ORIGINAL ARTICLE

Oral perception in tongue thrust and other oral habits

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Oral stereognosis is the ability of the mouth to recognize shape and texture. Oral shape recognition is sensitive to repetition and to topical mucosal anesthesia. Age, upper and lower arch perimeter, and labiolingual dysfunction also interact with oral stereognosis. The purpose of this investigation was to define the influence of age, arch size, and oral dysfunction on oral stereognosis when submitted to repeated trials. Fifty subjects were selected before orthodontic treatment. Each subject underwent 4 trials: T1 and T4 without anesthesia and strictly similar, T2 with topical anesthesia of the tongue, and T3 with topical anesthesia of the palate. Five test pieces or stimuli were used. The recognition time (RT) of each stimulus, the perimeter of upper and lower anterior dental arch, and the labiolingual dysfunction index (LLDI) were the main variables statistically evaluated. Subjects with a mild degree of dysfunction needed more time to recognize the stimuli in T3 when compared with T2. The number of RT3 > RT2 was 2.5 ± 1.12 in the group with a low LLDI (12 ± 1.5), and 1.57 ± 0.63 in the group with an LLDI of 16 ± 2.5 (P > .05). This may be attributed to different manipulation of the test pieces between the 2 groups, which could have been modified through sensory deprivation. Bolus recognition before the swallowing act needs to be paralleled to stereognostic performance. (Am J Orthod Dentofacial Orthop 2000;118:385-91)

Tongue thrust in swallowing and speech and other active or postural habits, such as tongue–lower lip seal, are frequently observed. Tongue thrust is often expressed in frontal or lateral open bite patients, whereas other habits may be observed in individuals with protruding upper incisors. Many authors[1-3] attribute oral habits to sucking and mouth breathing,[4-6] sensory stimulation,[7,8] or bad oral perception.[9,10] If bad oral perception is a factor, it should be possible to assess its influence on tongue posture and displacement.[10] It has been suggested that tongue ability may be tested through shape recognition or oral stereognosis.[9]

Oral stereognosis is the capacity of mouth organs to recognize shapes. It results from the stimulation of peripheral exteroceptive tact and mechanoreceptors and the central discrimination of the transmitted impulses at the cortex.[11]

Touch- as well as taste-afferent signals mainly follow the trajectory of the trigeminal nerve, but also the glossopharyngeal and facial (chorda tympani) nerves. Aside from the integrity of nerve transmission, oral stereognosis requires a performing activity of:

1. The intraoral and extraoral muscles that allow the test pieces to be palpated between the tongue and the surrounding structures in order to help define its configuration.
2. The cerebral areas in charge of evaluation of the sensory input and comparison with previously stored images.

Like visual or manual stereognosis, oral recognition requires coordination between the loci that collect sensation data and those that distinguish or perceive shapes. Oral stereognosis was first investigated in 1960.[12] Geometric and nongeometric forms were developed as stimuli to test oral recognition. The National Institute for Dental Research tested 20 plastic and metallic pieces for this purpose.[12,13] Performance in stereognosis seems to be affected by age, cultural, and dental factors, as well as the orthodontic state of the oral cavity.[12,14-17] Taste and hearing are also involved,[18] but gender appears to have no influence. Recognition may be enhanced by training.[19]

In order to avoid the learning effect in any attempt to investigate reliability through repetition, a special procedure was developed that replicates various stereognostic trials, including topical anesthesia of the tongue and palate. It has been observed that repetition with anesthesia will lead to opposite results in different subjects. In order to explore the reason for such differences, we hypothesized that specific factors may, separately or in combination, influence perception.

The objective of this investigation was to determine what influence age, upper and lower arch size, and local functional factors have on the perceptive reaction to superficial anesthesia.

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Table I. Oral stereognosis, a synopsis of the methodology

Patient	• Subjects should have the same cultural background.* • They should be seated comfortably in a quiet and stable environment.*
Examiner	• A single examiner must assume total management of the test.* • An aid could be required to operate measuring devices as the chronograph for the recording of the recognition time.*
Stimuli	The test pieces should: • Have a familiar geometric pattern based on those suggested by the National Institute for Dental Research.* • Have a maximum length of 10 mm and a maximum thickness of 4 mm with a good ratio of length and width.* • Be easily described with a moderate degree of confusion.* • Be directly positioned in the mouth* and secured by a thread or a thin stainless steel wire when used in children or handicapped persons.
Recognition	The protocol of recognition should be well established and well understood by the subject. It could be one of the following: • Oral description of the shape* • Drawing the test piece on a sheet of paper • Pointing to a similar pattern reproduced on a chart or a PC screen, illustrating all tests pieces in natural or proportionally enlarged size • Pointing to a computer-managed slide show that displays the illustration of the test pieces
Scoring	May be based on the response, the time of recognition, the pressure exerted on the piece or the amount of saliva excreted during the recognition. • The response with 2 different scale systems: 1. A 2-point scale with correct (1) or incorrect (0) identification* or 2. A 3-point identification that will be scored respectively for the correct (2), for the partially correct (1), and for the incorrect (0) answer. • The time spent to recognize 1 piece, which starts with the closure of the mouth and ends with the oral recognition by yes or no or the pointing to the illustrated shape. Description is not included in the time of recognition.* • The pressure exerted during recognition is measured by a strain gauge.
Oral conditions	• The first (reference) test should be performed in an asymptomatic dental and oral condition with no history of recent treatment, current pain, or excessive tooth mobility.*

*Indicate the methodological steps applied in the investigation.

MATERIAL AND METHODS

Fifty subjects, 8 to 17 years old (median age, 10 years 6 months; range, 8 years 1 month to 17 years 4 months) were selected at random from a regular orthodontic practice before any orthodontic treatment. All had a history of oral habits, including lower lip-tongue or lower incisal seal or tongue thrust. The selection included patients representing a wide variety of ages, levels of dysfunction, and degrees of malocclusion. The oral stereognostic test, described in Table I, was strictly applied and repeated in 4 different trials at 1 session. Five test pieces of simple and more complex geometric shapes were selected (Fig 1). The same stimuli were used in different order in the various trials. The trials were as follows: T1, without anesthesia; T2, with anesthesia of the tongue apex using a topical pineapple-flavored jelly for 1 minute; T3, with anesthesia of the incisal papilla and the area behind the upper incisors; and T4, without anesthesia. The trials were separated by 5-minute intervals.

Before the 3 last trials, tongue and palate sensation were tested using a 2-point discrimination test.[20] An I-shaped or U-shaped pointing device, made of 0.3-mm stainless steel wire (the U form was approximately 3-mm wide) was applied using light pressure (>5 g) and heavy pressure (>50 g). Trials T2 and T3 were performed only after the subject responded in the negative 3 times.

Evaluation

Forty variables were selected. Among them were:

1. Age, calculated in months
2. Labiolingual dysfunction index (LLDI),[21] used to evaluate oral dysfunction. LLDI is based on the clinical observation of the lips, tongue, and cheeks at rest and during specific perceptive and active tasks, including speech and swallowing. The maximum score is 30 and the minimum is 0.[21]
3. Recognition time (RT) for identifying the test piece, used as the only stereognostic variable. It was expressed in seconds (s) with an accuracy of .01 s. RTs for the 5 test pieces were designated A, B, C, D, and E (Fig 1). RTs for the 4 trials were subclassified and labeled according to each test piece, from 1 to 4. A wrong answer or no answer was given the maximal penalty time of 60 s.
4. Upper and lower arch forms, measured in width (W), length (L), and perimeter (P). The site of the measurement was defined as 3 for the canine area and 6 for the molar area, and as U for the upper arch and L for the lower arch. Hence, the width measured at the upper canine area was labeled W3U. Measurements were made in millimeters using a modified caliper (Fig 2). Reference points

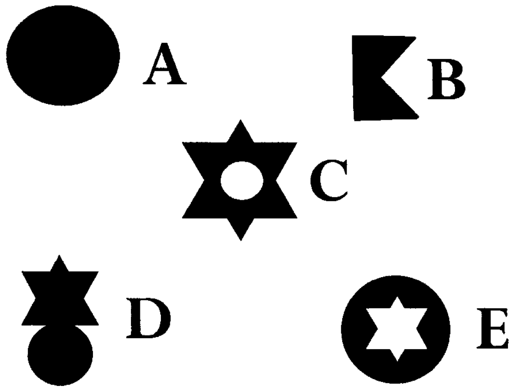

Fig 1. Stereognostic test pieces (stimuli) used in different trials.

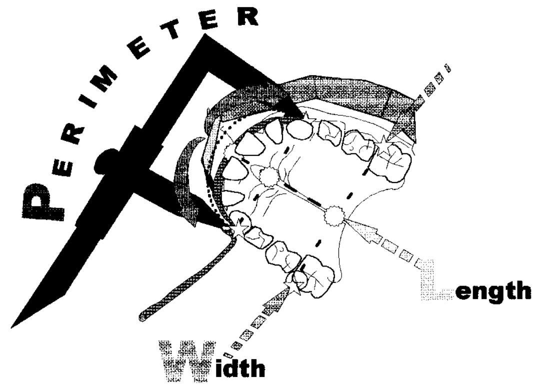

Fig 2. Assessment of dental arch size.

for measuring width and perimeter were 2 mm cervical to the cusps of the left and right canines and the mesiobuccal cusps of the left and right first permanent molars. Length was assessed as a median sagittal perpendicular drawn from the line joining the left and right (reference) cusps of the canines and molars to the central incisor edge.

The remaining variables resulted from the first statistical evaluations and included recognition time of the second trial minus recognition time of the third (RT2 – RT3) and the number of test pieces showing increased recognition time from the second trial to the third (# RT3 > RT2, could reach a maximum score of 5 for each subject).

Statistical Methods

The data were tested for normality (probability plots) and evaluated using a correlation test and a 2-way analysis of variance followed by a 1-way analysis of variance.[22,23] The 50 subjects were sorted according to the following variables: age, from 8 years 1 month to 17 years 4 months; upper arch perimeter, measured from the left upper canine to the right (P3U), from 29.3 mm to 41.1 mm; lower arch perimeter, measured from the left lower canine to the right (P3L), from 21.6 mm to 40.0 mm; and LLDI, from 22 to 10.

A Wilcoxon rank sum test was followed by a comparison of the mean using the *t* test. The Wilcoxon test was applied to investigate the relationship between the variable RT2 > RT3 and age, arch size, and oral dysfunction. Data of the sorted variables of 10 cases were close to the median value that were removed. The selection was made for each of the files used for the analysis of variance. Two subgroups of 20 subjects each, sorted according to age, P3U, P3L, and LLDI, respectively, were created and ranked according to the variable RT2 > RT3 (Table I).

RESULTS

Correlations

1. The recognition times of the test pieces were weakly correlated to each other. The trials, especially those performed with form E, showed greater correlations (Table III).
2. The second and third trials (RT2 and RT3) were the only ones that correlated for all the test pieces (Table II).
3. The variables assessing arch size (not illustrated here) correlated differently with age or degree of dysfunction. Upper arch perimeter (P3U) and lower arch perimeter (P3L) seemed to be the only measurements that were independent from each other as well as from the subject's age or LLDI level.

Analysis of Variance

Factors. Each of the factors (test piece, trial, age, upper and lower arch perimeter, LLDI) influenced the resulting stereognostic score, with differences in their main effects.

Groups. The trend in the data leads to different recognition times when the sorted values decrease or increase. The second group required less time for identification than the first when comparing age, upper arch perimeter, or LLDI. Lower arch perimeter showed a reverse influence, with the RT greater in the group with a larger arch size (group II) (Fig 3).

Test pieces. Test pieces were recognized differently at the .01 level of significance: A, 8.77 s; B, 11.32 s; C, 11.69 s; D, 16.35 s; and E, 10.37 s. When related to the trials in the 2-way analysis of variance, each of the 5 test pieces showed significant differences for RT

Table II. Groups sorted according to median value of each main effect

Group	*Mean age*	*SD*	*Mean P3U*	*SD*	*Mean P3L*	*SD*	*Mean LLDI*	*SD*
I	9 y 1 m	6 m	32.4 mm	1.3	26.8 mm	2.2	16	2.5
II	14 y 2 m	20 m	37.3 mm	1.2	32.6 mm	2	12	1.5

Table III. Correlation matrix of test pieces

Piece	*RT1/RT2*	*RT1/RT3*	*RT1/RT4*	*RT2/RT3*	*RT2/RT4*	*RT3/RT4*
A	A1/A2 NS	A1/A3 NS	A1/A4 NS	A2/A3 .59***	A2/A4 NS	A3/A4 NS
B	B1/B2 NS	B1/B3 NS	B1/B4 .47**	B2/B3 .38**	B2/B4 NS	B3/B4 NS
C	C1/C2 .50***	C1/C3 .32*	C1/C4 NS	C2/C3 .43**	C2/C4 NS	C3/C4 .38**
D	D1/D2 NS	D1/D3 .45**	D1/D4 NS	D2/D3 .48**	D2/D4 NS	D3/D4 .31*
E	E1/E2 .41**	E1/E3 .73***	E1/E4 .55***	E2/E3 .33**	E2/E4 .61***	E3/E4 .51***

*P < .05; **P < .01; ***P < .001.

Table IV. Nonparametric and parametric comparison of the number of test pieces that needed longer recognition time in third stereognostic trial than in second (Wilcoxon rank sum test, *t* test)

Sorting variable	*I*	*II*	*Z*	*P*	*Mean I*	*SD*	*Mean II*	*SD*	*P*
Age	379	441	–0.84	NS	1.87	0.99	1.95	0.94	NS
P3U	384	436	–0.7	NS	1.87	0.05	1.95	0.89	NS
P3L	404	416	–0.16	NS	1.9	0.91	1.93	1.03	NS
LLDI	342	478	–1.84	<.05	1.57	0.63	2.25	1.12	<.05

between trials. Test pieces A and B were less affected by repetition than the 3 other test pieces. The RTs for C and E varied more than for the remaining shapes with regard to age, arch size, and oral dysfunction.

Trials. The test repetitions indicated a significant learning effect. The RTs in trial 4 for all test pieces were shorter than those in trial 1. In trial 2, after anesthesia of the tongue tip, the subjects usually took more time to discriminate the shape of the stimulus than in trial 3 (anesthesia of the upper retroincisal area, RT2 > RT3). In a relatively high percentage of cases—40% of the total tests and 66% of the tests with pieces C and E—RT3 was greater than RT2. In these cases, the effect of age, arch size, or dysfunction on recognition was almost always significant.

In the group with the larger arch perimeter (P3U), the stimulation with test piece A also resulted in a greater RT2 than RT1 (A2 > A1).

The Wilcoxon Rank-Sum Test

Table IV shows that of the various main effects, only LLDI seems to be statistically significant. The sum of ranks of the variable RT3 > RT2 was higher in the group with light dysfunction.

The *t* Test

The *t* test confirmed the previous finding. The number of subjects in trial 3 with greater recognition times was significantly greater (2.25) in group II than in group I (1.57, P > .01) (Table IV).

The 1-Way Analysis of Variance

The 1-way analysis of variance compared trials and forms in the 2 subgroups. In the file sorted according to LLDI, it indicated that 2 test pieces (C and E) seemed to be particularly able to discriminate the level of dysfunction, with their complex shapes stimulating differently the subjects when submitted to palatal anesthesia (Fig. 4).

Group I showed a regular reduction in RT from trial 1 to trial 4, whereas group II showed a marked increase in RT at trial 3. The effect of tongue anesthesia, which was otherwise less evident, seemed to increase the recognition time of shape A in group II. This finding needs to be compared with the previous one concerning reduction in recognition time through repetition in individuals with larger upper arch perimeters.

DISCUSSION

Sensation and motor behavior are closely related in the oral cavity. The trigeminal (V), glossopharyngeal (IX), and superior laryngeal (SLN) nerves influence the hypoglossal nerve and resulting tongue posture.[24,25] Even the control of swallowing by peripheral sensory feedback seems to be evident.[26-28] Tongue thrust or other oral habits may be associated with disturbed swal-

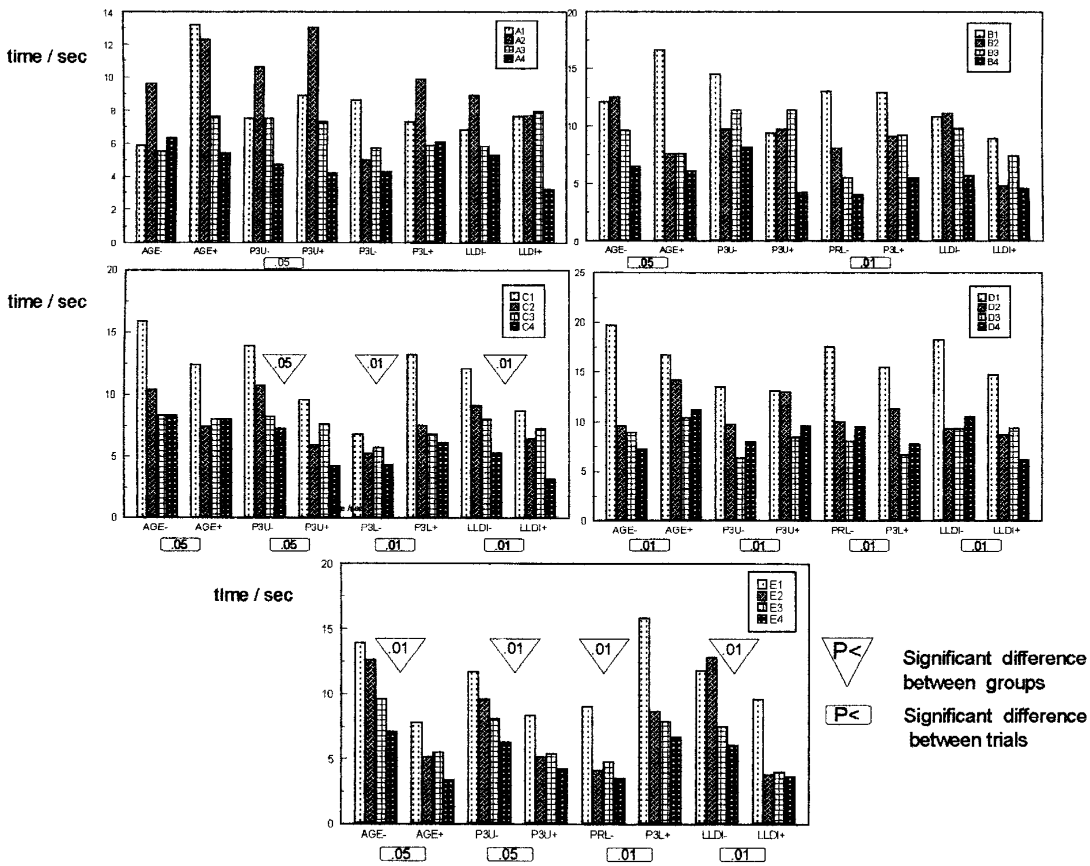

Fig 3. Two-way analysis of variance shows significant differences between groups selected according to one main effect (age, upper and lower anterior arch perimeter, and labiolingual dysfunction index) and between trials (1, 2, 3, and 4) for each shape (A, B, C, and D, and E).

lowing and speech.[29,30] Stereognostic ability could aid in assessing such dysfunction.[31-33] Stereognosis relies on perception, which is a further step in the central response mechanism to peripheral stimulation. It adds to the integrated sensation in the retrocentral gyrus other higher brain activities,[34] including the synthesis of different inputs such as memorization, discrimination, and identification. Shape and volume recognition needs iteration, practice, and integration.[35,36] Once acquired, it seems to be more anchored than a simple reflex to sensation or even trained muscle behaviors.

Our results confirm that the stereognostic approach as a psychophysical assessment of perception is applicable to the oral cavity. It shows a learning effect that seems to be directly related to the number of repetitions and to the complexity of the stimulus. Combined geometric shapes need more trials to be more quickly discriminated. The particular shape of test piece E and its possible confusion with that of piece C may be responsible for the higher correlations existing between different trials. This observation of a complex stimulus influencing perception could be paralleled to the effect of anesthesia expressed in the steady correlation between the second and the third trials. Though differently applied, topical anesthesia seems to have modified oral perception as previously observed.[15,34]

The measurement of arch perimeter, in comparison with the conventional assessment of width or length, seems to be independent from subject age or level of dysfunction. It should be investigated further in order to estimate its discriminating value when age and therapeutic influences are compared.

Comparison of the selected effects on oral stereognosis indicates that recognition time in seconds is sensitive to factors such as stimulus shape, repetition, age, arch size, and dysfunction. The more complex or confusing the shape, the more time will be needed to discriminate its details. Repetition usually simplifies

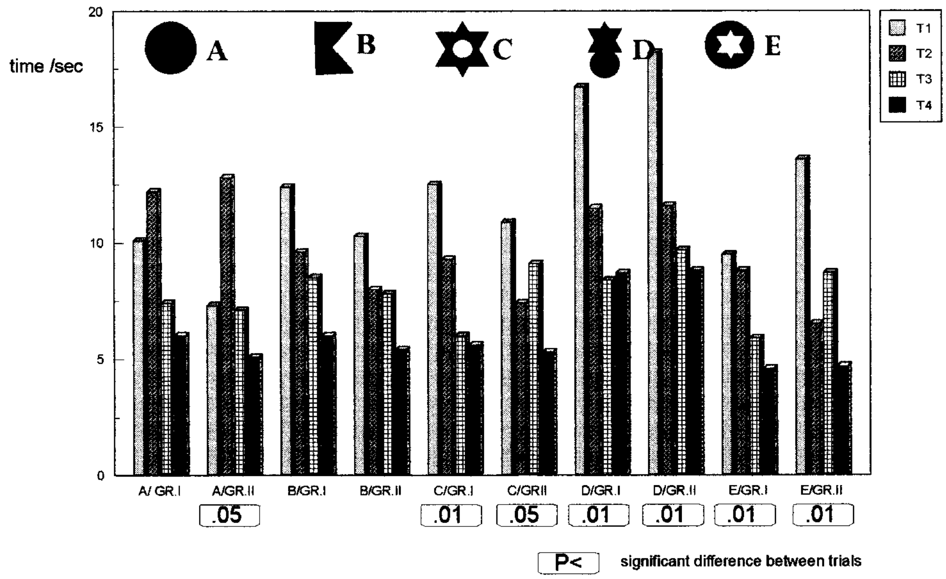

Fig 4. One-way analysis of variance displaying different test pieces and main effect trials in each group (T, trial; Gr I and II, groups).

recognition. However, the observation that topical anesthesia of the palate results in a smaller reduction in recognition time than anesthesia of the tongue is interesting. It seems to confirm what has been clinically observed, but needs more testing.

The Wilcoxon rank sum test helps to identify oral dysfunction as the only effect liable to modify oral stereognosis in relation to anesthesia. The effects of age and upper or lower arch perimeter were not significant. The *t* test expressed this trend; furthermore, a larger number of pieces seem to be related to the group with a lower LLDI. These findings strongly suggest that superficial tactile deprivation of the anterior palatal area influences the stereognostic ability in the group with less oral dysfunction. The 1-way analysis of variance adds further information: specific shapes (C and E) can discriminate severe or light dysfunction more than others.

Perceptive reaction to topical anesthesia of the palate is opposed to that following the one of the tongue tip. The reduction in recognition time through repetition was, with the exception of test piece A, almost always seen in our observations. Tongue tip sensory deprivation seems to be less likely to influence oral stereognosis, a conclusion that will support findings on surgical reduction of the tongue in macroglossia cases.[37] The round shape (A), should be further investigated in its relation to tongue tip anesthesia and upper anterior arch size.

The reduced stereognosis after palatal anesthesia in subjects with discrete signs of dysfunction needs to be better explained. Anesthesia modifies stereognostic manipulation and the oral site of recognition.[38] In adult swallowing, the motor sequence is to propel food from the mouth to the stomach[39] by placing the tongue on the palate lingually to the upper incisors.[27] Though not requisite for the motor act itself,[40,41] early stimulation of the buccopharyngeal region by the presence of the bolus can facilitate the initiation of swallowing.[39] Referring to the usual location of oral burns which are experienced when eating or drinking food that is too hot, it is probable that swallowing is sensory-initiated by the presence of the bolus behind the upper incisors. Infantile swallowing with tongue thrust or tongue-lower lip seal may be related to a different type of oral stereognosis than adult swallowing. Anesthesia may have less effect on those subjects who are used to recognizing food in other places within the oral cavity and more effect on those who need the palate for stereognosis.

The hypothesis that bolus recognition interacts with the swallowing act is interesting and needs further investigation. From a clinician's point of view, the major problem will be the selection of test pieces that would provide greater simulation of the bolus. Besides shape, texture and taste must be included and their relationship to various malocclusions more precisely defined.

CONCLUSION

Sensory feedback is important for muscle function. Stereognostic testing can be used to assess tactile perception. Oral recognition of shape is enhanced by repetition. Stereognosis is sensitive to age, upper and lower anterior arch perimeter, and oral habits. Findings on repetition and topical anesthesia strongly suggest that some test pieces may be useful in differentiating light from severe oral dysfunction, according to LLDI. The possibility of an interaction between bolus location, stereognosis, and the swallowing act needs further investigation.

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