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ABSTRACT

The objectives of this project were the instrumental analysis and detailed description of the phonetic features of American English and of the foreign languages most commonly taught in the United States--German, Spanish, and French. Eleven prosodic features, 13 vocalic features, and 16 consonant features of each are compared to English. A three-way instrumental technique of research was developed: (1) The spectrograms of utterances that have been composed and recorded for a special purpose were analyzed and those of English compared with the corresponding ones of German, Spanish, and French. This led to hypothesizing about the acoustic differences between English and the other languages regarding certain phonetic characteristics. (2) The hypotheses were verified or refuted by means of spectrographic synthesis. (3) Motion picture X-rays of the utterances were made and studied frame by frame by means of special projectors, to discover the articulatory features that correlated with the acoustic ones found by spectrographic analysis and synthesis. As a complement to this instrumental research, phonetic features of English and foreign languages were investigated by statistical analysis, related to such features as phoneme frequency and distribution and syllable types. "Two notes on Semitic Laryngeals in East Gurage" by R. Hetzron is included. (DO)

OE/IIS

FINAL REPORT

Contract No. OEC-0-9-097701-0775/014

THE GENERAL PHONETIC CHARACTERISTICS OF LANGUAGES

Pierre Delattre

The Regents of the University of California
University of California
Santa Barbara
California

December 1969

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

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It is with great regret that we must report the death of our Director, Professor Pierre Delattre, on July 11, 1969. The new Director of the Speech Synthesis Project at the University of California at Santa Barbara is Professor André Malécot. The research reported in this Final Report was completed under Dr. Delattre and the rough manuscripts were ready prior to his death.

TABLE OF CONTENTS

INTRODUCTION

THE PROBLEM

In the teaching of foreign languages to American students one of the major problems has always been that of acquiring a satisfactory pronunciation. Language Institutes have had more difficulty in this respect than in any other. With the present emphasis on "speaking," this problem has taken on more importance every year. In order to make an effective use of the phonemic system of a second language, one must develop good articulatory habits. Improvements in the teaching of pronunciation have been hampered by an insufficient knowledge of the segmental and prosodic features of foreign languages. Problems of interference are partly due to a lack of really objective data on the phonetic features of the first language as well as of the second -- data which would allow phonetic contrasting of the two languages in a truthful and realistic manner.

OBJECTIVES

The long range objectives of this project are the instrumental analysis and detailed description of the phonetic features of American English and of the foreign languages that are commonly taught in the United States. The foreign languages toward which our main attention is turned at present are German, Spanish, and French. Results of our investigations are to appear in article or book form.

Exploratory research has led us to divide our investigation into 40 sections -- 11 prosodic features, 13 vocalic features, and 16 consonant features. As a result, we are comparing English to German, English to Spanish, English to French, each under the 40 following headings:

Prosodic Features: 1. Declarative Intonation. 2. Non-Declarative intonation. 3. Place of Logical Stress in the Word. 4. Place of Logical Stress in the Sense Group. 5. Nature of Logical Stress. 6. Place of Emphatic Stress. 7. Nature of Emphatic Stress. 8. Variations in Syllable Weight. 9. Internal Juncture and Syllabication. 10. Syllable Type. 11. Tension.

Vocalic Features: 12. Articulatory Description. 13. Acoustic Description. 14. New Vowel Sounds for the English Speaker. 15. Distribution (Positional and Allophonic). 16. Frequency of Occurrence. 17. Duration System. 18. Neutral Position. 19. Loss of Color. 20. Effect of Consonant Anticipation on Vowels. 21. Diphthongization. 22. Effect of Syllable Type on Vowel Color. 23. Attack and Release. 24. Nasality.

Consonantal Features: 25. Articulatory Description. 26. Acoustic Description. 27. New Consonant Sounds for the English Speaker. 28. Distribution (Positional and Allophonic). 29. Frequency of Occurence. 30. Duration System. 31. Neutral Position. 32. Consonantal Weakening. 33. Effect of Vowel Anticipation on Consonants. 34. Speed of Articulation. 35. Tongue Fronting. 36. Aspiration. 37. Affrication. 38. Palatalization. 39. Final Release. 40. Voicing.

PROCEDURES

In order to complete these investigations with a high degree of objectivity, we have developed a three-way instrumental technique of research based on the successful design and construction of special instrumentation.

1) This three-way technique generally begins with the spectrographic analysis of utterances that have been composed and recorded for a special purpose. The comparison of spectrograms of English with corresponding ones of German, Spanish or French leads to making some hypotheses to the acoustic differences between English and the other languages, regarding certain phonetic characteristics.

2) Then, the hypotheses are verified or refuted by means of spectrographic synthesis. Spectrographic patterns of the contrastive utterances are painted and transferred into sound by a speech synthesizer. It is thus possible to judge by ear to what extent the assumed acoustic differences produce the appropriate auditory differences.

3) Finally, motion picture X-rays of the utterances are made and studied frame by frame by means of special projectors, to discover the articulatory features that correlate with the acoustic ones found by spectrographic analysis and synthesis.

4) As a complement to this instrumental research, phonetic features of English and foreign languages are investigated by statistical analysis, related to such features as phoneme frequency, phoneme distribution, syllable types, etc.

RELATED RESEARCH

Our investigation of the phonetic characteristics of languages is related to research in the general field of Applied Linguistics in that it will contribute to our conclusive knowledge of English and foreign languages and will make it possible to improve their teaching.

It is also related to research in Methodology, seeing that experiments aimed at obtaining better results in language teaching will use our data.

Finally, it is related to research in General Linguistics because our acoustic and articulatory studies are closely connected with the determination of the "distinctive features" of phonemes and prosodemes.

RESULTS

During this year of research under contract with the Office of Education we have completed six studies, the texts of which follow.

SYLLABIC FEATURES AND PHONIC IMPRESSION
IN ENGLISH, GERMAN, FRENCH AND SPANISH

INTRODUCTION

Among the major linguistic factors which contribute to the subjective impression a listener experiences upon hearing a foreign language, one is certainly related to syllabic features such as C and V structure, phonic content, and phonic distribution within syllables. With this in mind, we have made a phonological analysis of syllables in English, French, German, and Spanish, hoping that contrasts among the four languages would further help in characterizing their syllabic preferences.

In each of the four languages, 2000 syllables were used -- half from a narrative passage and half from a dramatic text. All materials are by contemporary authors. The narrative passages were chosen from short stories, and the dramatic texts were taken from modern plays with rapid sequences of dialogue. Both types of materials were selected for their naturalness and spontaneity of expression while remaining within the formal bounds of the two literary genres.

In all materials, syllabic division was made according to De Saussure's theory of consonant apertures.[1] In French and Spanish, syllables were divided irrespective of word boundaries within the sense-group. But in English and German, where there is strong consonantal anticipation, word-final consonants were retained with the last syllable of the word. If this favored the count of closed syllables in the two Germanic languages, there is certainly an adequate compensation in the fact that, within the word, an intervocalic consonant was always counted as belonging with the syllable of the following vowel. Such a convention permits one to apply the rules proposed by De Saussure while still taking into account the broad tendencies of syllable division in each of the four languages.

Once the 8000 syllables had been extracted from our narrative and dramatic materials, they were recorded on individual cards both in concrete phonetic script and in abstract C and V structure so as to facilitate their statistical manipulation. The various relationships which came to light in this manner suggested that our analysis touch upon seven points of comparison among the four languages: phonic content of the syllables, consonantal load of the syllables, variety and complexity of running-syllable structures, syllabic length, syllabic opening, frequency of different-syllable structures, and average group frequency vs. syllable length. We shall now examine each of these features in the above order while keeping in mind the correlation between objective data and subjective impression.

1. PHONIC CONTENT

The 10 most frequent syllables from both the narrative and dramatic texts are presented in Table 1 for each language. By their high degree of frequency, these syllables should tell us something about the sound combinations preferred by each language and the subjective impression that each one imparts.

Narrative and dramatic materials were kept apart in the event a major difference might appear, but actually the two series of syllables prove to be quite similar. As a matter of fact, 6 out of 10 are repeated in German, 6 out of 10 in English, 5 out of 10 in Spanish, and 7 out of 10 in French. At least half of the exact syllables are common to both types of material.

In these few most frequent syllables, each language prefers certain general features of consonant-vowel combinations. For the most part, English combines apical consonants with central vowels, German combines apical consonants with central and front vowels, French combines apical consonants with front vowels, and Spanish combines apical consonants with a balance of the open and mid-open vowels. The most marked difference which sets each language apart is its vocalic preference. English typically centers its articulation around the neutral vowel /ə/; German gravitates from the central position towards front vowels such as /e/ and /i/; French definitely prefers front vowels, especially /e/; and Spanish slightly favors the mid-open vowels /e/ and /o/ over the open vowel /a/. The place of articulation of consonants, on the other hand, is similar in the four languages -- it is always predominantly apical -- but their manner of articulation can differ considerably. All four languages favor the consonant /r/ with its unique articulation in each. All choose /t/ and /d/, but these consonants are dental in French, Spanish, and German; alveolar in English. In addition, /t/ is unaspirated in Spanish and French, but aspirated in German and English. The preferred dentals of German include the strong affricate /ts/, while the dentals of English make frequent use of their soft interdental /ð/. Spanish and French tend to use more liquids

Syllables from Narrative Material

German:	ʊnt	tə	er	gə	das	tsu	di	der	zai	ai
	40	24	24	22	20	20	17	16	14	13
English:	ə	əv	ðə	ɪn	ænd	ai	tu	ri	fɔr	ðæt
	45	33	30	18	17	15	12	11	11	10
Spanish:	de	a	e	la	ba	do	ke	i	to	ra
	38	28	23	22	20	20	18	18	17	16
French:	te	de	le	se	la	də	e	a	re	ma
	25	23	22	17	15	14	14	13	13	13

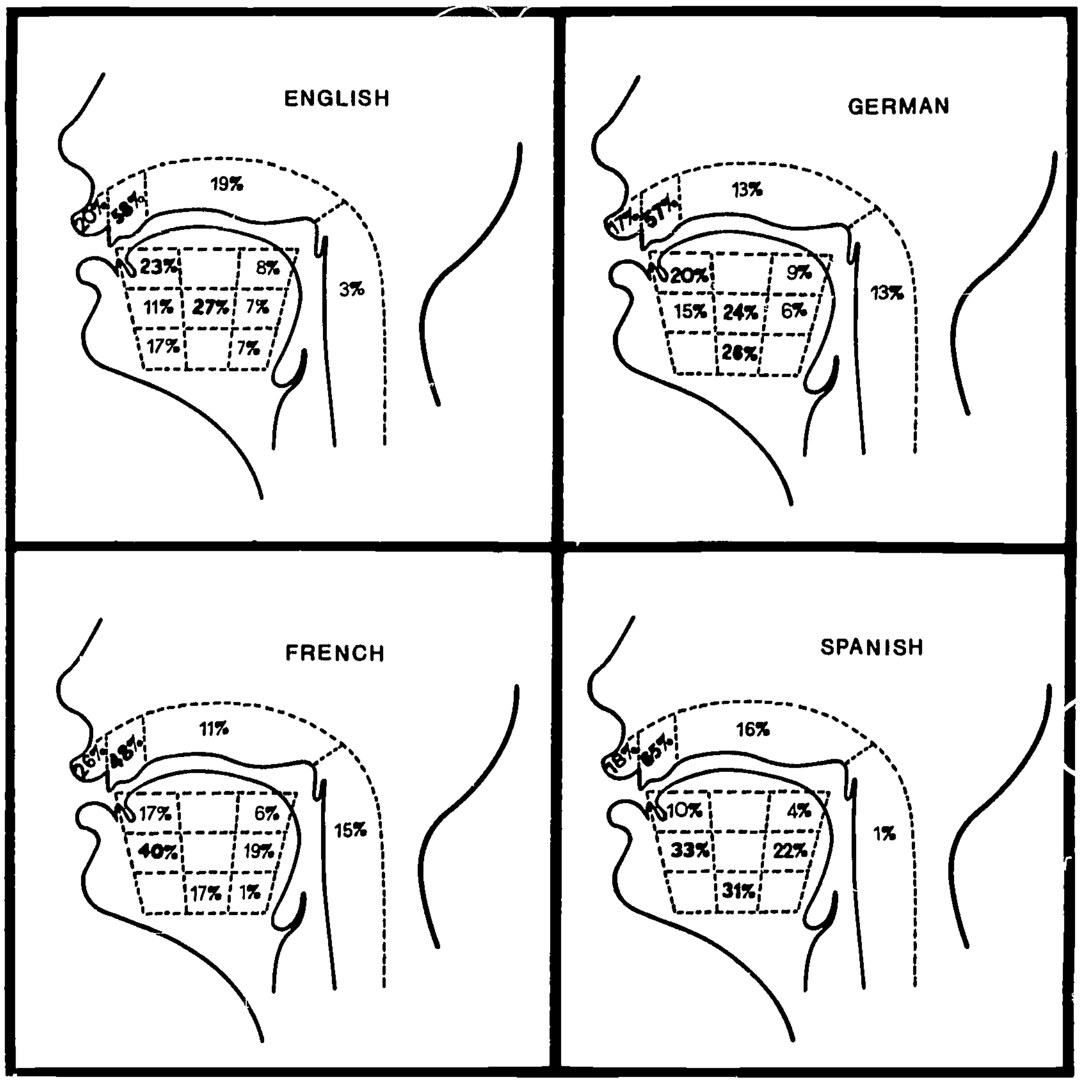
Syllables from Dramatic Material

German:	das	du	ɪç	gə	di	ai	nə	nɪçt	ʊnt	tə
	27	25	24	20	19	19	18	17	14	14
English:	ə	ju	tu	ai	ðə	ɪt	ænd	ɪn	ðɪs	nə
	40	27	24	22	18	18	15	14	14	13
Spanish:	de	te	no	do	ke	se	ka	a	to	da
	33	28	28	26	26	24	20	19	18	18
French:	il	pa	le	a	te	la	se	de	nu	e
	26	25	22	20	19	17	16	15	15	14

TABLE 1. The 10 most frequent syllables are presented for narrative and dramatic texts separately. Figures under each syllable indicate frequency of occurrence in 1000.

FIGURE LEGEND

Figure 1. Percentages are presented for 4 categories of consonants based upon point of articulation (labial and labio-dental, dental and alveolar, palatal and velar, glottal and pharyngeal) and for 9 categories of vowels based upon relative tongue position (high, mid, low vs. front, central, back). In both consonant and vowel categories, dots have been added to indicate relative frequency so that dark areas of high density can be seen at a glance.


ENGLISH
20%
19%
23%
8%
11%
27%
7%
3%
17%
7%
GERMAN
17%
13%
20%
9%
15%
24%
6%
13%
26%
FRENCH
26%
11%
17%
6%
40%
19%
15%
17%
1%
SPANISH
18%
16%
10%
4%
33%
22%
1%
31%

than English and German. In short, consonant and vowel sounds are combined into syllables which are highly individualistic for each language.

A further comparison of phonic content might be made to determine to what extent these tendencies of the most frequent syllables conform to those of the entire texts. For this purpose all of the 2000 syllables of each language were analyzed. Percentages were calculated for four categories of consonants based upon points of articulation (labial and labio-dental, dental and alveolar, palatal and velar, glottal and pharyngeal), and nine categories of vowels based upon relative tongue position (high, mid, low, vs. front, central, back). These percentages are presented in graphic form in Figure 1 so that consonant-vowel combinations of high frequency categories can be seen at a glance.

This pictorial presentation clearly confirms that denti-alveolar consonants dominate in all four languages: 58 per cent of all consonants in English, 57 per cent in German, 48 per cent in French, and 65 per cent in Spanish. The classes of vowels with which the preceding classes of consonants combine the most frequently are different in each language: In English they mainly combine with mid-central (27%), and high-front (23%) vowels; in German with low-central (26%), mid-central (24%), and high-front (20%); in French with mid-front (40%); and in Spanish with mid-front (33%), low-central (31%), and mid-back (22%). These combinations based on total frequency in the texts differ little from those found in the most frequent syllables. The same vocalic categories are of high frequency and the denti-alveolar (apical) consonants are strongly favored. The /r/, as it was clearly present for each of the languages in Table 1, is certainly greatly responsible here for a high proportion of pharyngeals in French and German, palatals in English, and alveolars in Spanish.

To these objective differences of syllabic content must correspond certain general subjective impressions of a combined consonantal and vocalic nature. The typical phonic impression left by English should be an apical with strong central resonance, German an apical with central and front resonance, French an apical with strong front resonance, and Spanish an apical with rather equally balanced vocalic resonance of slight front predominance over central and back. The series of non-sense syllables of Table 1, when read in quick succession, furnish a good illustration of this subjective impression which each language produces.

2. CONSONANTAL LOAD

Another factor that contributes to the general phonic impression which distinguishes one language from another is the ratio of consonants to vowels in syllables. Since a syllable is composed of a vowel and a varying number of consonantal elements, we would expect each language to add these consonantal elements in different proportions. From the few most representative syllables of Table 1, the following ratios of consonant to vowel can be extracted:

	Consonants	Vowels
German:	2.5	2.0
English:	2.1	2.0
Spanish:	1.6	2.0
French:	1.6	2.0

Since each syllable possesses only one vowel, the average number of consonants per syllable is about 1.2 in German, 1.0 in English, and 0.8 in Spanish and French. Consonantal load is greatest in German, somewhat less and almost equally balanced in English, and much less in Spanish and French. These differences in consonantal ratio are certainly audible to the listener. We find that the more loaded the syllable, that is, the richer it is in consonants, the heavier, slower, and more interruptive the subjective impression. German is, therefore, choppy and consonantal; English is more uniform and neither predominantly consonantal nor predominantly vocalic; French and Spanish are flowing and vocalic.

3. VARIETY AND COMPLEXITY OF RUNNING SYLLABLE-STRUCTURES

Now it is of interest to view the syllable on a more abstract level. If we consider consonants and vowels, stripped of their individual distinctive value and existing only as structural members of two mutually exclusive categories, we can say something about the distribution of these categories and the different orders in which they combine. When the syllable is considered as a structure, composed of two types of building blocks, consonants and vowels, arranged in various sequences, it appears that each language is characterized by a rather limited number of syllabic structures.

The frequency of occurrence of each syllabic structure can be specified either by its actual number of occurrences in the text, or by the number of times it occurs with different phonetic shapes. The former is based on a count of running syllables and the latter on a count of different syllables. For instance, in the English sequency That cat did that, the frequency of the CVC structure is 4 in running syllables and is 3 in different syllables.

Table 2 gives the frequency of occurrence of syllabic structures in running syllables. These structures are grouped by type and arranged in descending order of absolute frequency, first for narrative and dramatic texts separately, then for both in combination.

We note first that the four languages vary considerably in the number of possible C and V combinations. From the 2000 syllables analyzed, only 10 different structures emerge for French and Spanish, and the syllables of these two languages vary from one vowel alone to one vowel plus 4 additional consonants. In English 14 different structures appear, and in German there are 15 different ones; moreover, the syllables of those two languages vary in shape from one vowel to one vowel plus 5 consonants. According to the data of Table 2, therefore, the syllables of the two Germanic languages show both greater structural variety and greater complexity than those of the two Romance languages.

Another feature to be observed is that the sum of a very small number of these syllable structures holds the majority of total occurrences. Whether narrative and dramatic texts are considered separately or in combination, there seems to be a rather abrupt decline in frequency after the first 3 or 4 types in each series. These most frequent syllable structures are CVC, CV, and VC for the Germanic languages, and CV, CVC, and CCV for the Romance languages. Since two of these types are common to both pairs of languages, we are actually dealing with only 4 structures in this high frequency category: CVC, CV, VC, and CCV. As a matter of fact, those four types of structure contain 75.3 per cent of the syllable occurrences in English, 79.9 per cent in German, 88.1 per cent in French and 88.7 per cent in Spanish. They are presented below with their individual percentages for each of the four languages.

	CVC	VC	CV	CCV
German:	38.1	9.8	28.7	3.3
English:	31.8	11.9	27.6	4.0
Spanish:	19.8	3.1	55.6	10.2
French:	17.1	1.9	54.9	14.2

RUNNING SYLLABLES

ENGLISH		GERMAN		FRENCH		SPANISH	
CVC	301	CVC	395	CV	555	CV	542
CV	297	CV	284	CVC	179	CVC	206
VC	126	VC	105	CCV	145	CCV	91
V	74	CVCC	69	V	57	V	74
CVCC	70	VCC	46	CCVC	39	CCVC	51
CCVC	53	V	41	CVCC	9	VC	29
CCV	49	CCV	33	VC	8	CCCV	5
VCC	23	CCVC	20	CCCV	8	VCC	1
CCVCC	15	CCVCC	4		1000	CCCVC	1
CCVCCC	4	CVCCC	1				1000
CVCCC	3	CCCVC	1				
CCCV	1	CVCCCC	1				
CCCVC	1		1000				
CCCVCC	1						
	1000						

CVC	336	CVC	368	CV	544	CV	571
CV	274	CV	311	CVC	164	CVC	191
VC	112	VC	92	CCV	139	CCV	114
V	88	CVCC	86	V	64	V	52
CVCC	64	V	40	CCVC	34	CCVC	35
CCVC	43	CCV	34	VC	31	VC	33
Vcc	35	VCC	26	CVCC	11	CVCC	4
CCV	31	CCVC	15	CCCV	11		1000
CCVCC	11	CVCCC	14	VCC	1		
CVCCC	3	CCVCC	10	CVCCC	1		
VCCC	2	CVCCCC	2		1000		
CCCVC	1	VCCCC	1				
	1000	CCVCCC	1				
			1000				

CVC	637	CVC	763	CV	1099	CV	1113
CV	553	CV	595	CVC	343	CVC	397
VC	238	VC	197	CCV	284	CCV	205
V	162	CVCC	155	V	121	V	126
CVCC	134	V	81	CCVC	73	CCVC	86
CCVC	96	VCC	72	VC	39	VC	62
CCV	80	CCV	67	CVCC	20	CCCV	5
VCC	58	CCVC	35	CCCV	19	CVCC	4
CCVCC	26	CVCCC	15	VCC	1	VCC	1
CVCCC	6	CCVCC	14	CVCCC	1	CCCVC	1
CCVCCC	4	CVCCCC	3		2000		2000
VCCC	2	CCCVC	1				
CCCVC	2	VCCCC	1				
CCCV	1	CCVCCC	1				
CCCVCC	1		2000				
	2000						

TABLE 2. Syllabic structures for running syllables are grouped by type and arranged in descending order of frequency. Structures are presented first for narrative and dramatic texts separately, then both in combination.

The prevailing types of structure are not only different, but they stand out differently in each family of languages -- two types share the majority (CVC and CV) in the Germanic languages, whereas a single type (CV) holds the majority in the Latin languages. German strongly favors the CVC type; English is more equally divided between CVC and CV, nevertheless, favoring the former over the latter; Spanish and French clearly prefer the CV type to all others.

4. SYLLABLE LENGTH

These type preferences suggest that German and English prefer a longer syllable, one containing more segmental phonemes, than French and Spanish; the most frequent syllable type in English and German is CVC with 3 segments; the preferred type in French and Spanish is CV with 2 segments. If we analyze the entire 2000 syllables for each language, calculations reveal that the number of segmental phonemes per syllable is about 2.6 for English and German and 2.3 for Spanish and French; the over-all syllabic load is somewhat greater for the Germanic languages than for the Romance languages.

5. SYLLABIC OPENING

Frequency characteristics of the four most frequent syllabic structures also indicate the type of syllable terminal preferred by each language. The fact that English and German prefer CVC to CV and VC to CCV while French and Spanish prefer CV to CVC and CCV to VC, shows well that the Germanic languages use a consonantal terminal more than the Romance languages.

If we consider all syllables for each language as listed in Table 2, the following percentages emerge for the open and closed varieties:

	Closed Syllables	Open Syllables
German:	63	37
English:	60	40
Spanish:	28	72
French:	24	76

The results are clear. The predominance of closed syllables in the two Germanic languages is almost as marked as the predominance of open syllables in the two Romance languages. German has a somewhat stronger preference for closed syllables than English, and French has a slightly stronger preference for open syllables than Spanish. This comparison of syllable terminals, more than any other, closely allies German with English and French with Spanish, and sets the two pairs of languages apart.

These extreme differences in syllabic structure must contribute considerably to the subjective impression which the four languages give. The fact that French and Spanish syllables are less complex than English and German ones is perhaps one of the reasons why the Romance languages sound more repetitious, more monotonous than the Germanic languages. On the other hand, the preference in German and English for a slightly longer syllable with a consonantal closure gives a heavy, halting, and restraining impression. The tendency in Spanish and French for a shorter syllable with a vocalic terminal emphasizes their light, sonorous and legato qualities.

6. FREQUENCY OF DIFFERENT-SYLLABLE STRUCTURES

Table 3 is similar in format to Table 2, but it furnishes the number of <u>different</u> syllables for each syllable structure. This presentation permits us to look behind the structure itself in order to determine how many actual phonetically different syllables it represents. Again the narrative and dramatic materials are presented both separately and in combination. Up to this point in our analysis, the division of materials has yielded no remarkable difference. But here the narrative texts have consistently a greater number of different syllables than the dramatic texts. This difference is by 114 syllables in English, 68 in French, 30 in Spanish, and 8 in German. The difference may be related to style -- a more formal tone in narrative has greater syllable variety than a conversational tone in drama.

In the combined figures of Table 3, a new divergence among the four languages begins to appear. Spanish shows the smallest number of different syllables; English the greatest number. French and German lie between the two extremes, but much closer to English than to Spanish. With Spanish as the basis of comparison, there are 43% more different syllables in German, 52% more in French and 62% more in English. These figures indicate that Spanish is highly repetitive, while German, French and English show much greater variety. Of the latter three languages, German is more repetitive than English, and

DIFFERENT SYLLABLES

ENGLISH		GERMAN		FRENCH		SPANISH	
CVC	160	CVC	152	CV	144	CVC	109
CV	106	CV	90	CVC	124	CV	72
CVCC	54	CVCC	47	CCV	90	CCV	52
CCV	39	VC	23	CCVC	32	CCVC	38
CCVC	39	CCV	23	V	11	VC	12
VC	25	CCVC	15	CCCV	7	V	5
CCVCC	14	V	9	CVCC	7	CCCV	5
V	8	VCC	5	VC	3	VCC	1
CCVCCC	4	CCVCC	3		418	CCCVC	1
VCC	3	CVCCC	1				295
CVCCC	3	CCCVC	1				
CCCV	1	CVCCCC	1				
CCCVC	1		370				
CCCVCC	1						
	458						

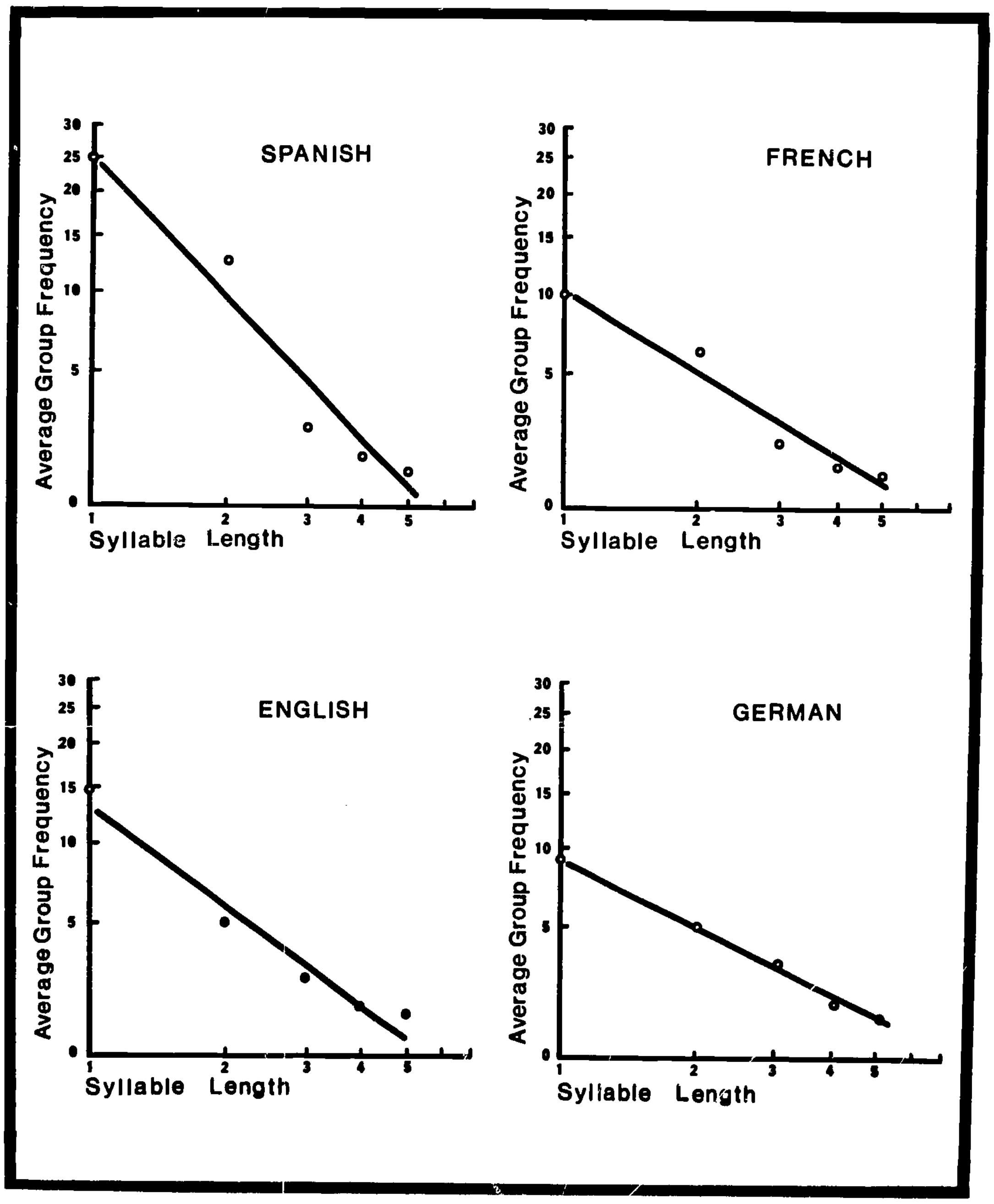
ENGLISH		GERMAN		FRENCH		SPANISH	
CVC	141	CVC	147	CV	126	CVC	90
CV	79	CV	88	CVC	93	CV	67
CVCC	40	CVCC	46	CCV	71	CCV	63
CCVC	23	VC	21	CCVC	27	CCVC	26
VC	21	CCV	15	CVCC	10	VC	11
CCV	15	CCVC	12	V	9	V	5
V	8	CVCCC	10	CCCV	7	CVCC	3
CCVCC	8	V	8	VC	5		265
VCC	5	CCVCC	7	VCC	1		
CVCCC	2	VCC	5	CVCCC	1		
VCCC	1	VCCCC	1		350		
CCVC	1	CVCCCC	1				
	344	CCVCCC	1				
			362				

ENGLISH		GERMAN		FRENCH		SPANISH	
CVC	247	CVC	233	CVC	189	CVC	147
CV	127	CV	132	CV	175	CCV	89
CVCC	87	CVCC	82	CCV	137	CV	78
CCVC	58	CCV	32	CCVC	59	CCVC	56
CCV	48	VC	29	CVCC	17	VC	16
VC	31	CCVC	24	CCCV	13	V	5
CCVCC	21	CVCCC	11	V	12	CCCV	5
V	11	CCVCC	10	VC	7	CVCC	3
VCC	6	V	9	VCC	1	VCC	1
CVCCC	5	VCC	8	CVCCC	1	CCCVC	1
CCVCCC	4	CVCCC	1		611		401
CCCVC	2	CCCVC	1				
VCCC	1	VCCCC	1				
CCCV	1	CCVCCC	1				
CCCVCC	1		574				
	650						

TABLE 3. Syllabic structures for different syllables are grouped by type and arranged in descending order of frequency. Structures are presented first for narrative and dramatic texts separately, then both in combination.

FIGURE LEGEND

Figure 2. Syllable length by number of length units is presented on the abscissa and average-group frequency on the ordinate. On logarithmic scale, the syllablic curves of AG frequency to length appear as nearly straight lines indicating a constant and direct relation between parameters.


SPANISH
FRENCH
ENGLISH
GERMAN
Average Group Frequency
Syllable Length
30
25
20
15
10
5
0
1
2
3
4
5

French stands equidistant between the two. This divergence in number of different syllables sets Spanish apart from the other three languages and explains the rather uniform and monotonous subjective impression that language gives, and the fact that German, French, and English sound much less repetitious.

7. AVERAGE-GROUP FREQUENCY vs. SYLLABLE LENGTH

Counts of running syllables and different syllables in Tables 2 and 3 further enable us to calculate average-group frequencies. AG frequency is found by dividing the number of running syllables by the number of different syllables. For example, in a group of 100 running syllables which contains 25 different syllables, its AG frequency is 4. If the number of different syllables is reduced to 20, its AG frequency becomes 5. Thus, as the number of different syllables is reduced, that is, as the group becomes more repetitious, its AG frequency increases.

In our materials, AG frequency is most profitably viewed in relation to syllable length. Since Tables 2 and 3 present frequency information according to individual syllable structures, there must be a temporary reorganization of this data according to syllable length. Syllables of one length unit are composed of the structure V, syllables of 2 length units are composed of the structures CV and VC, etc. Through this re-computation and the frequent conflation of 2 or more structures into one length category, English and German emerge with a maximum syllable length of 6 units and Spanish and French with a maximum of 5 units. For purposes of comparison among the four languages, only the first 5 length-categories are considered.

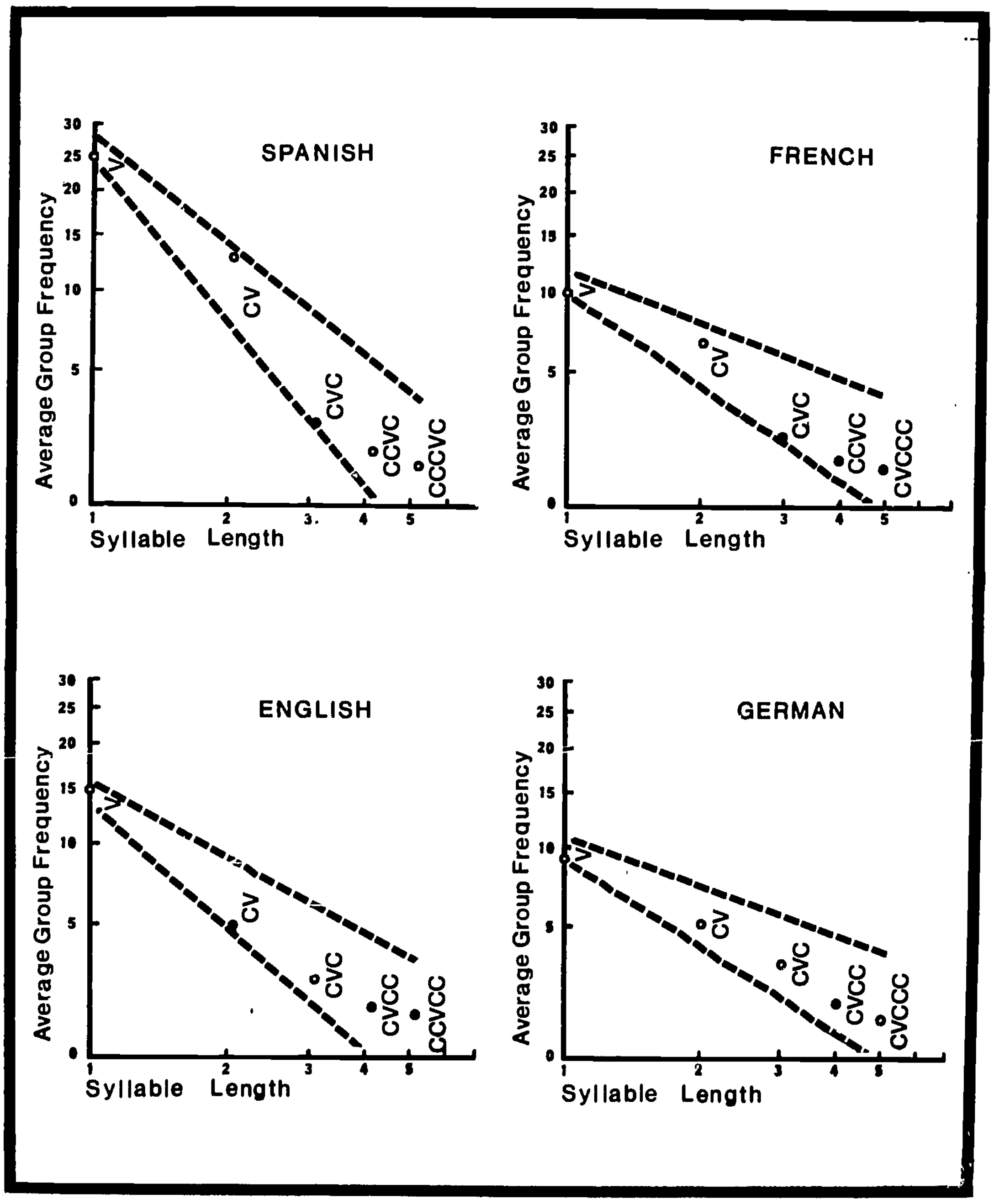
After finding totals for these 5 length categories in both running syllables and different syllables, AG frequencies for each language were calculated. The results are presented by the four graphs of Figure 2, where syllable length is plotted on the abscissa and AG frequency on the ordinate. When plotted in logarithmic scale, the syllabic curves of average frequency to length appear as nearly straight lines, showing a fairly constant and direct logarithmic relation between parameters.

Figure 3 shows the actual consonant- and vowel-structures marked by circles in Figure 2.

In these graphs, all four languages reveal the same

FIGURE LEGEND

Figure 3. The same correlation as Fig. 2 is shown -- the longer the syllables, the less frequent they are -- but, in addition, the actual CV structures of the syllables in our results are shown.


SPANISH
FRENCH
ENGLISH
GERMAN
Average Group Frequency
Syllable Length
V
CV
CVC
CCVC
CCCVC
CVCCC
CVCC
CCVCC
30
25
20
15
10
5
0
1
2
3
4
5

general tendency: the shorter the syllable, the more frequent its occurrence. However, this frequency-to-length correlation is not the same for all four languages. It is most marked in Spanish, somewhat less in English, and slightly less in French and German. Seen from another angle, if we compare the extremes, it appears that the short syllables are each repeated more often, and the long syllables less often in Spanish than in German. English and French stand between the two extremes, but closer to German than to Spanish.

In the previous comparison, which was based on the total number of different syllables in Table 3, each language revealed different degrees of repetitiveness -- Spanish was much more repetitive than English, German, or French. In the last comparison between syllable length and AG frequency, based on both Tables 2 and 3, each language reveals different degrees to which it repeats its shorter or longer syllables. Again Spanish is set apart by repeating its shorter syllables more often than the other three languages. Where the two forces meet, Spanish stands quite alone both in being the most repetitive of the four languages and in repeating most often its shorter syllables. The other three languages, compared with Spanish, are quite similar in both tendencies; nevertheless, the Germanic languages are at one extreme, since English is the least repetitive of the four languages, and German stresses the least its shorter syllables.

The combined effect of both tendencies is unmistakable. The more repetitive a language becomes, the more monotonous is the subjective impression. The more it stresses its shorter syllables, the more staccato the impression. In subjective terms, Spanish is certainly the most uniform and monotonous of the four languages as well as the most staccato.

CONCLUSION

These several comparisons show that the subjective impression which each of the four languages makes upon a listener can be objectively related to the phonetic and distributional structure of its syllables. Phonetic content of the most frequent consonant and vowel combinations in the syllable as well as the ratio of consonant to vowel clearly set each language apart as having a very characteristic sound quality or resonance. Distributional positioning of these sounds within the syllable also shows individual differences, usually by setting two languages against two or one against three. The Germanic languages clearly oppose the Romance languages in structural complexity of the syllable and nature of syllabic terminal. Spanish opposes the three others in frequency of different syllables, and average-group frequency vs. syllable length. Through these differences of phonic content and sound distribution in the syllable, each language is sharply characterized.

SUMMARY

An attempt is made to analyze objectively the syllabic features which contribute to the subjective impression a language makes upon a foreign ear. Four languages are involved in this analysis -- English, German, French and Spanish. The syllabic character of each one is emphasized by comparison with the others. 2000 syllables are analyzed in each of the four languages. Seven aspects of the syllable emerge from the objective data.

1. Phonic content in terms of place of articulation based either on the ten most frequent syllables or on the complete corpus of 2000 syllables, shows the following preferences: in English, apical consonants with central vowels; in German, apical consonants with center and front vowels; in French, apical consonants with front vowels; in Spanish, apical consonants with a balance of open and mid-open vowels.

2. Consonant-to-vowel ratio, or simply consonantal load since each syllable has only one vowel, is highest in German, almost balanced in English, and lowest in French and Spanish.

3. Variety and complexity of syllabic structures are both greater in the two Germanic languages than in the two Romance languages. The prevailing structures are divided among CVC and CV in German and English, whereas in Spanish and French the CV structure holds a majority by itself alone.

4. Syllable length, in terms of number of phonemes, is also greater in Germanic than in Latin languages.

5. The predominance of closed syllables in German and English (63 and 60 per cent) is almost as marked as the preference for open syllables in Spanish and French (72 and 76 per cent).

6. In frequency of different-syllable structures, Spanish stands alone -- it shows the smallest number of different syllables; English shows the largest number, with German

and French not far behind.

7. And again Spanish is set apart with respect to the relationship of syllable length with average-group frequency -- Spanish repeats its shorter syllables more often than the three other languages.

To these objective data correspond subjective impressions such as frontal resonance, active articulation, auditory richness, forward motion, heaviness, musical predominance, sequential legato, repetitiveness, monotony, (or their opposites) the sum of which contributes considerably to characterizing a language.

X X X

FOOTNOTES

[1]In the Cours de Linguistique Générale by Ferdinand de Saussure, 5 degrees of consonant aperture are identified which nearly coincide with the traditional division by manner of articulation. With increasing aperture they are: stops, nasals, fricatives, liquids, and semi-consonants. Even though syllable division may well occur within a consonant, in intervocalic clusters, for practical reasons, division is made either before or after a consonant. Thus the French word patrie would be divided before the consonant group (pa-trie), while the word partie would be divided within the consonant group (par-tie) even though the "valley" of syllabic division may be during the [t] or during the [r].

AN ACOUSTIC AND ARTICULATORY STUDY OF VOWEL REDUCTION IN FOUR LANGUAGES

I. Introduction

Vowel reduction in medial position will be studied here in such pairs as:

English:	Com'peting/Compe'tition
German:	Ma'nier/manie'riert
Spanish:	A'chican/Achi'caban
French:	Fa'tigue/Fati'gué

for the purpose of comparing the patterns of modification under the influence of weak stress as they emerge in English, in German, in Spanish, and in French.

Subjectively, reduction is perceived as an obscuration of color with respect to the target color of the vowel. Such loss of quality reduces the distinctive function of a vowel and raises its confusion factor -- the unstressed medial e and i of complement and compliment are more likely to be confused with one another than the stressed e and i of met and mitt.

Objectively, vowel reduction can be observed at the articulatory level by means of motion-picture X-rays which make visible the position of the tongue, lips, and other articulators, as well as the shape and volume of the resonance cavities of the vocal tract. At the acoustic level, it can be observed by means of spectrographic representations which make visible the position of vowel formants on an appropriate frequency scale.

8 The two means of objective analysis -- acoustic and articulatory -- are not equally practicable. The frequency of formants can be measured with a sufficient degree of ease and accuracy, whereas the position of the articulators, or the shape and volume of the vocal-tract cavities, are not 'mathematically manageable' -- they cannot be expressed in simple numbers, they can only be 'evaluated' by comparison with simplified geometrical shapes which are, in turn, mathematically manageable. It seems, therefore, appropriate to base a study of vowel reduction primarily upon the acoustic measurement of spectrograms, and to use the motion-picture X-rays in a second stage for the interpretation of the acoustic patterns of vowel reduction in articulatory terms. This is feasable because the correlation between formant frequency and cavity volume has been studied exten-

sively and yields acceptable approximations. It is by combining the technique of acoustic measurement with that of cineradiography that we propose to compare, here, the patterns of vowel reduction in four languages.

But one should not go into the subject of vowel reduction without first considering its causes.

X X X

THE CAUSES of vowel reduction are numerous; we shall recall, here, the major ones only, keeping in mind our present purpose -- the comparison of languages.

1. Basically, reduction is related to rhythm. Monosyllabic rhythm, found in languages which place a medium beat on each syllable so that a more or less equal amount of stress falls on all syllables, produces less vowel reduction than polysyllabic rhythm, found in languages in which strong beats fall at irregular syllabic intervals, the rhythmical unit being one strong syllable flanked by weak ones. The rhythm of French is of the first type, that of English of the second; Spanish and German are intermediary.

2. Languages that are articulated with muscular tenseness such as French, are likely to show less vowel reduction than those that are articulated with muscular laxness, such as English.

3. Reduction correlates with stress. Weakly stressed, or 'unstressed,' vowels suffer more obscuration than strongly stressed ones.

4. Reduction also correlates clearly with vowel duration -- the shorter the vowel, the more obscure it tends to become. A recent spectrographic study by Björn Lindblom relates reduction in Swedish vowels to duration rather than to stress.[1] The author is opposed to the hypothesis that "...vowels occurring in weakly stressed syllables are articulated with less effort and adjustment of the vocal organs, which leads to their modification and reduction."[2] He contends that "...timing is the primary variable in determining the reduction of sounds, and the articulatory imprecision of laxness that may hypothetically be associated with reduced stress can be neglected in this connection."[3] Having included in his study some experiments in which the rate of utterance (or syllabic tempo) was purposely varied, and not the degree of stress, and which showed that "In spite of efforts on the part of the talker to hit the bull's eye at a fast rate of articulation, he cannot do so owing to the inertia inherent in the articu-

latory mechanism,"[4] he concludes that "...it is immaterial whether a given length of the vowel is produced chiefly by the tempo or the degree of stress. Duration seems to be the main determinant of the reduction."[5]

This would be convincing if Lindblom could also show that duration does not merely correlate with vowel reduction but is its primary cause. Unless he can do this, we must continue to consider stress and tempo the primary determinants of vowel reduction, and duration a product of stress and tempo and, therefore, a secondary determinant of vowel reduction.

Furthermore, Lindblom fails to note that vowel duration can vary because of many other factors besides tempo of utterance and degree of stress. Vowel duration varies extensively under the influence of the following consonant or consonants -- this sort of non-distinctive conditioning gives the /a/ of French sac one-third the length of the /a/ of French sage. Duration also varies according to the vowel itself. In English, the vowels of lick, look, luck, are shorter than those of leak, Luke, lock. In French, the vowels of pâte, paume, cinq, are longer than those of patte, pomme, sec.

It is also relevant to note here that the subjective impression of vowel obscuration can be produced by shortening the duration alone, without modification of formant frequencies. Experiments with synthetic speech show that as the length of an /a/ vowel segment is reduced the vowel is identified as /a/ less frequently. Complete loss of /a/ color occurs for a duration of about 1.5 centiseconds. Each vowel has a different duration-to-obscuration ratio -- the /i/ color becomes unintelligible with a duration of 1.25 cs.

5. A factor of vowel reduction often neglected is physical intensity, measured by the amplitude of the composing sound waves and perceived by loudness. The lower the intensity of a vowel, in relation to the average intensity of the utterance, the more obscure it becomes.

Research indicates that in languages of polysyllabic rhythm, weaker stress correlates regularly with lower intensity whereas it does not always correlate with reduced duration -- in hurry, city, picture, for instance, the final UNSTRESSED vowel is as long or longer, but much less intense (loud), than the initial stressed vowel.[6]

6. Finally, vowel reduction is regularly produced by contextual assimilation. As early as 1948, in his book Acoustic Phonetics,[7] Martin Joos pointed out that second-

formant frequency is considerably lower in bab than in gag. Acoustically, this can be explained by the formant transitions that precede and follow the vowel. In bab, the transitions of the second formant are negative (they come from a lower level than a and return to a lower one) and have a lowering effect on that formant; in gag they are positive (they come from a higher level than a and return to a higher one) and have a raising effect on the frequency of the second formant. Physiologically, the study of motion-picture X-rays shows that the tongue lowers more in bab, where the large front cavity required by labials pushes it down at the onset, than in gag, where the contact with the palato-velum raises it at the onset.

We have verified the behavior of this effect in a study of the relation between vowel reduction and the locus of the flanking consonants. (The term "locus" designates the implicit frequency to which a formant transition must point in order to maximally contribute to the perception of a target place of articulation for a given class of consonants.) The following measurements are typical of the effect of contiguous consonants on stressed vowels. According to our statistics, the American /ʌ/, spoken by male subjects, averages 1200 cps for formant-2 and 600 cps for formant-1. In deducts [dɪdʌkts], the formant frequencies of /ʌ/ are generally around 1300 cps and 600 cps -- the second formant is obviously attracted to higher than average frequencies by the denti-alveolar locus, which is higher than 1200 cps (at 1800 cps). In publication [pʌblɪkeʃən], the formant frequencies of /ʌ/ are at about 1100 cps and 600 cps -- the second formant is now lower than average because it is attracted to the labial locus, which is lower than 1200 cps (at 700 cps). In gum [gʌm], the /ʌ/ by a male voice keeps the formant frequencies of the average /ʌ/ because it is attracted on one side to the high locus of velars and on the other side to the low locus of labials. These two opposite attractions balance one another.

From this we can deduce that the formant transitions that precede and follow a vowel have a reducing effect, but a very different and much smaller one than the effect of stress. The formant-transition effect is acoustically translated by a relatively small attraction of formant-2 toward the loci of the contiguous consonants; it can add to, as well as subtract from, the centering effect of unstress depending on whether the consonant loci are higher or lower than the second-formant frequency of the vowel. Not only is this effect small, but it is practically the same in all languages and, therefore, is of little interest for a cross-linguistic comparison such as the present one.

As we can see, the problems and factors relating to vowel reduction are numerous. We shall confine our attention, here, to the comparative effect of stress and unstress in modifying the color of the various vowels of English, German, Spanish, and French. Here, stress is strictly 'what makes a syllable stand out,' irrespective of which correlates contribute -- higher amplitude, longer duration, or wider frequency variation than in the other syllables.

At first, we shall concern ourselves with the ACOUSTIC aspect of vowel reduction -- our charts will be based exclusively on acoustic data: the frequency of formants -- but the major articulatory interpretations of the acoustic data will be outlined early for those who are principally trained in physiological phonetics.

II. Experimental Procedure

Pairs of words such as com'peting/compe'tition, in which the stressed and the unstressed forms of a vowel alternate, were selected to illustrate all the monophthongal vowels of English (12), German (14), Spanish (5), and French (10), with the following exceptions: The French back /ɑ/ was not included, because of its instability; neither were the four French nasal vowels because of the difficulty incurred in measuring their first formant -- the main correlate of vowel nasality is the low intensity of the first formant in relation to the second. The pairs of words used for each language are listed below.

ENGLISH

	STRESSED	UNSTRESSED
i	com'peting	compe'tition
ɪ	ex'hibit	exhi'bition
e	dis'able	disa'bility
ɛ	seg'menting	segmen'tation
æ	a'dapting	adap'tation
ɑ	an 'author	an au'thority
ɔ	a'bolish	abo'lition
o	con'voking	convo'cation
ʊ	you 'should be	you should 'stay
u	con'suming	consu'mation
ʌ	in 'substance	insub'stantial
ɚ	con'versing	conver'sation

FRENCH

	STRESSED	UNSTRESSED
i	fa'tigue	fati'gant
e	pre'ssé	précé'dant
ɛ	dé'teste	détes'ter
a	cons'tate	consta'ter
ɔ	pro'voque	provo'quer
o	com'pose	compo'ser
u	re'coupe	recou'per
y	é'tude	étu'dier
ø	au 'deux	au deu'xième
œ	on 'meuble	on meu'blait

GERMAN

	STRESSED	UNSTRESSED
i	Ka'lif	Kali'fat
ɪ	Mathema'tik	Mathe'matiker
e	Ju'wel	Juwe'lier
ɛ	Sub'jekt	subjek'tiv
a	Dy'nast	Dynas'tie
ɑ	Foto'graf	Fotogra'fie
ɔ	Para'dox	parado'xal
o	I'diom	idio'matisch
ʊ	Tri'umph	trium'phal
u	Kon'sum	konsu'miert
y	Mani'küre	Manikü'ristin
Y	'Flüsse	'überflüssig
ø	Er'lös	'unerlösbar
œ	'Götter	'abgöttisch

SPANISH

	STRESSED	UNSTRESSED
i	a'chican	achi'caban
e	al'ternan	alter'naban
a	a'gradan	agra'daban
o	re'cobran	reco'braban
u	o'cupan	ocu'paban

Each word was recorded twice by five native subjects of each language. The recording subjects were all men; formant-frequency averages, therefore, represent male values only. Spectrograms of the recordings were made and the frequencies of formant-1 and formant-2 were measured at the point where the first formant is highest. The ten numerical readings for each formant frequency (2 recordings by 5 subjects) were averaged. Tables 1, 2, 3, and 4 present those averages for the four languages, respectively. Formant-1 and formant-2 frequencies of all the stressed and unstressed vowels were then plotted on logarithmic paper, formant-1 in ordinate and formant-2 in abscissa, to obtain the acoustic-phonetic charts of Figures 1, 2, 4, 6, and 8.

For those who are not familiar with the acoustic charts of vowels and their use in phonetics, it should be explained that their interest lies in the analogy found between the articulatory and the acoustic criteria. Basically, both can produce the same kind of triangular shape. A simple illustration can be given by charting the vowels [i, a, u] both ways. On the basis of tongue height and tongue fronting, the highest point of the tongue dorsum is high-front for [i], high-back for [u], and low-center for [a]. This can form a triangle such as the Spanish one of Figure 9. On the acoustic basis of the two lowest formants (the two notes, or resonance frequencies, of the vocal tract by which a vowel is perceived as distinct from another), if [i] is placed high-left on the acoustic chart, [u] must be placed high-right, and [a] must be placed low-center, as on the acoustic chart of Fig. 8. The formant frequencies of Spanish /i, a, u/, according to Table 4, are, for /i/, formant-1 at 300 cps (high on the chart), formant-2 at 2250 cps (left on the chart); for /a/, formant-1 at 750 cps (low on the chart), formant-2 at 1400 cps (center on the chart); for /u/, formant-1 at 300 cps (high on the chart), formant-2 at 800 cps (right on the chart).

It must be remembered, however, that acoustic charts of vowels are not only more objective but also more informative than the articulatory charts of similar shape conceived by the early phoneticians and supported by the International Phonetic Association. Articulatory charts have only two dimensions; they are based on 'tongue height' and 'tongue fronting' and would show a rounded vowel like /y/ at the same location as an unrounded vowel like /i/, as long as both have the same tongue position. The acoustic charts place /y/ well to the right of /i/ because lip-rounding has lowered the frequency of the second formant by narrowing the opening of the front cavity.

Before going into the detailed analysis of each chart,

TABLE 1

ENGLISH

	STRESSED		UNSTRESSED	
i	Formant-2 . .	2200	Formant-2 . .	1600
	Formant-1 . .	300	Formant-1 . .	375
ɪ		1700		1600
		375		400
e		1900		1500
		425		400
ɛ		1750		1600
		550		500
æ		1650		1600
		700		550
ɑ		1100		1150
		700		500
ɔ		1000		1100
		600		475
o		900		1100
		450		425
ʊ		1300		1500
		425		375
u		1000		1350
		325		375
ʌ		1200		1400
		600		400
ɚ		1200		1300
		450		400

TABLE 2

FRENCH

	STRESSED		UNSTRESSED	
i	Formant-2 . .	2400	Formant-2 . .	2200
	Formant-1 . .	275	Formant-1 . .	325
e		2200		2050
		400		400
ɛ		1900		1950
		550		475
a		1400		1500
		750		650
ɔ		1050		1050
		575		475
o		800		900
		400		400
u		775		850
		275		325
y		1900		2000
		275		325
ø		1600		1650
		400		425
œ		1350		1450
		600		525

TABLE 3

GERMAN

		STRESSED		UNSTRESSED
i	Formant-2 . .	2300	Formant-2 . .	2200
	Formant-1 . .	300	Formant-1 . .	325
ɪ		2100		2000
		350		350
e		2100		2000
		400		375
ɛ		1850		1825
		525		475
a		1400		1450
		725		650
ɑ		1200		1300
		750		625
ɔ		950		1050
		550		500
o		850		975
		425		425
ʊ		875		975
		375		375
u		825		1000
		300		325
y		1750		1750
		300		325
Y		1600		1700
		350		350
ø		1550		1600
		400		400
œ		1475		1550
		525		525

TABLE 4

SPANISH

		STRESSED		UNSTRESSED
i	Formant-2 . .	2250	Formant-2 . .	2200
	Formant-1 . .	300	Formant-1 . .	300
e		1950		1800
		475		475
a		1400		1350
		750		650
o		950		1000
		475		475
u		800		800
		300		300

let us glance for an instant at all of them together on Fig. 1 in an effort to gain a practical knowledge of the articulatory and acoustic correlations. Broken lines and arrows indicate the acoustic displacement of unstressed vowels with respect to stressed ones. Such displacements point to poles which must, therefore, be given acoustic meaning. For instance, when a pole approximates the center of a chart, what the arrows represent is not articulatory centering; rather, it is what we shall call acoustic centering. To be sure, acoustic centering is related to articulatory centering -- it does, to some extent, reflect the tongue displacements toward the center of the mouth -- but it also reflects many other articulatory changes, especially changes in lip rounding and lip spreading, in jaw closing and jaw opening, etc.

Here are, roughly, and in an introductory manner for all languages, the articulatory correlates of acoustic centering which apply to the various categories of vowels, according to the present state of research. (Articulatory correlation to acoustic data can be made (a) in terms of the shape and volume of the vocal tract cavities, the calculation of which is mathematically unmanageable because of the complexity of the curves, and can only be accomplished by means of drastic simplifications into manageable geometrical forms; (b) in terms of place, width, and length of the constrictions along the walls of the vocal tract from end to end; (c) in terms of tongue height, tongue fronting, lip rounding, and lip spreading. We shall use here whichever correlation is the most appropriate.)

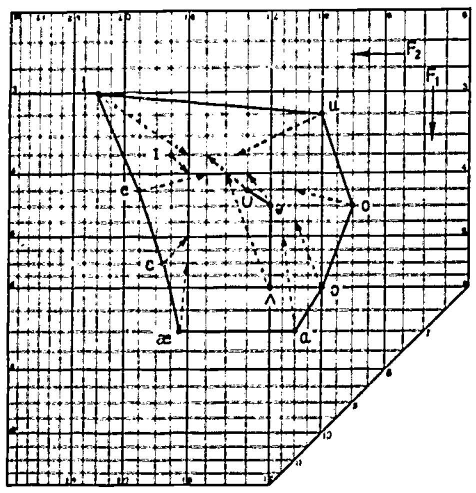
In the case of vowels that are at the extreme left of the charts, such as /i, e, ɛ/ in Fig. 1, arrows pointing toward the right correlate principally with tongue unfronting (backing) and/or lip unspreading. (Both of these articulatory movements lower the frequency of the second formant.)

In the case of vowels that are at the extreme right of the charts, such as /u, o, ɔ/, arrows pointing toward the left correlate principally with tongue fronting and/or lip unrounding. (Both of these articulatory movements raise the frequency of the second formant.)

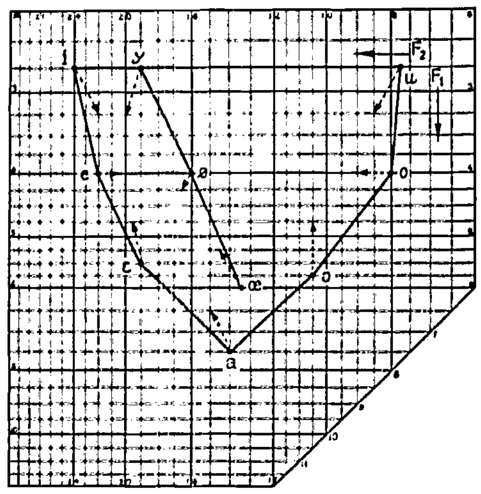
In the case of mixed vowels, such as /y, ø/, very short arrows toward the left, as we see them on the German and the French charts, must represent mixed effects of lip unrounding and tongue unfronting, compensating for one another. (Tongue unfronting lowers the frequency of the second formant, while lip unrounding raises it.) The fact that arrows point slightly toward the left seems to indicate that lip unrounding has more acoustic effect than tongue

FIGURE LEGEND

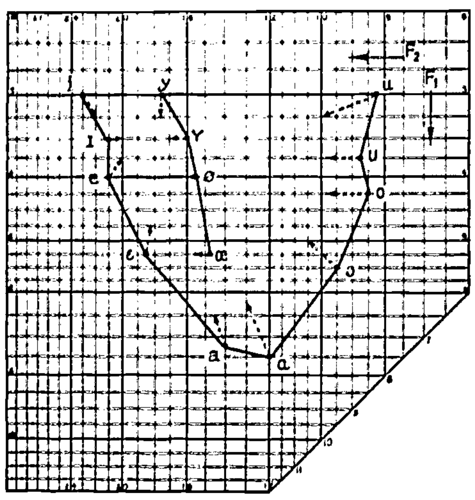
Figure 1. A comparison of the acoustic centering of unstressed vowels in four languages. The greater length of broken lines in English indicates a higher degree of vowel reduction in this language than in the three others.



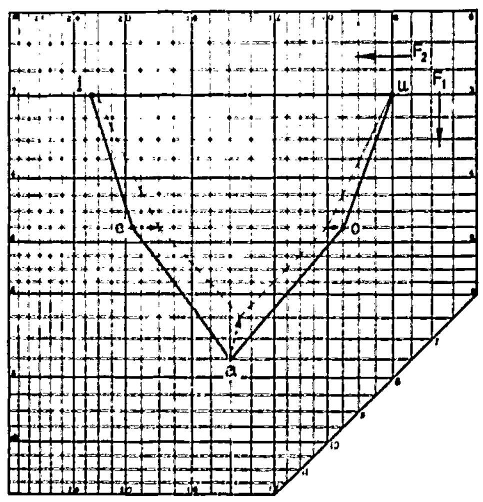
vowel reduction in English



vowel reduction in French



vowel reduction in German



vowel reduction in Spanish

unfronting, in the reduction of those mixed vowels.

In the case of high vowels, such as /i, u/, arrows pointing down should mean a lowering of the tongue dorsum and/or a backing of the tongue constriction (the farther away the constriction is from the lips, that is, the nearer it is to the vocal cords, the higher the first formant -- the /a/ constriction is the nearest to the glottis and the /a/ vowel has the highest first-formant of all vowels).

In the case of low vowels, such as /a, ɑ/, arrows pointing up should correlate with a raising of the tongue dorsum and/or a fronting of the tongue constriction.

Arrows at various angles obviously combine the effects of the horizontal axis with those of the vertical axis.

III. Results

A visual comparison of the four charts, in Fig. 1, shows that the extent of vowel reduction due to unstressing in medial position is much greater in English than in the three other languages. German and French are next. And Spanish seems to offer the smallest degree of vowel reduction of those four languages.

The visual impression of Fig. 1 is confirmed by the statistical analysis of Tables 1, 2, 3, and 4. When the modifications of formant-1 and formant-2 are analyzed in terms of frequency differences between the formants of stressed vowels and the formants of unstressed vowels, the following percentages of reduction emerge:

	Formant-2	Formant-1	Combined
English	16.24%	19.32%	17.78%
French	5.99%	11.40%	8.69%
German	6.85%	5.94%	6.39%
Spanish	5.06%	2.25%	3.65%

The arrows are there to remind one that the centering effects of formant-2 reductions operate on the horizontal plane (acoustically) and the centering effects of formant-1 reductions operate on the vertical plane (acoustically). Very roughly, at the articulatory level, the horizontal arrows also remind one of tongue unfronting-unbacking and lip unspreading-unrounding, whereas the vertical arrows remind one of tongue and/or jaw raising-lowering.

Let us now examine each language separately.

ENGLISH REDUCTION

Fig. 2 presents an acoustic chart of the reduction of 12 English vowels in medial unstressed position. (Two of the American vowels of Fig. 2, the stressed and unstressed /ɚ/, have to be visualized as if on a raised surface, above the surface of the other vowels, because they are sharply distinguished from the surrounding vowels by the low frequency of the third formant which gives them what is known as 'r-color.') All the vowels of our charts are characterized by two formants, except the stressed, or unstressed, American /ɚ/ which is characterized by three formants. The articulatory correlate of third-formant lowering appears on Fig. 3 as a double tongue constriction, one at the pharynx and another at the palate; the other vowels have no more than one tongue constriction.

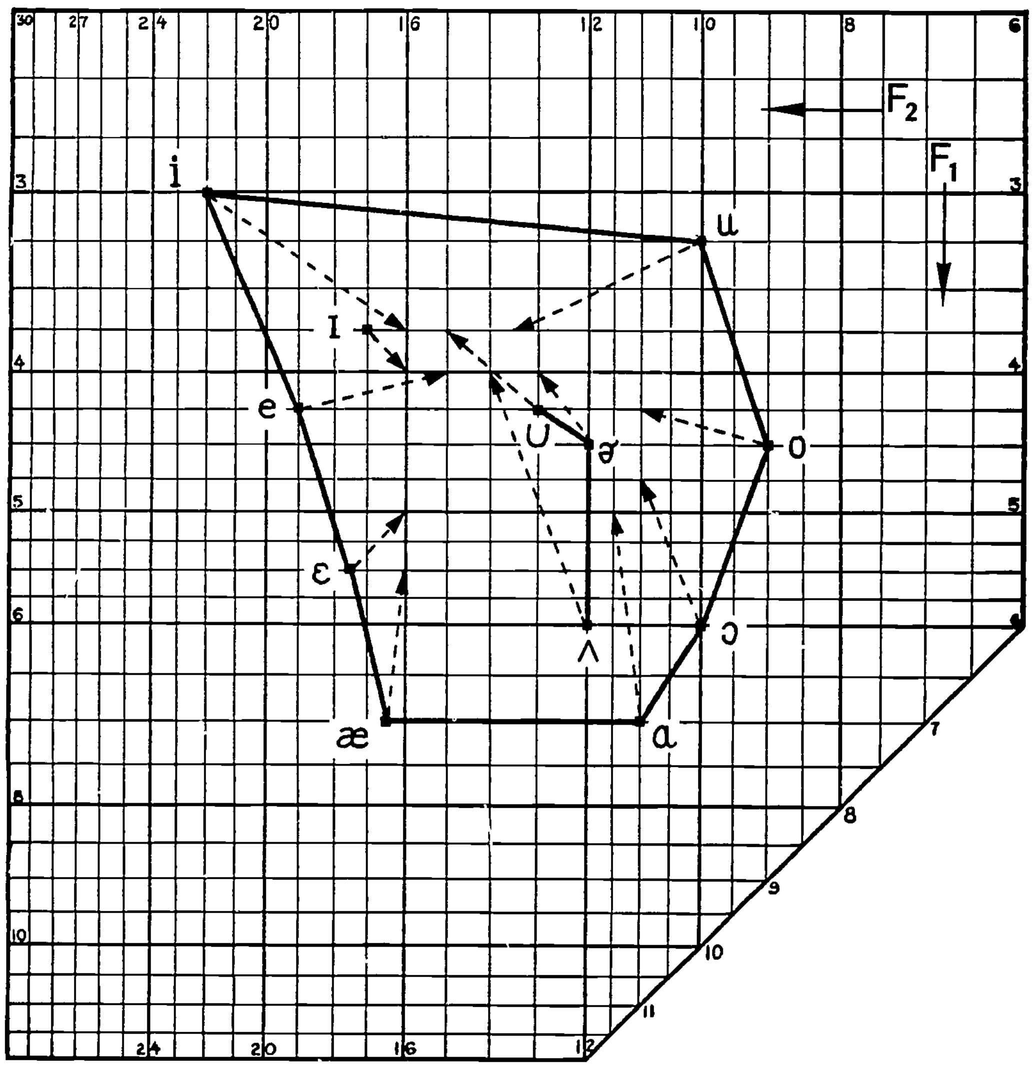
THE ACOUSTIC PATTERN of vowel reduction in English is sharply different from that of the three other languages.

1. English vowel-reduction is strong. This is shown by the considerable length of the broken lines and by the fact that the arrows from the left and the right, from the top and the bottom, nearly meet one another.

2. The overall pattern of English vowel-reduction due to unstressing in medial position is one of 'acoustic centering' toward a pole which is slightly higher and more front than center. The general acoustic center seems to be located a little below the unstressed /ʌ/, this vowel offering perhaps the most typical of all the reduced vowel colors.

3. A more detailed pattern of vowel reduction in English suggests the presence of three poles of attraction. The actual places of the arrows seem to cluster around a high-center pole for /i, ɪ, e, ʌ, ɚ, u, ʊ/, a low-front pole for /ɛ, æ/, and a low back pole for /ɑ, ɔ, o/.

Remarks. (a) The weak reduction of /ɛ/, by comparison with /e/, seems to be due to the fact that /ɛ/ occurs in a closed syllable. (b) The fact that reduced vowels hardly ever get across the mid-line of 1400 cps on the English chart and remain on the same side of the triangle as the corresponding stressed vowels, indicates that the tie between stressed and unstressed vowel is never completely



vowel reduction in English

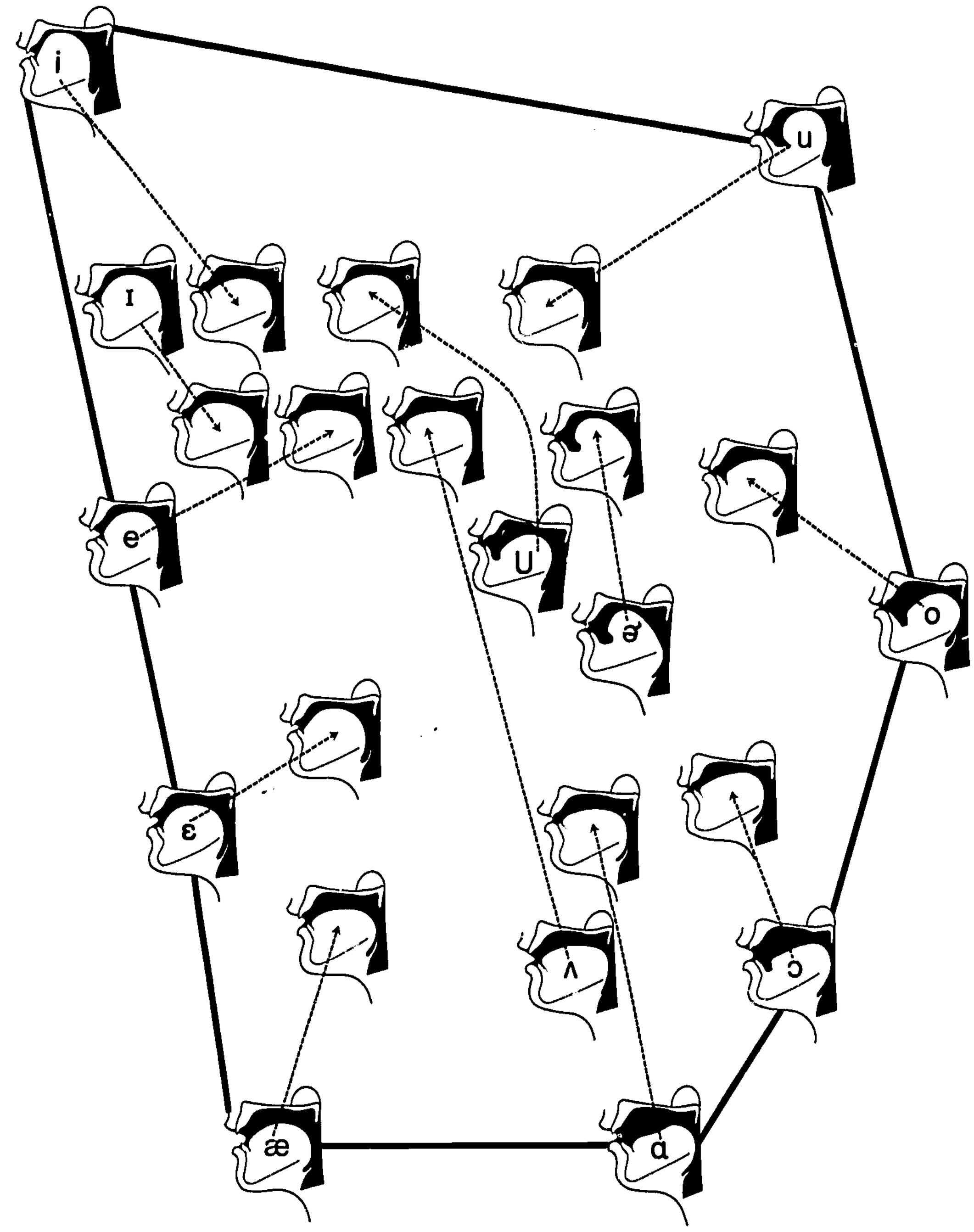

i
u
I
e
U
ɚ
o
ɛ
ʌ
ɔ
æ
ɑ

FIGURE LEGENDS

Figure 2. An acoustic chart of vowel reduction in English. The acoustic centering of unstressed vowels is shown by the length and direction of broken lines.

Figure 3. An articulatory chart of vowel reduction in English. The X-ray profiles showing tongue centering of unstressed vowels are placed according to the acoustic chart.

broken. The only exception to crossing the mid-line is /ʊ/, but it can be explained by the consonants that flank it in the word should -- alveolars strongly attract the second formant of /ʊ/ to a high frequency (which is equal to a fronting influence in articulatory terms).

4. On the average, long vowels like /i, e, u/ seem to suffer more reduction than short ones like /ɪ, ʊ, ɛ, ɚ/. However, this requires qualifications. For /ɛ/, closed syllabication may have a conservative effect, and for /ɪ/, /ʊ/, and /ɚ/ there is not far to go to reach the acoustic center. But the fact that /ʌ/, a short vowel, travels a long way to reach its reduced form (400-1400 cps) suggests that it is not a question of vowel length -- short vowels can suffer great reduction as well as long ones.

In a language such as English, which does not stress lip rounding, the major articulatory correlate of acoustic centering should be tongue centering. In order to verify this assumption and to observe in detail the articulatory behavior of reduction for English vowels, we have made motion-picture X-rays, at 24 frames per second, of all the pairs of words listed at the beginning. We used several speakers for the X-rays of each language but for the illustrations of Figs. 3, 5, 7, 9, we used the X-rays of a single speaker because it was not practical to average the articulatory positions of all the speakers of the same language.

Fig. 3 presents the articulatory profiles of stressed and unstressed English vowels, as uttered in the pairs of words listed in Table 1 at a reasonably fast syllabic rate. For each vowel, the frame that was selected for Fig. 3 is the most characteristic of that vowel. In the case of diphthongized vowels like /o/, /e/, /ɪ/, the position that was selected was near the middle of the glide.

The arrangement of frames on Fig. 3 is not made according to articulatory criteria (this would be too complex if all the articulatory factors were taken into account) but according to acoustic criteria -- each vowel occupies approximately the place it has in the acoustic chart of Fig. 2.

To emphasize the shape of the resonating cavities of vowels, the vocal tract is painted in black. The lower limit of the vocal tract, at the bottom of the pharynx, indicates the place of the glottis and the upper opening of the esophagus. The protrusion behind the root of the tongue is the epiglottis. The velum is always shown as closed since its partial lowering, even though frequent with American subjects, is not relevant here.

As we compare each unstressed vowel with its stressed counterpart, as well as the unstressed vowels among themselves, we must realize that small differences are not necessarily significant since they may be due to the influence of the consonants that precede and follow the vowel. We need to point out only the characteristics that many unstressed vowels have in common.

THE ARTICULATORY PATTERN of vowel reduction in English is clear. Three differences emerge between stressed and unstressed vowels. (a) Compared with their stressed counterparts, the unstressed vowels show a more central position of the tongue -- on the one hand, the front vowels are backed, and the back vowels are fronted; on the other hand, the high vowels are lowered, and the low vowels are raised. (b) Except for the highest vowels, such as /i/ and /u/ which already have a narrow jaw-opening, the unstressed vowels regularly have a much narrower jaw opening than their stressed counterparts. This seems attributable to the shorter time given to unstressed vowels -- the jaws, which are slower than the lips and tongue, generally fail to open more than for the closest vowels. (c) The back-rounded vowels lose a considerable amount of their lip-rounding when they are in unstressed position. This is visible in /u/, /o/, and /ɔ/.

The most typical articulatory shape of unstressed vowels is perhaps that of the unstressed /ʌ/: the lips assume a spread or neutral shape, the jaw opening is narrow, the tongue is relatively low and central, and the vocal tract assumes the shape of a fairly uniform tube. All unstressed vowels tend toward this articulatory description. Its distinction is perhaps in the contrast presented by the jaws and the tongue -- <u>the jaws are close, yet the tongue is rather low</u>. This is the characteristic effect of vowel reduction in English. The /ɚ/ is the only vowel that does not conform to this tendency. The unstressed version of /ɚ/ preserves the <u>two</u> characteristic constrictions of the stressed counterpart -- at the palate and at the pharynx -- but these constrictions are not as narrow as for the stressed position. The acoustic reduction shows the same tendency. The unstressed /ɚ/ shows a clear lowering of the third formant, but only to about 1700 cps, not to the usual 1500 cps of the stressed /ɚ/.

FRENCH REDUCTION

Fig. 4 presents an <u>acoustic</u> chart of the reduction of 10 French vowels in unstressed medial position. (The four nasal vowels were not included because of the difficulty encountered in measuring the first formant; this formant nearly disappears when nasality is marked. The backed /ɑ/ is not stable enough in the traits that distinguish it from the fronted /a/.)

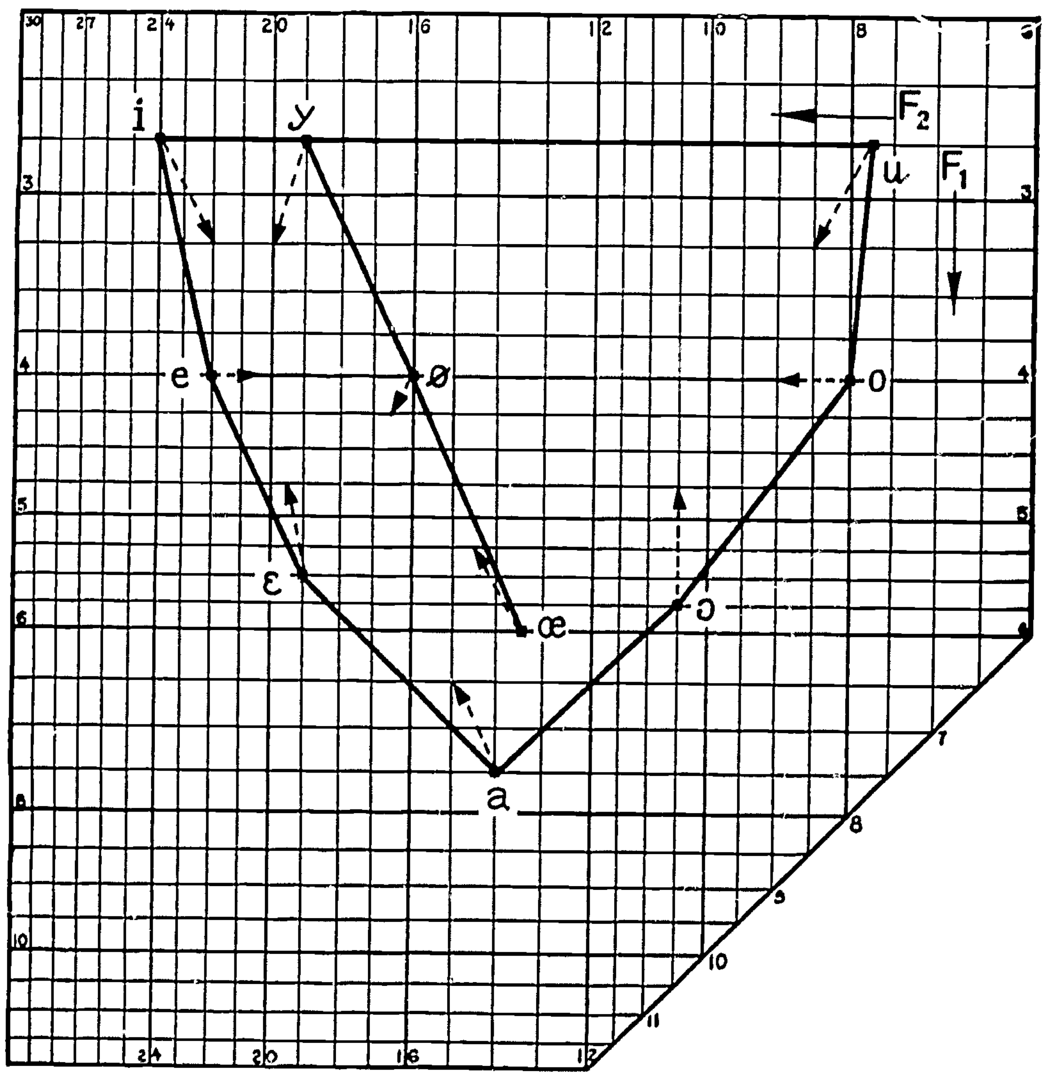
According to previous observations made on X-rays of French vowels,[8] the relation between the acoustic and the articulatory levels must be understood as follows. The spread vowels /i, e, ε/ owe their high second-formant frequency (shown by their extreme-left position on the chart) to extreme fronting of the tongue and spreading of the lips. The front-rounded vowels /y, ø, œ/ owe the lowering of their second-formant frequency (shown by a less extreme-left position on the chart) not to a lesser degree of tongue-fronting, but to a marked rounding of the lips, the effect of which is to reduce the front-cavity opening, thereby lowering its note of resonance. The back-rounded vowels /u, o, ɔ/ owe their extreme lowering of the second-formant frequency (shown by their extreme-right position on the chart) to the combined effects of tongue backing and lip rounding, which both produce a lowering of the note of resonance of the front cavity, one by enlarging this cavity, the other by narrowing its opening.

THE ACOUSTIC PATTERN of vowel reduction in French contrasts sharply with that of English.

1. Very little reduction occurs in French by comparison with English -- the French arrows are not far from the stressed vowels.

2. French reduction due to unstressing in medial position is characterized by a small degree of mid-high and fronted acoustic centering. This is shown by the direction of the broken lines: high vowels fall and mid-low, as well as low, vowels rise, whereas mid-high vowels nearly preserve their level. It is also shown by the fact that the broken lines of the back-rounded vowels are longer than those of the front-spread ones. The French acoustic pole of attraction of unstressed vowels is perhaps located slightly below and to the left of /ø/. It is, therefore, lower and more to the left than the English pole.

3. In articulatory terms, we know that acoustic centering can mean three things: tongue centering, lip unrounding (for the back-rounded and the front-rounded vowels), and lip unspreading (for the front-spread vowels). We also know that, for the front-spread vowels, displacements to the right can mean tongue backing as well as lip unrounding (they both have the effect of lowering the second formant) and that, for the back-rounded vowels, displacements to the left can mean tongue fronting as well



vowel reduction in French

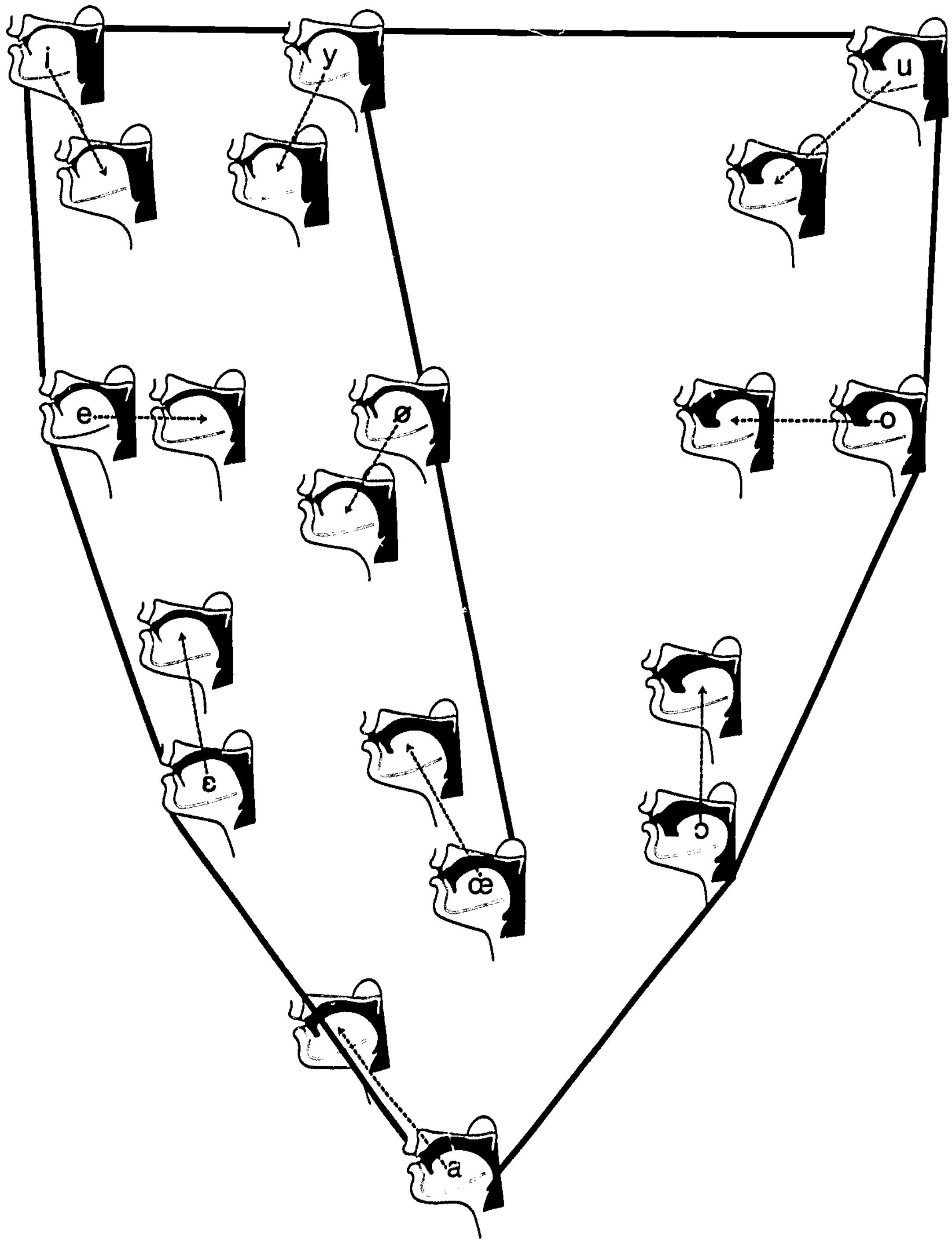

i
y
u
e
ø
o
ɛ
œ
ɔ
a

FIGURE LEGENDS

Figure 4. An acoustic chart of vowel reduction in French. The acoustic centering of unstressed vowels is shown by the length and direction of broken lines.

Figure 5. An articulatory chart of vowel reduction in French. The X-ray profiles showing tongue centering of unstressed vowels are placed according to the acoustic chart.

as lip unrounding (they both have the effect of raising the second formant); but for the front-rounded vowels, /y, ø, œ/, displacements to the left can only mean lip unrounding because the tongue is already as far fronted as it can be.

Being acoustically lower indicates that the French unstressed vowel is on the average more open than the English unstressed vowel (the tongue is lower), a fact that correlates with our data on syllable length[9] -- unstressed syllables being longer in French than in English, the articulators are given time to open wider.

Being acoustically more to the left correlates with the well known tendency of French toward tongue fronting, which contrasts with the tendency of American English toward tongue backing.

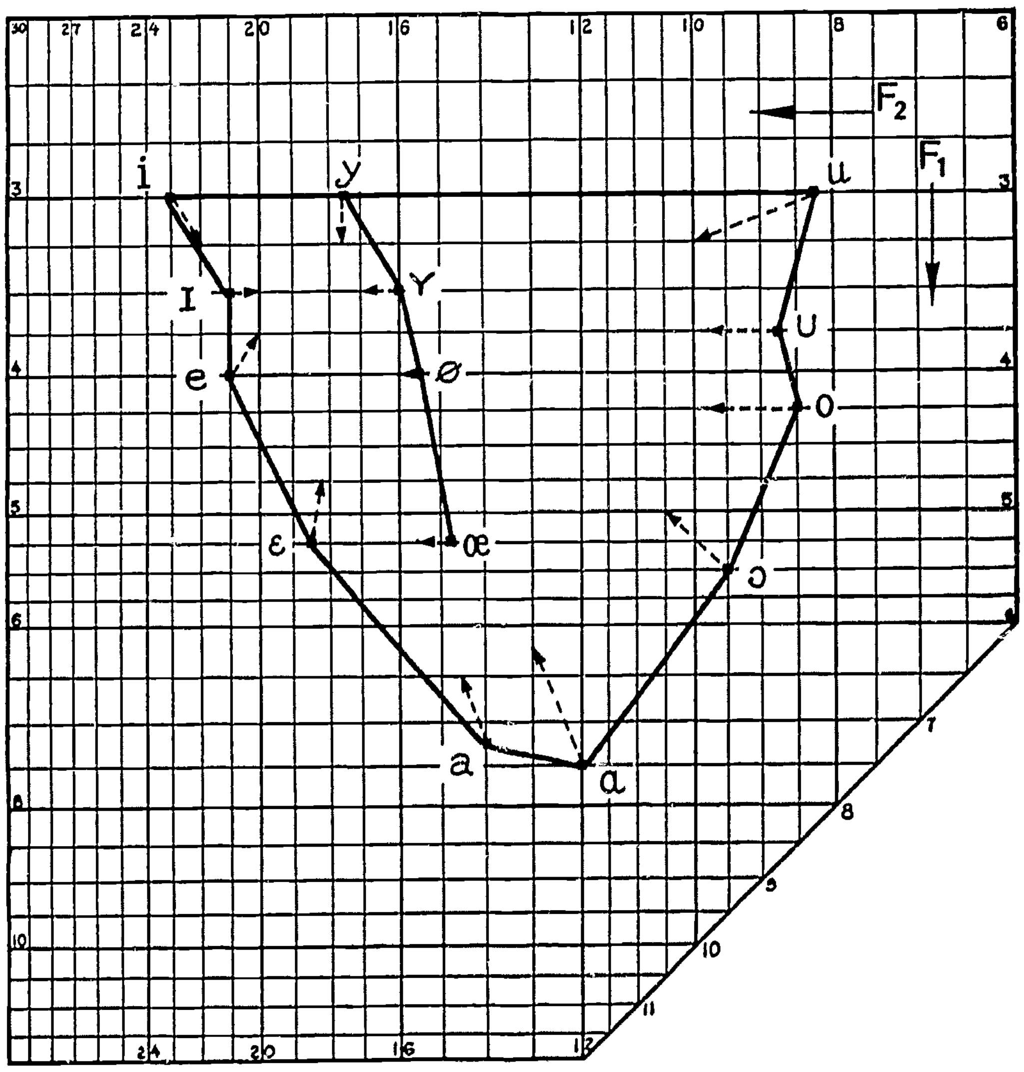
In order to see which one, or which ones, of these possible articulatory factors are responsible for the acoustic centering of Fig. 4, let us examine Fig. 5 which presents the articulatory profiles of final (stressed) and non-final (unstressed) French vowels as uttered by one French speaker in the pairs of words listed earlier. (This speaker has a slight peculiarity: for the vowels /u/ and /o/, his tongue is unusually fronted. The majority of French speakers would make the /u/ tongue constriction farther back along the velum and the /o/ tongue constriction along the pharyngeal wall rather than at the velum.)

THE ARTICULATORY PATTERN of vowel reduction in French is simple. For the front-spread vowels, /i/ and /e/ show both a small degree of tongue centering and a small degree of lip unrounding, whereas /ɛ/ shows closing toward /e/ and /a/ closing toward /ɛ/ (which are manners of centering).

For the back-rounded vowels, /u/ and /o/ show more lip unrounding than tongue centering, and /ɔ/ mostly shows closing toward /o/.

For the front-rounded vowels, /y/ and /ø/ show both lip unrounding and tongue centering, and /œ/ mostly shows closing toward /ø/.

In short, where unstressed the high and mid-high vowels of French tend to combine tongue centering with unrounding (if they are rounded) or with lip unspreading (if they are spread), whereas the low and mid-low vowels simply tend to close a little toward their mid-close counterpart.



vowel reduction in German

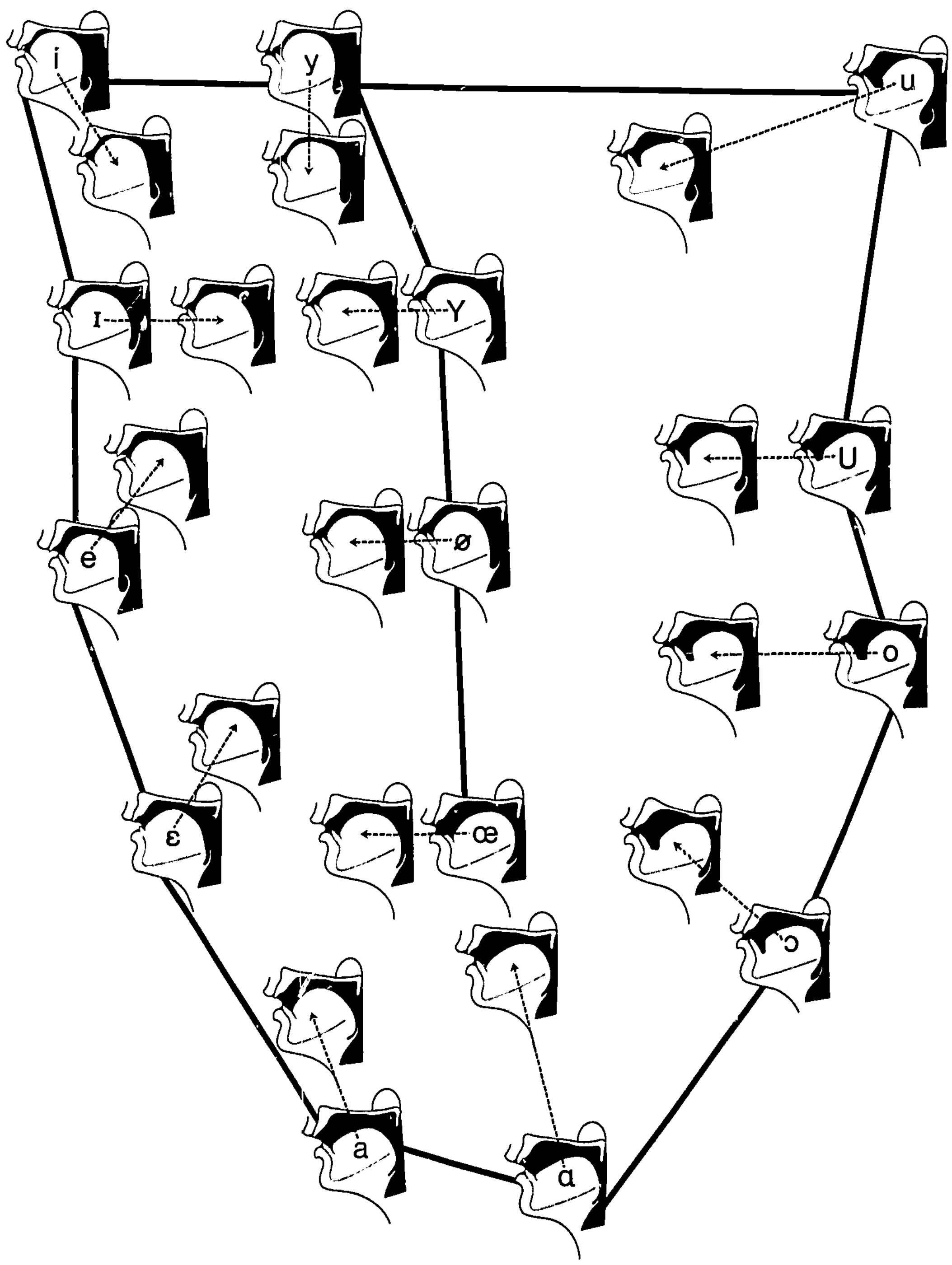

i
y
u
ɪ
Y
U
e
ø
o
ɛ
œ
ɔ
a
ɑ

FIGURE LEGENDS

Figure 6. An acoustic chart of vowel reduction in German. The acoustic centering of unstressed vowels is shown by the length and direction of broken lines.

Figure 7. An articulatory chart of vowel reduction in German. The X-ray profiles showing tongue centering of unstressed vowels are placed according to the acoustic chart.

GERMAN REDUCTION

Fig. 6 presents an acoustic chart of the reduction of 14 German vowels in unstressed medial position.

The correlations between the acoustic values of the chart and the articulatory positions they reflect are similar to those already described for French. They need not be repeated.

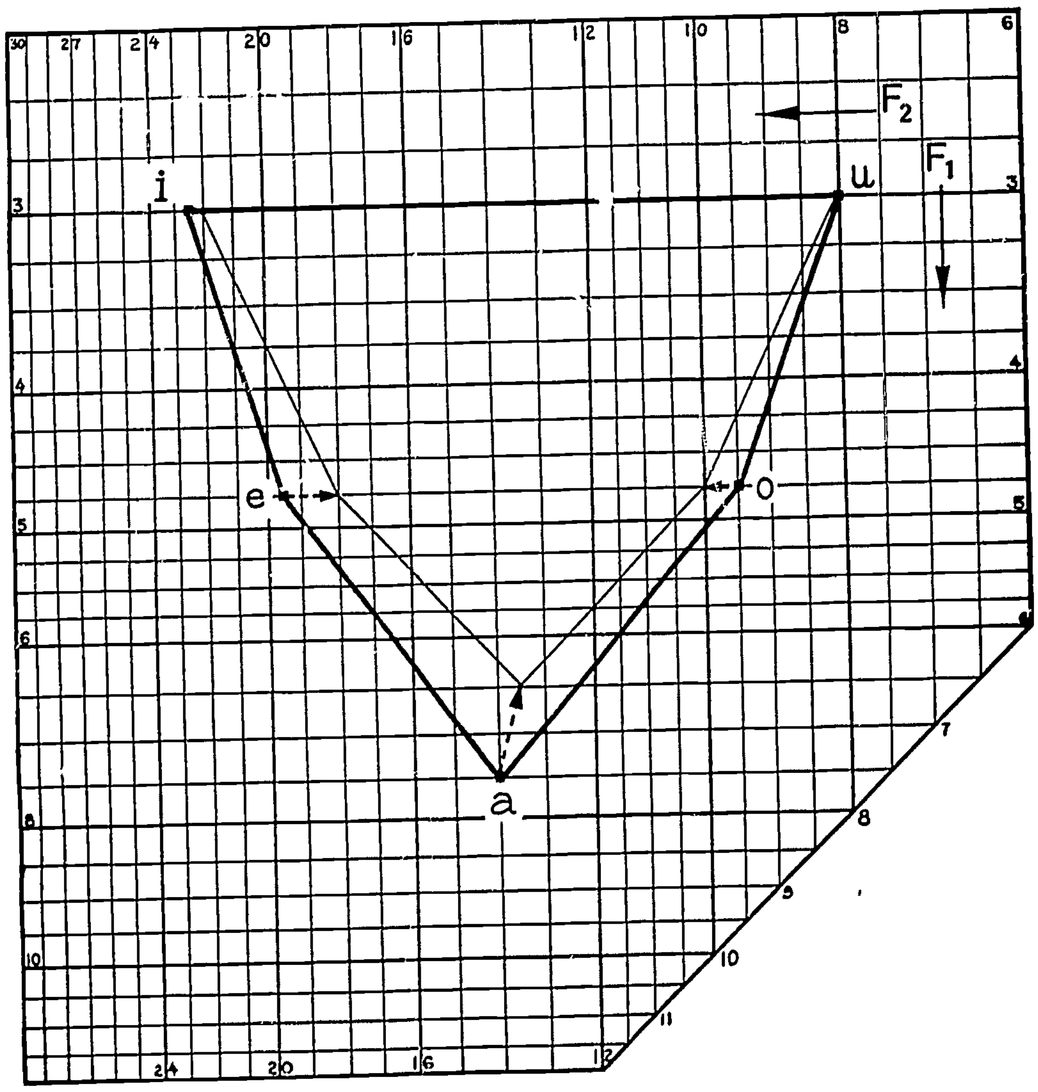
THE ACOUSTIC PATTERN of vowel reduction in German can be described as follows:

1. The extent of vowel reduction is much smaller than in English and slightly smaller than in French -- the broken lines are short, even shorter than in French. As in French, every unstressed vowel remains close to its stressed counterpart.

2. As in English and in French, the pattern of reduction due to medial unstressing is in general one of acoustic centering. But two poles of attraction seem to function, a mid-high fronted one for the spread vowels, and a mid-fronted one for the rounded vowels. This is especially well shown by the broken lines issuing from the back-rounded vowels; these lines neatly point to a central-fronted pole. A single pole can also be assumed as a compromise between these two.

3. As in French, the acoustic data point to three possible articulatory correlates of vowel reduction: centering, unrounding, and unspreading. The reasoning which justifies this assumption is similar to the one previously formulated for French reduction: (a) the short broken lines on the left suggest a combination of tongue centering and lip unspreading, but both in remarkably small amounts; (b) the relatively long broken lines of the right suggest a combination of tongue centering and lip unrounding, the latter effect being much more marked than the former; (c) the very short broken lines issuing from the mixed vowels suggest that tongue centering and lip unrounding both operate, but in opposite directions which compensate for one another; and the fact that the arrows point to the left rather than to the right shows that the acoustic effect of lip unrounding is greater than that of tongue centering.

Fig. 7 should help to specify the contribution made by each one of those articulatory correlates. Similar to Figs. 3 and 5, it presents the articulatory profiles of 14 stressed vowels and their 14 unstressed counterparts as uttered before the X-ray motion-picture camera by one



vowel reduction in Spanish

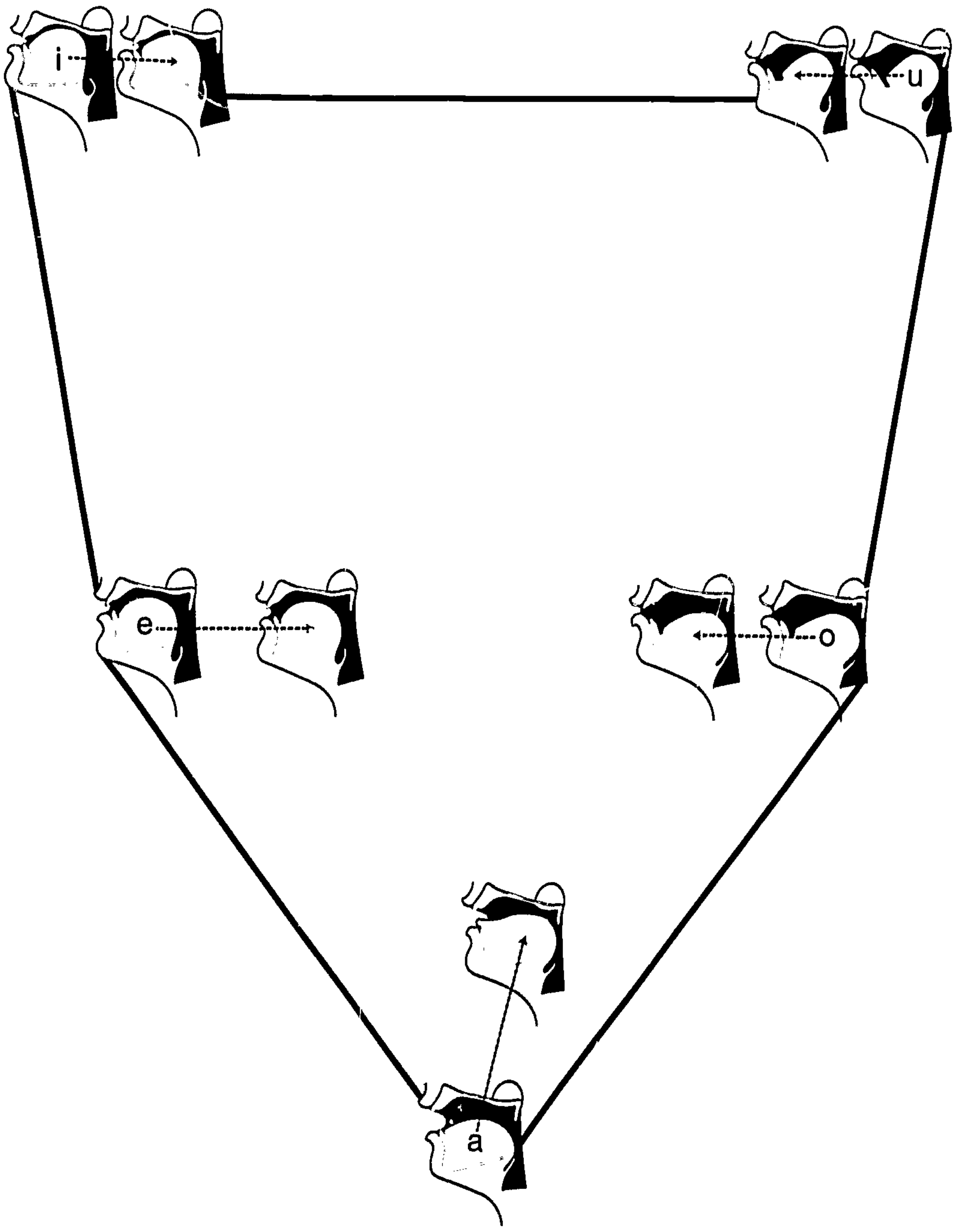

i
u
e
o
a

FIGURE LEGENDS

Figure 8. An acoustic chart of vowel reduction in Spanish. The acoustic centering of unstressed vowels is shown by the length and direction of broken lines.

Figure 9. An articulatory chart of vowel reduction in Spanish. The X-ray profiles showing tongue centering of unstressed vowels are placed according to the acoustic chart.

German speaker in the pairs of words listed in Table 3.

THE ARTICULATORY PATTERN of vowel reduction in German shows original tendencies. Unlike the French subject of Fig. 5, who reduces vowels by lip unspreading and lip unrounding more than by tongue centering, the German subject of Fig. 7 reduces vowels almost exclusively by tongue centering; his lips are practically as markedly spread (for spread vowels) or as markedly rounded (for rounded vowels) in the unstressed vowels as in their stressed counterparts. In most cases, the characteristic tongue constriction is wider when the vowel is unstressed. This is especially noticeable with the back-rounded vowels /u/, /ʊ/, /o/, but it is also clear with the front vowels, whether spread or rounded, except with /ɛ/ which closes toward /e/ or /ɪ/. The /a/ and /ɑ/, too, show a wider pharyngeal constriction when unstressed. To this major tendency toward tongue centering, we might add a slight tendency toward tongue fronting which seems to appear in unstressed /ɪ/, /e/, and /ɛ/.

SPANISH REDUCTION

Fig. 8 presents an acoustic chart of the reduction of the five Spanish vowels in medial unstressed position.

THE ACOUSTIC PATTERN of vowel reduction in Spanish is simpler than in the three other languages.

1. The effect of unstressing seems to be even smaller than in French -- the high vowels are not significantly modified, the mid vowels are slightly mid-centered, and the /a/ is somewhat raised and backed. This high degree of stability in vowel color may be related to the fact that in medial position, unstressed syllables are nearly as long as stressed ones, in Spanish. According to a study already mentioned,[9] Spanish syllable-length shows that in non-final syllables, the length ratio of stressed to unstressed was 1.11 to 1.00. If the whole stressed syllable is only 11 per cent longer than the unstressed one, the difference of length between stressed and unstressed vowels is perhaps no greater than 5 or 6 per cent. Moreover, Spanish has no centered schwa vowel -- one more sign of near syllabic equality.

2. According to Figs. 4 and 6, in German and in French the back vowels suffer more reduction than the front ones. In Spanish, according to Fig. 4, it is rather the opposite -- the reduction of the back vowels is slightly less extended than that of the front vowels, suggesting that unrounding takes no part in the reduction. This is

perhaps related to the fact that in Spanish lip rounding is not distinctive -- all back vowels have lip-rounding and all front vowels have lip-spreading, so that stressing the rounding in stressed syllables is not necessary.

THE ARTICULATORY PATTERN of vowel reduction in Spanish is also very simple. The X-ray profiles of Fig. 9, obtained like those of the other languages, confirm the acoustic data in showing how small are the effects of unstressing upon Spanish medial vowels. Compared with their stressed counterparts, the unstressed front vowels /i/ and /e/ are slightly backed, the unstressed back vowels /u/ and /o/ are slightly fronted, and the unstressed /a/ shows a higher tongue dorsum and a higher pharyngeal constriction. These modifications are smaller than in the three other languages.

IV. Conclusion

This study was undertaken because in every language vowels are less distinctive, more obscure, in an unstressed syllable than in a stressed one. The reason is that the unstressed vowel is physically and physiologically 'reduced.' But it is not reduced by the same amount and in the same manner in all languages.

In an attempt to compare most objectively the behavior of vowel reduction in four languages, we have combined a physical (acoustic) analysis with a physiological (articulatory) one, using successively spectrographic and cine-radiographic techniques.

The acoustic charts constructed for American, French, German, and Spanish vowels in stressed and unstressed position, by plotting the frequencies of the first and second formants on logarithmic paper, reveal how the auditory patterns of vowel reduction differ in each language. The X-ray profiles of vowel positions, superimposed upon these acoustic charts, show in articulatory terms how the auditory differences related to vowel distinctions are produced in each language.

The patterns of vowel reduction are the following:

The extent of vowel reduction in medial position is much greater in (American) English than in the three other languages, and it is somewhat smaller in Spanish than in French and German. The acoustic charts actually show the length and the direction of the acoustic displacement of each vowel, and the pattern formed by such displacement in each language. On the English chart, the displacement lines of opposite sides almost join each other in the center. In the other languages the displacement lines are short -- unstressed vowels are close to their stressed counterparts.

Whether the displacement lines are long or short, however, there always seems to be a pole, on each chart, toward which all the unstressed vowels are attracted.

Using traditional articulatory directions, we might describe the location of the English acoustic pole of attraction as high mid-high and a little front of central. This location nearly coincides with that of the unstressed /ʌ/, on the acoustic chart. This unexpected height of English unstressed vowels must be attributed to the shortness of stressed syllables which does not give time for much jaw lowering. In addition to the major pole described above, there might also be two minor poles of attraction located in the mid region, a little front of central and a little back of central.

In French and in German, the acoustic pole of attraction is again located in the mid-front region, but considerably lower and more front than in English. It could be described as low mid-high and between front and center. The location of the pole in a lower acoustic region than in English must be related to the fact that unstressed syllables are longer in French and German than in English, which allows more time for jaw lowering.

In Spanish, the acoustic pole of attraction of unstressed vowels in medial position seems to be located slightly back of center. The absence of fronting which distinguishes Spanish from French and German must be related to the perfect balance of the Spanish vowel system: two front, two back and one central vowel. In French and German, there are twice as many front vowels as back ones.

The X-ray profiles show that English vowel reduction is produced by combining a central flattening of the tongue (a marked tongue centering) with a narrow opening of the jaws. This contradictory combination gives the reduced vowel an articulatory shape of its own, well distinct from all stressed vowels since, in these, tongue lowering always coincides with jaw separation.

In French, tongue centering is not marked. With the high and mid-high vowels the main articulatory factors of vowel reduction are lip unrounding (for the rounded vowels) and lip unspreading (for the spread vowels). With the low and mid-low vowels, it is simply tongue raising.

German, unlike French makes little use of the lips in producing vowel reduction in medial position. It prefers centering the tongue and widening the characteristic tongue stricture.

Spanish is comparable to German in that it does not make any appreciable use of the lips -- its vowel reduction in medial position is simply produced by a very slight tongue centering. It is noteworthy, however, that Spanish, unlike the other languages, shows more backing of the front vowels than fronting of the back vowels, and that for the unstressed Spanish /a/ the rise inclines toward the back rather than the front.

In brief, vowel reduction is much more marked in English then in French, German or Spanish, and each one of those four languages offers a reduction pattern of its own.

V, Summary

Vowel reduction is perceived as an obscuration of vocalic color. It occurs when a vowel is in an unstressed syllable. The extent and the pattern of vowel reduction in English, German, Spanish, and French are analyzed, here, by spectrographic measurement of formants one and two, and by motion-picture X-rays of the tongue positions. The stressed and unstressed vowels of each language are compared in such pairs of words as: English: Com'peting/Compe'tition; German: Ma'nier/manie'riert; Spanish: A'chican/Achi'caban; French: Fa'tigue/Fati'gué. The results are presented in five acoustic charts and four articulatory charts which show the acoustic pattern of vowel reduction in each language and the articulatory profiles of stressed and unstressed vowels for one subject in each language. The extend of vowel reduction is much greater in English than in the three other languages. Statistical analysis of formant frequencies give the following percentage of reduction: English: 17.78%, French: 8.69%, German: 6.39%, Spanish: 3.65%. The acoustic patterns of vowel reduction show that all unstressed vowels are attracted toward an acoustic pole. In Spanish this pole is slightly back of the acoustic center. In English, German, and French, it is mid-high and front of center, but it is clearly higher and less front in English than in German or in French. The X-ray profiles of vowel reduction show a general tendency toward tongue centering in all four languages, but this tendency is more pronounced in English than in the other languages. In English, the typical reduced-vowel is clearly distinct from the stressed ones and combines a very small opening of the jaws with a considerable lowering of the tongue. In the other languages, a reduced vowel has no shape of its own; it tends to preserve the tongue shape of its stressed counterpart.

FOOTNOTES

[1]Björn Lindblom, On Vowel Reduction, Stockholm, Royal Institute of Technology, 1963.

[2]Op. Cit., p. 86.

[3]Ibid.

[4]Op. Cit., p. 88.

[5]Ibid.

[6]Pierre Delattre, Comparing the Phonetic Features of English, German, Spanish, and French, Chilton Books, Philadelphia, 1965, or Julius Groos Verlag, Heidelberg, 1965, p. 35.

[7]Martin Joos, Acoustic Phonetics, Supplement to Language, Journal of the Linguistic Society of America, Language Monograph #23, Vol. 24, No. 2, Suppl., April-June 1948.

[8]Pierre Delattre, "La radiographie des voyelles françaises et sa corrélation acoustique," French Review 42,1: 48-65.

[9]Pierre Delattre, "A comparison of syllable length conditioning among languages," IRAL 4,3: 183-198.

TWO TYPES OF NASALITY:

VOCALIC AND CONSONANTAL

It is time to reconsider the unusual fact that French nasal vowels and French nasal consonants have very little in common today, despite their historical tie. Marguerite Durand had pointed this out some fifteen years ago,[1] but the acoustic data upon which she relied were inaccurate, as we tried to demonstrate shortly thereafter.[2] However, her basic hypothesis may have been correct, and we should like to reconsider it with the help of our research installations which are equipped for the acoustic analysis and synthesis of the speech wave and for the cineradiography of the speech organs in action.

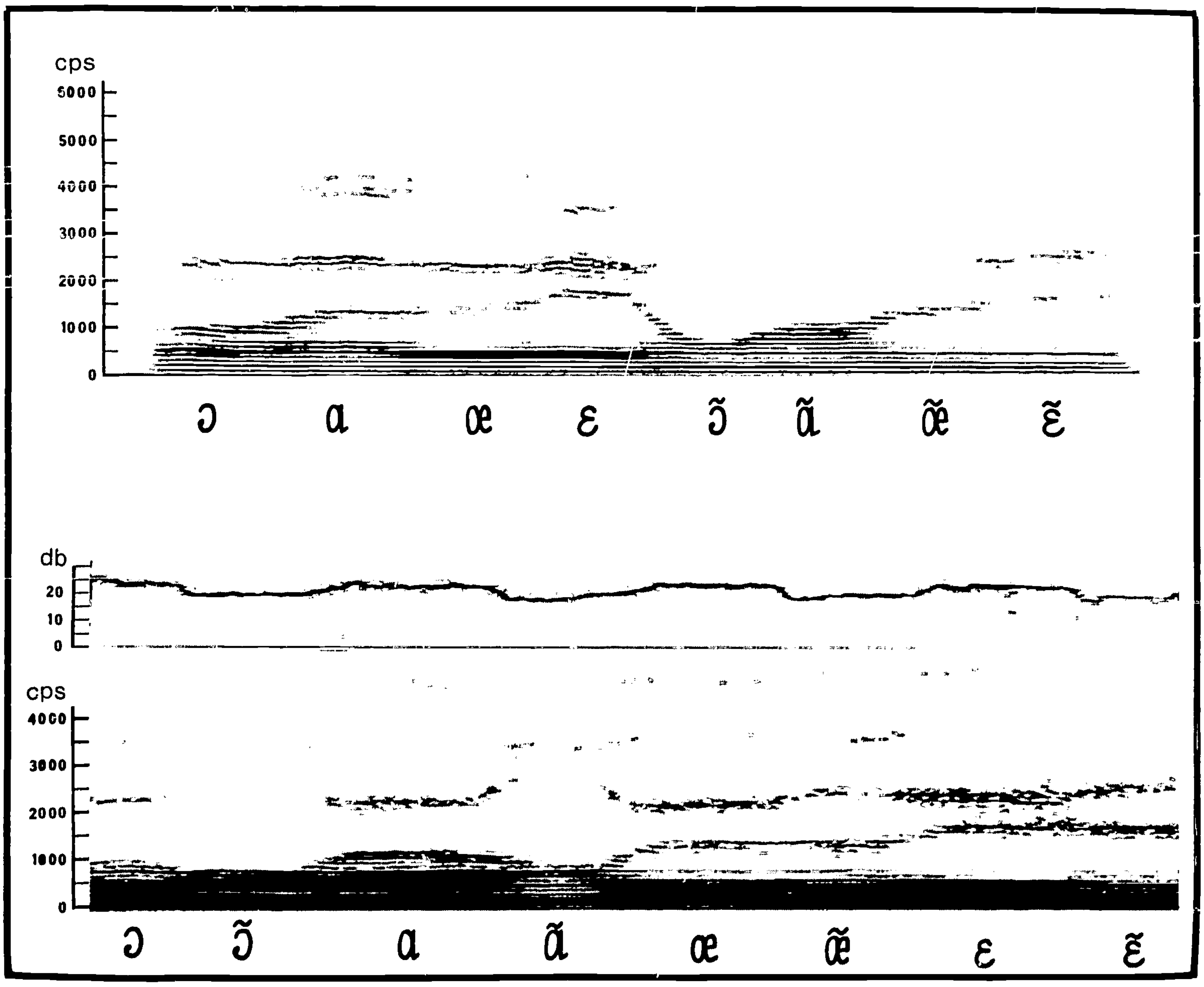
Let us review what is presently known about the nasality of French vowels from three different standpoints: perceptual, acoustic and articulatory. In order to understand the discussion which follows we must have a general understanding of the present state of research.

Perceptually what we call 'nasality' in a vowel is nothing more than an imbalance in the intensity of the first two formants in favor of the second. In a nasal vowel, the second formant is predominant, the first one having lost much of its intensity, and the end result is a chord of formants in which the high frequencies are much more audible than the low frequencies. To put it another way, since every vowel is a complex chord of formants, the nasal vowel is a chord with a higher average frequency than its corresponding oral vowel because the low-intensity first-formant weighs little in the averaging.[3] It is essentially this imbalance which distinguishes /œ̃/ from /œ/, /ɛ̃/ from /ɛ/, etc. An easy way to realize this is to whisper oral and nasal vowels which have the same formants (or approximately the same) — the chord of whispered /ɛ̃/ is clearly higher than the chord of whispered /ɛ/. This has already been confirmed by perceptual tests in which the relative intensities of the two formants of artificial vowels were controlled with precision. When the intensity of the first formant of /ɛ/ was reduced by twelve decibels, all the French speaking subjects heard /ɛ̃/.

Acoustically, intensity reduction of the first formant can be observed in two measurable forms on spectrograms — cancellation and damping. These two forms produce the same type of subjective effect, but at different degrees — cancellation actually eliminates some harmonics; damping

FIGURE LEGEND

Figure 1. Comparison of French nasal and oral vowels. The nasals are distinguishable by a strong attenuation of the first formant which, on these spectrograms, is reduced to a thin harmonic. The frequency of this harmonic is uniform for the four nasal vowels. The other differences, such as the frequency of the second and third formants, are not pertinent to the perception of nasality, according to synthetic experiments.


cps
5000
4000
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2000
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0
ɔ ɑ œ ɛ ɔ̃ ɑ̃ œ̃ ɛ̃
db
20
10
0
cps
4000
3000
2000
1000
0
ɔ ɔ̃ ɑ ɑ̃ œ œ̃ ɛ ɛ̃

merely spreads the condensed harmonics over a wider frequency band.

Fig. 1 shows intensity reduction in the first formant by cancellation such as it is produced for French vowels when they have distinctive nasality. In the four nasal vowels of the top row we see that the first formant is reduced to a single, very weak harmonic -- the other harmonics (visible in the oral vowels at the left) are cancelled by harmonics which resonate in inverse phase in the rhino-pharyngeal cavity which prolongs the pharynx above the velum -- whereas the second formant keeps about the same intensity as in the corresponding oral vowels that are at the left. The bottom row of Fig. 1 permits us to compare each nasal vowel with its corresponding oral vowel and to note how much /ɔ̃/, and especially /ɑ̃/, are different from the oral vowels /ɔ/ and /ɑ/, even frequency-wise. We also see in this figure that all the nasal vowels (of French) have the same first-formant frequency, a feature to which we shall return later.

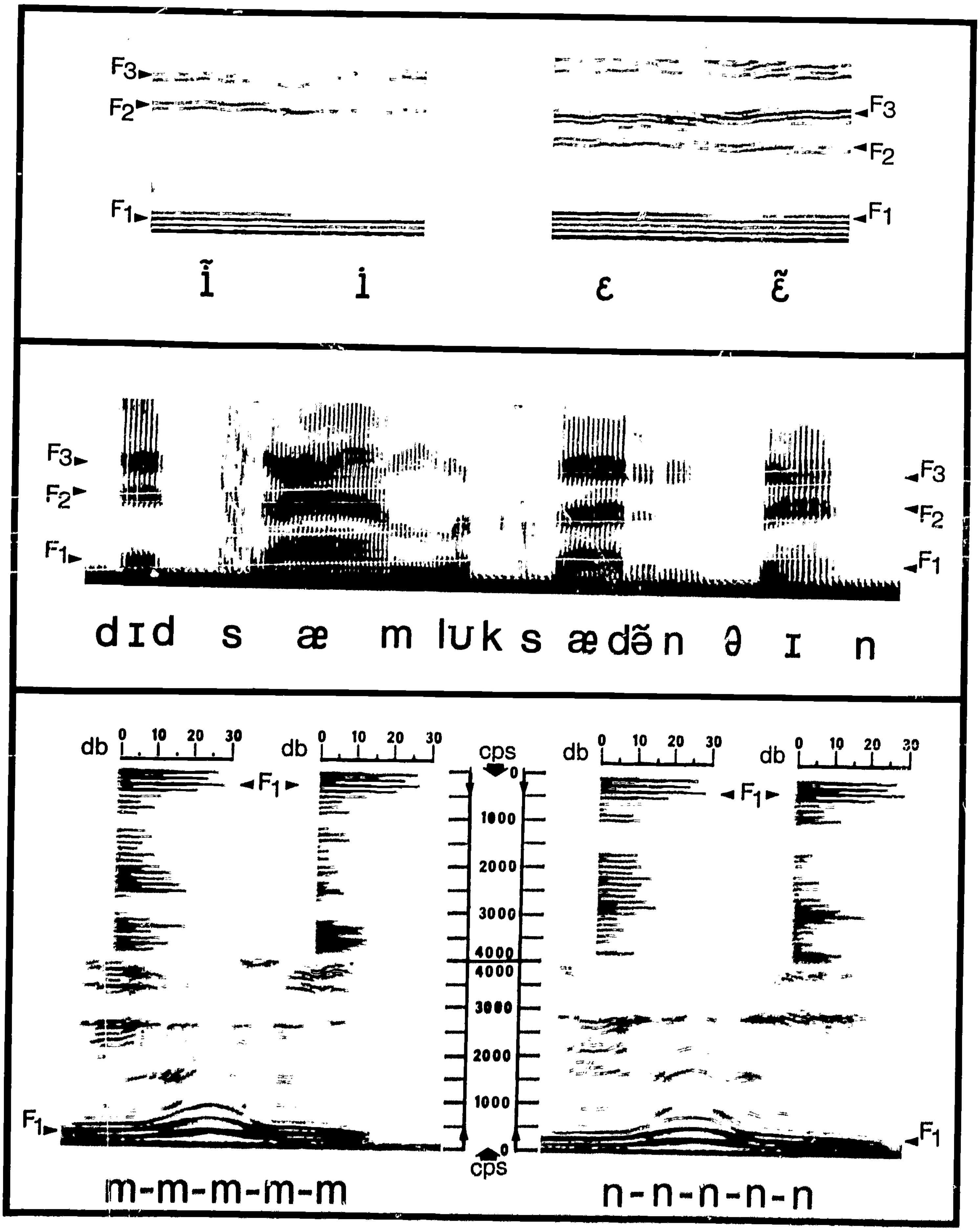
When the subjective reduction of loudness is produced by damping, the first formant widens without appreciable change in total amplitude -- the number of harmonics increases and the amplitude of each harmonic decreases. It is this damping phenomenon that can be observed in the nasalization of the close vowels [ĩ], [ẽ], [õ], [ũ], (as they nearly appear in Portuguese) or in the non-distinctive nasalization produced by the anticipation of a nasal consonant, as it occurs in English. In fact, the two procedures, cancellation and damping, are not always separable and may well occur simultaneously, and therefore accumulatively, in the loudness reduction of the first formant which makes nasality audible.

Fig. 2 offers an example of the nasalization of /i/ by simple damping of the first formant, and an example of the nasalization of /ɛ/ by both damping and cancellation -- the fourth harmonic of /ɛ̃/ is considerably reduced and the fifth harmonic is entirely eliminated.

This figure also gives examples of first-formant reduction by anticipation of the nasality of an /m/ or /n/ in Sam, thin. Such reduction does not occur before the oral consonants of sad, did, whose first formants are as intense as the second ones. (In addition, changes in the third formant are seen which seem to correspond to the very moment when the velum starts its descent in anticipation of the nasal consonant, but the synthesis of nasal vowels has shown that these frequency changes of the third formant have no auditory effect with respect to nasality.)

FIGURE LEGEND

Figure 2. Spectrograms showing the disparity between vocalic and consonantal nasality. First row: nasalization of /ĩ/ by damping of the first formant, and nasalization of /ε̃/ by damping and cancellation of harmonics. Second row: vocalic nasalization (weakening of the first formant) by anticipation of the following nasal consonant in Sam, thin; and non-nasalization in sad, did. In the consonantal murmurs the first formant is stronger than the upper formants, completely the opposite of the case of nasal vowels. Third row: detail of two nasal murmurs by amplification. Above the horizontal formants, the intensity reduction of the upper formants can be measured in decibels on the 'sections' taken at four different instants. In these sections, the highest line is the zero line; the second line is the first harmonic, and so forth to the bottom of the figure.



F3
F2
F1
ĩ i ɛ ɛ̃
F3
F2
F1
dɪd s æ m lʊk s ædə̃n θ ɪ n
db 0 10 20 30
F1
cps
0
1000
2000
3000
4000
m-m-m-m-m
n-n-n-n-n

Finally, Fig. 2 offers examples of the nasal murmur in the consonants /m/ and /n/; this will be discussed later.

Articulatorily, nasality can now be observed by X-ray not only in static photographs of artificially held positions but in motion-picture films of naturally spoken sentences, taken at twenty-four frames per second.

In these films vowel nasalization appears in two forms -- (1) either by the mere lowering of the velum, a motion which connects the nasal cavities with the pharyngeal cavity and causes the acoustic damping of the first formant, or (2) by a double articulation: (a) a lowering of the velum, (b) a volume adjustment of the pharyngeal cavity to the volume of the small rhino-pharyngeal cavity which is situated in the prolongation of the pharynx, exactly above the velum, all of which produces not only a damping of the first formant, but also a cancellation of some of the harmonics of the first formant (see Fig. 2). It is this double articulation that is generally seen in motion-picture X-rays of French nasal vowels.

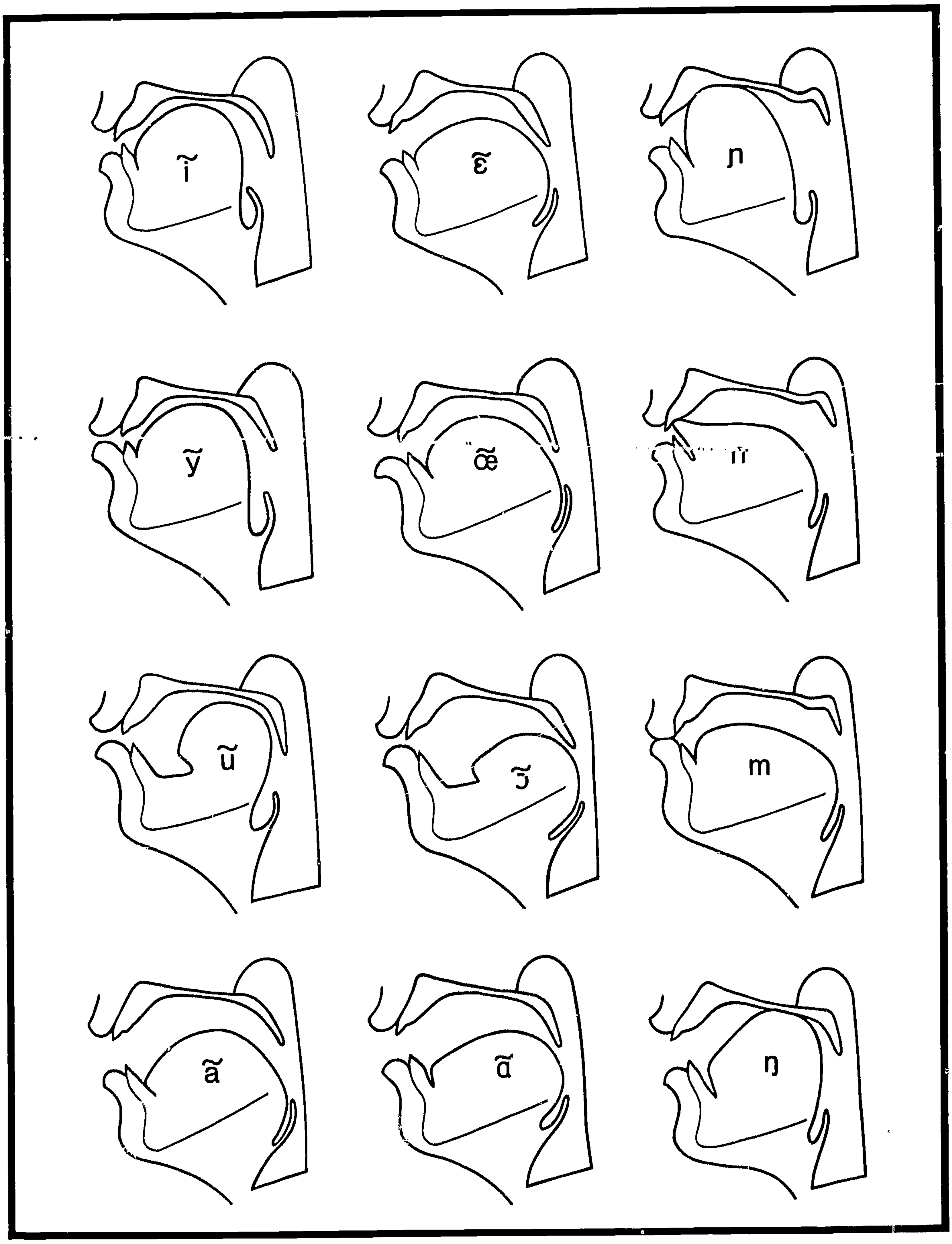
Fig. 3 shows, in the middle column, the cavity shapes which nasal vowels attained after centuries of medieval evolution and, in the left column, some of the cavity shapes from which these evolutions started. We see immediately that the four nasal vowels of Modern French all have approximately the same pharyngeal cavity-shape (below the pharyngeal constriction, at the lower right corner of each sketch) and that each nasal vowel is only distinguishable from the others by the shape of the anterior buccal cavity.

Originally the Old French vowels that were nasalized by anticipation of a nasal consonant had very unequal pharyngeal cavities. The left column of Fig. 3 shows that for [ĩ], [ỹ], [ũ], for example, the pharyngeal cavity must have been very large -- much larger than for [ɛ̃], [œ̃], [ɔ̃] -- whereas for [ã], it must have been rather small -- smaller than for the modern [ɑ̃]. Fig. 3 also shows, in the right column, how different the nasal consonants are from the nasal vowels. The nasal consonants, [ɲ], [n], [m], and [ŋ], are shown during maximal buccal occlusion. We note two essential differences -- (a) the cavity behind the buccal constriction is large for the nasal consonants, small for the nasal vowels, (b) the nasal-consonant murmur has only one exit, through the nose; the nasal-vowel sound has two exits, one through the mouth and one through the nose, the latter not being used for diffusion.

Next we note, in the second column of Fig. 3, that the volume of the pharyngeal cavity, for the modern nasal

FIGURE LEGEND

Figure 3. X-rays for the comparison of resonance cavities in nasal vowels and consonants. First column: four nasalized vowels of Old French; second column: the four nasal vowels of Modern French which correspond; third column: four nasal consonants.


ĩ
ɛ̃
ɲ
ỹ
œ̃
ũ
ɔ̃
m
ã
ɑ̃
ŋ

vowels, is similar to the volume of the small rhino-pharyngeal cavity with which they are connected by the velic passage when the velum is lowered. There are reasons to believe that this velar cavity alone has walls firm enough for efficient resonance; the other nasal cavities, those which terminate in the nostrils, have fibrous walls and could only have a damping effect.

Finally we recall that to this uniformity of pharyngeal cavities corresponds one which is just as striking, uniformity of the first-formant frequency. Fig. 1 had shown that the four nasal vowels of Modern French all have the same first-formant frequency -- this thin harmonic which indicates that the first formant is as low for /ɑ̃/ as for /ɛ̃/.

It seems, therefore, that in order to produce a maximal degree of nasality, after or during the historical effacement of the nasal consonant which had caused the simple lowering of the velum, it is not essentially a general opening motion which took place (since /ɑ̃/ is closer than either /a/ or /ɑ/) but <u>an evolution of the pharyngeal cavity toward the small pharyngeal volume which most favors the distinctive power of nasality</u>.

Vocalic nasalization caused by the mere lowering of the velum, with no adjustment in pharyngeal volume, acoustically produces only damping of the first formant. Such damping gives a weaker impression of nasality than the one perceived in the French nasal vowels. This weak form of nasalization is frequent in a language like American English in which the tendency to anticipate consonants is pronounced. In distinguishing <u>bent</u> from <u>bet</u>, it is a question whether the [n] or the nasality of the [ɛ] plays the major role. This nasalizing tendency of English is probably comparable to that of <u>dent</u>, as compared with <u>dete</u>, in Medieval French during the Gallo-Roman period. The spectrograms of Fig. 2 have already shown us striking examples of it in the sentence <u>Did Sam look sad and thin</u>. Before a nasal consonant the intensity of the first formant becomes lower than that of the second formant. Besides, the first formant is wider (damping effect) before a nasal consonant than before an oral one.

We find the same kind of nasalization, caused by the simple lowering of the velum, in a language such as Portuguese where nasal vowels have remained relatively high, [ĩ], [ẽ], [ə̃], [õ], [ũ], the large pharyngeal cavity not having adjusted to the voulme of the velar cavity. The /ĩ/ of Figs. 1 and 2 illustrates the Portuguese type of nasality.

We might ask, of course, why the Portuguese nasal vowels have not evolved in the same way as the French nasals. The answer seems simple. Portuguese has preserved until this day a tendency to close syllables which has prevented the complete loss of preconsonantal nasal consonants and restrained the evolution of the preceding vowel. Furthermore, nasal consonants had a closing effect on preceding nasalized vowels during the Gallo-Roman period.[4] In France, on the contrary, the Gallo-Roman tendency toward closed syllabication dramatically changed, later, into a strong tendency toward open syllabication, allowing the disappearance of pre-consonantal nasal consonants and the denasalization of nasalized vowels when the nasal consonant was followed by a vowel. Once liberated from the tyranny of subsequent nasal consonants, French nasal vowels were free to evolve into articulatory positions more favorable to the oral/nasal distinction.[5]

X X X

We have surveyed the present state of knowledge concerning the nature of vocalic nasality and we may now proceed to the analysis of consonantal nasality.

A series of impressive experiments, made by acoustic analysis and synthesis, have demonstrated that an occlusive nasal consonant is perceived principally by two types of cues: (a) transitions of formants two and three, which reflect the motions of buccal opening (or closing) and which, almost alone, serve to distinguish among the places of articulation (labial nasal, dental nasal, palatal nasal, velar nasal, etc.), and (b) a nasal murmur which occurs during the hold of the buccal closure while the lowered velum allows the sound-wave to pass through the nostrils. The murmur is essentially a manner of articulation cue -- its function is to distinguish a nasal consonant from its corresponding oral occlusive: /m/ from /b/, /n/ from /d/, /ɲ/ from /ɖj/, /ŋ/ from /g/. It is connected with the preceding and following formants in a discontinuous manner which also plays a role in identifying the occlusive as nasal.

It is this murmur alone which interests us here. Let us examine its acoustic structure in Fig. 2, first as it appears on typical wide-band spectrograms in the /m/ and /n/'s of the sentence Did Sam look sad and thin, then, below that sentence (bottom of Fig. 2), on a strongly amplified narrow-band spectrogram of isolated /m/ and /n/ closures which show some detailed structure that is not loud enough to appear in Sam, and, thin, or, for that matter, to be more than barely heard in normal speech. In the lower display of [m] and [n] murmurs, the voice melody (fundamental, or first harmonic) begins or ends at about 125 cps and rises by about one octave (to 250 cps) in the middle; this helps to bring out the formants. Above the horizontal formants, 'sections' display the exact amplitude of each harmonic (on a decibel scale) at four different instants. The upper section appears as a mirror image of the lower formants, the lowest frequencies being at the top.

In Sam, the /m/ murmur (above the broad zero line) shows a fairly strong first formant, centered at about 250 cps, (much lower than the first formant of /æ/ which is centered at about 750 cps), and two upp^r formants. In and [ən], the /n/ shows only one upper formant above the weak first one. (The upper formant is actually much weaker than the low one; they appear as dark as they do because spectrograms emphasize the visibility of high frequencies to compensate for an intensity decrease of 9 decibels per octave.) And in thin, the /n/ shows no clear upper formant, the lower one being already very weak. These three illustrations of murmurs are typical of what commonly appears on spectrograms: a low formant at about 250 cps, and one, two, or even no upper formants with very low intensity. The second formant is usually stronger and lower for /m/ than for /n/ and the third formant is stronger for /n/ than for /m/. But it has been shown, by synthetic-speech manipulation as well as by tape-splicing of natural speech, that the role of these upper formants in distinguishing /m/ from /n/ is negligible.[6] Thus, formant transitions alone must perform the task of distinguishing labials from dentals or from other places of articulation.

In the detailed acoustic structure, at the bottom of Fig. 2, seven or eight formants appear within a frequency range of 4000 cps. It can be seen, however, that those of /n/ are not very different from those of /m/ and that the upper formants are much weaker than the lower one, marked F-1 (often called F-N, or nasal formant, to avoid a terminological confusion with the first formant of oral vowels). This nasal formant, or first formant of the nasal murmur (marked F-1 at the bottom of Fig. 2), is quite the same in the /m/ murmur as in the /n/ murmur. It is centered at the second harmonic (above the zero base-line) when the pitch is at about 125 cps, at the beginning or the end of /m-m/ or /n-n/; it is centered at the first harmonic when the pitch is raised to about 250 cps in the middle of the /m-m/ or /n-n/.

According to Fig. 2, then, the first formant of the nasal murmur has a frequency of about 250 cps and is complemented by an indefinite number of higher formants of very low intensity and of irrelevant frequency as far as distinguishing one place of articulation from another. All this has been confirmed by the manipulation of synthetic speech. (The frequency of 250 cps is fairly critical -- when it is changed to 350 or 400 cps, /ma/ changes to /la/.)

An interesting hypothesis can be made about the articulatory source of this nasal-murmur first-formant. Its frequency of 250 cps is the same as the first-formant frequency of a high vowel like /i/, /y/, or /u/. The X-ray profiles of Fig. 3 permit us to compare the pharyngeal cavities of nasal consonants such as /ɲ/, /n/, /m/, /ŋ/, with the pharyngeal cavities of close vowels such as /i/, /y/, /u/. We note that they have comparable volumes.

Since the first formants of /i/, /y/, /u/ are closely related to the volume of the pharyngeal cavity, the first formant of the nasal murmur could well be also assigned to this cavity. A confirmation of this hypothesis is found in the fact that /ŋ/, whose pharyngeal cavity is somewhat smaller than that of the other nasal consonants, has a slightly higher frequency of first formant in the nasal murmur.

X X X

Let us finally compare nasal vowels with the nasal murmurs of nasal consonants.

None of the acoustic characteristics described above for nasal murmurs are shared by Modern French nasal vowels, neither in the formant frequencies nor in the structural distribution of energy.

The first formant of the nasal vowels is at about 500 cps; that of nasal murmurs is at about 250 cps. The upper formants of the nasal vowels play a distinctive role with respect to the perception of vocalic place of articulation; those of the nasal murmurs do not help in distinguishing one nasal consonant from another.

As for the distribution of energy, the opposition is still more apparent. In nasal vowels the first formant is weak and the others strong; in nasal murmurs the first formant is clearly stronger than the upper formants.

With respect to their articulatory characteristics, the nasal vowels and murmurs have only one common feature, the opening of the velic passage which connects the nasal and oral cavities. (And still, these openings are produced differently. For nasal vowels the velum is always lowered in the form of an arch, parallel to the curve of the tongue; for the murmurs the velum usually maintains its square-angle shape and separates itself from the pharyngeal surface (more exactly from the Passavant bulge) in a horizontal accordeon-like motion.) For French nasal vowels, the pharyngeal cavity (lower half of the pharynx) is rather small, being adjusted to the volume of the rhino-pharynx, whereas for nasal murmurs the pharyngeal cavity is so large that it compares with the large volume of high oral vowels.

X X X

Let us summarize. According to the acoustical, articulatory, and perceptual evidence that has been gathered by successive experiments, nasal vowels, as they are found in French, have little in common with nasal consonants. It was only at the first stage of the evolution of French nasal vowels that nasal vowels shared a common feature with nasal consonants, and this feature was only articulatory -- the velic opening. From this point on, the two 'nasalities' gradually became remarkably different from each other. Acoustically, they acquired different frequencies and, even more important, inverse distributions of intensity -- the nasal vowels are characterized by the weakness of their first formant and the strength of their upper ones; the nasal murmurs of consonants are characterized by the strength of their first formant as compared with the weakness of their upper ones. The primary cause of these pronounced divergences is that, from the beginning, the resonance systems of nasal vowels were opposed to those of nasal consonants. Nasal vowels were oriented toward the buccal cavities which remained opened during their occurrence; they were, then, diffused at the lips. On the contrary, the nasal murmurs were blocked by a buccal closure and their only possible exit was through the nasal cavities. By passing through these 'dead' chambers, their high frequencies were damped and attenuated.

FOOTNOTES

[1]Marguerite Durand, "De la formation des voyelles nasales," Studia Linguistica, 7: 33-53, 1953.

[2]Pierre Delattre, "Les attributs acoustiques de la nasalité vocalique et consonantique," Studia Linguistica, 8,2: 103-109, 1955.

[3]By the same token, the color of nasal vowels is less distinctive than that of oral vowels -- nasal vowels are less distinguishable among themselves than are oral vowels -- probably because they have a single formant, as the first of the distinctive formants is reduced. It should not surprise us then that poets treat them as 'veiled' vowels.

[4]See M. K. Pope, From Latin to Modern French, 1952, p. 166.

[5]This emancipation of the French nasal vowels is perhaps what will cause their deterioration. Because of it, even though they have gained distinctive nasality and have reinforced their opposition to oral vowels, they have decreased the distinction of color among themselves. This attenuation of the first formant should eventually reduce these four phonemes to two: /ɛ̃/ and /ɔ̃/. This opposition of two nasals only would be more stable -- it would rest on the opposition of two articulatory features: anterior-spread vs. posterior-rounded, and a wide frequency difference in the second formants: F-2 at 1800 cps vs. F-2 at 800 cps.

[6]André Malécot, "Acoustic cues for nasal consonants, an experimental study involving a tape-splicing technique," Language, 32,2: 274-284, April-June 1956.

EXPLAINING THE CHRONOLOGY OF NASAL VOWELS

BY ACOUSTIC AND RADIOGRAPHIC ANALYSIS

For the past few years, the nasality of vowels has been the subject of detailed analysis, by radiographic as well as spectrographic techniques. Certain coincidences in the results are now suggesting the existence of a striking correlation between the chronology of nasal vowels in Old French and the changing shape of the pharyngeal cavity during the slow development of nasality. The cine-radiographic comparison of nasal and oral vowels offers an explanation of the fact that the four nasal vowels of French did not acquire their distinctive nasality simultaneously but sequentially, one at a time, in the course of several centuries, and the acoustic analysis of nasality lends support to this explanation.

The present study will mainly rely on the articulatory study of nasality by means of motion-picture X-rays, but it will also involve the acoustic analysis of nasal quality on spectrograms. Let us, therefore, begin by reviewing what is already known about the acoustics of nasality. Thanks to the perceptual testing of vowel nasality by psycho-acoustic techniques, based on the manipulation of synthetic speech, the acoustic cues and acoustic features, which distinguish a nasal vowel like /ɛ̃/ from an oral vowel like /ɛ/, are now rather well understood. A simple spectrogram will illustrate these acoustic distinctions.

Figure 1 contrasts nasal vowels and oral vowels by means of spectrograms of the two following sentences:

<u>L'ascète est à cinq</u> [l asɛt et a sɛ̃k]

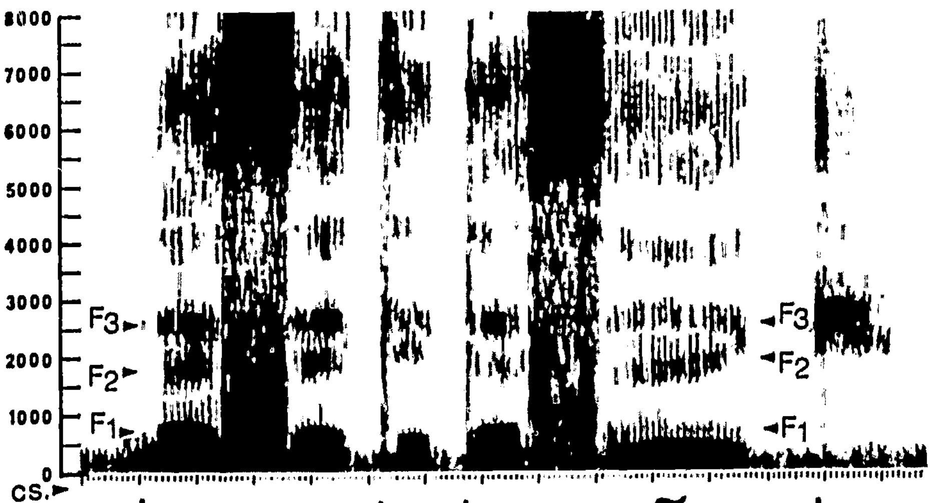
and

<u>L'enceinte est à sec</u> [l ɑ̃sɛ̃t et a sɛk]

It shows that, for each nasal vowel, the first formant is weaker than the second formant of the same vowel and is weaker than the first formant of the corresponding oral vowel. The relative intensity of each formant can be evaluated by its degree of darkness. If we compare [la] of the upper spectrogram with [lɑ̃] of the lower spectrogram, we note that for [la] the first formant (F-1 on Fig. 1) is very dark and the second (F-2 on Fig. 1) considerably lighter; for [lɑ̃], the opposite condition prevails -- the first formant (F-1) is lighter than the second (F-2) and is lighter than the first formant of [la] of the upper spectrogram.

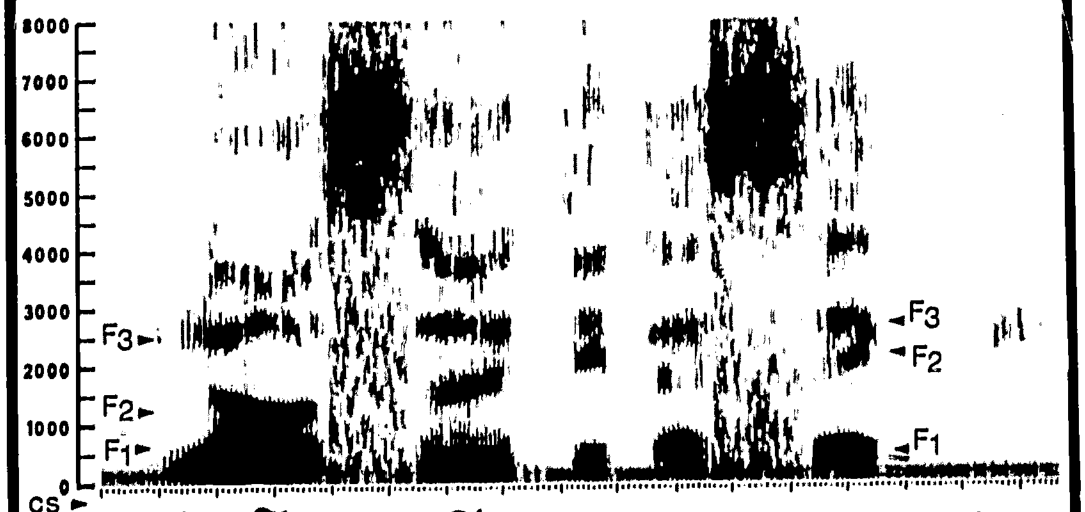
FIGURE LEGEND

Figure 1. Wide-band spectrograms showing the acoustic features of nasal vowels /ɑ̃/, /ɛ̃/, in contrast with their oral counterparts /a/, /ɛ/. It appears that nasality is perceived by an imbalance in the intensity of the first and second formants. In the nasal vowels of <u>cinq</u>, <u>l'en-</u> and <u>-ceinte</u>, the first formant (F-1) is always less intense (less dark on the spectrograms) than the second formant (F-2); the first formant of each nasal vowel is also less intense than the first formant of the corresponding oral vowel.



l a s ɛ t e t a s ɛ̃ k

l'ascēte est à cinq



l ɑ̃ s ɛ̃ te t a s ɛ k

l'enceinte est à sec

Similar comparisons can be made for other pairs of vowels. In [sɛ] of the upper spectrogram the first formant is somewhat darker than the second; in [sɛ̃] of the lower spectrogram, the first formant (upper portion of the lowest darkness, the lower portion corresponding to the always present fundamental harmonic) is considerably lighter than the second. In the nasal [ɛ̃] of cinq (upper spectrogram) the first formant (F-1) is lighter than the second (F-2), whereas in the oral [ɛ] of sec (lower spectrogram) the first formant (F-1) is at least as dark as the second formant (F-2). In short, the first formants of the three nasal vowels in l'enceinte and cinq show less intensity than the first formants of the three oral vowels in l'ascète and sec.

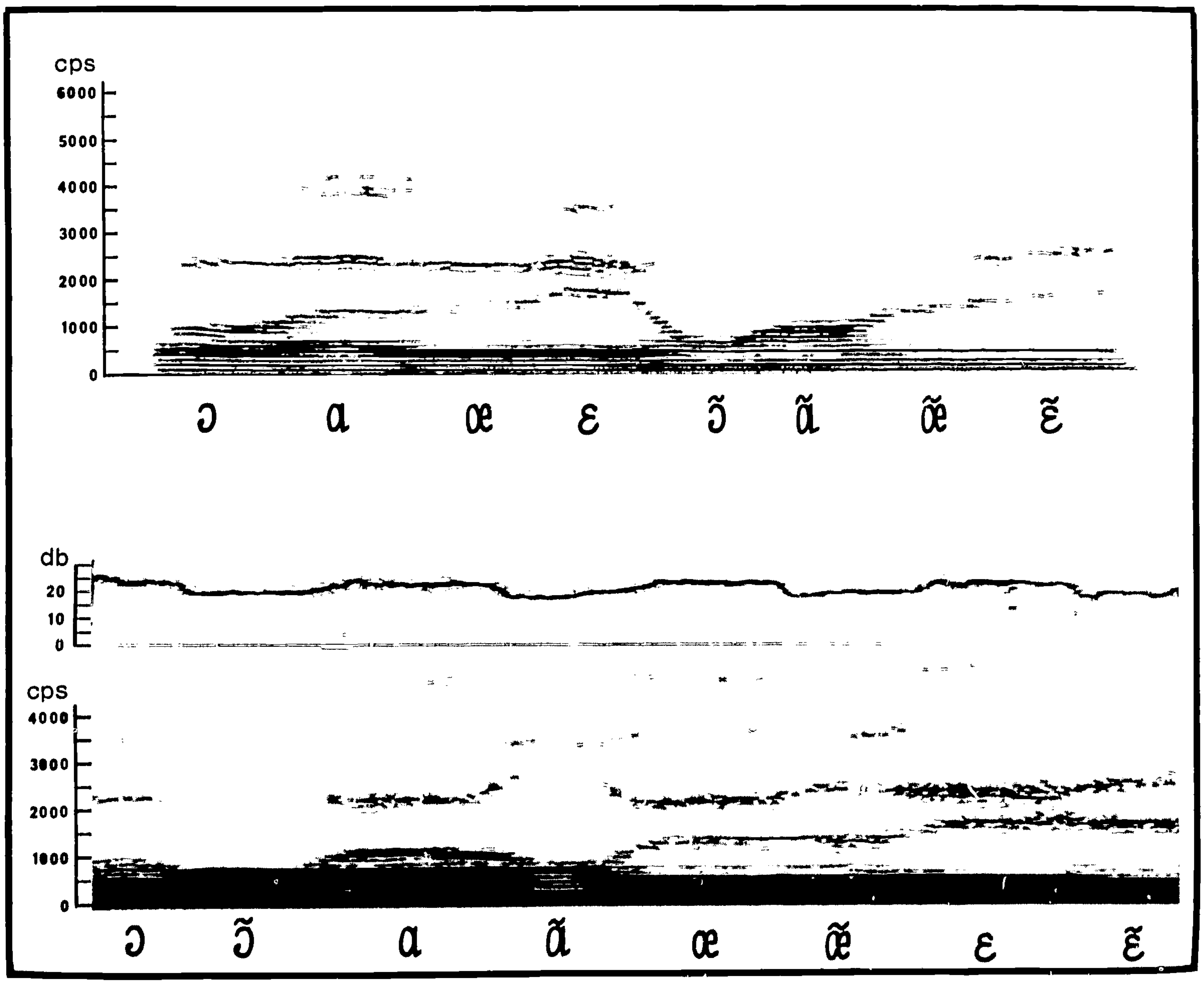
The main acoustic correlate of nasality is, therefore, the loss of intensity of the first formant. The subjective impression which is called nasality (in vowels) is caused by a lack of balance in the relative intensities of the two lowest formants -- the second formant dominates the first instead of submitting to it or combining with it on fairly equal terms as in oral vowels. This has been thoroughly verified by the controlled manipulation of synthetic speech. An artificial vowel is synthesized with two formants of equal intensity. Then the intensity of the first formant is gradually reduced in steps of three decibels while the intensity of the second formant is kept constant. French listeners start hearing a nasal vowel for a first formant reduction of 9 decibels and they are unanimous in calling it nasal when the reduction reaches 15 decibels.

Fig. 2 illustrates this reduction of the first formant intensity with more precision than Fig. 1, thanks to the narrow filtering which uncovers each individual harmonic of the formants. For the oral vowels (left portion of the upper spectrogram) both formants (the first and the second) are composed of several harmonics each -- mostly of two, three, or four harmonics. But for the nasal vowels (right portion of the upper spectrogram) the first formant is reduced to a single thin harmonic, the others having been either weakened by acoustic damping or eliminated by acoustic counter-resonance.

We also notice, in Fig. 2, that the first-formant frequency of the nasal vowels is the same for all of them. Nasal vowels, therefore, are not distinguished from each other by their first-formant frequency but only by their second-formant frequency -- a very minimal distinction since two vowels can be distinguished from each other by as many as three acoustic features: first-formant frequency, second-formant frequency, and first-formant intensity.

FIGURE LEGEND

Figure 2. Narrow-band spectrograms of four French oral vowels and of their nasal counterparts. The detailed harmonic structure shows a marked loss of intensity in the first formant of the nasal vowels in comparison with the oral ones. The first formant of oral vowels appears as two or three dark harmonics, whereas the first formant of the nasal vowels, in the lower as well as in the upper spectrogram, has only one light harmonic. Furthermore, the frequency of this light harmonic is very nearly the same for all nasal vowels.


cps
6000
5000
4000
3000
2000
1000
0
ɔ a œ ɛ ɔ̃ ɑ̃ œ̃ ɛ̃
db
20
10
0
cps
4000
3000
2000
1000
0
ɔ ɔ̃ a ɑ̃ œ œ̃ ɛ ɛ̃

This is the case of [e] vs. [ɑ̃] or [a] vs. [ɔ̃], for instance.

Once these acoustic correlates of nasality were known, the question of their physiological explanation was raised. Beyond the fact that the velum was lowered, one wanted to know what the articulatory correlates of the first-formant reduction could be. For this purpose, the technique of motion-picture X-rays was improved until it became possible to clearly see on X-ray frames the velum lowering as well as the shape of the complete mouth and pharynx cavities. It is in the course of such cineradiographic investigations that the historical correlation we are concerned with here made its appearance.

Let us now consider the historical aspect of nasality in French vowels.

Fig. 3 presents the articulatory conditions which must have prevailed at the beginning and at the end of the nasalization process according to X-ray motion pictures of natural speech. These vocal cavities are those of a single French person but it must be emphasized that conformity among subjects appears much greater on motion-picture X-rays than on still X-rays. When subjects had to hold an articulatory position while being photographed, striking individual divergences seemed to exist for the same sound. The motion-picture technique showed that these divergences did not exist in naturally articulated speech. Within the carpenter's square shape of Fig. 3 are the articulatory profiles of the four nasal vowels of Modern French. Outside of the carpenter's square shape are the profiles of the vowels which nasalized in Old French when the velum was lowered in anticipation of a following nasal consonant. These nasalizing vowels, at the beginning of their nasal evolution, are marked with a dotted tilde. To simplify our argument, let us select four of the vowels and see how their resonance cavities were modified by nasalization.

In the course of the Middle Ages,

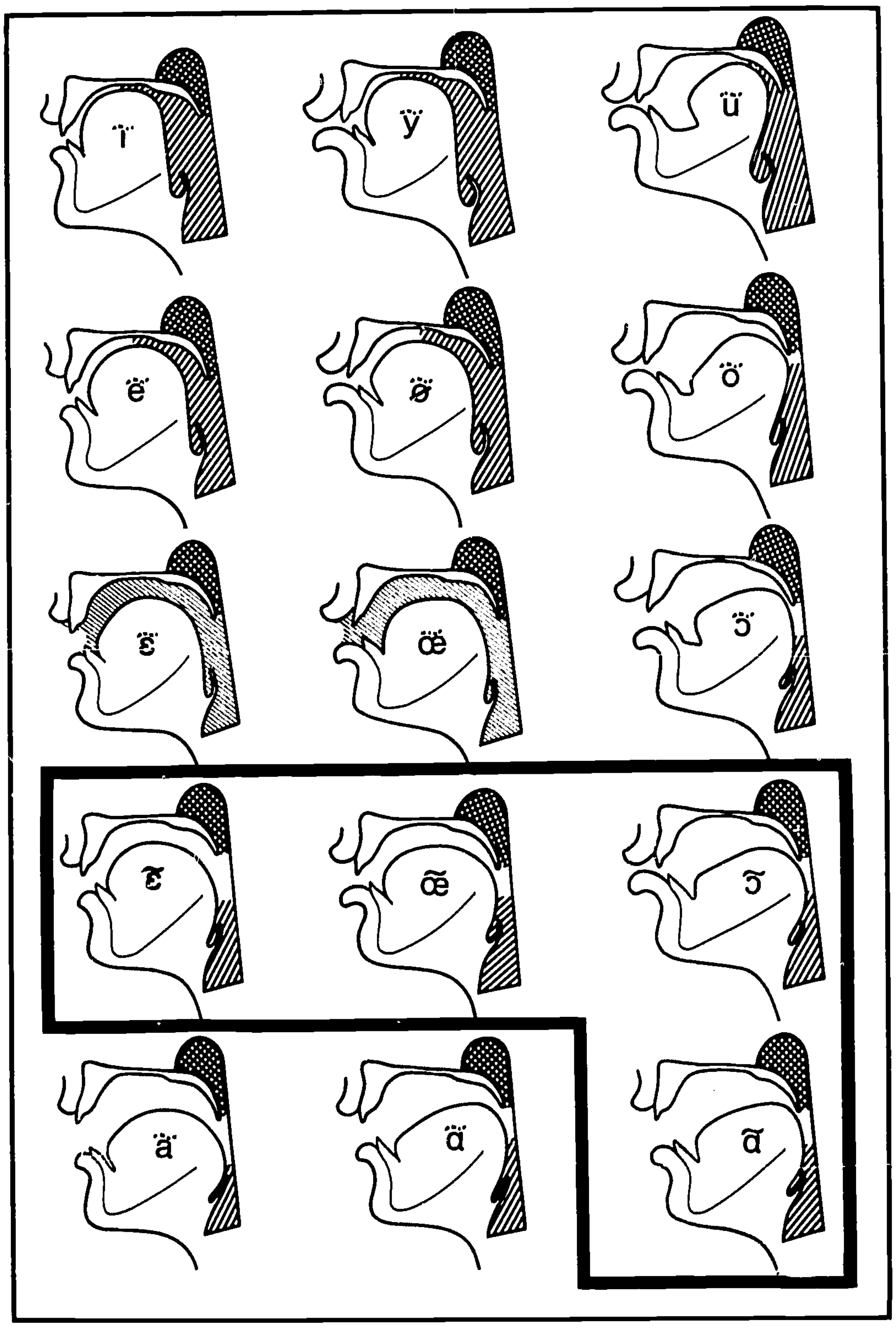
nasalized	ĩ	before	[n]	or	[m]	became	ɛ̃
"	ỹ	"	"	"	"	"	œ̃
"	ũ (o+n)"		"	"	"	"	ɔ̃
"	ã	"	"	"	"	"	ɑ̃

Between the appearance of the left-side vowels and the realization of the right-side vowels, from ten to fifteen centuries elapsed.

In Fig. 3, the pharyngeal cavities are marked with

FIGURE LEGEND

Figure 3. An X-ray comparison of the pharyngeal cavities (slanted lines) of the nasal vowels of Modern French (in the carpenter's square) with the pharyngeal cavities of the nasalized vowels that can be assumed to have occurred in Old French. (a) Nasalized /i/, /y/, /u/ have much larger pharyngeal cavities than nasal /ɛ̃/, /œ̃/, /ɔ̃/, but nasalized /a/ has a <u>smaller</u> pharyngeal cavity than nasal /ɑ̃/. (b) It is assumed that all four nasal vowels of Modern French have arrived at comparable pharyngeal dimensions by adjusting their volume to that of the rhino-pharynx (crossed lines) in the course of centuries, seeking the <u>most favorable dimension</u> to distinctive nasality.



The evolution of nasal vowels

slanted lines and the rhino-pharyngeal cavities (above the velum) by crossed lines. Only these two cavities are of concern to us here, the front (mouth) cavity not being involved in the nasalizing of nasal vowels but only in distinguishing the nasal vowels among themselves. Let us observe the differences in volume between the nasalizing vowels of early Medieval French and the nasal vowels of late Medieval French. For nasalizing /i/, /y/, and /u/ (upper row), the pharyngeal cavity is very large (and accordingly, the first formant is very low); for nasal /ɛ̃/, /œ̃/, and /ɔ̃/, this pharyngeal cavity is much smaller (and accordingly, the first formant higher). For nasalizing /a/ (lower row), the pharyngeal cavity is very small (and accordingly, the first formant is very high); for nasal /ɑ̃/, the pharyngeal cavity is somewhat larger than for /a/ (and accordingly, the first formant is lower). Thus, in the course of nasalization, the cavities of /i/, /y/, and /u/ became larger and that of /a/ became smaller in such a way that all four nasal vowels ended with practically equal volumes of their pharyngeal cavity (and accordinly, with similar frequencies of the first formant). This is the first remarkable fact that concerns us. If it is not a coincidence, it has a reason. The most natural assumption is that the evolution of the four nasal vowels has ended with similar pharyngeal dimensions because this dimension is the most <u>favorable</u> to distinctive nasality. A second remarkable fact is that the 'favorable dimension' of the pharyngeal cavity of all French nasal vowels is equal, or comparable, to that of the rhino-pharyngeal cavity just above it (crossed lines). Now, according to acoustic theory, when two communicating cavities have the same volume, such as the pharyngeal and rhino-pharyngeal cavities of nasal vowels, their harmonic sound-waves may resonate in opposite phase and cancel each other. It is obviously by such harmonic cancellations or reductions that the first formant (which is closely related to the pharyngeal cavity) becomes weaker in nasal vowels than in oral ones. Our second assumption, therefore, is that in the development of distinctive nasality, (in seeking to nasalize maximally) the variable volume of the pharyngeal cavity has gradually adjusted itself to the fixed volume of the rhino-pharyngeal cavity. Equalizing the two volumes is probably the most effective way of reducing the intensity of the first formant. Simply lowering the velum, without adjusting to the 'favorable dimension' of the pharynx, only has the effect of 'damping' the first formant. This does reduce the loudness of the first formant, the harmonics being less condensed, but it does not actually cancel certain harmonics. It is most likely that the development of French nasal vowels began with mere damping of the first formant when the velum was lowered, and ended with harmonic cancellations in addition to damping when the pharynx adjusted its volume to that of the rhino-pharynx.

Let us now consider the temporal sequence of vowel nasalization during the Middle Ages.

The first established fact which concerns us here is that at one time or other all the vowels of Old French nasalized when followed by a nasal consonant, and in all stressed syllables this nasality eventually played a distinctive role: V.L. *annu* > O.F. *an* [ãn], with a nasal [a], whereas V.L. *arcu* > O.F. *arc* [ark] with an oral [a]. As early as the *Song of Roland*, the nasal [a] of *champ* [tʃãmp], from V.L. *campu*, did not assonate with the oral [a] of *charn* [tʃarn], from V.L. *carne*, and by the end of the Medieval Period two words like *champ* /ʃã/ and *chat* /ʃa/ were distinguished from each other by the presence or absence of nasality.

The development of vowel nasality must have been very slow since it began in the first century B.C. the first time a Gaul attempted to pronounce a Latin word, and the first evidence we have of its distinctive status is in the eleventh century A.D.

(If Modern French vowels are no longer nasal in words like *année*, *aîné*, it is because in late Old French, when the nasal consonant was followed by a vowel, open syllabication caused that nasal consonant to move to the syllable of the following vowel, and the nasal vowel, having lost its close contact with the nasal consonant, lost its nasality and became oral again. This is known as Middle French denasalization. It explains such losses of nasality as V.L. *annata* > F. *année*, by way of O.F. [ãne], Mid. F. [ã-ne], Mod. F. [a-ne]; V.L. *antiu* > F. *aîné*, by way of early O.F. [ãine], late O.F. [ɛ̃ne], Mid. F. [ɛ̃-ne], Mod. F. [e-ne]; V.L. *femina* > F. *femme*, by way of early O.F. [fɛ̃mə], late O.F. [fãmə], Mid. F. [fã-mə], Mod. F. [fa-m].)

It is furthermore established that nasalization did not produce distinctive nasality at the same time for all vowels. On the basis of the rimes and assonances of literary texts, the lapse of time separating the earliest and the latest occurrences of distinctive nasality is of at least three centuries, possibly of six. At the time when a nasal /ã/ no longer assonated with an oral /a/ in the Song of Roland, nasal /ĩ/, /ỹ/, and /õ/ still assonated with oral /i/, /y/, and /o/. According to most grammarians, the chronology of nasality is approximately the following: Nasalized /a/ may have become distinctive as early as the tenth century, nasalized /ɛ/ during the eleventh or later, and nasalized /ɔ/ during the twelfth. As for nasalized /i/, /y/, and /u/, they may have attained distinctiveness toward the end of the thirteenth century, but more likely in the sixteenth century only when their timbre modification into the final forms of /ɛ̃/, /œ̃/, and /ɔ̃/ developed rather suddenly.

Whatever the actual chronology may have been, it is certain that the distinctive degree of nasality was reached first by the lowest vowels, then by the mid-low and mid-high ones, and lastly by the high ones. This brings us to the heart of our argument. If, instead of considering tongue height, we observe the volume of pharyngeal cavities (Fig. 3), we note that the chronology of distinctive nasality correlates with the difference between the pharyngeal-cavity volume of the original oral vowels and the pharyngeal-cavity volume of their nasal counterparts (the favorable volume). For /i/, /y/, /u/, the pharyngeal cavity is very large; it is much larger than the 'favorable dimension' illustrated by /ɛ̃/, /œ̃/, /ɔ̃/, /ɑ̃/. The difference between the pharyngeal volume and the favorable volume being considerable, one would expect the modification from one volume to the other to take centuries.

For /e/, /ɛ/, /o/, /ɔ/, the difference between the original pharyngeal cavity and the favorable pharyngeal cavity being smaller, one would expect the modification from one volume to the other to take less time. And for /a/, the difference between the original pharyngeal volume and the favorable pharyngeal volume being the smallest, one would expect the modification from one volume to the other to take the least time. In brief, the larger the modification to which the pharynx had to submit before reaching the dimension most favorable to nasality, the longer the period of time required.

This new hypothesis to explain the extended chronology of nasal vowels in Medieval French would not have been possible without the recent advances in cineradiographic techniques. The scientific comparison of contemporary articulations may be relevant to the understanding of historical phonetics.

Should our hypothesis be true, two new points must be added to the history of nasal vowels. (a) It has often been said that, in the process of nasalization, vowels <u>opened</u> (the tongue was lowered). This is only partly true -- the /a/ vowel actually closed (the tongue was raised) as it became more nasal. (b) Actually, it is neither closing nor opening that is primarily involved in French nasalization, it is seeking the pharyngeal dimension which is the most favorable to distinctive nasality -- a dimension which is considerably smaller than that of the highest vowels but clearly larger than that of the lowest ones; this dimension is determined by that of the rhino-pharyngeal cavity which the pharyngeal cavity seeks to equal. Raising or lowering the tongue are only secondary factors in nasalization; the primary factor is the adjustment of the pharyngeal cavity to the 'favorable dimension.'[1]

SUMMARY

A motion-picture X-ray comparison between the pharyngeal cavity of nasal vowels in Modern French and the pharyngeal cavity of the nasalized vowels from which they must have come in Old French suggests a new explanation for the historical fact that low vowels, such as /a/, acquired distinctive nasality early (10th century), high vowels, such as /i/, /y/, /u/, late (13th century or later) and mid vowels, such as /ɛ/, /ɔ/, /e/, /o/, in between. A striking correlation is found between the different lengths of time each vowel required to reach distinctive nasality and the difference in pharyngeal volume between the nasal vowels of Modern French and the nasalized vowels of early Old French. The greater the difference between the pharyngeal volume of the nasal vowel and the pharyngeal volume that vowel had at the start of nasalization, the longer the time a vowel took to acquire distinctive nasality. In other words, it can be assumed that a vowel like /a/ acquired distinctive nasality, /ɑ̃/, early (when followed by a nasal consonant) because it had a very small pharyngeal cavity which did not need a great length of time to adjust its volume to that of the small pharyngeal cavity that is most favorable to distinctive nasality and is found in all Modern French nasal vowels. But a vowel like /i/ acquired distinctive nasality, /ɛ̃/, late because it had a very large pharyngeal cavity which needed a great length of time (at least three centuries more than /a/) to adjust its volume to that of the small pharyngeal cavity found in all Modern French nasal vowels (the 'most favorable' volume). Other facts, confirming this assumption, are found in the dimension of the rhino-pharynx, which, in nasal vowels, is comparable to that of the pharynx, and in the acoustics of French nasality which is characterized by a low-intensity first formant whose frequency (like its pharyngeal volume) was nearly the same for all the nasal vowels toward the end of their long evolution.

FOOTNOTE

[1]It must be noted here that articulatory seeking of the favorable pharyngeal dimension to produce fully nasalized vowels was made possible by the tendency to open syllables which appeared and kept increasing during the late Old French and the Middle French periods. In Portuguese, if nasality did not produce the same sort of pharyngeal modification as in French (nasal /i/, for instance, keeping its large pharyngeal cavity rather than modifying it toward that of /ε̃/), it must be because closed syllabication has always prevailed, keeping the nasal consonant in close contact with the preceding vowel. According to M. K. Pope (From Latin to Modern French, pp. 176-177) a nasal consonant has a closing effect over the preceding [o].

SYNTAX AND INTONATION,
A STUDY IN DISAGREEMENT

Our theme is inappropriateness in intonation. Its effects will be observed by covering syntactic structures with intonation curves that are not the most appropriate to the structures.

Poets have known for a long time that inappropriateness is a rich source of expression. In "Rien n'est plus cher que la chanson grise," Verlaine suggests its deliberate use and, at the same time, offers a subtle example of it: in "chanson grise" the inappropriate alliance of sound and color illustrates the evocative power of synesthesia -- a single notion is perceived simultaneously by two different senses, here hearing and sight. Before Verlaine, of course, Baudelaire had used such illogical sequences as "un vieux flacon qui se souvient" or "une fleur qui s'évapore."

Similarly, alliances of syntactic structures with intonation curves that are inappropriate can express a number of attitudes which contrast with those of the appropriate curves in a predictable manner. Let us take as an example the utterance: "Quand partez-vous." When said with the falling intonation (4-1) which is logical for an interrogation (information question), it has the literal meaning of "When are you leaving?" If the rising curve which would be appropriate for a yes-or-no question is substituted [kɑ̃ parte vu]: (2-4+), it takes on the meaning of "Are you asking me when I am leaving? Do you have the nerve to do that?" most likely with a connotation of indignation. If a rising curve of implication is substituted [kɑ̃ parte vu]: (2-4-), the directness of the question is softened, a note of respect, of consideration, is added. When the moderate rise of minor continuation is used by a listener in repeating the falling interrogation of a speaker [kɑ̃ parte vu]: (2-3), perplexity, as a bewildered objection, is expressed, which could mean: the answer is not so simple as you seem to believe. And if the intonation of parenthesis [kɑ̃ parte vu]: (1-1) is substituted, a reflecting or wondering mood pervades which might be translated by "What exactly do you mean by that?"

Before surveying the effects of inappropriate curves, let us review the intonation curves in their appropriate uses. A statistical study, based on the analysis of French plays, by ear and by spectrograms of actors' diction yielded ten major curves related to syntactic structure or distribution.[1] The systematic testing of those ten curves was done by neutralizing the segmental content, either by means of minimal pairs in which the same phonemes are said with different intonations (You think it's raining. / You think it's raining?) or by erasing the segmental content of a recording without erasing the supra-segmental features. The result of those tests indicates that, in French, the ten major curves form only seven distinctive units, five being individually distinctive, two being in complementary distribution (the high parenthesis and the low parenthesis) and three being not clearly distinctive from one another (the three curves falling from 4 to 1) but distinctive from all the others as a group. The ten curves we have in mind are illustrated in Figure 1 by a single sequence of segmental phonemes: [kɛltɔ̃b], which can be spelled: Quelle tombe, or Qu'elle tombe, the meaning depending on syntactic structure or distribution combined with intonation.

Figure 1 presents the ten appropriate curves on a convenient four-level scale, using curve shapes that are reminiscent of the actual frequency variations that can be seen on spectrograms. Note that curves 1 to 4 are rising; curves 5 and 6 are level; and curves 7 to 10 are falling.

The seven distinctive curves can be described as follows:

1. THE QUESTION CURVE. In the first line of Figure 1, qu'elle tombe has a rising slope which must rise to a higher level than C'est là, with an increasing degree of rise (2-4+).

2. THE MAJOR CONTINUATION CURVE. In the second line of Figure 1, qu'elle tombe has a rising slope which must rise to a higher level than C'est là, but with a decreasing degree of rise (2-4).

3. THE IMPLICATION CURVE. In the third line of Figure 1, qu'elle tombe rises to a higher level than C'est là and the degree of rise is decreasing, as in line 2, but the decrease in rise is more stressed than in line 2, so that the curve of implication reaches a high plateau early and tends to slack toward the end (2-4−).

4. THE MINOR CONTINUATION CURVE. In the fourth line of Figure 1, Qu'elle tombe rises decreasingly and to a lower level than ou non (or qu'elle tombe of line 2); it can even be falling instead of rising but is so only exceptionally. The minor continuation curve of line 4 indicates that Qu'elle tombe is a smaller sense-group, belonging to the larger sense-group Qu'elle tombe ou non in which the major continuation curve of ou non announces the end of a related

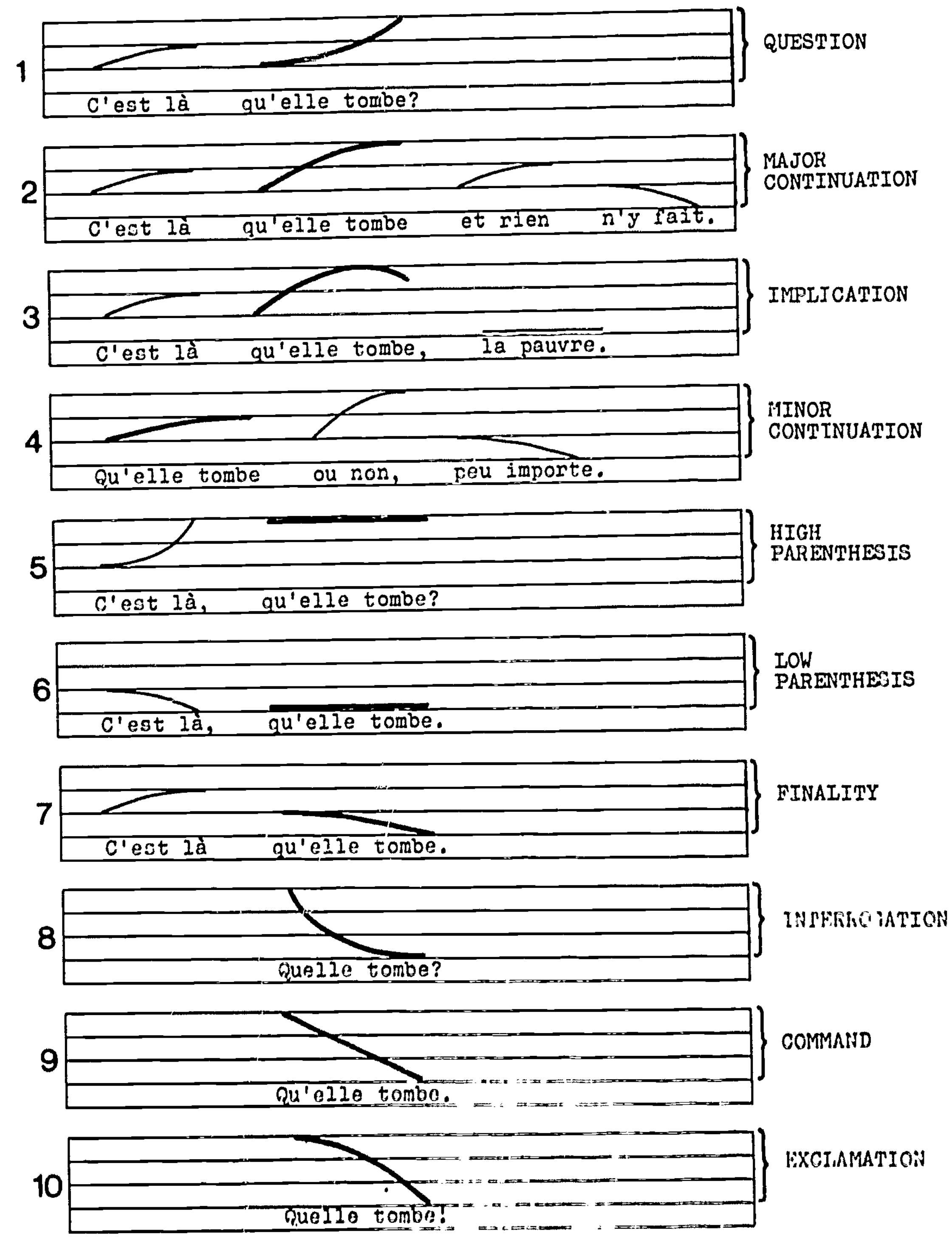

1
C'est là qu'elle tombe?
QUESTION
2
C'est là qu'elle tombe et rien n'y fait.
MAJOR CONTINUATION
3
C'est là qu'elle tombe, la pauvre.
IMPLICATION
4
Qu'elle tombe ou non, peu importe.
MINOR CONTINUATION
5
C'est là, qu'elle tombe?
HIGH PARENTHESIS
6
C'est là, qu'elle tombe.
LOW PARENTHESIS
7
C'est là qu'elle tombe.
FINALITY
8
Quelle tombe?
INTERROGATION
9
Qu'elle tombe.
COMMAND
10
Quelle tombe!
EXCLAMATION

FIGURE 1

series of sense-groups. The fact that the curves of Qu'elle tombe in line 4 and qu'elle tombe in line 2 are distinctive can be demonstrated by such meaningful oppositions as: Il a peint (2-4) // la dame (2-3) / en noir (2-1) vs. Il a peint (2-3) / la dame (2-4) // en noir (2-1).

5. THE PARENTHESIS PLATEAU. The high plateau of qu'elle tombe in line 5 (also called echo) and the low plateau of qu'elle tombe in line 6 are allotones of the same intoneme since their level is conditioned by the curve that precedes them. They are said to be in complementary distribution. Whatever their pitch level is -- low or high -- the parentheses tend to have a flat shape, which is noted by 4-4 or 1-1.

6. THE FINALITY CURVE. In the seventh line of Figure 1, the curve of qu'elle tombe falls increasingly from level 2 to level 1. To express declarative finality without ambiguity, this falling curve must start at a lower level than là of C'est là. Should it start at a higher level than là, qu'elle tombe would take on the meaning of command rather than a declaration.

7. THE INTERROGATION - COMMAND - EXCLAMATION CURVE. The pitch curves of lines 8, 9, and 10 must fall rapidly from level 4 to level 1 in order to be distinguished from the slow fall (2-1) of declarative finality. Those three curves have slightly different shapes, as indicated in Figure 1, but their differences are not sharp or stable enough to be clearly identified without context. They may therefore be considered as three allotones of the same intoneme. The three meanings are distinguished from one another by syntax rather than by intonation.

Those seven distinctive curves can also be profitably illustrated by a dialogue such as the following:

Quand j'ai vu	Minor continuation: 2-3
l'accident,	Major continuation: 2-4
j'ai pris peur.	Finality: 2-1
Quelle horreur!	Exclamation: 4-1
Aidez-nous.	Command: 4-1
Vous ne voyez pas,	Question: 2-4$_+$
Monsieur l'agent?	Echo: 4-4
Je vois fort bien,	Implication: 2-4$_-$
chère Madame.	Parenthesis: 1-1
Que puis-je faire?	Interrogation: 4-1

And here is, for comparison, an illustrative dialogue in English with the appropriate levels for that language.

Look at him.	Command: 3-4-1
What a play!	Exclamation: 4-4-1
Had he run	Minor continuation: 2-3-2
and not passed,	Major continuation: 2-3-1-2
he'd be safe.	Finality: 2-3-1
And what next,	Interrogation: 3-4-2
according to you?	Parenthesis: 1-1
Pass again,	Question: 2-1-4
do you suppose?	Echo: 4-4
Of course.	Implication: 2-4-3

Now that we are familiar with the ten basic appropriate curves of French and with the syntactic form they logically cover, we can proceed to make inappropriate substitutions.

The most productive substitution is the one which uses the implication curve. In order to realize the shape of this curve, let us examine it in opposition to a few others. The implication of

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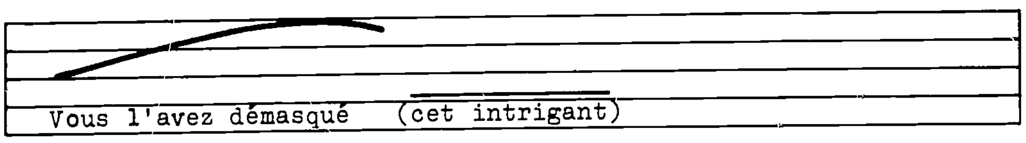

cannot be confused with the finality of

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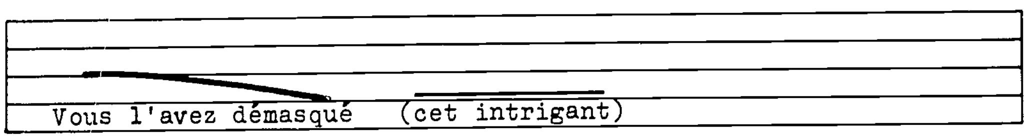

nor can it be confused with the question of

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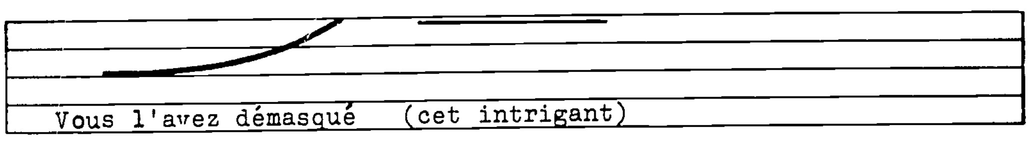

or with the continuation of

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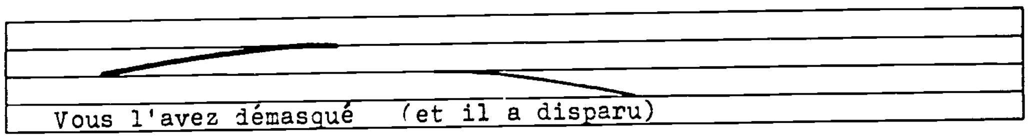

As in illustration 3 of Figure 1, the implication curve is characterized here by an early rise followed by a slight weakening toward the end of the last syllable.

1. COMMAND > IMPLICATION

The appropriate curve for a short command is a direct fall, starting at the highest level, as in

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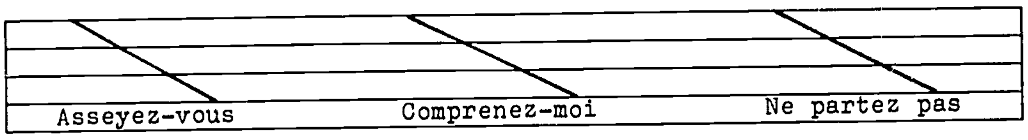

Substituting a curve of implication, we have:

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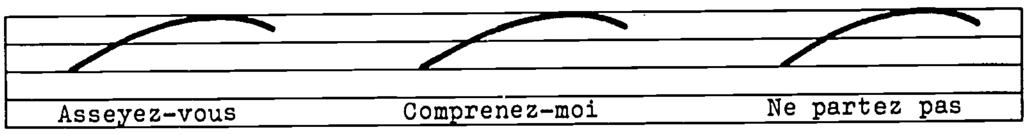

Since the syntax of command is generally unambiguous, the meaning of a command is not lost; here, it is simply enriched and attenuated by an attitude of consideration, of respectful request. The implicit words, following the implication, could be, for instance:

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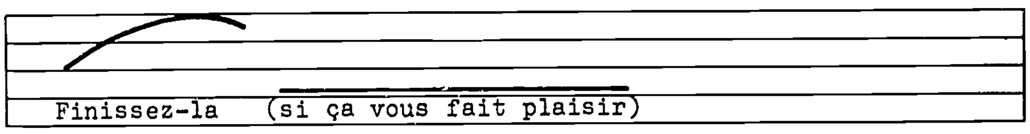

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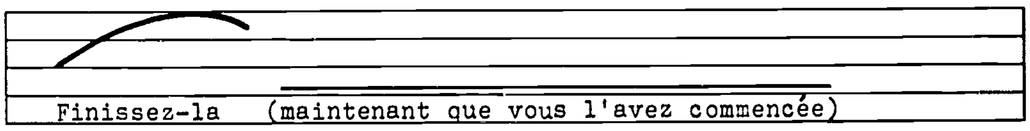

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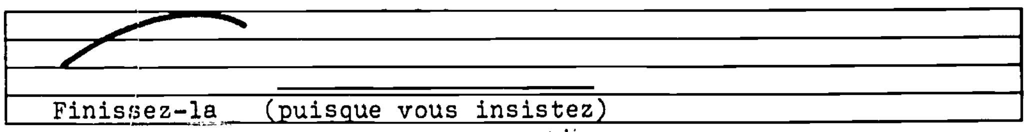

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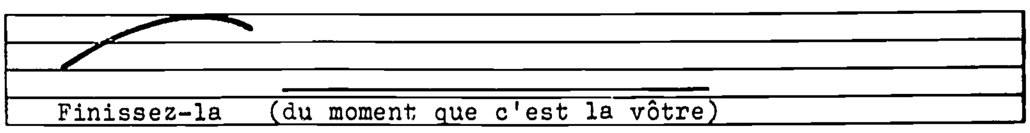

What the speaker does not explicitly add, the listener understands well enough because he is aware of the speaker's state of mind and is perhaps helped by a gesture or a facial expression.

2. EXCLAMATION > IMPLICATION

The appropriate curve for an exclamation is a rapid fall with an increasing slope, as in

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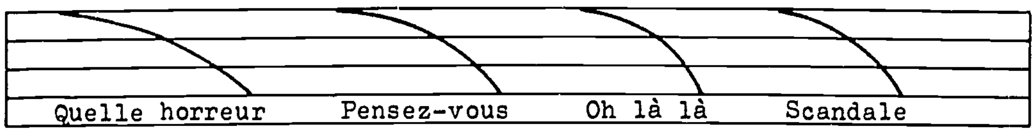

Substituting a curve of implication adds such notions as mystery, secrecy, hypocrisy, even calumny:

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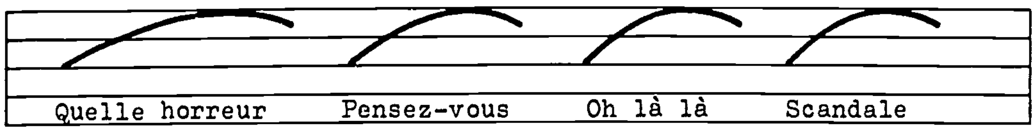

Moreover, in the process of pitch-curve substitution, the syllabic intensity which characterizes an exclamation is subdued, the initial consonants lose some of their expressive energy.

3. QUESTION > IMPLICATION

Here, we must treat separately the questions in which intonation is redundant because of syntactic form: Viendrez-vous?, Est-ce que vous viendrez? and the questions which depend on intonation alone to be heard as questions: Vous viendrez?

A. Questions without redundancy

The appropriate curve of questions without redundancy is rising with an increasing slope, as in

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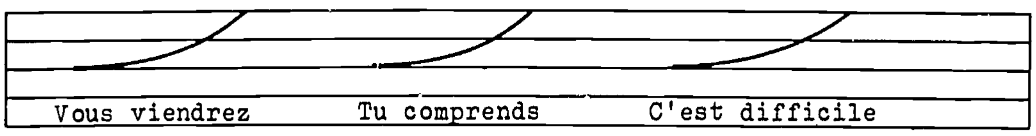

If the implication curve is substituted, as in

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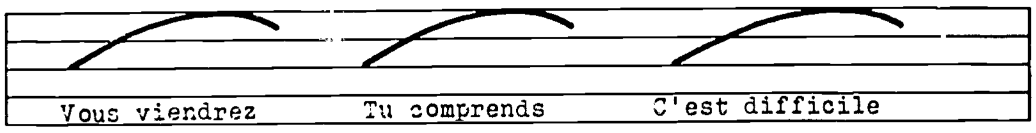

it takes on the meaning of a request for agreement, for consent, for confirmation. Such a request is often complemented by a n'est-ce-pas or an hein.

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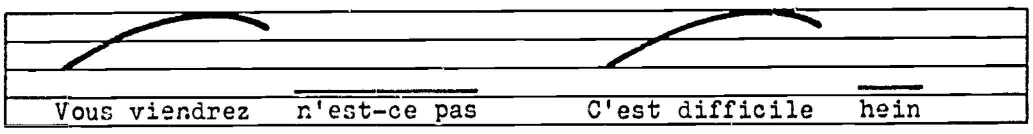

Dramatic authors usually put a question mark at the end of such requests for agreement. It serves to indicate that the sentence is not declarative, but it does not show whether the author meant a true ascending question or an implicative request for agreement. For example, in the first scene of Sartre's Huis Clos (No Exit) we find Garcin saying: "Vous n'êtes pas sans savoir ce qu'on raconte là-bas?" [sur la terre] (You are not without knowing what they say over there?) where the question mark is misleading since it is not a question meaning literally "Do you know it?" but a request for agreement meaning "Obviously, you must know it." Similarly a few lines farther, after Garcin has enumerated the names of the torture instruments he expects to be used in hell, the waiter answers: "Vous voulez rire?" Here also the question mark is misleading, for it is not a question asking "Would you like to laugh?" but a request for agreement, meaning "I can see that you are not serious." If one could make a rule that an affirmative syntactic structure followed by a question mark indicates a request for agreement, all would be well; but that is not the case -- a little farther down, on the same page, we find: "...ça ne vous dit rien?" where the question mark indicates a real question, meaning "doesn't that mean anything to you?"

B. Questions with redundancy

In theory, the appropriate curve of questions that are indicated by the syntax has the same rising shape, with an increasing slope, as questions without redundancy. In practice, however, when the intonation is redundant it is often omitted, or less marked, than in the following illustrations:

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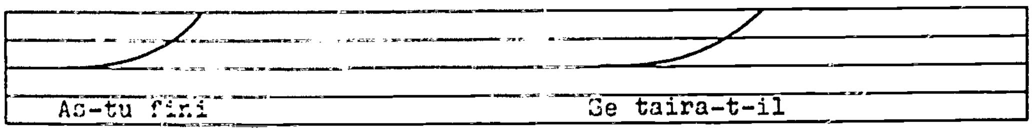
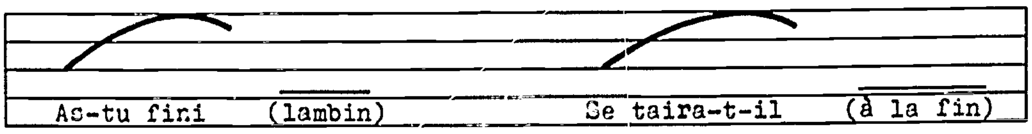


When an implication curve is substituted, the utterance expresses exasperation and no yes-or-no answer is expected:

27


Whether the use of an implication curve over a question produces a request for agreement or a mood of exasperation depends, therefore, on the syntax. In the following examples the implication in parenthesis emphasizes the contrast: *Tu es prêt* (*n'est-ce pas*)? *Es-tu prêt* (*à la fin*)? The fact that it is impossible to imply *n'est-ce pas* after *Es-tu prêt* makes it clear.

4. INTERROGATION > IMPLICATION

We call "interrogation" the falling question which generally begins with an interrogative word. The appropriate curve of interrogation is falling with a decreasing slope:

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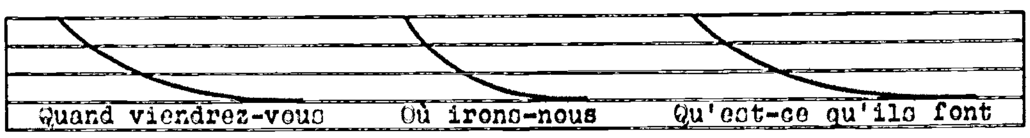

When the implication curve is substituted, a mild note of irritation, desperation, hopelessness is added:

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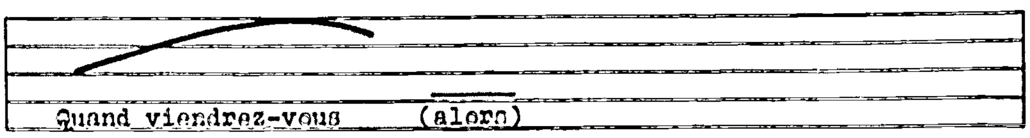

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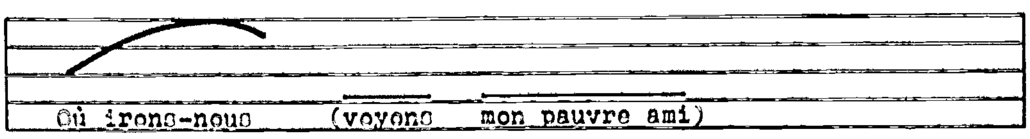

31


Naturally, the interrogative word with which such utterances must begin compells the meaning to remain that of an interrogation.

5. FINALITY > IMPLICATION

Here we shall need three sub-classes. In each one of them the curve which is appropriate to a declarative ending falls from low to very low with an increasing slope. The effect of the substitution of inappropriate curves depends on whether the sense-group of finality is isolated or not, and if not it depends on what follows and precedes in the structure of the whole sentence.

A. When a declarative utterance is followed by a reduplication, the falling curve of finality makes the statement sound cold, indifferent, literal, almost unnatural.

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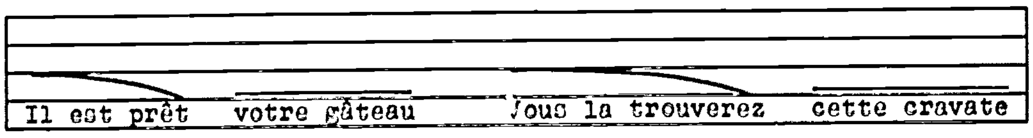

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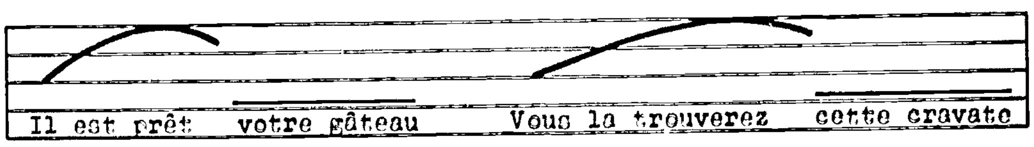
The substitution of an implication curve seems to make the statement more natural; implication goes well with reduplication, it prepares for it. In addition it expresses a gentle warning.

34


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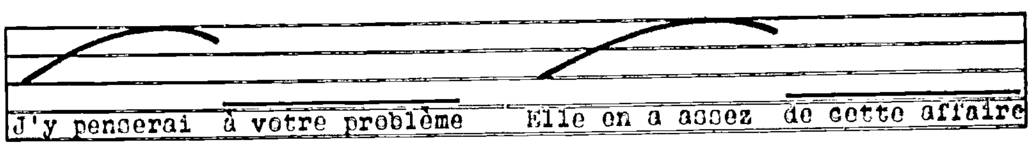

Perhaps in this case, it is the implication curve that is appropriate and the finality curve that is not.

B. A short isolated declaration normally uses the falling curve of finality. But in a dialogue, if the finality curve is used too many times in succession, the expression is flat, it is tasteless. When, on the other hand, implication curves are substituted, an undercurrent of tacit understanding is established between the speakers. To realize this, let us compare two different dictions of the same conversation between a brother and his sister.

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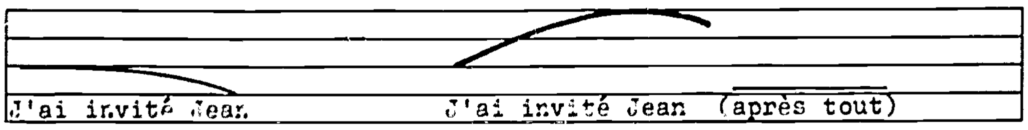

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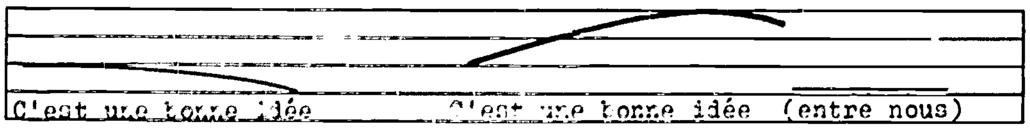

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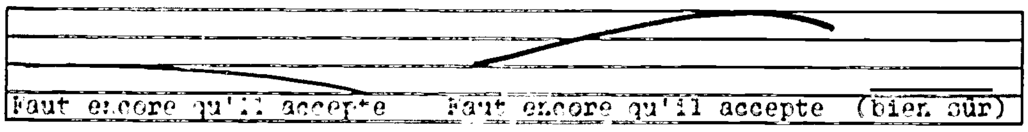

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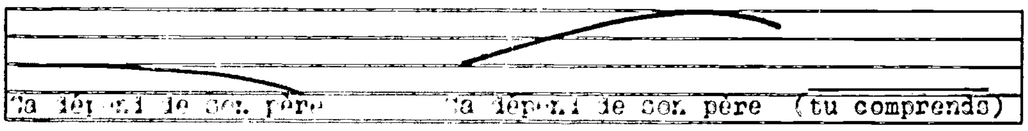

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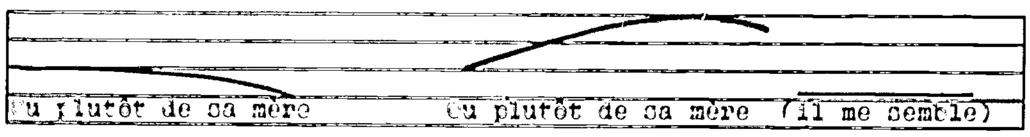

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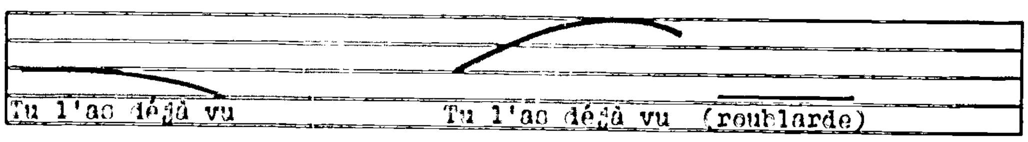

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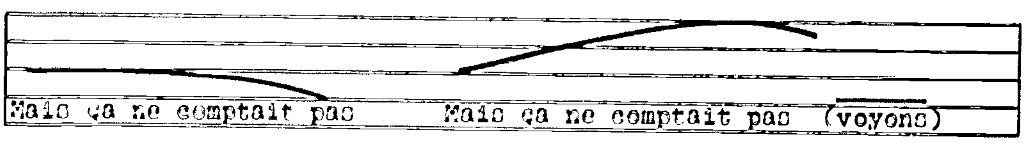
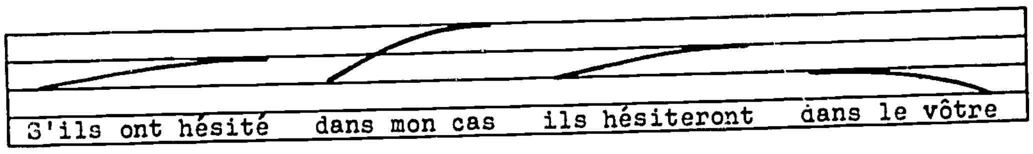


44


45


It is obvious that the curve of implication is more often suitable than that of declarative finality.

C. When, in the final group of a complex sentence, a finality curve is replaced by an implication curve, an expression of obviousness is added.

46


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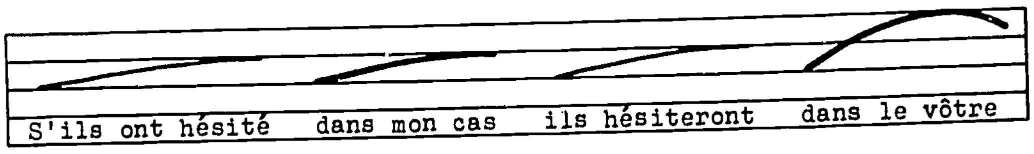
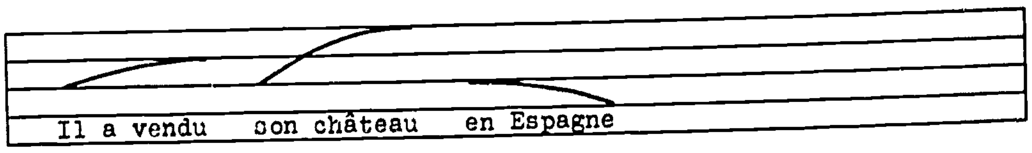
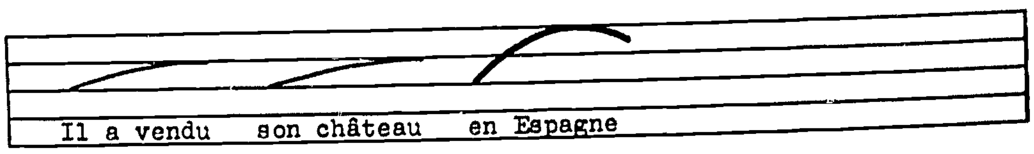


In addition, if the final statement of a complex sentence is preceded by major and minor continuations, the substitution of the finality curve by an implication curve conditions other transformations in the sentence according to the following rule: No major-continuation curve can appear before an implication curve in the same sentence. That is why, in a sentence like 46, the substitution of an implication curve in the last sense-group forces the additional substitution of a minor continuation curve in the second sense-group, as seen in 47.

In certain cases this rule may be the cause of ambiguity. In a sentence like the following one:

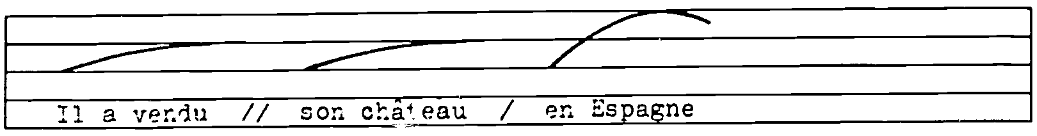
48


if the last group is said with an implication curve,

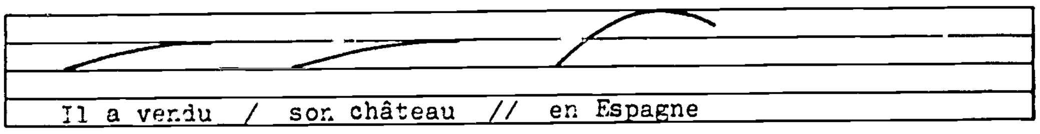
49


the second group is reduced from a major continuation to a minor continuation. Then the role of intonation in distinguishing whether the castle is in Spain or not is nullified, and that distinction is left to pauses alone.

50



51



The possibility of distinguishing lighthouse keeper from light housekeeper by the relative intervals of time between words as well as, or better than, by pitch and stress variations has been studied experimentally by Bolinger and Gerstman.[2] The results of their tests can perhaps be applied to French as well. When the immediate constituents of a sentence cannot be identified by means of pitch contours, the role of pauses is emphasized to compensate.

6. CONTINUATION > IMPLICATION

The appropriate curve of continuation shows a moderate rise (2-3) with decreasing slope when the continuation is minor or a substantial rise (2-4) with decreasing slope when the continuation is major. Minor and major continuations were illustrated in example 48 by:

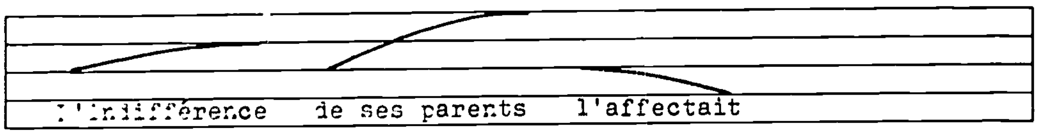
Il a vendu (2-3) son château (2-4) en Espagne (2-1).

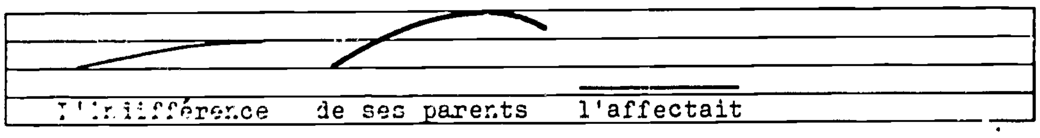
The fact that those two continuations contrast with each other is shown by crossed minimal pairs -- if we interchange the levels of the first two groups and say:

Il a vendu (2-4) son château (2-3) en Espagne (2-1).

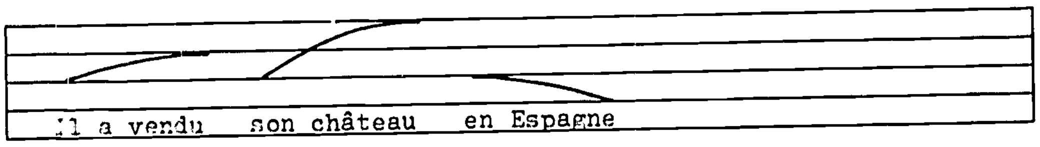
the meaning is changed; in the first example, the selling took place in Spain, in the second the castle was in Spain.

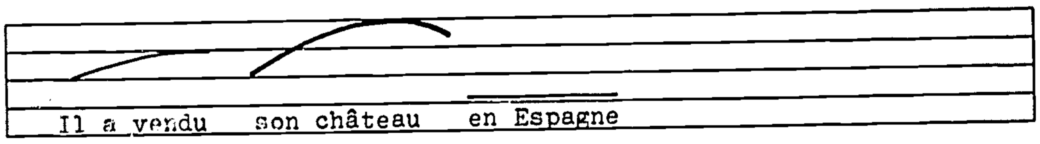
But here we need not distinguish major continuation from minor continuation. If we substitute a curve of implication for either one, it has the same effect -- it gives emphasis to the sense-group which is subjected to a pitch substitution. In addition, the following modification rule must be applied: any group which follows an implication group in the same sentence takes on a parenthesis curve. In sentences like 52 and 53, the center of gravity changes from the last group to the one before last.

52


53


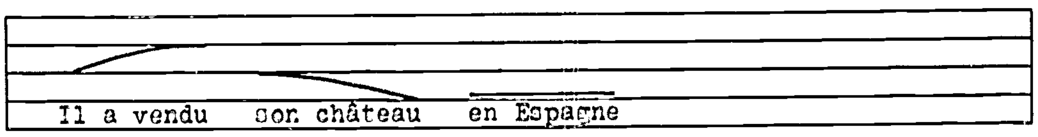
Here is an additional example of the structural modification necessitated by the substitution of an implication curve for a continuation curve; finality is transformed into parenthesis and the center of gravity moves back one step:

54


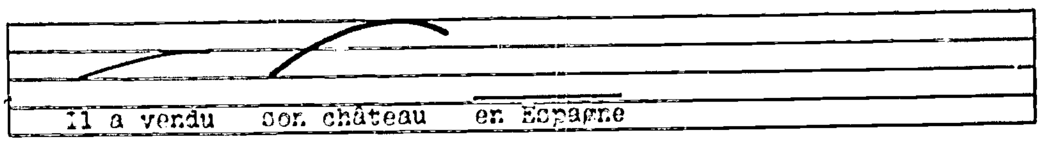
55


Both 54 and 55 show that the proprietor went to Spain and that while he was there he sold his castle (which could be in France). But 55 emphasizes that it is his castle (not his villa) which he sold while in Spain, a fact that 54 does not consider.

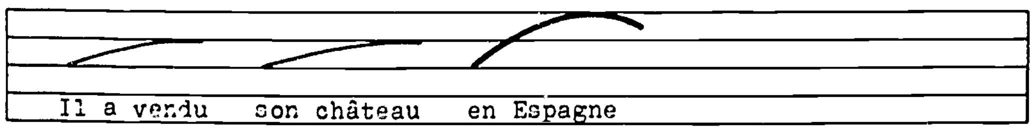
The emphatic function of an implication curve substituted for a continuation curve can further be brought to light by means of questions. To the question: <u>Qu'a-t-il fait en Espagne?</u> (What did he do in Spain?) the answer will be:

56


But to the question: <u>Qu'a-t-il vendu, en Espagne?</u> (What did he sell in Spain?) it will be:

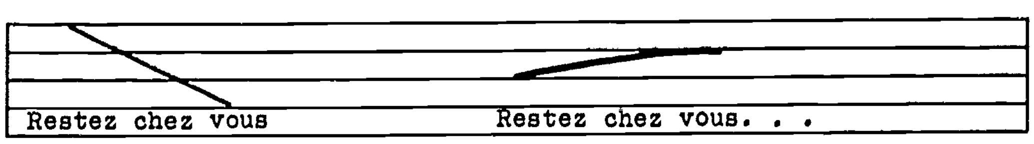
57


And to the question: <u>Où a-t-il vendu son château?</u> (Where did he sell his castle?) it will be:

58


7. REPEATING WITH A MINOR CONTINUATION

When we repeat what has just been said to us, whether it be a command, a statement, an interrogation, an exclamation, a question, or an implication, if we substitute for the curve we have heard the curve of a minor continuation, we express a strong feeling of objection, of resistance to what we have heard. Let us illustrate this effect by comparisons. In 59 to 64, what is heard is on the left, what is repeated while objecting is on the right.

59


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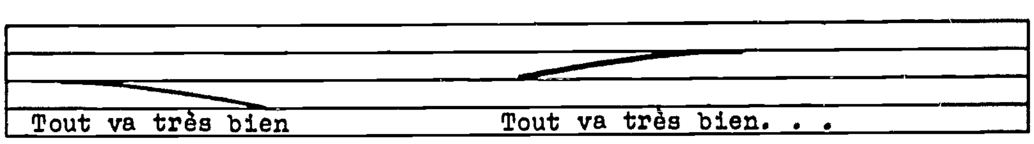
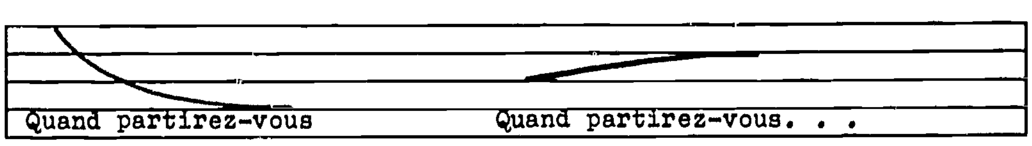


61


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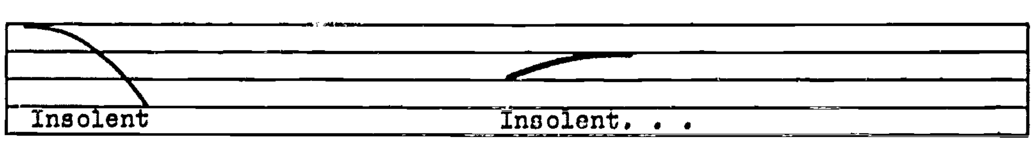
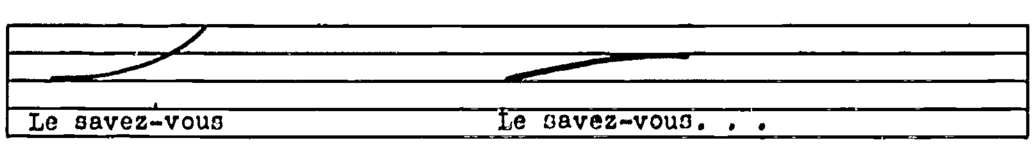


63


64

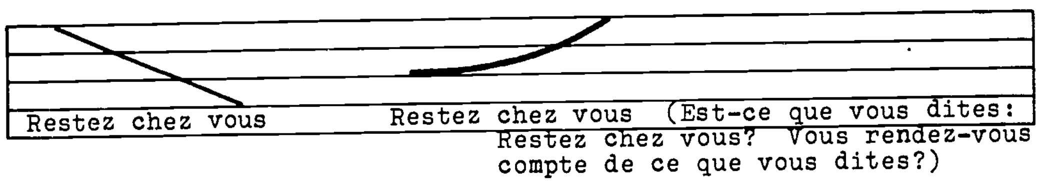

To each objection, one could add such reflections as:

That's easy to say. It's not so simple. What if you were in my place! C'est facile à dire. Ce n'est pas si simple que ça. Je voudrais vous y voir. If uttered aloud, these afterthoughts would require an intonation of implication.

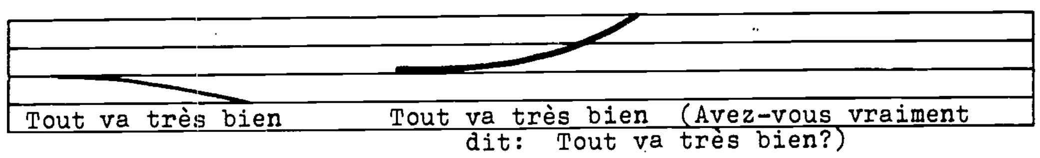
8. REPEATING WITH A QUESTION CURVE

When we repeat what has just been said to us, whether it be a command, a statement, an exclamation, an implication or an interrogation, if we substitute, for the curve we have heard, a question curve, we express a mixture of doubt and indignation. Comparisons will illustrate this. In 65 to 69, what is heard is on the left, and what is repeated with indignation is on the right.

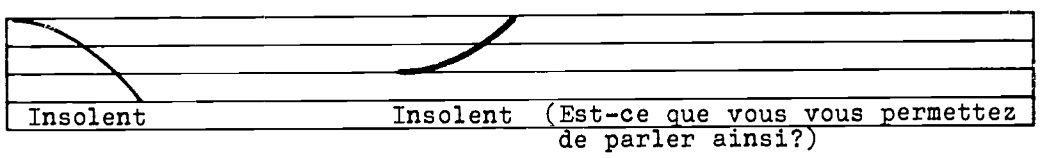
65



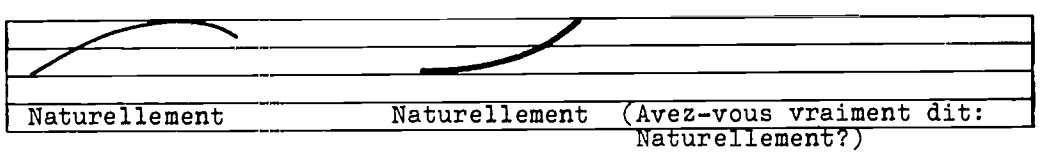
66



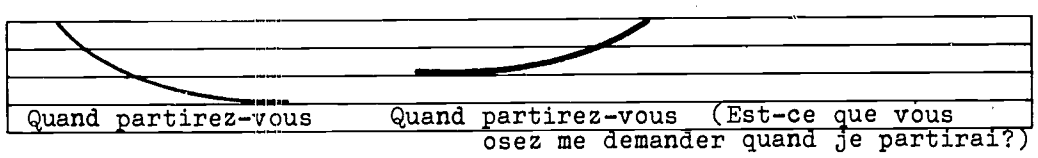
67



68



69



This last contrastive pair emphasizes the difference between the interrogation, which begins with an interrogative word and normally has a falling curve, and the question, which is to be answered by yes or no and normally has a rising curve with increasing slope. "Quand partirez-vous?" said with a question curve (2-4+) does not mean "When are you leaving?" but "Are you asking me when I expect to leave?"

CONCLUSION

An exploratory examination of the effects of inappropriateness in intonation, that is, the effects of covering a syntactic structure with a basic curve that is not the one most appropriate to this structure, has yielded a means of expressing a number of different attitudes: consideration, mystery, request for agreement, exasperation, hopelessness, warning, obviousness, tacit understanding, emphasis, objection, and indignation. The fact that all these attitudes can be expressed with a certain degree of predictability without forging a single new intonation curve besides the ten basic ones which agree with their syntactic structure suggests that the number of intonation curves is much smaller than the number of concepts, attitudes, or sentiments they can express or to whose expression they can contribute.

X X X

FOOTNOTES

[1]P. Delattre, "Les dix intonations de base du français," The French Review, XL, 1: 1-14, October 1966.

[2]D. L. Bolinger and L. J. Gerstman, "Disjuncture as a cue to constructs," Word, 13,2: 246-255, August 1957.

TWO NOTES ON SEMITIC LARYNGEALS IN EAST GURAGE

R. Hetzron

with a contribution by P. Delattre
on Arabic laryngeals

East Gurage is a Semitic dialect cluster spoken south of Addis Ababa, in the area west of the lake Zway and on the islands of this lake. It has two major divisions, Səlti, Wäläne, ʒnnäqor and Ulbarag on the one hand, and Zway (Laqi) on the other. The differences between the dialects of the first group are minor. Moreover, the relatively most divergent language, Zway, seems to differ from them in a number of details only. The East Gurage languages are closely related to Harari and with it they further belong to the Transversal South-Ethiopic group also comprising Amharic and Argobba. The other branch of South-Ethiopic is the Outer South-Ethiopic group, composed of Northern Gurage, Western Gurage and Gafat. The term "Gurage" is nothing but a mere common denomination of Semitic-speaking tribes on a Semitic "island" in a Cushitic area.

Relatively little has been done on these languages. W. Leslau has, in different articles, given us data on Səlti, Wäläne and Zway, and rarely Ulbarag. A. J. Drewes is working on Səlti. I have investigated Səlti, Wäläne and ʒnnäqor during my stay in Ethiopia in 1965-66.[1] The material of the first section of these notes is mainly based on Leslau's publications (acknowledged in due place) and the second section exclusively contains my ʒnnäqor material.

The following study is not an exhaustive and all-encompassing treatment of the fate of the Semitic laryngeals in East Gurage. It only deals with two peculiar phenomena that deserve special attention: the fate of word-initial ḥ and ʕ in East Gurage, and the occasional trace of ʕ and ʔ in the form of a glottal stop ʔ in certain environments in ʒnnäqor.

We must keep in mind that these languages or dialects are spoken in a Cushitic, East Sidamo area. The speakers are racially Cushites. The Semitic tongues were imposed on them by the cultural and military superiority of Semitic speakers, to a great extent Cushiticized themselves, that had come from the North in very early times. The East Gurage languages had most probably been territorially connected with Harari to the East, until the turmoils of the war in the 16th century that upset entire Ethiopia. Since then, they have been disconnected from their closest genetic relative, Harari. They have found themselves isolated in the area where representatives of the other branch of South-Ethiopic: Northern and Western Gurages were dominating.

1. Traces of ḥ and ʕ in East Gurage

1.1 In South-Ethiopic languages, we sometimes find non-etymological n's in certain words, at the end of an initial syllable. Such examples are -- in Amharic and "one" [from *(a)had], ənčät "wood" (old root *ʕs), ənqəfat "obstacle" (old root *ʕqf), Western Gurage änq'äfä "he embraced" (old root *ḥqf), anq'ä "after" (from *ḥaq(w)), etc., and plenty of examples from East Gurage (see later). The insertion of the n in these words was mentioned by Leslau in his "The expressions of 'under, after' in the Ethiopic languages," on p. 242, fn. 3. It was later explained by him as a Sidamo influence in "Sidamo features in the South Ethiopic phonology," on pp. 3-4 (5th Insertion of n). He gives a number of examples of Eastern Sidamo, confronting dialects that have added an n in places where other dialects have nothing. He makes a reservation himself (fn. 19) "Since I do not know the Cushitic etymologies of certain roots it is quite possible that in some roots n is original and was eliminated elsewhere ... ." In his Etymological Dictionary of Harari (abbreviated henceforth EDH), he speaks of "an inserted n indicating most probably the nasalization of the following consonant ..." (p. 6).

I think that neither a Sidamo influence nor the vague statement about the "nasalization of the following consonant" can provide a satisfactory explanation for the emergence of this non-etymological n. The crucial point is why this n was inserted in the given place and not elsewhere. In other words, one must look for the conditioning of the apparition of this n, to see whether it is limited to a certain context or not.

We find that, except in a very few cases, this n occurs in a context where there had been *LVC-, i.e. initial laryngeal ḥ or ʕ (L_1), (but not x or ɣ,) followed by a vowel that is, in its turn, followed by another consonant (as we shall see later, other than m, n, r and l). In this context, the laryngeal is reduced to ḥ → h and ʕ → ʔ ($L_1 \rightarrow L_2$), and an n appears between the vowel and the subsequent consonant, namely

$$\#L_1VC \rightarrow \#L_2VnC.$$

Thus, it seems obvious that the apparition of this n is somehow connected with the reduction of the laryngeals. On the other hand, the inserted element is in reality not an n, but a homorganic nasal, thus m before the labials b and f. This suggests that there must be a relation between the laryngeals ḥ and ʕ and nasality.

When I came to this conclusion, I remembered that Arabic ḥ and ʕ had sounded to me somehow nasal, and, the similar phonemes of Somali, spoken near the East Gurage area, probably even more. However, my stating nasality on the laryngeals ḥ and ʕ was only impressionistic.

1.2. Arabic laryngeals. Therefore, I asked the leading authority on phonetics, Professor P. Delattre, whether this impression of mine can be substantiated by a more concrete approach to the articulation of these phonemes in Arabic. He very kindly showed me his X-ray films of the articulation of different laryngeals in Arabic and subsequently put to my disposal the following text and figure. I take this opportunity to express my gratitude to him for devoting so much of his precious time to my problem.

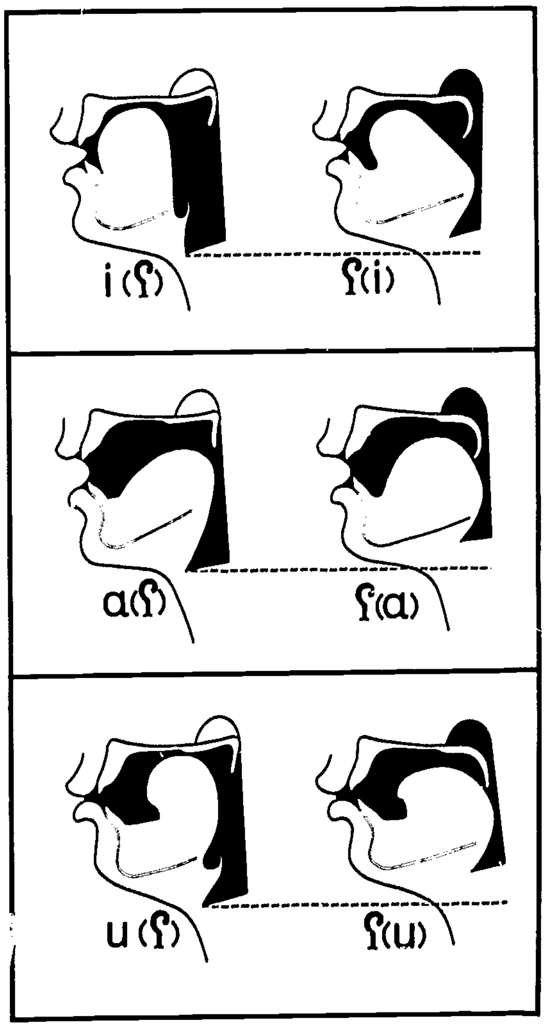
Professor Delattre's Statement[2]

"In order to see whether a physiological explanation could be found for the fact that vowels nasalized after /ʕ/ and /ḥ/ but not after /γ/ and /x/, we used the X-ray facilities of the Speech Synthesis Project, which is supported by the Office of Education for the phonetic comparison of languages. There, we made motion-picture X-rays of all the Arabic laryngeals in intervocalic position between /i/, /a/ and /u/ vowels, using a native of Iraq as a subject to pronounce the appropriate syllables before the X-ray camera. Once the film was developed, we studied it in motion as well as frame by frame. We found that for /ʕ/ and /ḥ/, three articulatory motions occurred, regardless of the vowel that preceded or followed. In other words, all the /ʕ/ and /ḥ/ articulations had clearly three motions in common: (a) the root of the tongue backed very sharply toward the lower part of the pharyngeal wall; (b) the larynx rose considerably (by about 8 mm after /i/, 13 mm after /a/ and 15 mm after /u/); (c) the uvula (the end of the soft palate) lowered far down along the root of the tongue and curled up its tip as if to vibrate.[3]

We can only speculate about the reason for this lowering of the uvula. We know from having observed motion-picture X-rays of French /R/, that when a pharyngeal constriction occurs, the uvula tends to lower its tip

FIGURE LEGEND

Figure 1. Selected frames, from a motion picture X-ray, showing the modification of the tongue shape for the articulatory movement from Arabic /i/ to /ʕ/ in the top row, /ɑ/ to /ʕ/ in the middle row, and /u/ to /ʕ/ in the bottom row. The features that distinguish each /ʕ/ from the preceding vowel are: (a) a narrow constriction between the root of the tongue and the lower laryngeal wall, (b) a marked rise of the larynx (seen here at the level of the glottis), and (c) a marked lowering of the velum extremity along the tongue root. This uvular lowering is so extended that it forces an opening of the velic passage and produces the nasalization of the preceding vowel. The X-rayed speaker was a native of Iraq.


i (ʕ)
ʕ(i)
a(ʕ)
ʕ(a)
u (ʕ)
ʕ(u)

to a point of the tongue just above that constriction. The constriction for French /R/ is high along the pharyngeal wall, therefore the tip of the uvula has no difficulty reaching the tongue without causing the velic passage to open.

In the articulation of /ʕ/, it appears that the uvula lowers its tip in an effort to reach, along the tongue root, the place which is most favorable to vibrating, that is, the place just above the constriction. But since the radico-pharyngeal constriction of /ʕ/ is very low, the uvula tip must reach very low. In so doing, the uvula forces the velum to leave the rhino-pharyngeal wall and creates a velic opening such as the one found in the nasal vowels of a language like French.

If this sort of velic opening does not occur in the case of Arabic /γ/, it is presumably because the pharyngeal constriction is high (as in French /R/), and the uvula can reach the tongue, just above the constriction, without causing the velum to leave the rhino-pharyngeal wall, that is, without opening the nasal passage.

Figure 1 gives tracings of the X-ray frames that are closest to the initial /i/, /a/ and /u/, and to the /ʕ/ phonemes which occurred immediately after the vowels (about two or three frames after). After each vowel, the /ʕ/ shows the three features mentioned earlier in the description of the articulatory movements: (a) a low linguo-pharyngeal constriction; (b) a high position of the larynx; (c) a lowered velum which allows the rhino-pharyngeal cavity to resonate together with the pharyngeal and mouth cavities."

1.3. South-Ethiopic. The above description by Professor Delattre has shown that the articulation of the laryngeals ḥ and ʕ has indeed something in common with nasality. We can thus surmise that when the Cushites learned the imported Semitic tongues, they tried to pronounce these laryngeals, the articulation of which was alien to their speech-habits, at their best. Then, on the basis of the acoustic impression described above for Arabic, they reinterpreted these phonemes as nasalized h and ʔ, and transferred the nasality to the subsequent vowel. This vowel further decomposed into "vowel + nasal consonant". Thus,

$$\#\underline{h}/ʕ + V + C \rightarrow \#\underline{h}/ʔ + \tilde{V} + C \rightarrow \#\underline{h}/ʔ + V + \underline{n} + C$$

In the word for "bird", exceptionally, the nasal vowel (the intermediary stage) was maintained: East Gurage ũf, Central Western Gurage ãf^{w}, Peripheral Western Gurage ããf^{w} from *ʕof.

The above change occurred in word-initial positions only (see however 1.8). This type of reaction to Arabic ḥ displayed by Cushitic was recorded by Leslau in JAOS, vol. 79,

p. 4, Alaba and Gudella (Eastern Sidamo) hanqa from Arabic haqq "truth" (also in Western Gurage anq), and other examples in his EDH. The examples in Amharic, Argobba, Harari and Western Gurage are scarce and by no means regular. This type of trace of an older ḥ and ʕ is limited to a small number of words and is absent from most words that had had these initial laryngeals. I could not find any regular conditioning of the apparition of this nasal element in these languages. On the other hand, in East Gurage the nasals have appeared quite regularly, with relatively few exceptions. Therefore, we shall devote the rest of this section to East Gurage only.

Since the description of Professor Delattre referred to Arabic, there is no absolute certainty whether the articulation of Proto-Ethiopic ḥ and ʕ was identical with that of the Arabic phonemes. All the same, there is no real reason to doubt it. Phonetically, there are no really different possibilities of articulation for these laryngeals. On the other hand, modern North-Ethiopic languages of the same language family, as well as Somali of the same area, testify to the existence of an Arabic-like articulation of the said laryngeals. A description of the Somali laryngeals can be found in the study of Armstrong, "The phonetic structure of Somali"[4]. A sound [ḥ] is also attested in Harari, representing the merger of the Proto-Ethiopic phonemes /x/, /ḥ/ and /h/. And, at last but not at least, the existence of the nasality in modern East Gurage also constitutes a proof of the old nasal-like articulation of these laryngeals.

The following examples were mainly taken from Leslau's EDH, except for the entries "to see", "to take", "to close" and "to be sick" that come from my collection. Numbers after the examples refer to pages in EDH. The languages mentioned are Səlṭi (abbreviated S), Wäläne (W), Zway (Z) and occasionally Ḥarari (H). Ǝnnäqor (E) examples are all mine. The abbreviation C means Cushitic (Eastern Sidamo) languages spoken in the area. The old root, if reconstructible, will be marked by an asterisk. First we shall enumerate the cases that create no problems. Afterwards, problematic cases will be dealt with.

1.4. Occurrences of the nasal. The hormorganic nasal appears in the following cases.

(a) as a trace of *ʕ.
"bird", *ʕwf, S.W.Z. ũf, also in Western Gurage ãf^w/ãã f^w.
"pea", *ʕtr, Z. antärä (unattested for other East Gurage tongues).
"wood", *ʕṣ, S. hinṭ, W. ənče, Z. ənṭeṭ. The n appears in other Ethiopian languages too, even in North-Ethiopic,

Təgrəɲɲa Ϛənsäyti, and in South-Ethiopic, Amharic ənčät, Argobba ənčed, H. inči, Gafat and Soddo ənčä, but not in Western Gurage: äčä.

(b) as a trace of *h.

"to adze", *hkl, Z. ĩnkälä.

"after", *hqw, Z. anči, also in Western Gurage anq'ä/ĩʔĩ.

"to carry on the back", *hzl, Z. anzälä.

"to chew", *hyk, S. enke, W. enkä, Z. ĩnkä. The relation with Amharic aññäkä given by Leslau (EDH 81) would require further clarifications.

"to close", S.W. wänte, E. honte. I do not know the etymology of this verb. The root seems to have been *hwt (where t may represent an older t, s, or d). Its connection with the Gəʿəz root *Ϛsw is not excluded. Ʒnnäqor indicates an initial h, although one cannot rely on an Ʒnnäqor h (see 1.7. f, "bone").

"embrace", *hqf, S.W. enqäfä, Ʒ. hanqäfä, Z. anqäfä. The nasal also appears in Northern and Western Gurage: anq'äfä-/änqäfä-/enqäfä-, etc. Leslau (EDH 80) also mentions the borrowing of this Semitic root in C: hanqáffo/hanqafi.

"fence, to make a", *hṣr, S.W. entärä, Ʒ. hentärä, Z. intärä.

"to gather with hands", *hfs, S.W.Z. amfäsä, borrowed by C. hamfašš̌o.

"scratch", *hkk, S.W.Z. ankäkä.

"see", *hzy, S. anži, W. anže, Ʒ. hanže.

"sick, to be", *hqy, E. hanče.

"snake", *hbb, S. imbab, W.Z. əmbab.

"to stroke", *hss/hsy, S. onše, W. anše, Z. anšĩ. Both roots are attested in Təgrəɲɲa, see Leslau EDH 88.

1.5. Other cases with the nasal. We have a few occurrences of the nasal that is not justified by a reconstructible h or Ϛ.

"finger", *(ʔ)sbϚ, S.W.E.Z. əntabit. The initial ʔ usually is not regarded as a radical, however it occurs everywhere in Semitic. To explain the n in East Gurage, we must posit an assimilation ʔ → Ϛ, thus ʔsbϚ → ϚsbϚ.

"foot", *ʔgr, S.W.E.Z. əngər, H. igir or ingir, Argobba ingir. The root ʔgr is attested in Gəʿəz. The n is inexplicable in the context.

"hand", *ʔd, S.W. əndʒ̆, E. əndʒe, Z. əndʒi, also Argobba əndʒ. I have no explanation for the n.

"viper", S. ənfəñña, W. umfäññet, Z. ũmfiññi. The Semitic etymology *ʔfϚ (Leslau EDH 80) is farfetched and does not explain the Harari form *hiffiñ*. Whatever the etymology is, the East Gurage form seems to have come from something similar to the Harari form, with an initial *ḥ*.

1.6. *Original x*. We know that in modern North-Ethiopic the old phonemes */ḥ/ and */x/ merged into /ḥ/, e.g. Təgrəñña *hasärä* both for *ḥsr* "to make a fence" and *xsr* "to be short" of Gəʿəz. The evidence of the following examples shows that in Proto-East Gurage a similar merger must have taken place.

"short", **xsr*, adjective: S.W.Z. *ančər*, E. *hančər*,
verb "to be short"; S.W.Z. *antärä*, E. *hantärä*.
"to spend the night", **xdr*, S.W.Z. *andärä*, E. *handärä*.

If we attribute the emergence of the nasal to the phonetic character of *h* that is not valid for *x* (see Delattre in 1.2. above), we must posit that the above forms come from intermediary roots **hsr* and *hdr* respectively.

One verb, "to take", has an original root **ʔxz*. In Amharic, it became *yazä* that suggests an intermediary **yhz*. The East Gurage forms contain the *n* that is usually a trace of an initial *h*. Therefore, a further intermediary **hyz* (*hezä*) may be posited for Proto-East Gurage, although the initial *y-* of Wäläne speaks against it. The forms are S. *enzä*, W. *yenze*, E. *enze*.

1.7. *Absence of n*. There are cases where the expected *n* is absent. First of all, no *n* appears when the second radical is *m*, *n*, *r*, *l*, or a semivowel.

(a) Mid radical *m*.
"ashes", **ḥmd*, S.W.Z. *amäd*.
"cabbage", **ḥml*, S.W.Z. *aməl*.
"five", **xms*, S.W.Z. *amməst*.
"to slander", **ḥmy*, S. *ema*, W. *emä*, Z. *ĩmä*.

(b) Mid radical *n*.
"to strangle", **xnq*, S.W.Z. *anäqä*, E. *hanäqä*.

(c) Mid radical *r*.
"to be naked", **ʕrz*, Z. *t-aräzä*, and S. *iraz*, W.Z. *əraz*, "hide of an animal serving to cover nakedness" (Leslau 32).
"to plough", **ḥrs*, S.W.Z. *aräsä*.

(d) Mid radical *l*.
"to count", **xlq/xʷlqʷ*, S.W. *eläqä*, Ulbarag *heläqä*, Z. *ĩläqä*.

"to milk", *hlb, S.W.Z. aläbä; "milk", S.W.Z. ay(ə)b.
"to pass", *xlf, S.W.Z. aläfä.

(e) Mid radical: semivowel.
"to say", *ʕwd, S.W. ewädä, Z. īdä.
"eye", *ʕyn, S.W.Z. in.

(f) Inexplicable absence of n.
"to abandon", *xdg, S.W.Z. adägä, E. hadägä.
"bone", *ʕsm, S.W.Z. atəm, E. hatəm (h for old *ʕ!).
"new", *hdš, S.W. adʒiš.
"to swell", *hbt, S.W.Z. abätä.
"ten", *ʕsr, S.W.Z. assər.
"to think", *hsb, S.W. esäbä (Leslau), assäbä (my collection). The latter form may be an Amharism.
"to wash", *xḍb, S.W. aṭäbä, W. haṭäbä.

(g) Etymologies to be revised.
"soil, earth", the East Gurage form, as well as everywhere else in Ethiopian, is afär. Leslau (EDH 20) connects it with the root ʕfr of Semitic, and considers Gəʽəz ʔafär as an Amharic loanword. Here, the absence of n suggests that the root ʔfr of Gəʽəz is original, and the root is to be compared with Hebrew ʔeֽfer "ashes".
"to tie, bind", East Gurage agädä. Gəʽəz and Hebrew have ʕqd that for some reason has been considered as the etymology of this verb, with assimilation of q to g (voiced). However, the etymology suggested by Littmann and rejected by Leslau (EDH 21), namely Hebrew ʔgd seems to be more plausible. The absence of the n in East Gurage would favorize the ides of ʔgd.

All the same, we cannot definitely accept the absence of n as a decisive argument in the matter of etymology in view of the roots in f above, where no conditioning for the absence of n could be found. These two roots may also belong there.

1.8. Solidarity of the root. It has been stated that n appeared after decadent INITIAL h and ʕ yielding h and ʔ respectively. There are some reservations concerning the verb "to take" (1.6.) where the h (from x) could have been preceded by a semivowel y-.

Furthermore, when a verb acquired the n in its Perfect forms where the first radical is word-initial, it also extended it to the whole conjugation, including Imperfect and Jussive, where prefixes had made the laryngeal non-initial. Thus, from andärä "he spent the night", we obtain Sg. 3m. Imperfect yandər-, Jussive yindär (Sg.3f. tandər-/tindär), from anqäfä "he embraced", Imperfect yanqəf-, Jussive yinqäf, etc. This is also true for the derived stems -- in spite of the derivative prefixes, there is n, e.g. atendärä/yatendər-/yatindər, the three main forms of "to give hospitality", a factitive from andärä; W. tinzazu "they held each other", a reduplicative reciprocal form with the passive preformant t- from yenze "to take", etc. In these cases, the n had been acquired after a word-initial laryngeal, and then extended to the whole tense- and derivational system of the same root. Genuine non-initial laryngeals left no such trace in East Gurage.

2. The Glottal Stop in Ǝnnäqor

In Addis Ababa, I had been looking for a Mäsqan-speaker for a long time. Finally, I found a 20 year old man Šamil Bäyyan, who claimed to be a Mäsqan. A very short investigation showed that he spoke an East Gurage dialect, very closely related to Səlti. Leslau had classified Mäsqan as Western Gurage, and a later trip of mine to Mäsqan country (Buttajira area) enabled me to confirm it. My "Mäsqan" was genuinely convinced that he spoke the same language as the inhabitants of the Buttajira area -- which was not true. He did not claim, however, that he was from that area himself, but named Ǝnnäqor as his country of origin. This convinced me to identify his language with what had already been mentioned as Ǝnnäqor. This was probably a case where tribal boundaries did not coincide with linguistic ones.

My first encounter with the phoneme /ʔ/ in this dialect, unattested in Səlti and Wäläne, was in the adjective fäyʔa "good" (fäyya elsewhere, probably of Cushitic origin). Further investigation demonstrated that /ʔ/ in Semitic words is a trace of the old phonemes */ʕ/ and /ʔ/ in certain contexts. There is a comparable phenomenon in Peripheral Western Gurage[6], but it had not yet been attested in East Gurage. Here are the cases where there exists a /ʔ/ representing an older */ʕ/ or */ʔ/, and corresponding to zero in other East Gurage dialects. Most of the examples are verbs. I shall give the Sg. 3m. forms of Perfect/ Main Imperfect/Jussive. Old roots will be marked by an asterisk.

The glottal stop representing an older */ʕ/ or */ʔ/ has survived in contact with the consonants m, ñ, l and r, both preceding and following them. These are verbs the second radical of which had been /ʕ/ or /ʔ/ and the third one was or has become one of the four consonants mentioned, or vice versa, with second radicals /m/, /ñ/, /l/ or /r/ and last radical /ʔ/.

(A) In contact with m.
"to hear, listen, understand", *smʕ, säm'ä/yəsäm'an/yäsm'a.
"to kiss", *sʕm, sa'mä/yəsi'man/yäsa'm.

(B) In contact with ñ.
"to sleep", eñ'ä/yə'ñan/yi'ñ. Notice the displacement of the glottal stop. This verb has been connected with the Semitic root *nwm. The presence of the glottal stop in Ʒnnäqor invalidates this etymology. In Western Gurage, Ʒnnämor has ne'ä for "to sleep" and Čäha nəyä-m. The root seems to be *nyʔ or *nyʕ. Amharic has tä-ña.

(C) In contact with l.
"to ask", *sʔl, with passive preformant tä-, täsa'lä/yətsa'lan/yätsa'l.
"to covet", hel'ä/yel'an/yil'a. This verb is also attested in Western Gurage, Ʒnnämor has ell'a. The origin of the root is unknown.
"to eat", *blʕ, bäl'ä/yəbäl'an/yäbl'ä.
"to be plenty, full", *melʔ, mel'ä/yəmel'an/yäml'ä.
"to spend the day", *wʕl, wa'lä/yəwi'lan/yäwa'l.

(D) In contact with r.
"to boil, cook", dʒe'rä/yədʒe'ran/yädʒi'r, probably Cushitic.
"peace, to make", her'a/yer'a/yir'a. Probably Cushitic *hrʔ. Its factitive is "to pacify" ater'ä/yater'an/yatir'a, and the passive "to be pacified" ter'ä/yəter'an/yätir'a.
"to remove, dismiss", *sʕr, ša'rä/yəši'ran/yäša'r.
"to show", *rʔy, ater'ä/yater'an/yatirʔ. Factitive of the Semitic root *rʔy that has survived in the factitive form only.
"to slaughter", gor'ä/yəgor'an/yägur'a. Origin unknown, apparently *gʷrʔ.
"to sow", *zrʔ, zär'ä/yəzär'an/yäzr'a. In Semitic, the root is zrʕ, but Gəʿəz already has zrʔ.

(E) In the adjective "good", there is a glottal stop fäy'a.

(F) A special case. The verb for "to be fat" has a glottal stop: mig'äre/yəmeg'äran/yämg'är. Origin unknown. This is the only cluster of g and ʔ so far found.

Summary

"The radico-pharyngeal constriction of the Arabic laryngeals /ʕ/ and /ḥ/ is so low that the uvula tip must reach very low to reach the place which is most favorable for vibrating -- just above the constriction. In so doing, the uvula forces the velum to leave the rhino-pharyngeal wall and creates a velic opening such as the one found in nasal vowels" (P. Delattre). This creates a nasal impression in these laryngeals. Proto-East Gurage must have had similar laryngeals /ʕ/ and /ḥ/ (the latter representing the merger of older */ḥ/ and */ẋ/) that must have been interpreted by Sidamo-speakers (the substratum of East Gurage) as nasalized ʔ̰ and ḫ. In initial positions, the following change took place:

#ʕ/ḫ+V+C...→#ʔ/ḫ+Ṽ+C...→#ʔ/ḫ+V+n̰+C...

In ʒnnäqor, the old phonemes */ʕ/ and */ʔ/ have survived in the form of a glottal stop if they came in contact with one of the following phonemes: /m/, /ñ/, /l/ or /r/.

x x x

FOOTNOTES

[1]Jointly sponsored by the Near Eastern Center and the African Studies Center of the University of California, Los Angeles. I am indebted to them for this interesting and fruitful stay in Ethiopia.

[2]The research reported herein is partly related to a contract with the United States Office of Education, Department of Health, Education and Welfare.

[3]However, no vibrating motion could be seen on the X-ray in motion, because it was taken at 24 frames per second. It would take about ten times that speed to record vibrations in such a way that they would appear on the film.

[4]See 1, esp. on pp. 129-130.

[5]dʒ corresponds to g with ᵛ in traditional Ethiopian linguistics.

[6]See Wolf Leslau, "Traces of the laryngeals in the Ethiopic dialect of Ennemor".

December 31, 1969

With this final report, which includes six completed studies, the Office of Education will receive, according to contract, five copies of each one of the publications which have appeared in print in the course of the past contract-year as a result of research done under previous NDEA contracts. The titles of these publications follow:

"The role of duration in the identification of French nasal vowels" (with Michel Monnot), IRAL, VI/3: 267-288, 1968.

"From acoustic cues to distinctive features," Phonetica, 18: 197-230, 1968.

"La radiographie des voyelles françaises et sa correlation acoustique," The French Review, XLII,1: 48-65, 1968.

"A dialect study of American R's by X-ray motion picture" (with Donald C. Freeman), Linguistics, 44: 29-68, 1968.

"Duration as a cue to the tense/lax distinction in German unstressed vowels" (with Margaret Hohenberg), IRAL, VI/4: 367-390, 1968.

"Syntax and intonation: a study in disagreement," Study of Sounds, XIV: 21-40, 1969.

"Syllabic features and phonic impression in English, German, French and Spanish" (with Carroll Olsen), Lingua, 22/2,3: 160-175, 1969.

"L'intonation par les oppositions," Le Français dans le Monde, 64: 6-13, 1969.

"L'/R/ parisien et autres sons du pharynx," The French Review, XLIII,1: 5-22, 1969.

"Two notes on semitic laryngeals in East Gurage" (by Robert Hetzron, with statement by Pierre Delattre), Phonetica, 19: 69-81, 1969.

The six studies included in this final report present the research that has been completed in each one of the six categories of our 1968-1969 objectives.