DOCUMENT RESUME

ED 116 154 CS 002 318

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TITLE Models for Predicting How Adults Pronounce Vowel Digraph Spellings in Unfamiliar Words.
INSTITUTION Wisconsin Univ., Madison. Research and Development Center for Cognitive Learning.
SPONS AGENCY National Inst. of Education (DHEW), Washington, D.C.
REPORT NO WRDCCL-TR-346
PUB DATE Oct 75
CONTRACT NE-C-00-3-0065
NOTE 21p.

EDRS PRICE MF-$0.76 HC-$1.58 Plus Postage
DESCRIPTORS Adult Learning; College Students; Consonants; *Context Clues; Educational Research; *Models; *Predictive Measurement; *Pronunciation; *Vowels; Word Recognition

ABSTRACT

This study was designed to explore relationships between type and token frequencies and contextual position effects; specifically, the major question was whether or not vowel cluster pronunciation preferences of adult readers were more affected by frequency of occurrence than by graphemic environment. Two opposing hypotheses were tested regarding four vowel digraph spellings. Six synthetic words were constructed for each vowel cluster according to contextual and word position constraints. The subjects were 51 undergraduates whose task was to read the synthetic words and note how they pronounced the underlined vowel cluster. Three models were constructed to assess the hypotheses and to predict responses for each vowel cluster. The models were a final consonant model, a variant type-token model, and an invariant principal response model. Several data analysis techniques were used. The final consonant model was superior to the other two models, but it was found that other factors, not yet assessed, were present in the results. (Author)

ED116154

Technical Report No. 346

MODELS FOR PREDICTING HOW ADULTS PRONOUNCE VOWEL DIGRAPH SPELLINGS IN UNFAMILIAR WORDS

by

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Report from the Project on
Conditions of School Learning and Instructional Strategies

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2

Wisconsin Research and Development
Center for Cognitive Learning
The University of Wisconsin
Madison, Wisconsin

October 1975

Published by the Wisconsin Research and Development Center for Cognitive Learning, supported in part as a research and development center by funds from the National Institute of Education, Department of Health, Education, and Welfare. The opinions expressed herein do not necessarily reflect the position or policy of the National Institute of Education and no official endorsement by that agency should be inferred.

Center Contract No. NE-C-00-3-0065

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FUNDING

The Wisconsin R&D Center is supported with funds from the National Institute of Education; the Bureau of Education for the Handicapped, U.S. Office of Education; and the University of Wisconsin.

ACKNOWLEDGMENT

The assistance of Mr. Robert Kuhn of the Wisconsin Research and Development Center Technical Services Section is gratefully acknowledged.

TABLE OF CONTENTS

LIST OF TABLES

I

INTRODUCTION

English letter-sound correspondence patterns fall into three distinct categories (Venezky, 1974). Some are invariant or nearly invariant (b → /b/, k → /k/, and m → /m/), some are variant but predictable (c → /s/ before e, i, or y, but c → /k/ otherwise), and others are variant and unpredictable (ch → /č/, /š/, or /k/ as in church, chef, chorus; and ea → /i/, /ɛ/, or /e/ as in team, bread, great). Recently several studies have examined the pronunciation strategies of good and poor readers for both invariant and variant-predictable letter-sound correspondences (Venezky, Chapman, & Calfee, 1972; Venezky & Johnson, 1973). Only one major study, however, has reported on variant-unpredictable correspondences (Johnson, 1970).

Johnson (1970) compared the relationships of type and token pronunciation frequencies of real words that contained vowel digraphs to the pronunciations by elementary school children of synthetic words that contained the same digraphs. Johnson compiled word type frequencies from a list based on the 20,000 most common words in the Thorndike Century Senior Dictionary (1941), and he tabulated word token frequencies from the top 1,000 words in the Brown University corpus (Kučera & Francis, 1967).[1]

Johnson's results showed that subjects' responses were much more closely related to word type proportions than to word token proportions. The most common (principal) pronunciations based on word types appeared to be the best predictors of vowel cluster pronunciations by children. Furthermore, (1) good readers consistently gave more principal pronunciations than poor readers; (2) the percentage of principal pronunciations increased from second, to fourth, to sixth grade; and (3) suburban children scored higher on principal pronunciations than urban and rural children.

Since previous research had indicated that contextual features may influence pronunciation preferences (Calfee, Venezky, & Chapman, 1969), these features were also examined by Johnson (1970). The pronunciations of some vowel clusters, although considered unpredictable, were indeed affected by contextual features or by the cluster's position within the word. For example, when ie preceded s, it received the /ai/ pronunciation more frequently than the principal /i/ pronunciation. The reverse

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[1] Word types are distinct words, so that each different word has the same weight regardless of its frequency of occurrence in speech or print. Word tokens are distinct occurrences of a word, based upon total occurrences in printed texts or in speech.

was true when ie preceded k and when it was in final position. Likewise, oo was more often pronounced /u/ when followed by t, but received the /ʊ/ pronunciation more frequently when followed by k. Similarly, ow usually received the /au/ pronunciation, but was more likely to be pronounced /o/ when in final position. These contextual-positional effects seemed to be highly related to real word occurrences.

The present study was designed to explore further the relationships between type and token frequencies and contextual-positional effects. The basic question being asked was whether the vowel cluster pronunciation preferences of adult readers are more affected by frequency of occurrence features than by graphemic environment. Based upon earlier findings, the specific environmental feature selected for examination was the following consonant. Two opposing hypotheses for how adult readers would pronounce vowel clusters in synthetic English words (i.e., in English-like words) were postulated:

H_1. The pronunciations will vary according to the number of real words that have the same clusters in the same graphemic contexts (i.e., the same following consonant and position).

H_2. The pronunciations will vary according to the type or token counts of real words with the same clusters, regardless of graphemic context.

To test these hypotheses, four vowel digraph spellings were selected on the basis of their variant, but seemingly patterned, pronunciations in a corpus of high frequency words. The digraph spellings selected were oo, ou, ea, and ow; their pronunciations in common monosyllabic and disyllabic words are summarized as follows.[2]

oo is usually /u/ before n, m, or l (moon, broom, fool) and /ʊ/ before k or d (book, good), but about equally /u/ and /ʊ/ before t (boot, foot).

ou is usually /au/ before n, t, and d (ground, trout, loud) and /ʌ/ before p, b, or ch (couple, trouble, touch).

ea is usually /i/ before k or t (beak, heat) and /ɛ/ before th or l (heather, wealth), but about equally /i/ and /ɛ/ before d or n (plead, dead, mean).

ow is usually /o/ in final position (grow, slow, snow) and /au/ before d (chowder, crowd), but about equally /o/ and /au/ before n (grown, crown).

Table 1 presents the principal pronunciations of each of the four vowel clusters by word type frequency and by word token frequency. This table shows that for two of the selected vowel clusters, ou and ea, the principal pronunciations for word types and word tokens are

[2] This summary is based upon unpublished data on the letter-sound correspondences of the 20,000 most common words in English.

TABLE 1

WORD TYPE AND WORD TOKEN PRINCIPAL PRONUNCIATIONS AND PERCENTAGES FOR THE VOWEL CLUSTERS <u>OO</u>, <u>OU</u>, <u>EA</u>, AND <u>OW</u>*

	Word Types		Word Tokens	
	Principal Pronunciation	Percentage	Principal Pronunciation	Percentage
<u>oo</u>	/u/	62.2	/ʊ/	50.0
<u>ou</u>	/au/	50.1	/au/	36.4
<u>ea</u>	/i/	53.1	/i/	57.4
<u>ow</u>	/o/	51.2	/au/	51.4

*Data from Johnson (1970).

the same, while for the other two, <u>oo</u> and <u>ow</u>, the principal pronunciations for word types and word tokens are different.

II

METHOD

STIMULI

For each of the four selected vowel clusters six synthetic words were constructed according to the contextual and word position constraints discussed previously. Each stimulus was then matched with four real word alternatives; one alternative contained the principal pronunciation of the vowel digraph in the synthetic word, and the other three contained frequently occurring pronunciations of this digraph. The 24 test items were then randomized and printed on an 8-1/2 x 11 sheet of paper (see the Appendix).

SUBJECTS

The 51 subjects were undergraduates at the University of Wisconsin. Twenty-seven were enrolled in a beginning course in computer programming and 24 were enrolled in a beginning course in elementary education.

PROCEDURE

Subjects were told to read a synthetic word to themselves and to note how they pronounced the underlined vowel digraph. They then were to circle the real word in the same row that contained the same vowel sound. The test was group administered (separately to the two groups), and subjects were encouraged to work as quickly as they could.

III

RESULTS

A summary of the responses of each group to each digraph, summed across test items for each digraph, is shown in Table 2. Separate chi-square analyses of the digraph responses comparing the total number of principal responses to nonprincipal responses by group showed a significant group difference for oo ($\chi^2 = 0.68$, $df = 1$, $p < .01$) but no significant group differences for the other three digraphs. Consequently, the two groups were combined for subsequent analyses.

The responses to each test item, summed across the subject groups, are shown in Table 3. For all six ea test items, a single pronunciation (/i/) dominated; there was only a slight deviation in the responses to theat. The response /u/ dominated for all oo items except yook, which received twice as many /ʊ/ responses as /u/ responses. (Plood, although assigned the dominant pronunciation by 64 percent of the subjects, received a relatively high number of /ʊ/ responses--10 of 51.)

Both ou and ow, although assigned dominant pronunciations (/au/ for both) in 69 percent and 67 percent of the cases, respectively, showed more variation in response patterns than did the other two digraphs. For ow, an /o/ pronunciation was selected by 80 percent of the subjects for smow, by 37 percent for drow, and by 21 percent for towd. In all, the /o/ pronunciation accounted for about 29 percent of the responses to ow words. For ou, an /u/ pronunciation was selected by 53 percent of the subjects for thoup, by 27 percent for loun, and by 16 percent for soud. In all, the /u/ pronunciation accounted for about 20 percent of the responses to ou test items.

For assessing the various hypotheses stated earlier, three models were constructed and then used to predict the number of principal responses to be expected for each vowel digraph. The models tested were:

1. Final consonant model. For each test item, all of the monosyllabic words in the Thorndike word list (see Johnson, 1970) that had the same vowel and consonant ending as the test item (or vowel plus juncture in the case of smow and drow) were listed by vowel pronunciation. The percentage of these words that contained principal pronunciation for the test word digraph was then used to predict the number of principal responses that would occur for the test item.

TABLE 2

PERCENTAGES OF RESPONSES BY SUBJECT GROUP AND DIGRAPH

	ea			
	/i/	/ε/	/ʌ/	/e/
Group 1 (Edu.)	86.8	11.8	0.7	0.7
Group 2 (C.S.)	93.2	5.6	0.0	1.2
Total	90.2	8.5	0.3	1.0
	oo			
	/u/	/ʊ/	/a/	/o/
Group 1 (Edu.)	66.7	16.7	6.3	10.4
Group 2 (C.S.)	82.7	11.1	2.5	3.7
Total	75.2	13.7	4.3	6.9
	ou			
	/au/	/u/	/ʊ/	/ʌ/
Group 1 (Edu.)	74.3	14.6	5.6	5.6
Group 2 (C.S.)	64.6	24.2	6.2	5.0
Total	69.2	19.7	5.9	5.3
	ow			
	/au/	/o/	/a/	/ʌ/
Group 1 (Edu.)	70.1	25.7	2.1	2.1
Group 2 (C.S.)	63.6	31.5	3.1	1.9
Total	66.7	28.8	2.6	2.0

2. Variant type-token model. The higher of the type and token percentages for the principal response for each digraph was used to predict the number of responses to all stimuli within a digraph group. Token percentages were based upon the top 1,000 words in Kučera and Francis (1967), while type percentages were based upon the Thorndike list mentioned previously.

3. Invariant principal response model. This model assumes that all responses to a digraph will be the principal response for that digraph.

The predictions made by each model for each stimulus item are reported in Table 4, which also shows the actual responses made by the combined subject populations. (Since no English words end in -oub, the test item doub was eliminated from the comparison of models, leaving 23 stimuli in four digraph groups.)

TABLE 3

TOTAL RESPONSES TO EACH TEST ITEM
BY VOWEL PRONUNCIATION
(N = 51)

ea	/i/	/ɛ/	/a/	/e/
yeath	45	4	0	2
brean	48	3	0	0
theat	38	13	0	0
pleal	48	1	1	1
glead	48	3	0	0
feak	49	2	0	0
oo	/u/	/ʊ/	/o/	/ʌ/
foon	50	0	0	1
nool	46	2	3	0
toom	46	2	2	1
yook	16	32	3	0
plood	32	3	6	10
doot	40	3	7	1
ow	/au/	/o/	/a/	/ʌ/
smow	9	41	1	0
bown	44	7	0	0
drow	32	19	0	0
trowd	41	6	1	3
towd	36	11	4	0
pown	42	4	2	3
ou	/au/	/u/	/ʌ/	/ʊ/
doub*	33	4	8	5
frout	49	1	0	1
thoup	19	27	1	4
loun	33	14	3	1
rouch	41	6	0	4
soud	36	8	4	3

*One subject did not respond to this item.

TABLE 4

THE NUMBER OF PREDICTED AND ACTUAL PRINCIPAL RESPONSES TO EACH TEST ITEM

Word	Model 1	Model 2	Model 3	Actual
foon	51	32	51	50
nool	45	32	51	46
stoom	51	32	51	46
yook	5	32	51	16
plood	23	32	51	32
doot	40	32	51	40
smow	21	26	51	9
bown	26	26	51	44
drow	21	26	51	32
trowd	51	26	51	41
towd	51	26	51	36
pown	26	26	51	42
frout	51	26	51	49
thoup	0	26	51	19
loun	51	26	51	33
rouch	38	26	51	41
soud	51	26	51	36
yeath	41	29	51	45
brean	51	29	51	48
theat	43	29	51	38
pleal	51	29	51	48
glead	18	29	51	48
feak	44	29	51	49

To compare the three models, several different measures were used. The following were used in the analyses.

xik the response of the ith student to the kth word. (xik is 1 if the principal response is given, and zero otherwise.)

$\hat{y}$km the predicted number of principal responses to the kth word under the mth hypothesis.

yk the actual number of principal responses to the kth word ($y_k = \Sigma_i x_{ik}$).

The measures used to compare the three models were as follows.

1. Sum of absolute values of differences, based on group scores. This required the computation of

$$A_m = \Sigma_k \left| \hat{y}_{km} - y_k \right|$$

for each of the three models and was probably the weakest test that was run. The resulting values were $A_1 = 218$, $A_2 = 314$, and $A_3 = 287$. According to these results, model 1 (final consonant) had the least amount of error, followed by model 3 (invariant principal) and then by model 2 (variant type-token).

2. Sum of squares of absolute differences, based on group scores. This was similar to analysis 1, but gave higher weight to the more deviant results. For

$$Sm = \Sigma_k \left| \hat{y}_{km} - y_k \right|^2$$

the resulting values were $S_1 = 3338$, $S_2 = 4982$, and $S_3 = 6283$. Model 1 thus remained in the same position as in analysis 1, but models 2 and 3 changed places.

3. Analysis of variance--sum of differences. This required the computation of

$$Z_{lmi} = \Sigma_k \left| W_{ikm} \right|$$

where $W_{ikm} = x_{ik} - \hat{y}_{km}/51$.

Z_{lmi} was a measure of the error made under the mth hypothesis for the ith student. Then, an analysis of variance was performed to test the hypothesis that $U_{11} = U_{12} = U_{13}$, where $U_{lm} = E\, Z_{lmi}$.

This comparison, using repeated measures, showed a significant difference among the means [$F(2/49) = 128.6508$, $p < .0001$]. Pair-wise contrasts showed that model 3 was superior to model 1 and that model 1 was superior to model 2.

4. Analysis of variance--sum of squares. This was analogous to analysis 3, but was based upon

$$Z_{2mi} = \Sigma_k \left| W_{ikm} \right|^2 .$$

Once again, a significant difference between the means was found [$F(2/49) = 15.4$ $p < .001$]. At the .05 level, model 1 was significantly better than model 2 and model 3, while model 2 was better, but not significantly better, than model 3.

Several other analysis techniques were attempted. Two of these analyses were similar to analyses 3 and 4, but included the random assignment of the subjects into 17 groups of three subjects each. These latter two analyses both showed model 1 to be superior but were not consistent in the ordering of models 2 and 3.

IV

DISCUSSION

That the responses to certain words such as yook, thoup, and smow deviated from the principal responses in a manner that tended to be predictable on the basis of following consonant indicates that the simple type/token models in which all test items in a digraph class are assigned the same expected frequency for the principal response are inadequate. Following consonant had a definite influence over the responses that the subjects gave, even though it is evident from this study that final consonant is not the only factor that influences pronunciation. The final consonant model was superior in both comparisons based on deviations of group scores from predicted scores (analyses 1 and 2) and in the analysis of variance based on the square of the individual variations from the predicted scores (analysis 4). Only in the analysis of variance based on absolute values of individual deviations (analysis 3) was the final consonant model not superior to the other two. The change in the position of the final consonant model from analysis 3 to analysis 4, however, implies that the final consonant model has less variance than the other two models.

We conclude from these analyses that the final consonant model is indeed superior to the other two models, but that other factors which have yet to be assessed also are present in the results. A model that might provide a higher degree of predictability than the models used here is a final consonant model based on token counts rather than on type counts. This model would be especially effective if the final consonant influence derives from analogy with a few high frequency words rather than from a generalization based on all real words that contain a particular spelling. At the same time, the influence of initial consonant cannot be rejected, especially in light of the different response patterns that smow and drow elicited.

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APPENDIX

PRONUNCIATION TEST

1.	yeath	meet	bed	ton	play
2.	smow	about	boat	ton	mop
3.	bown	ton	about	boat	mop
4.	foon	put	blue	ton	boat
5.	doub	put	ton	cow	blue
6.	brean	play	bed	meet	ton
7.	theat	bed	ton	play	meet
8.	frout	blue	put	cow	ton
9.	drow	boat	ton	mop	about
10.	trowd	ton	mop	about	boat
11.	thoup	ton	cow	put	blue
12.	loun	cow	ton	blue	put
13.	pleal	bed	meet	play	ton
14.	towd	boat	about	mop	ton
15.	nool	ton	boat	put	blue
16.	stoom	blue	ton	boat	put
17.	rouch	blue	cow	ton	put
18.	yook	blue	put	boat	ton
19.	pown	mop	boat	about	ton
20.	glead	ton	meet	bed	play
21.	plood	boat	blue	put	ton
22.	feak	play	meet	bet	ton
23.	doot	ton	put	blue	boat
24.	soud	ton	blue	put	cow