SOME MOTORIC PARAMETERS OF FUNCTIONAL MISARTICULATION

by

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ABSTRACT

The description of functional or developmental misarticulation in terms of phoneme-specific speech-motor behaviour has been unsatisfactory because of much inconsistency. Some of the inconsistency has been eliminated by postulating phoneme position-in-a-word as pertinent to articulation difficulty. However research tends to point to patterns of basic speech-motor behaviour larger than phoneme-specific units. Two such supra-phoneme motoric parameters are hypothesized and tested in the responses of a group of 65 normal kindergarten children, using test items selected from the Templin-Darley Diagnostic Test of Articulation.

These test items were dichotomized as hypothetically easy or difficult in terms of the two proposed parameters, namely range of anterior-posterior tongue movement and number of lingual constrictions of the buccal cavity, required in the response to each test item. Also, in each instance of misarticulation, the substituted response was analysed for changes with respect to the hypothesized parameters.

Responses were electronically tape recorded and phonetically analysed under controlled conditions.

Results indicated some evidence for range of anterior-posterior tongue movement as an independent parameter of speech-motor behaviour of kindergarten children. However this was not the case for number-of-lingual-constrictions of the buccal cavity.

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I INTRODUCTION

Distortion of speech among preschool or older children, free of major anatomical or neurological defects, is commonly termed functional misarticulation. It is presumed to be an indicator of speech still in the process of development and refinement. Moreover its nature is theorized to be symptomatic of certain developmental difficulties or lags.

Since treatment or instruction designed to correct severe cases (representing a significant developmental lag) is based on causal relations, the explanation of functional misarticulation has definite bearing on the special education requirements.

The various explanations offered over the past 30 years reveal considerable change and development: Historically the first explanations were anatomical or neuromuscular. If severe structural defects caused severe speech problems, then minor structural defects were presumed to cause minor speech defects (Van Riper, 1965, p.20). However research did not support such contentions. The indications are that difficulties in mechanical arrangement, or motor control, of the tongue occur as often in the normal as in the abnormal development of speech (Fairbanks, 1950; Morley, 1965, p.33). The reason for such inconsistency would appear to be the tremendous ability of the articulators to compensate for minor deviations of an anatomical or neuromuscular nature (McDonald, 1967).

A somewhat more sophisticated explanation was then forthcoming in diadokinesis measures (the relative speed of rapidly alternating motor activity). However it was soon established that there was no reliable correlation between motor difficulty, as expressed by slow diadokinetic rates and misarticulation (Fairbanks, 1950; Powers, 1957, p.780; Van Riper, 1965; Shelton et al, 1966; McDonald, 1967).

The major weakness of the foregoing explanations is that they are couched in terms of non-speech motor behaviour. Moreover misarticulation thus explained is inclined to be quantitative only, disregarding significant qualitative differences in functional misarticulation, particularly as manifest at different age levels. Compare the description of Bakes (1966). Such qualitative differences require the keying of motor difficulties to speech sounds, that is speech-motor behaviour. The International Phonetic Alphabet (Ward, 1950) and other phonetic codes had theorized specific postural counterparts in speech-motor behaviour. In fact developmental research established norms specifying at what age the average child was able to articulate each phoneme correctly (within the allophone range permissible). The developmental sequence immediately implied levels of developmental difficulty for each specific articulatory posture required for each phoneme. Functional misarticulation could be explained as simply the failure to develop, mature or learn the specific motor pattern required for the particular phonemes misarticulated. To further express qualitative differences in misarticulation, yet still maintain some measurement of it, Barker and England (1962) developed a weighting scale of phoneme errors, keying them to frequency of occurrence in normal language usage. The dedication to the specifics of phoneme misarticulation is made complete by Palmer and La Russo's (1965, p.204) "Physiologic Phonetics" in which the specific action of every muscle is described for each phoneme, thus making possible a detailed myographic explanation of misarticulation.

Unfortunately such phoneme-specific descriptions of misarticulation ignore considerable inconsistency of correct or incorrect articulation of a given phoneme. This difficulty is met with, in part, by adding to phoneme-

specific explanations, the factor of position-in-a-word (i.e. initial, medial or final). The developmental sequence of Templin (1957) is based on this idea.

Even with the position specified, phonemic misarticulation is still found to be inconsistent (Leopold, 1953; Dorsey, 1959; McDonald, 1967). In fact correct or incorrect articulation of a given phoneme seemed to depend on adjacent phonemes, i.e. phoneme context. The phenomenon is one of assimilation or "overlapping" (Shohara, 1939) such that the articulation of each phoneme is modified by preceding and following articulations (Stetson, 1951; McDonald, 1967). If there is no specific invariate motor action or articulatory posturing for each phoneme of the language, phoneme-specific units of speech-motor and phoneme-specific explanations of misarticulation are open to question. Stetson (1951) and Carrell and Tiffany (1960) propose instead a supra-phoneme or syllabic unit of speech-motor behaviour. Their arguments are based on analysis of speech rhythm and the fact that articulatory movements are auxiliary overlays on the fundamental breath (syllabic) pulse of speech. Strong support for some kind of supra-phoneme unit is to be seen in the neurological evidence cited by Lenneberg (1967) in which he shows that the high speed and complexity of speech-motor behaviour cannot be produced in a contiguity sequence of single phoneme bits. The minimum possible time factor for discreet nerve impulses is too large to make speech at normal rates a product of sequenced single "phoneme commands". It is interesting to note that the same critical time factor applies to audition. It is physiologically impossible to hear and synthesize a contiguity sequence of single phoneme units at normal speech rates (Liberman et al, 1965; Liberman et al, 1967).

What then is the nature of this supra-phoneme or multiple-phoneme unit of speech-motor behaviour? From their studies of inconsistency of phoneme misarticulation Spriesterbach and Curtis (1951) concluded there must be "laws of assimilation". Carrell and Tiffany (1960) concluded speech could no longer be regarded as a sequence of phoneme-specific postures. In fact speech synthesized by the splicing together of tape recordings of phoneme-specific utterances proved to be unintelligible (Carrell and Tiffany, 1960, p.242).

To date, the specification of such "laws of assimilation, or of easy versus difficult phoneme groups or syllable clusters, is only rudimentary. Curtis and Hardy (1959) show that misarticulation containing /r/ could be predicted by the consonant-vowel sequence pattern. Fromkin (1966) reported variation in electromyographic data from the lips which could be predicted according to the phoneme adjacent to the labial sound in the syllable. MacNeilage and DeClerk (1967, pp.27 and 31) confirmed, by combined cinefluorography and electromyography the variation in "phoneme commands" with contextual variations in the syllable.

In a recent review of misarticulation research Locke (1968) condemned most of it as being of an "ad hoc" nature expressing circular arguments in which misarticulation is explained as specific motor difficulty, while the only evidence for motor difficulty was the specific misarticulation itself.

What seems to be required is to view speech-motor behaviour as a programming skill (Osgood, 1963, p.260; McDonald, 1967) rather than a sequencing of phonemes in contiguity. Certainly the neurological superstructure for such a programming system exists (Berry and Eisenson, 1956;

Hecaen et al, 1964; Brain, 1965; Roberts, 1966, Lenneberg, 1967) as well as the necessary feedback mechanisms (Jerger, 1963; Bosma, 1967).

Perhaps speech-motor behaviour should be viewed as the output of simultaneous (spatial) programming of a temporal pattern of movement encompassing phoneme groups. Misarticulation would then be deficient programming and would be described in terms of those programme patterns which are more, or less frequently produced in a satisfactory manner as required by the phonetic rules of the language.

The change in viewpoint, if substantiated by research, will have considerable significance for management of functional misarticulation and perhaps for speech improvement procedures generally. Thus:

1) the International Phonetic Alphabet may be rendered obsolete because the increasing range of allophones established by laws of assimilation, or patterns of speech-motor behaviour, may render stereotyped designations of phoneme-specific postures virtually meaningless (Stetson, 1951);
2) developmental sequences for articulation refinement may have to be revamped in terms of patterns of speech-motor behaviour;
3) speech improvement procedures which are phoneme-specific are already in jeopardy and may have to be completely revamped in terms of patterns of speech-motor behaviour (McDonald, 1967, p.142).

II PROBLEM

What are these supra-phoneme patterns of speech-motor behaviour and how do they arrange themselves with regard to ease or difficulty of articulation? The answer to this question would seem to be found in hypothesizing distinctive speech-motor behaviour patterns or motoric parameters and assessing their relationship to correct or incorrect utterances.

The author has chosen two hypothetical parameters from the many which are possible. The first comes from an observation by Berry and Eisenson (1956, p.35) that the substituted utterance the child uses, in place of the correct adult standard for the language, exhibits a reduction in anterior-posterior movement of the tongue. For example, when [tæ kɪn] is substituted for [tæ kɪŋ] a reduction in anterior-posterior movement of the tongue is accomplished. The second hypothetical parameter was derived from the fact that 10 of the 11 most common phoneme-specific misarticulations are lingual constrictions of the buccal cavity (Templin, 1957; Powers, 1957, pp.714 and 724; Berry and Eisenson, 1956; Morley, 1967, p.45). It was therefore hypothesized that the number of lingual constrictions required for a given utterance will have a bearing on whether or not it is misarticulated, and moreover that the substituted form will show a reduction in the number of lingual constrictions.

Before formally stating the hypotheses it is necessary to clarify two points of definition:

1) Articulation, as herein referred to, is actions of the vocal tract mechanisms which change the shape and size of the tract above the glottis, <u>and does not therefore include voicing</u> (Stetson, 1951; Harris, Lysaught and Schney, 1965; McDonald, 1967).

2) It is recognized that in terms of vocal tract constrictions the difference between vowel and consonant is only a matter of degree (McDonald, 1967). Therefore what does or does not constitute a vocal tract constriction is to some degree arbitrary. Herein the basis for categorization will be that of Johnson et al (1967, pp.534 and 537).

III NULL HYPOTHESES

Hypothesized Principle I

When items of the Templin-Darley Diagnostic Test of Articulation (1968) are categorized as requiring a large or small range of anterior-posterior tongue movement (See Appendix A for category criteria and item classification), there will be:

A) no significant difference in the frequency of misarticulation of items categorized as having a large or small range of tongue movement;

B) no significant difference in the number of large or small movement items which, in the misarticulated form, show a reduction in the amount of anterior-posterior tongue movement (as compared with the required, correct utterance).

Hypothesized Principle II

When items of the Templin-Darley Diagnostic Test of Articulation are categorized as requiring single or multiple (3 or more) lingual constrictions of the buccal cavity (See Appendix A for category criteria and item classification), there will be:

A) no significant difference in the frequency of misarticulation of items categorized as having single or multiple lingual constrictions of the buccal cavity;

B) no significant difference in the number of single or multiple tongue constriction items which, in the misarticulated form, show a reduction in the number of lingual constrictions (as compared with the number required in the correct utterance).

Special Note

For clarity and simplicity test items classified as having a

small range of anterior-posterior movement or a single lingual constriction will be designated "easy", while items classified as having a large range of movement or multiple lingual constrictions will be designated "difficult". For a more specific description of "easy" and "difficult" see "Appendix A" pages 37 and 38.

IV METHOD

A. Sample

In order to allow as broad a generalization as possible (McDonald, 1967; Locke, 1968) a relatively unselected sample of normal children was studied. The sample came from the total enrolment of 150 of 6 different public school kindergarten classes situated in three widely separated parts of a rural-urban community with population 20,000.

Although tuition is free, parents are required to provide their own transportation. Since there is no public transport system and the distances involved may be six miles or more, the enrolment tended to eliminate the lowest socio-economic level from representation in the sample studied. Indeed the results of a survey of the parents whose children were tested would seem to indicate that the above-mentioned selection factor was operative. Thus it revealed the following distribution of fathers' occupations:

15% professional

15% executive or self-employed

36% skilled tradesmen

27% semi-skilled workers

7% unskilled

The questionnaire also revealed that 30% of the children had at least one parent whose native tongue was not English. This percentage may not be representative of the general Western Canadian situation, since the 1961 census showed that only 1 in 8 Canadians (not counting French) had a non-English mother tongue (Canada, 1964). In the sample studied here 1 in 5 parents had a non-English mother tongue. Therefore the results for these children were assessed separately to detect any differences in

these data compared with the children whose parents' native tongue was English. Both these subgroups are then in turn compared with the full sample.

Children selected for study were the first 65 cases available who showed no significant hearing loss and no speech pathology. They were tested in January and February of 1969 when their average age was 5 years 6 months (range 5 years 0 months to 6 years 5 months). There were 32 males and 33 females.

B. Controls

1) Responses to the test items were recorded at a speed of 7-1/2 inches per second on a Telefunken tape recorder Model 97 with a headset microphone which maintained a standard mouth to microphone distance while the subject remained free to move his head or body. Playback of the tapes for response analysis and phonetic recording was through an 8 ohm coaxial external speaker.

2) The same test items were presented in the same order to all subjects. The manner of presentation was to use the picture stimulus and any necessary additional verbal stimulus except the response word.

3) From the 65 cases analysed a sub-sample of 7 cases was selected by means of a table of random numbers. This sub-sample had all its responses phonetically recorded by a panel of five listeners who had no knowledge of the hypotheses under test. The purpose of this verification procedure was to detect any bias in the original phonetic analysis which might have been produced by knowledge of the hypotheses.

4) All cases considered for study were given an audiometer sweep test at 15 db. Any subjects showing a loss were eliminated.

5) All subjects showing a subnormal articulation were assessed by a qualified speech therapist and eliminated from the study if they showed indication of speech pathology.

6) Although their responses remained in the general data, the group of children who had a parent with a non-English native tongue also had their responses analysed separately to test for any differences.

C. Procedure

1) Items were selected from the Templin-Darley Diagnostic Test of Articulation on the basis of the hypothesized principles (See Appendix A for items used).

2) These items were presented to each subject and his reponses were recorded on tape.

3) Recorded responses were played back and phonetically analysed. Each response was designated as either correct, incorrect or non-response (the last of these was used to designate responses which were obviously the wrong word entirely). The incorrect responses had the substituted form phonetically recorded.

4) Each parent was sent a questionnaire (See Appendix B) in order to provide pertinent background information.

5) The recorded responses were analysed with respect to the hypotheses.

V RESULTS

A. Analysis with Reference to Hypotheses

TABLE I: General Data on Templin-Darley Test Items

		Total	Average per Child	Range
Test Items Presented		4579	70.46	69-75
Non-response Items:				
Improper responses	488			
Unanalysable responses	19	507	7.80	0-33
Items analysable		4072	62.65	37-70
Misarticulations		627	9.65	0-40
Correct		3445	53.01	28-69

TABLE II: Classification of Analysable Items as "Easy" or "Difficult" under Hypothesized Principles I and II (See Appendix A for criteria)

Classification	Principle I	Principle II
"Easy"	2300	1207
"Difficult"	1719	2348
Total	4019	3555
Unclassified	* 53	* 517
Total	4072	4072

* These items dichotomized under one principle but not the other.

TABLE III: Analysis of Responses under Hypothesized Principle I-A (Range of Anterior-Posterior Tongue Movement)

	Items Misarticulated	Items Correct	Total
"Easy	320 * (343)	1980 (1957)	2300
"Difficult"	279 (256)	1440 (1463)	1719
Total	599	3420	4019

* For X^2 Analysis the numbers in brackets indicate the expected frequencies when actual frequencies are corrected for difference in total available "easy" or "difficult" items.

An inspection of the raw data of Table III shows that 13.91% of the "easy" items were misarticulated and 16.24% of the "difficult" ones. This differential is in the direction to be expected if the null hypothesis I-A is rejectable.

For Table III X^2 is 4.24.

Since there were actually three response classifications, namely, correct, incorrect or non-response, and since the distribution of the non-response items is not pertinent (and would make X^2 spuriously high) they should not be considered in the statistical analysis except to increase the degrees of freedom to 2 (Siegel, 1956, p.104). With 2 degrees of freedom the probability that the differences found in Table III are due entirely to chance is between 0.20 and 0.10.

TABLE IV: Distribution of Instances of Reduced Range of Tongue Movement in Misarticulated Responses
(Substitute Utterances as Compared with Required Responses)

	Reduction	No Reduction	Total
"Easy"	49 *(123)	271 (197)	320
"Difficult"	181 (107)	98 (172)	279
Total	230	369	599

* Figures in brackets are for X^2 analysis and indicate the expected frequencies when actual frequencies are corrected for differences in total available "easy" or "difficult" items.

An inspection of the raw data of Table IV shows that 15.3% of the items originally categorized as "easy" under hypothesized Principle I were, in the misarticulated form, reduced in range of tongue movement. This compares with 64.9% of the "difficult" items similarly reduced. This differential is in the direction to be expected if null hypothesis I-B is to be rejected.

For Table IV X^2 is 155.

With 1 degree of freedom the probability that the differences found in Table IV are due entirely to chance is less than 0.01.

TABLE V: Analysis of Responses under Hypothesized Principle II-A (Number of Lingual Constrictions)

	Items Misarticulated	Items Correct	Total
"Easy"	111 *(201)	1096 (1006)	1207
"Difficult"	483 (393)	1865 (1955)	2348
Total	594	2961	3555

* For X^2 analysis the numbers in the brackets indicated expected frequencies when actual frequencies are corrected for differences in total available "easy" or "difficult" items.

An inspection of the raw data of Table V shows that 9.2% of items categorized as "easy" were misarticulated compared to 20.57% of the "difficult" items. This differential is in the direction expected if null hypothesis II-A is to be rejected.

For Table V X^2 is 73.09.

Since there were actually three response classifications, namely correct, incorrect and non-response, and since the distribution of the non-response items is not pertinent (and might make X^2 spuriously high), they should not be considered in the statistical analysis except to increase the degrees of freedom to 2. With 2 degrees of freedom the probability that the differences found in Table V are due entirely to chance is less than 0.01.

TABLE VI: Distribution of Instances of Reduction in the Number of Lingual Constrictions in Misarticulated Responses (Substitute Utterances as Compared with Required Responses)

	Reduction	No Reduction	Total
"Easy"	91	20	111
"Difficult"	319	164	483
Total	410	184	594

An inspection of the raw data of Table VI shows that 82% of the items originally categorized as "easy" under hypothesized Principle I had, in the misarticulated form, fewer lingual constrictions. This compares with only 66% of the items originally classified as "difficult" which had a similar reduction in number of lingual constrictions in misarticulated form. The differential is in the reverse of the direction to be expected if null hypothesis II-B is to be rejected.

B. Analysis with Reference to Neutral Observer Data

The author's knowledge of the hypotheses may have biased his classification of responses. To assess this, a panel of 5 listeners uninformed on the hypotheses were asked to phonetically record the responses of 7 cases selected by means of a table of random numbers from the total of 65 cases being studied. A general comparison of results for the 497 items presented to these cases is shown in Table VII.

Though the 18 items on which there was disagreement are a small percentage, this could still represent a significant bias. Therefore further comparisons were made in terms of each hypothesis as shown in Tables VIII to XV. In each case the panel results are consistent with those of the author and with the findings for the full sample of 65 cases.

TABLE VII: General Comparison of Author's and Uninformed Panel's Recording of Responses

The numbers in the table refer to total test item responses for the 7 randomly selected cases.

Classification	Panel Agrees with Author	Panel in Disagreement
Non-response Items	48	0
Misarticulations	77	2
Correct Items	354	16
Total	479	18

TABLE VIII: Analysis of Author's Recording of Comparison Sample on Hypothesis I-A

	Items Misarticulated	Items Correct	Total
"Easy"	34 (41)	218 (211)	252
"Difficult"	38 (31)	152 (159)	190
Total	72	370	442

TABLE IX: Analysis of Panel's Recording of Responses of Comparison Sample on Hypothesis I-A

	Items Misarticulated	Items Correct	Total
"Easy"	44 (51)	208 (201)	252
"Difficult"	45 (38)	145 (152)	190
Total	89	353	442

In Table VIII the percentage misarticulated was 13.5% "easy" and 20% "difficult". In Table IX it is 17.5% "easy" and 23.7% "difficult". In both cases the differential is in the expected direction. For Table VIII X^2 is 3.32, and for Table IX X^2 is 2.82. With 2 degrees of freedom, in neither case is this significant.

TABLE X: Analysis of Author's Recording of Responses of Comparison Sample on Hypothesis I-B

	Reduction	No Reduction	Total
"Easy"	5 (13)	29 (21)	34
"Difficult"	23 (15)	15 (23)	38
Total	28	44	72

TABLE XI: Analysis of Panel's Recordings of Responses of Comparison Sample on Hypothesis I-B

	Reduction	No Reduction	Total
"Easy"	8 (17)	36 (27)	44
"Difficult"	26 (17)	19 (28)	45
Total	34	55	89

In Table X the percentages showing reduction were 15% "easy" and 61% "difficult". In Table XI it was 18% "easy" and 58% "difficult". In both cases the differential is in the expected direction. For Table X X^2 is 15 and for Table XI X^2 is 15. With 1 degree of freedom this is significant at the 1% level in both cases.

TABLE XII: Analysis of Author's Recording of Responses of Comparison Sample on Hypothesis II-A

	Items Misarticulated	Items Correct	Total
"Easy"	10 (25)	122 (107)	132
"Difficult"	64 (49)	198 (213)	262
Total	74	320	394

TABLE XIII: Analysis of Panel's Recording of Responses of Comparison Sample on Hypothesis II-A

	Items Misarticulated	Items Correct	Total
"Easy"	13 (29)	119 (103)	132
"Difficult"	74 (58)	188 (204)	262
Total	87	307	394

In Table XII the percentages misarticulated were 7.6% "easy" and 24% "difficult". In Table XIII it was 9.8% "easy" and 28.2% "difficult". In both cases the differential is in the expected direction. For Table XII X^2 is 16.8% and for Table XIII X^2 is 17. In both cases this is significant at the 1% level.

TABLE XIV: Analysis of Author's Recording of Responses of Comparison Sample on Hypothesis II-B

	Reduction	No Reduction	Total
"Easy"	8	2	10
"Difficult"	41	23	64
Total	49	25	74

TABLE XV: Analysis of Panel's Recording of Responses of Comparison Sample on Hypothesis II-B

	Reduction	No Reduction	Total
"Easy"	10	3	13
"Difficult"	42	32	74
Total	52	35	87

In Table XIV the percentages showing reduction are 80% "easy" and 64% "difficult". In Table XV it is 77% "easy" and 57% "difficult". In both cases the differential is in the reverse of the expected direction.

C. Comparison of Data for Cases with English and Non-English Speaking Parents

TABLE XVI: Data Extracted from Table III for the 19 Children with a Non-English Parent

	Items Misarticulated	Items Correct	Total
"Easy"	125 (134.5)	559 (549.5)	684
"Difficult"	104 (94.5)	378 (387.5)	482
Total	229	937	1166

TABLE XVII: Data Extracted from Table III for the 46 Children for whom the Mother Tongue of Both Parents was English

	Items Misarticulated	Items Correct	Total
"Easy"	195 (207)	1421 (1409)	1616
"Difficult"	175 (163)	1107 (1119)	1282
Total	370	2528	2898

In Table XVI 18.3% of the "easy" items and 21.6% of the "difficult" items were misarticulated. In Table XVII the comparable percentages are 12.07% and 14.15% respectively. In both cases the differential is in the direction expected if Hypothesis I-A is rejectable. However for Table XVI X^2 is 2.023 and for Table XVII is 2.847. With 2 degrees of freedom, in neither case is this significant. Therefore Hypothesis I-A cannot be rejected for either English or non-English groups.

TABLE XVIII: Data Extracted from Table IV for the 19 Children with a Non-English Parent

	Reduction	No Reduction	Total
"Easy"	26 (50.2)	99 (74.8)	125
"Difficult"	66 (41.8)	38 (62.2)	104
Total	92	137	229

TABLE XIX: Data Extracted from Table IV on the 46 Children for whom the Mother Tongue of Both Parents was English

	Reduction	No Reduction	Total
"Easy"	23 (73)	172 (122)	195
"Difficult"	115 (65)	60 (110)	175
Total	138	232	370

In Table XVIII reduction of range of tongue movement occurred in 20.8% of the "easy" items and 63.5% of the "difficult" items. In Table XIX the percentages were 12% and 66% respectively. In both cases the differential is in the direction expected if Hypothesis I-B is rejectable. For Table XVIII X^2 is 42.9 and for Table XIX X^2 is 116. In both cases with 1 degree of freedom this is significant at the 1% level. Therefore Hypothesis I-B is rejectable for both the English and non-English groups.

TABLE XX: Data Extracted from Table V for the 19 Children with a Non-English Parent

	Items Misarticulated	Items Correct	Total
"Easy"	43 (77.9)	324 (289.1)	367
"Difficult"	182 (147.1)	512 (546.9)	694
Total	225	836	1061

TABLE XXI: Data Extracted from Table V on the 46 Children for whom the Mother Tongue of Both Parents was English

	Items Misarticulated	Items Correct	Total
"Easy"	68 (124)	772 (716)	840
"Difficult"	301 (245)	1353 (1409)	1654
Total	369	2125	2494

In Table XX the percentages of items misarticulated are 11.7% "easy" and 26.2% "difficult". In Table XXI the percentages are 8.1% and 18.2% respectively. In both cases the differential is in the direction to be expected if Hypothesis II-A is rejectable. In Table XX X^2 is 30.35 and in Table XXI X^2 is 44.7%. In both cases, with 2 degrees of freedom this is significant at the 1% level.

TABLE XXII: Data Extracted from Table VI for the 19 Children with a Non-English Parent

	Reduction	No Reduction	Total
"Easy"	33	10	43
"Difficult"	131	51	182
Total	164	61	225

TABLE XXIII: Data Extracted from Table VI on the 46 Children for whom the Mother Tongue of Both Parents was English

	Reduction	No Reduction	Total
"Easy"	58	10	68
"Difficult"	188	113	301
Total	246	123	369

In Table XXII the percentages of instances of reduction are, "easy" 77% and "difficult" 72%. In Table XXIII the percentages are 85% and 62.5% respectively. In both cases the differential is the reverse of that to be expected if Hypothesis II-B is rejectable. Therefore for both the English and non-English groups Hypothesis II-B cannot be rejected.

VI CONCLUSIONS

The results from data processed in Tables VIII to XV indicate the phonetic analysis was reliable and free of bias with respect to knowledge of the hypotheses.

The fact that a somewhat high percentage of the children had parents whose mother tongue was not English does not appear to have affected the results. The English and non-English groups showed consistently the same pattern (see Tables XVI to XXIII).

With respect to the stated hypotheses, the following is concluded:

Null Hypothesis I-A cannot be rejected. There is no evidence that "difficult" items, requiring a large range of anterior-posterior tongue movement are misarticulated more frequently than the "easy" items requiring a small range of such movement.

Null Hypothesis I-B can be rejected. There is evidence that, among all the items misarticulated, the "difficult" ones requiring a large range of anterior-posterior tongue movement more frequently demonstrated, in the misarticulated utterance, a reduction in the range of movement relative to that required for the correct utterance.

Null Hypothesis II-A can be rejected. There is evidence that "difficult" items, i.e. those involving multiple (3 or more) lingual constrictions of the buccal cavity, were more frequently misarticulated than were the "easy" items, i.e. those involving only a single lingual constriction.

Null Hypothesis II-B cannot be rejected. There is no evidence that among all the items misarticulated the "difficult" ones (requiring multiple lingual constriction) more frequently demonstrated, in the

misarticulated utterance, a reduction in the number of lingual constrictions relative to the number required in the correct utterance.

VII FURTHER INTERPRETATION OF RESULTS

Hypothesis I-A was retained while I-B was rejected, indicating limiting factors in the influence of the anterior-posterior tongue movement demands upon articulatory ability. It must be concluded that, for the population represented, the range of anterior-posterior tongue movement as herein dichotomized is not a paramount factor in determining which utterances will or will not be misarticulated. Yet when a word is misarticulated, if the anterior-posterior tongue movement requirement is difficult, the substituted utterance is reduced in range of movement 65% of the time (as compared to only 16% of the time for "easy" items).

It would appear that factors other than the one hypothesized determine which items shall be misarticulated, i.e. which ones are difficult to articulate. However, this difficulty being established, the substituted attempt at articulation frequently tends to reveal an easing of the anterior-posterior tongue movement requirement. A dimension of articulatory difficulty would seem to be involved such that the range of anterior-posterior tongue movement is a motoric parameter of functional misarticulation. This parameter would serve to explain misarticulated utterances without reference to phoneme-specific motor activity, or even motor activity specific to the phoneme position in a word.

With respect to the other hypothesized motoric parameter, namely the number of lingual constrictions of the buccal cavity required for a given utterance, the results are quite indefinite. Hypothesis II-A was rejected but II-B was retained. It would appear that multiple lingual constriction in a required utterance is more frequently associated

with misarticulation than is the hypothesized easier single lingual constriction. In fact multiple lingual constriction items were associated with double the number of misarticulated responses. In spite of this the tendency to reduce the number of lingual constrictions in substituted utterances, though a common occurrence (70% of all misarticulations demonstrated it), did not occur more frequently on the "difficult" items. In fact the reverse may be the case. Quite frequently responses requiring only a single lingual constriction were, when misarticulated, uttered without any lingual constriction. We must conclude that the number of lingual constrictions required for a given utterance is not a motoric parameter of functional misarticulation. Some other factor or factors co-varying with the number of constrictions must determine which items will or will not be misarticulated.

The implication of these results for diagnosis of misarticulation and for methods of speech improvement are of course curtailed by the preliminary nature of the study. Nevertheless, one may speculate that assessing the range of anterior-posterior tongue movement beyond which misarticulation is much more frequent, and then providing for speech-motor activities to increase this range may be of value. In any event this parameter warrants further investigation.

Similar assessment and practice does not seem indicated for the hypothesized parameter which dealt with the number of lingual constrictions required for a given utterance.

VIII LIMITATIONS OF GENERALIZATION

A. Growth Factors

There are indications of differential growth patterns in vocal tract structures which cause dimensional relations to change during the growing years (Evarts, 1965; Azuma, 1967). If this be so, generalization of the findings of this study to age levels other than that of the sample studied may not be justified.

B. Indirect Assessment of Movement Patterns

In this study movement patterns have been synthesized from established knowledge of phoneme-specific articulation (Ward, 1950; Carrell and Tiffany, 1960; Johnson et al, 1967). Furthermore these interpretations have been largely verified by sophisticated procedures in cinefluorography and electromyography (DeClerk et al, 1965; Lubker, 1968). Nevertheless, the assessment of speech-motor behaviour herein has still been indirect and undesirably dependent on phoneme-bound phonetic analysis. Studies of this sort should be carried out with direct monitoring of speech-motor behaviour during correct and incorrect utterances. Cinefluorography appears to be hazardous for this sort of thing (Ramsey et al, 1960). Moreover this technique can monitor in only one plane of reference. The technique of Mermelstein (1966) and Schroeder (1966) for monitoring speech-motor behaviour by direct acoustic analysis of formants and lip impedance may provide a suitable method.

C. Assessment Independent of Sensory-Perceptual Factors

Undoubtedly difficulties in motor programming do not alone establish a hierarchy of misarticulation difficulties. The demands of the language, in terms of more or less redundancy in information, exert

unequal demands for the refinement of speech-motor skill (Fairbanks and Guttman, 1957; Denes, 1963).

On the other hand, varying auditory distinctiveness probably offers unequal support to different aspects of speech-motor inefficiency. Thus those sounds which are by their own nature more difficult to hear will provide less feedback corrective data and therefore encourage some features of misarticulation more than others (Fairbanks, 1954; Kronvall and Diehl, 1954; Powers, 1957; Cohen and Diehl, 1963; Winitz, 1963; Aungst and Frick, 1964; Chase, 1965; Liberman et al, 1965; McDonald, 1967).

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X APPENDICES

A. Phonetic Classification Used to Dichotomize Test Items and to Assess Substitution

TABLE 1: Classification of Lingual Phonemes According to Anterior-Posterior Zone of Articulation

Dental	Alveolar		Palatal	Velar
ð	d	i	j	g
θ	t	ɪ	r	k
	z	e	ɝ	ŋ
	s	ɛ	ɚ	u
	dʒ	æ	ʌ	ʊ
	tʃ		ə	o
	ʒ			ɔ
	ʃ			ɑ
	l			
	n			

Criteria for Hypothesized Parameter I

Test items requiring the place of tongue articulation to twice shift to non-adjacent zones as specified in Table 1 above are categorized as having a large range of anterior-posterior tongue movement, and are designated "difficult". Test items requiring tongue articulation in only one or two adjacent zones are categorized as having a small range of anterior-posterior tongue movement, and are designated "easy".

For example [kek] is categorized "difficult" because tongue articulation shifts from velar to alveolar and back again to velar zones, while [lif] is categorized "easy" because tongue articulation is in the

alveolar zone for the whole utterance. Table 1 is also used to determine changes in range of movement in substituted utterances.

TABLE 2: Classification of All Phonemes of English in Terms of Lingual Constriction of the Buccal Cavity

Lingual Constriction			No Lingual Constriction		
ð	n	k	b	i	ɑ
θ	l	ŋ	p	I	u
t	ʒ	dʒ	m	e	U
z	ʃ	ɝ	w	ɛ	o
s	r	ɚ	v	æ	ɔ
d	j		f	ʌ	
tʃ	g		h	ə	

Criteria for Hypothesized Parameter II

Test items requiring the production of 3 or more of the sounds in the left hand column of Table 2 above (lingual constriction) are categorized as having multiple lingual constrictions of the buccal cavity and are designated "difficult". Test items requiring the production of no more than one sound from the left hand column of Table 2 and all the rest of the sounds from the right hand column are categorized as having a single lingual constriction of the buccal cavity and are designated "easy".

For example, because [snek] requires the 3 lingual constrictions [s], [n] and [k] it is categorized "difficult", while [fit] is categorized "easy" because it requires only the one lingual constriction [t].

TABLE 3: Clasification of Test Items
(In the Order Presented to Subjects)

Principle I		Principle II	
Easy	Difficult	Easy	Difficult
Feet (1) *		Feet	
Pin (2)		Pin	
Bed (3)		Bed	
	Balloon (6)		
	Clock (9)		Clock
Book (11)		Book	
	Music (13)		Music
Leaf (29)		Leaf	
	Valentine (31)		Valentine
Sheep (36)		Sheep	
Dishes (36)			Dishes
Fish (36)		Fish	
Television (37)			Television
Onion (41)			Onion
Engine (43)			Engine
Presents (44)			Presents
Dress (47)			Dress
	Crayons (48)		Crayons
			Planting (76)
	Clown (78)		Clown
Snake (96)			Snake
	Spider (97)		Spider
Stairs (98)			Stairs
	Sky (99)		

(Cont'd)

* Numbers in brackets indicate item numbers in Templin-Darley Test Booklet.

TABLE 3 (Cont'd)

Principle I		Principle II	
Easy	Difficult	Easy	Difficult
Twins (109)			Twins
Splash (120)			Splash
	Scratch (123)		Scratch
	Cake (16)		
	Nose (20)		
	Spoon (20)		
	Swinging (21)		Swinging
Pencil (22)			Pencil
Cup (22)		Cup	
Bear (23)		Bear	
Tub (23)		Tub	
	Doll (25)		
	Slide (25)		Slide
	Wagon (27)		
Bell (29)		Bell	
	Telephone (30)		Telephone
	Knife (30)	Knife	
	Bicycle (34)		Bicycle
Scissors (35)			Scissors
	Windows (35)		Windows
	Grasshopper (38)		Grasshopper
Wheel (39)		Wheel	
Sandwich (40)			Sandwich

(Cont'd)...

TABLE 3 (Cont'd)

Principle I		Principle II	
Easy	Difficult	Easy	Difficult
Hammer (53)		Hammer	
Paper (55)		Paper	
	Doctor (57)		Doctor
Ladder (58)			Ladder
	Cracker (59)		Cracker
	Tiger (60)		Tiger
	Mother (62)		
Arm (64)		Arm	
	Blocks (77)		Blocks
Apple (81)		Apple	
Bulb (89)		Bulb	
Wolf (92)		Wolf	
Nails (94)			Nails
Nest (98)			Nest
Sister (102)			Sister
First (105)			First
Lamp (114)		Lamp	
Elephant (115)			Elephant
	Locked (117)		Locked
	Stopped (118)		Stopped
	Squirrel (124)		Squirrel
	Fixed (125)		Fixed
Stamps (127)			Stamps

* Numbers in brackets indicate item numbers in Templin-Darley Test Booklet.

B. Parent Questionnaire

The speech development tests being given to the children at the _____ (Preschool or Kindergarten) are in conjunction with a research project under the direction of the Research Unit for Exceptional Children, University of British Columbia. In order to help us assess the test results on your child please answer the following questions and return this form to the Kindergarten or Preschool teacher:

_____

Child's Name: _____

Birth Date: Month _____ Day _____ Year _____

Mother's Name: _____ Occupation: _____

Father's Name: _____ Occupation: _____

What language did mother first learn to speak as a child? _____

What language did father first learn to speak as a child? _____

What language is usually spoken at home? _____

Does your child have any physical defect which might affect his speech?

_____