AN INVESTIGATION OF OCCLUSION RELATIONSHIPS AND THE ARTICULATION BEHAVIOUR OF SCHOOL-AGED CHILDREN

Marcus Slotiuk
Student
University of Western Ontario

ABSTRACT

The purpose of this study was to examine the relationship between articulation and over-jet, over-bite, or both for school-aged children with Angle Class I and Class II occlusion patterns. Findings indicated that articulation behaviour was independent of the dental measurements for the overall sample of children examined. Abnormal articulation tended to occur with abnormal over-jet for children in the Class I occlusion group, that is, with normal molar occlusion. The Class II group, with abnormal molar occlusion, showed normal articulation whether or not over-jet or over-bite was present. In view of the findings, it was concluded that most children studied were able to compensate articulatorily for abnormal occlusion.

The clinical literature concerned with the relationship between articulation behaviour and dentition has sought to determine to what extent dental deviations influence articulatory performance (Starr, 1972; Bzoch, 1972). Sibilant phonemes have been investigated carefully owing to the importance of dental structure in the production of this phoneme class. Bloomer (1971) and Hall-Powers (1971), from a review of the literature of malocclusion and articulation, concluded that /s,z,ʃ,ʒ,tʃ,dʒ,θ,ð,f,v/ were the phonemes most frequently misarticulated in association with malocclusion. Of these, the /s/ phoneme appeared to be the most vulnerable.

Studies with school-aged children have revealed inconsistent results concerning the relationship between defective articulation and the presence of malocclusion of molar relationship and malocclusion of anterior mandibular and maxillary teeth (Shelton, Furr, Johnson, and Arndt, 1975; Subtelny, Mestre, and Subtelny, 1964; Ward, 1964). Ward (1961) found that incidence of misarticulation, visceral swallowing and molar malocclusion all increased in normal children from grades one to three. She reported that slightly over half the children (55.2%) with molar malocclusion produced defective (s,z/ phonemes. Her results, however, were not subjected to statistical testing to determine whether a significant relationship existed between articulation proficiency and malocclusion. An influence from deviant molar relationship was not found by Subtelny, Mestre, and Subtelny (1964). Of their measures of molar and anterior malocclusion, only degree of over-jet was positively related to misarticulation of the target /s/ in isolation. Except for the over-jet effect, malocclusion was not a significant factor influencing articulation unless it occurred in the presence of one of more marked dental deviations.

Malocclusion of the anterior maxillary and mandibular teeth was also found to influence articulation performance (Shelton, Furr, Johnson, and Arndt, 1975). The above authors examined the possible relationship between orthodontic deviation, articulatory status and articulatory improvement of the defective /s/ phoneme. They found that a "tendency to open-bite was associated with deviant /s/ production". A

study by Pendergast, Dickey, and Soder (1969) was cited in support of the open-bite finding. In neither study was over-jet found to be a contributing variable to deviant articulation.

It appeared that articulation proficiency and malocclusion were related in some studies. However, it is not clear what aspects of malocclusion were involved which hinder accurate articulation of sibilants and affricates. In some cases degree of over-jet appeared involved; in others, open-bite was the factor and in still others, molar occlusion appeared implicated.

Occlusion studies have been subject to some criticism because measurements of articulation and dentition have not been carried out independently (Winitz, 1969). Starr (1971) pointed out that knowledge of the status of a subject's dentition during articulation testing may influence judgments of articulatory proficiency. Both authors recommended further research to control for this lack of independence.

Because of the inconsistent relationship reported between malocclusion and articulation, and the lack of independent measurement of these two variables, the present study was undertaken. It investigated the relationship between articulation and malocclusion within a sample of school-aged children being screened for potential orthodontic abnormality. The investigation was designed to answer the following questions:

1) Do children with Angle's Class I occlusion (normal) show more singleton consonant articulation errors that children with Class II malocclusion for the phonemes /s,z,v,ʃ,ʒ,tʃ,dʒ,θ,ð/?
2) Is the presence of abnormal over-jet, over-bite or both (that is, the number of dental abnormalities) related to abnormal articulation of these phonemes?

METHOD

Subjects:

The subjects consisted of thirty-five school children who were native speakers of English. They ranged in age from 7 to 12 years, with a mean age of 9-3 years. A 6- to -12 year age range was selected because research indicated that all the phonemes under test were typically acquired by the age of 6 years and consequently, misarticulations would not be expected on the basis of a maturational factor (Prather, Hedrick and Kern, 1975; Sander, 1972). In order to eliminate the possible influence of intellectual deficits, only subjects who were enrolled in regular classroom placements were included. Hearing sensitivity was screened at 30 db across the frequency range 125, 250, 500, 1000, 2000, 4000, 8000 hz using a Maico (Model MA-16) audiometer to preclude the influence of hearing loss. Only subjects who passed the screening in both ears were included.

Dental Measurements:

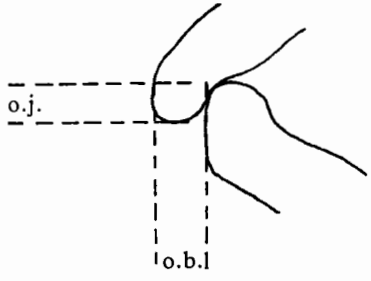
Dental measurements were made by two professors of Orthodontia on the Faculty of Dentistry at the University of Western Ontario. They classified the children's molar relationships according to Angle's method. The classes were described as follows: (Graber, 1972): "Class I - anteroposterior relationship of the maxillary and mandibular molars is correct, with the mesiobuccal cusp of the maxillary first molar occluding in the mesiobuccal groove of the mandibular first molar".

"Class II - the lower dental arch is distal or in posterior relation to the upper dental arch, as reflected by the first permanent molar relationship. The mesiobuccal groove of the mandibular first molar no longer receives the mesiobuccal cusp of the maxillary first molar but usually contacts the distobuccal cusp of the maxillary first molar, or it may be even further posterior. The interdigitation of the remaining teeth reflects this posterior relationship so that it is proper to say that the mandibular denture is 'distal' to the maxillary denture".

Malocclusion of anterior mandibular and maxillary teeth was measured in terms of amount of over-jet as a measure of the distance "from the labial edge of the mandibular incisor to the lingual incisor edge of the maxillary incisor" (Barnett, 1974). Over-bite was defined as a measurement of the distance "from the incisor edge of the maxillary incisor to the incisor edge of the mandibular incisor" (Barnett, 1974).

Over-jet and over-bite were measured in millimeters using a standard Boley guage. The presence of open-bite was noted but not quantitatively measured. According to the dental literature, normal over-jet and over-bite values range from 0 to 3.0 millimeters (Fleming, 1969; Birch, Higgens and Hallet, 1973; Barnett, 1974).

Figure 1. Orthodontic measurements of over-bite [o.b.] and over-jet[o.j.]



Articulation Materials and Testing Procedures:

Each subject was seated at a table across from an examiner. A Sony EMC-16 collar microphone was attached to the child's shirt and a Sony (Model TC-110B) cassette recorder was used to record the articulation test. Sixty-one pictures from a Peabody Articulation Cards Kit-Level P. (Dunn, Horton, and Smith, 1968) served as a stimuli to elicit the phonemes /s,z,f,v,ʃ,ð,θ,tʃ,ʒ,dʒ/ which were the sounds under test. These phonemes were selected because they were those most frequently reported to be associated with malocclusion. The pictures were presented in random order to each subject who was to name each picture simultaneously. Five of the pictures required examiner cues to elicit the desired word. If these were unsuccessful in eliciting the target word, the examiner said the word, placed the card aside and presented it again after two intervening stimulus items. If a spontaneous production was not forthcoming, the child imitated the examiner.

Stimulus words were selected such that the target phonemes occurred at least three times in prevocalic, intervocalic, and postvocalic positions. Several productions of each phoneme were required to minimize the possibility of chance misarticulation significantly influencing the results. Exceptions to this rule were /d_3/ which occurred only once both prevocalically and intervocalically and /$_3$/ which occurred twice in the intervocalic position only.

Normal articulation was defined as zero or one error as the current literature reported that children between the ages of 6 to 12 years usually made no more than one error on singleton consonants in all positions (Prather **et al**, 1975; Sander, 1972).

Prior to obtaining orthodontic measurements, each subject's tape-recorded articulatory responses were scored independently by two examiners approximately three weeks following the testing procedure.

A Pearson Product Moment Correlation Coefficient of +0.92 indicated a high degree of agreement between examiners' judgments. In cases of disagreement, each examiner totalled the subject's score and the mean error score was used.

RESULTS

Articulation Results:

The number of articulation errors made by the subjects ranged from 0 to 16.5 with 57.1% of the children producing zero or one error (normal articulation). The remaining subjects made up to 9 errors with the exception of one subject who made 16.5 errors. Subjects' error scores were distributed according to a J-shaped curve in the negative direction. Median values were therefore used for the measure of central tendency and are shown in Table I.

TABLE I. Medians and ranges for measurements of articulation errors, over-jet, and over-bite for Class I and Class II occlusion groups and for the total group.

Group	Articulation (no. of errors)		Over-jet (millimeters)		Over-bite (millimeters)	
	Median	Range	Median	Range	Median	Range
Calss I (N = 19)	1.12	0- 7.0	4.03	1.5-11.5	3.00	0-8.0
Class II (N = 16)	0.65	0-16.5	7.05	3.0-11.5	5.05	0-9.0
Total (N = 35)	0.83	0-16.5	4.54	1.5-11.5	3.98	0-9.0

Table I shows the median number of articulation errors and range of errors for the total group of subjects and for the subject divided into Class I and Class II molar occlusion groups. The median values of 0.83 and 0.65 for the total sample and the Class II group, respectively, were considered as normal articulation groups since median values did not exceed one error.

Interestingly, the Angle Class II malocclusion group made the least number of articulation errors. Since degree of Class II malocclusion was not measured by the orthodontists, its influence on articulation errors could not be ascertained. The Class I occlusion group (normal occlusion) deviated slightly from normal articulation performance, with a median error value of 1.12. These data suggested, then, that the deviant articulation of this group was not associated with deviant molar relationship.

Orthodontic Results:

Examination of Table I revealed that the overall sample in this study had median values greater than the norm for over-jet and over-bite, with medians of 4.54 mm, and 3.98 mm, respectively. This result was not surprising since the sample was obtained from a larger population of children being screened for potential orthodontic abnormality. The Class I group's median was slightly less than the overall group median for both over-jet and over-bite. The latter values were defined as abnormal for over-jet (4.03 mm) and maximal normal for over-bite (3.00 mm).

Class II occlusion group revealed the greatest deviations from normal for both measures, with abnormal over-jet being the most deviant (7:05mm) and over-bite less deviant (5.05 mm).

TESTING FOR THE INDEPENDENCE BETWEEN ARTICULATION AND DENTITION VARIABLES

a) Articulation and Occlusion Class:

A 2 x 2 contingency table (Table II) was constructed which categorized the subjects according to articulation (normal (N) or abnormal (A)) and occlusion (Class I or Class II).

TABLE II. Subjects dichotomized according to articulation and occlusion class.

		OCCLUSION CLASS	
		Class I	Class II
ARTICULATION	A#	9	6
	N!	10	10

$chi^2 = .059$

$p = .806$

$C'' = .099$

\# = Abnormal

\# = Normal

'' = Contingency Coefficient

Examination of Table II did not suggest an independent relationship between occlusion class and articulation performance. For the Class I group (normal occlusion), the number of subjects with normal and deviant articulation was almost identical. For the Class II group (malocclusion), a few more subjects demonstrated deviant rather than normal articulation. Statistical analysis using chi^2 substantiated the above findings ($chi^2 = .059$, $p = .806$).

The value of the corresponding Contingency Coefficient which measures the degree of association between articulation abnormality and occlusion class ($C = .099$) was

low relative to the maximum obtainable value for a 2 x 2 table (C = .707). Thus, the hypothesis of no association between articulation performance and occlusion class could not be rejected.

b) Articulation and Over-jet:

The 2 x 2 contingency tables (Table III was constructed which dichotomized the subjects according to articulation (normal (N) or abnormal (A)) and over-jet (normal (N) or abnormal (A)).

TABLE III. Subjects dichotomized according to articulation and over-jet for the total occlusion range.

	OVER-JET					
Total Sample (N=35)			Class I (N=19)		Class II (N=16)	
	A	N	A	N	A	N
ARTICULATION A#	14	1	8	1	6	0
ARTICULATION N!	13	7	4	6	9	1
	chi2 6 2.46		'Fisher's exact p = .039*		'Fisher's exact p = .625	
	p = .116		C'' = .451		C'' = .196	
	C'' = .334					

*p<.05

= Abnormal

! = Normal

'' = Contingency Coefficient

' = Fisher Exact Probabilities were computed where chi^2 was inappropriate.

Table III indicated that only for the Class I group (normal occlusion) was there a statistically significant relationship between articulation and over-jet (p = .039) using the .05 level of confidence. The value of the corresponding Contingency Coefficient (C) was moderate (C = .451) when compared with the maximum value (C = .707). For this group, therefore, the data indicated that abnormal over-jet and abnormal articulation were related.

A significant relationship between the two variables was found for neither the total sample (chi^2 = 2.46, p = .116) nor for the Class II occlusion group (p = .625) using the .05 confidence level.

c) Articulation and Over-bite:

Table IV shows contingency tables for the total sample and Class I and Class II occlusion groups for articulation (normal (N) and abnormal (A)) and over-bite (normal (N) or abnormal (A)).

TABLE IV. Subjects dichotomized according to articulation and over-bite for the total sample and Class I and Class II occlusion groups.

OVER-BITE

	Total Sample		Class I		Class II	
	A	N	A	N	A	N
ARTICULATION A#	9	6	6	3	3	3
ARTICULATION N!	12	8	3	7	9	1
	chi2 = .121		Fisher's exact p = .128		Fisher's exact p = .118	
	p = .727		C'' = .344		C'' = .408	

= Abnormal

! = Normal

'' = Contingency Coefficient

Examination of the data in Table IV did not suggest an independent relationship between articulation performance and abnormal over-bite. This was confirmed by statistical treatment which showed there were no significant relationships for the total sample ($p = .727$); for the Class I group ($p = .128$); or for the Class II ($p = .118$) group using the .05 level of confidence. The failure to reach significance suggested that any relationship between abnormal over-bite and abnormal articulation could have been due to sampling error.

d) Articulation and Number of Dental Abnormalitites:

In order to determine whether the number of dental abnormalities was associated with articulatory performance, 2 x 2 contingency tables were constructed. Table V shows these data for the overall sample and for the Class I and Class II occlusion groups. Subjects with the presence of either abnormal over-jet or no dental abnormalities were combined into one group, while subjects with the presence of both abnormal over-jet and over-bite represented the other group.

Only Class I occlusion group revealed a statistically significant relationship at the .05 level ($p = .049$). The corresponding Contingency Coefficient of .439 suggested a moderate association (relative to $C_{max} = .707$) between articulation and number of dental abnormalities. Subjects with zero or one dental abnormality tended to demonstrate normal articulation while subjects with two dental abnormalities tended to demonstrate abnormal articulation.

No significant relationship was found to exist for the total sample and the Class II occlusion group ($chi^2 = .021$, $p = .883$ and $p = 242$, respectively).

TABLE V. Subjects dichotomized according to normal [N] or abnormal [A] number of dental abnormalities for the total sample and Class I and Class II occlusion groups

	NO. OF DENTAL DEVIATIONS					
	Total Sample		Class I		Class II	
	2	0-1	2	0-1	2	0-1
ARTICULATION A#	8	7	5	4	3	3
ARTICULATION N!	9	11	1	9	8	2
	$chi^2 = .021$		Fisher's exact p = .049*		Fisher's exact p = .242	
	p = .883		C'' = .439		C'' = .299	
	C'' = .082					

*p < .05

\# = Abnormal

! = Normal

'' = Contingency Coefficient

DISCUSSION

No significant association between articulation performance, malocclusion, over-jet, over-bite and number of dental abnormalities were found for the total group of children screened for potential orthodontic abnormality.

When the total group was divided into Angle's Class I and Class II occlusion groups, however, the Class I group (normal occlusion) was the only group to show any relationships between articulation performance and the dental measures. Therefore, even normal molar relationships did not insure accurate articulation production. Class I subjects' articulation performance was related to the following dental abnormalities:

1) abnormal over-jet ($p < .05$)
2) number of dental abnormalities ($p < .05$)

In addition, it was found that over-bite alone did not occasion more articulation errors.

In the Class I group (N = 9) over-jet accounted for the relationship between articulation and over-jet for 8 children with over-bite accounting for the additional child who demonstrated abnormal articulation. While there were also children in this group who were able to compensate for both these dental abnormalities, of those who did not compensate, abnormal over-jet was the most influential of the two dental variables of over-jet reported by Subtelny **et al** (1964) who examined its effect on the /s/ phoneme in isolation.

The Angle's Class II occlusion group (N = 16), which represented a malocclusion between the maxillary and mandibular molar relationships, showed no association between articulation performance and the dental measures. In fact, this group showed the least number of articulatory errors with a median value of 0.65. This suggested that even with a malocclusion, the subjects appeared to be able to compensate for over-jet, over-bite or both. These results would support the conclusions of Bloomer (1971) and Cole (1972), that articulatory compensation for dental abnormality was the rule rather than the exception.

In order to understand better the nature of articulatory compensation, future, interdisciplinary research should focus on discovering the cluster of factors which prevent successful articulatory compensation for "dental and occlusal hazards" (Bzoch, 1972). It may be that static measures of dental parameters are less important than the dynamic movement patterns of the articulators related to dentition. Harvold (1970) has suggested investigating further the dynamic relationship between lips, tongue, and jaw, with reference to specific anatomical configurations of teeth and palate.

CONCLUSIONS

In the sample of 35 school-aged children screened for potential orthodontic abnormality, articulation accuracy was not found to be directly related to the presence of abnormal over-jet and/or abnormal over-bite. A significant relationship was found between articulation and over-jet only for children with normal molar occlusion (Angle Class I). Those with abnormal over-jet tended to make more articulation errors than those with over-jet within the normal range. A similar relationship was found between abnormal articulation and number of dental deviations for children with Class II occlusion. Subjects with zero or one dental abnormality tended to demonstrate normal articulation while subjects with two dental abnormalities tended to demonstrate abnormal articulation. The latter was demonstrated by 5 out of 19 subjects. Therefore, it was concluded that part of the Class I group was able to compensate. The children with molar malocclusion (Class II), appeared to be able to compensate articulatorily for abnormal over-jet, over-bite or both since no statistically significant relationships emerged. Therefore, from these data, one is led to the conclusion that the majority of children were able to compensate for the presence of abnormal over-jet and/or over-bite.

Address correspondence to:

Marcus Slotiuk
Department of Speech Pathology
Southwestern Regional Centre
Box 1000
Blenheim, Ontario
N0P 1A0

APPENDIX

Stimulus pictures from Peabody Articulation Cards Kit - Level P /f, ʃ, s, z, ʒ, t ʃ, d ʒ, v, θ, ð/ in Three or more Positions*

1. feather
2. fishing
3. five
4. coffee pot
5. fish
6. elephant
7. magnifying glass
8. giraffe
9. calf
10. knife
11. seven
12. seventeen
13. violin
14. volcano
15. Volkswagen
16. stove
17. glove
18. teeth
19. mouth
20. bath
21. thirteen
22. thumb
23. bathroom
24. toothbrush
25. toothpaste
26. grandfather
27. grandmother
28. this/that
29. they
30. glasses
31. bus
32. juice
33. scissors
34. sandwich
35. racing car
36. bicyle
37. matches
38. match
39. cheeze
40. cherries
41. magazine
42. lizard
43. zoo/zebra
44. zipper
45. dishes
46. dishwasher
47. shovel
48. brush
49. shirt
50. shoes
51. television > one
    T.V. > card
52. measure
53. church
54. pitcher
55. teacher
56. jeep
57. pajamas
58. garbage
59. bridge > one
    bridges > card
60. badge > one
    badges > card
61. cage

* Letters corresponding to the phonemes tested are underlined in each test word.

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