>
<td>61.3</td>
<td>(36)</td>
<td>38.4</td>
<td>39.4</td>
<td>(40)</td>
</tr>
<tr>
<td>Left molar</td>
<td>42.9</td>
<td>38.7</td>
<td>(36)</td>
<td>61.5</td>
<td>60.6</td>
<td>(40)</td>
</tr>
</tbody>
</table>

All data represent percentages for columns.
† Data from Schwartz (9) with permission.
* $X^2 = 29.4, df = 3, p < .0001$.

<table>
<thead>
<tr>
<th>Males</th>
<th>(n)</th>
<th>Females</th>
<th>(n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raisin 1 and graham cracker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right molar</td>
<td>35.8</td>
<td>(14)</td>
<td>53.4</td>
</tr>
<tr>
<td>Left molar</td>
<td>64.2</td>
<td>(14)</td>
<td>46.6</td>
</tr>
</tbody>
</table>

Sex by position: $X^2 = 8.91; df = 1; p < 0.003$.
All data represent percentages for columns.
† Data from Lange (10) with permission.
ment were found for raisin 1, but a significant difference was noted for graham cracker ($X^2 = 27.4; df = 3; p < .0001$; see Table 3a).

There were no significant differences between raisins and graham crackers in children with Down’s syndrome. However, a significant sex-by-position interaction was noted in the latter group (see Table 3b). Males showed a left-side preference of 64.2% (right-side preference was 35.8%), whereas females showed a right-side preference of 53.4% (left-side preference was 46.6%). ($X^2 = 8.91; df = 1; p < .003$.)

The movement of food from one side of the mouth to the other (lateralization) is one of the more advanced oral motor skills a child develops. Our data (see Table 4) show the progression from attempts at lateralization to successful completion of this skill. At 2 years of age, one-third of all children were unable to lateralize; this number declined to 0.0% at 5 years of age. The sequence of lateralization progresses from tilting the head, to rolling food, to moving food slowly, and then to moving food across smoothly and efficiently. The smooth motion increases from 7.0% at 2 years of age to 15.4% at 5 years of age. However, rolling and slow movement were still predominant and increased from 38% to 76% between 2 and 4 years of age. Although only 55.2% of the responses were in the slowly and rolls categories among 5-year-olds, this low percentage was offset by 16% of puckers. Some of the older children of Schwartz (9) moved food with their mouths closed, and thus the tongue could not be observed. Two-year-olds did not use fingers to move food. Fingers were used by 5.8% of the 3-year-olds and by 1% and 0% of the 4- and 5-year-olds, respectively. The category other declined from 14% at 2 years of age to 6.5% at four years of age, indicating that, as children became more skillful at lateralizing food, awkward movements were observed less and less.

A comparison of the lateralization data by Schwartz (9) and Schwaab (7) should be regarded as preliminary. Although the authors agree on most items among 4-year-olds, rolls and other were the categories with the widest discrepancies.

Among children with Down’s syndrome, 1.2% and 17.2% moved food slowly across at 4 and 5 years of age, respectively. This rapid increase must be attributed to the contribution by males (see Table 4b). An average of 25% of children 4 and 5 years old rolled food from side to side. Inability to move food from side to side declined from 70.7% to 31.4% within one year, but alternate solutions, such as tilting the head or using fingers, increased from 4.9% to 25.7%. A significant age-by-position interaction ($p < .0000$) was noted. Marked sex differences in achieving lateralization skills were noted among Down’s syndrome children. Boys preceded girls in moving food smoothly across (15.0% vs. 1.4%, respectively), but girls outnumbered boys in rolling food across (33.3% vs. 16.3%, respectively). Boys outnumbered girls in not being able to move food across (61.2% vs. 43.1%, respectively), and a greater number of girls than boys used alternate solutions to

### Table 4

**a) Lateralization of Food* by the Tongue in Normal 2-, 3-, 4-, and 5-Year-Old Children**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Smoothly, side to side</th>
<th>Slowly, side to side</th>
<th>Rolls tongue, side to side</th>
<th>Does not move food</th>
<th>Tilts head</th>
<th>Uses fingers</th>
<th>Other</th>
<th>Puckers</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>7.0</td>
<td>20.4</td>
<td>17.8</td>
<td>33.8</td>
<td>7.0</td>
<td>0.0</td>
<td>14.0</td>
<td>16.0</td>
</tr>
<tr>
<td>3</td>
<td>9.9</td>
<td>23.2</td>
<td>53.2</td>
<td>0.0</td>
<td>1.6</td>
<td>5.6</td>
<td>6.3</td>
<td>16.0</td>
</tr>
<tr>
<td>4</td>
<td>14.5</td>
<td>36.5</td>
<td>39.5</td>
<td>0.5</td>
<td>1.5</td>
<td>1.0</td>
<td>6.5</td>
<td>11.3</td>
</tr>
<tr>
<td>5</td>
<td>15.4</td>
<td>52.1</td>
<td>3.1</td>
<td>0.0</td>
<td>2.1</td>
<td>0.0</td>
<td>11.3</td>
<td>16.0</td>
</tr>
</tbody>
</table>

$N = 56; 28$ males, $28$ females.  
All data represent percentages for columns.  
* Raisins.

**b) Lateralization of Food† by the Tongue in 4- and 5-year-old Down’s Syndrome Children**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Sex</th>
<th>Smoothly, side to side</th>
<th>Slowly, side to side</th>
<th>Rolls tongue, side to side</th>
<th>Does not move food</th>
<th>Tilts head</th>
<th>Uses fingers</th>
<th>Other</th>
<th>Puckers</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Male</td>
<td>1.2</td>
<td>23.2</td>
<td>70.7</td>
<td>4.9</td>
<td>7.5</td>
<td>4.9</td>
<td>4.9</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Female</td>
<td>17.2</td>
<td>25.7</td>
<td>31.4</td>
<td>25.7</td>
<td>7.5</td>
<td>22.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Age by position: $X^2 = 35.97; df = 3; p < .0000$.
Sex by position: $X^2 = 22.16; df = 3; p < .0001$.
Other: Consists of categories k, l, and m, as described by Schwartz (9).
All data represent percentages for columns.
† Raisins; data from Lange (10) with permission.
move food (22.2% vs. 7.5%, respectively). A significant sex-by-position interaction was noted (p < .0001). In general, skills improved greatly from 4 to 5 years of age, but when compared with normal children, Down's syndrome children lagged behind markedly.

**Observer Reliability**

Reliability was computed for one observer by comparing the first half with the second half of each trial, and between two independent observers over five trials each (three trials for Down's syndrome children). The first procedure was necessary to demonstrate that children responded consistently over all 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 half of the total of all trials for each food.

For all children, reliability of "where the tongue first moves the food" ranged from .54 to .64 for one observer, and from .53 to .83 for two observers. For "tongue lateralization" reliability ranged from .46 to .58 for one observer and from .41 to .45 for two observers. The lower values occurred mostly with data from Down's syndrome children, with whom fewer trials were used and with whom a larger variability of eating behavior was generally observed.

**Discussion**

A shift in preference of initial food placement from the right to the left side took place in normal children between 2 and 4 years of age. Thus, a more mature response was established at 4 years of age, which persisted at least to 5 years of age (9). The shift to left-side preference of food placement is supported by the work of Proffit and associates (17). When graham cracker and raisin 1 responses were separated, right-side preference was observed at 2 and 3 years of age for graham cracker, whereas left-side preference prevailed at 4 and 5 years of age. In raisin 1, right and left placements were distributed equally at 2 years of age, whereas left-side preference was already established at 3 years of age. Thus, it appeared that in younger children solid foods that dissolve in the mouth elicited a right-side preference, whereas viscous (non-dissolving) foods elicited a left-side preference. This observation may need further investigation with other foods of viscous and solid texture to determine whether side preference in young children is indeed texture dependent.

Although Down's syndrome children as a group also showed a left-side versus left-side preference (44.1%, left side; 55.9%, right side) (10), a closer inspection of the data revealed a significant right-side preference in females and a left-side preference in males. The more mature responses in Down's syndrome males with respect to initial food placement in the mouth was also observed in other categories of the eating assessment. Males showed more normal tongue positions when anticipating food than did females. Similarly, males demonstrated more normal tongue patterns than did females during swallowing (11). Whether these findings are unique to the sample studied needs to be verified by others.

Moving food from one side of the mouth to the other proceeds from primitive to more skilled patterns of movement by the tongue. Similar developmental sequences were described by Morris (8). These sequences were placed in chronological order for the first time in this study. Although Morris describes the appearance of lateralization at the early age of 5 months, one-third of our 2-year-olds were not able to move a raisin across the mouth at all, and only 15.4% of the 5-year-olds moved a raisin smoothly from side to side. Whether this low level of achievement of the task is due to the particular food chosen needs to be studied further.

Four-year-old Down's syndrome children were less skilled than normal age mates in moving food from one side of the mouth to the other. In fact, most did not lateralize food at all (71%). Compared with normal children, only half of the Down's syndrome children resorted to alternate methods such as tilting the head or using fingers. The five-fold increase of alternate approaches to lateralizing at 5 years of age may suggest that some of the 4-year-olds did not understand the instructions although they had watched a demonstration by the investigator (10). Gender
differences were again observed, with fewer girls showing the most mature pattern.

**Summary**

Normal children 2 to 5 years old underwent a transition from placing food preferentially on the right side to placing it preferentially on the left side as they got older. The same was observed in age-matched Down's syndrome children, except that a right-side preference existed in females for solid foods. Transitions in lateralization were characterized by a tilting of the head, rolling of the tongue, and eventually smooth movement from side to side. Smooth movement was only gradually achieved; rolling and slow movement from side to side were still predominant in 4-year-old normal children, whereas slow movement was achieved by half of the 5-year-olds. The percentage of Down's syndrome children who accomplished this task was even smaller than the percentage of normal children.

**REFERENCES**