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Prosodic characteristics of English, German, Spanish, and French are compared and contrasted in this second of a series of articles on general phonetic characteristics of American English. Major attention is given to declarative intonation, place of logical stress in the word and sense group, nature of logical stress, variations in syllable weight, and internal juncture and syllabication. Nondeclarative intonation and the place and nature of emphatic stress are also discussed. For related documents see FL 000 781 and FL 000 784. (AF)

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COMPARING THE PROSODIC FEATURES OF ENGLISH, GERMAN, SPANISH AND FRENCH

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COMPARING THE PROSODIC FEATURES OF ENGLISH, GERMAN, SPANISH AND FRENCH [1])

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Cet article – le deuxième d'une série consacrée à la description comparée des caractéristiques phonétiques de l'anglais (américain), de l'allemand, du français et de l'espagnol – porte sur l'intonation, l'accentuation et les phénomènes démarcatifs. *Intonation:* l'étude de l'intonation, qui a été effectuée à l'aide d'un spectrographe (spécialement modifié à cet effet), a permis de degager les courbes d'intonation caractéristiques de chacune des langues considerées. À l'aide d'un synthétiseur et en pratiquant des omissions et des variations systématiques, on a pu ensuite déterminer les portions ou les caractéristiques pertinentes d'une courbe donnée. Les résultats obtenus pour chacune des langues sont comparés, ce qui permet une prévision des phénomènes d'interference. *Accentuation:* La distribution d'accent parmi les syllabes des mots et des phrases dans les différentes langues est examinée statistiquement. Ensuite le rôle respectif des facteurs – tels que l'intensité et la durée – qui dans chacune des langues contribuent à donner à une syllabe un relief particulier est etudié. Enfin, pour les quatre langues, les phénomènes démarcatifs ("jointures") et les modes de transition d'une syllabe à une autre sont dégagés et comparés.

Der Aufsatz ist der zweite in einer Reihe von Artikeln, in denen die allgemeinen *phonetischen* Eigenschaften des amerikanischen Englisch mit denen des Deutschen, Spanischen und Französischen verglichen werden, den drei in Amerika am häufigsten gelehrten Sprachen. Dabei wird vorausgesetzt, daß der amerikanische Deutsch-, Spanisch- und Französischlehrer – dem diese Untersuchungen vornehmlich dienen sollen – mit den phonemischen Systemen dieser drei Sprachen vertraut ist, daß er aber mehr von ihren phonetischen Merkmalen wissen muß, um seinen Unterricht wirkungsvoller gestalten zu können.

Der erste Artikel behandelte ausführlich die Forschungstechnik, die in vier Abschnitten dargestellt wurde: spektrografische Analyse, spektrografische Synthese, radiografische Beobachtung (Kontrolle) und statistischer Überblick.

Der Beitrag behandelt die Prosodie unter dem Gesichtspunkt der unteilbaren Einheiten. Die späteren Artikel werden dann vergleichend auf die teilbaren Merkmale der vier Sprachen eingehen. Da die Forschungsarbeit noch im Gange ist, können die hier gebotenen Abhandlungen nur Teilergebnisse sein, doch geht Vf. auch auf die weitere Entwicklung ein.

Vf. untersucht die Prosodie in folgenden Teilabschnitten:

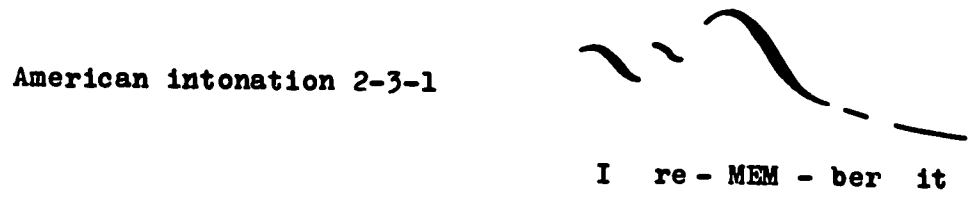
1. Intonation der Aussage, 2. Intonation der Nichtaussage, 3. Der logische Akzent im Wort, 4. Der logische Akzent in der Sinngruppe, 5. Das Wesen des logischen Akzents, 6. Das Vorkommen des emphatischen Akzents, 7. Das Wesen des Akzents, 8. Veränderungen im Silbengewicht, 9. Verbindung und Silbenbildung.

[1]) The research reported herein was performed pursuant to a contract with the United States Office of Education, Department of Health, Education and Welfare.

I. DECLARATIVE INTONATION

The use of pitch levels, or pitch phonemes, often indicated by digits *(Es regnet:* 2–3–1; *It's raining:* 2–3–1) has been found quite insufficient in teaching the intonation of a second language. Only a native of the language can interpret the digits correctly. The learner of a second language needs much more information than mere levels if he is not to impose his own pitch shapes on each syllable. For instance, our pitch research by spectrographic enlargement shows that, in attempting to say *I remember it* with a 2–3–1 intonation, a Spaniard will convert the 3 into a sharp rise because his habit is to fall only after a high unstressed syllable; a Frenchman into a rise followed by a high plateau; a German into an S-shaped rise starting with a slight dip. None of them will produce the „reversed-S" *falling* intonation which is so characteristic of American English. (See Figure 1.)

Figure 1. Examples of intonation interference: realization of 2–3–1 pitch levels by natives of Spain, France and Germany.



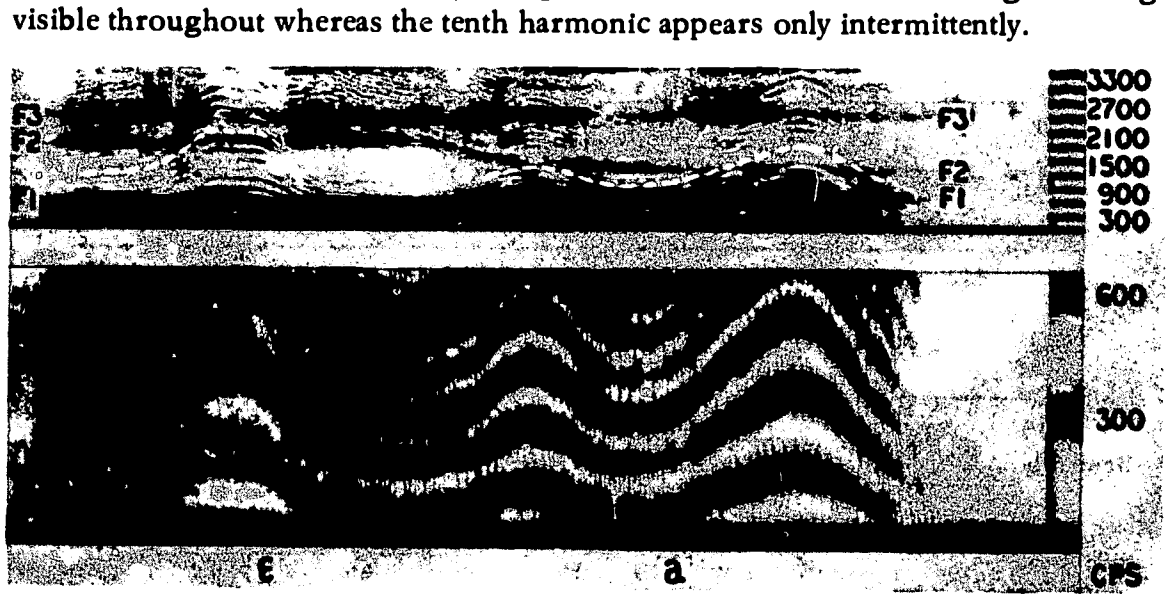
Realizing that it was necessary in teaching foreign languages to complement the use of pitch *levels* with actual *shapes,* we have undertaken to study, by objective

means, the most characteristic pitch shapes of English, German, Spanish and French for the expression of basic attitudes such as continuation, finality, command, interrogative question, informative question, implication and parenthesis.

At present we have results to report concerning the pitch shapes of declarative intonations in the four languages under study. They were obtained by spectrographic analysis of at least five minutes of spontaneous speech by cultivated natives of each country.

To obtain a well-defined pitch line, we amplify by a factor of ten the lowest frequency portion of each spectrogram (see Figure 2). This enlarges the frequency variations of the low harmonics (which are generally continuous for voiced sounds) and makes their observation relatively easy. We usually examine the rise and fall of pitch by following the first or second harmonic, whichever one shows more clearly at a given moment. (We assume in this study that the subjective impression of "pitch" variations nearly correlates with the objective measurement of "fre-

Figure 2. Frequency variations shown by harmonics. The low harmonics of the upper spectrogram are amplified ten times on the lower spectrogram. In this manner the tenth harmonic of the upper spectrogram (white dashed line) is similar to the first (lowest) harmonic of the lower spectrogram, but the latter has the advantage of being visible throughout whereas the tenth harmonic appears only intermittently.

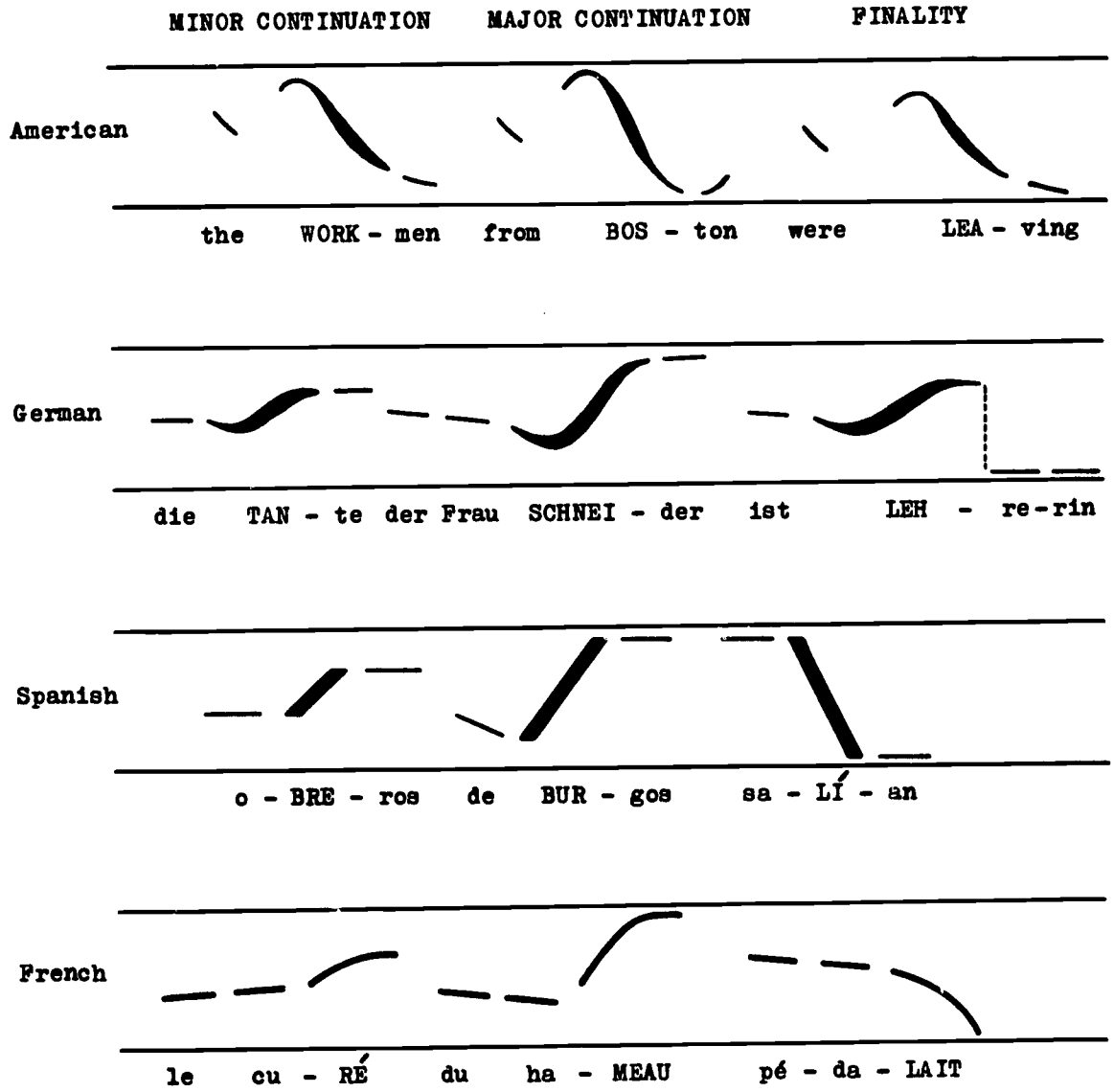


quency" variations. Cases in which length and intensity factors may interfere with this correlation have not yet been clearly determined by psycho-acousticians.) Then we make a statistical study of the various shapes that occur and recur for the expression of each attitude. Finally, we synthesize, on a speech synthesizer of the voback type, the prevailing shapes that have emerged, and we determine what portions, what traits of those shapes are essential to their characterization, by making omissions or changes and judging the effect by ear. We can also superimpose the pitch shapes of one language on the words of another, or even test

the intonation shapes of the four languages by using an identical nonsense utterance for all of them.

Figure 3 presents the prevailing pitch shapes we have found for minor continuation, major continuation, and finality in English, German, Spanish and French. In addition to frequency variations of the fundamental, intensity and duration variations are also present. French is quite different from the three other languages in that it shows no variations in intensity, and has the stress (by greater duration) on the ultima. The range of frequency, indicated by the fixed horizontal lines on the figure, is of 7 to 10 tones, depending on the subject rather than on the language.

Figure 3. A comparison of prevailing American, German, Spanish, and French intonation shapes for the expression of continuation and finality.



As we compare pitch shapes among the languages in Figure 3, let us consider each of the four sentences as being divided into three sense groups. On the whole,

English clearly stands apart from the three other languages; but marked differences are also apparent among the three. Let us observe one feature at a time.

1. In contrast to the other languages where rising portions prevail, *falling* portions are predominant in the American utterance, not only in the stressed syllables but in the unstressed ones as well. It is this constant recurrence of falling glides that characterizes American intonation for the ear of foreigners. Furthermore, the falling portions of stressed syllables are the ones that bear the greatest intensity (loudness); the rising portions, whether leading to the slope or following it, are weak and not very perceptible. In synthesized intonation, the pre-slope rise can be omitted without reducing the American characterization.

2. *Continuation* (major as well as minor) is mainly expressed by falling shapes in English, and by rising shapes in the three other languages. As to the actual characteristic shapes, English and German show nearly the converse of each other. The falling English continuation typically looks like a reversed-S or an inclined tilde. German continuation shows a long rise preceded by a slight dip, thus taking the shape of an S. Spanish rises more sharply than German, and in a straighter line. And in French the rise ends the last syllable of the sense group on a high plateau to form an overall concave shape.

The behavior of unstressed syllables of the same sense group also deserves notice. In English they are low before and after the stress. In German they contribute to the dip before the stress and are on a high plateau after the stress (in contrast with the low plateau of unstressed syllables for finality). In Spanish the unstressed syllables that precede the stress are low (in contrast with the high unstressed of finality), and the unstressed that follow are high (in contrast with the low unstressed of finality). In French, the unstressed syllables (which can only precede since stress is on the last syllable) are low, and the more the stressed syllable is to rise, the more the unstressed syllables tend to be low in contrast.

3. Let us see now what difference may exist between *major* and *minor* continuation shapes.

In a sentence such as

John left Henry running fast to find out who had come

major continuation shape is the inflection required on *Henry* to help make clear that John is running, not Henry (in which case a minor continuation shape covers *fast)*:

John left Henry//running fast/to find out who had come ǂ

or on *fast* to help indicate that Henry is running, not John (in which case a minor continuation shape covers *Henry)*:

John left Henry/running fast//to find out who had come ǂ

In this case, major continuation on *fast* unites the two minor sense groups, *John left Henry* and *running fast.* (Naturally, pause and stress can also play a part in identifying the one who runs, but we are only concerned here with the role of pitch variations.)

The contrast between minor continuation and major continuation is much more marked and much more frequently observed in the three target languages than in English; only very good English speakers observe it consistently. That is not to say that it should be ignored in English, as phoneticians have been doing – we have found subtle evidence of it in many examples of spoken American. As shown in *Boston* (Fig. 3), the major continuation has on the average a more pronounced fall (longer and steeper) and a larger proportion of rising hooks at the end. (A larger proportion of rising, instead of falling, curves is also found.) In German, Spanish and French, major continuation rises more frequently than minor continuation; the rise is steeper, higher, and/or preceded by a lower dip *(Schnei*der, *Bur*gos, ha*meau)*. The high end of the stressed rise is sustained and carried onto the unstressed syllables (if any) that form a part of the sense group.

4. Finality is mainly falling in all four languages. But how differently in each one!

In English the last stressed syllable takes the same reversed-S shape as in continuation, with unstressed syllables (if any) prolonging the slope.

In German, after the S-shaped glide, there is a sharp break of the unstressed portion (generally a series of syllables) to a flat low level which gives the impression of being separated from what precedes. A similar effect of separation would be produced in English if, instead of *street-car level,* we heard *street//car-level.*

In Spanish, on the other hand, finality is announced well ahead of the stressed syllable by a high unstressed portion – the pre-stress syllables of the final sense group. The stressed syllable falls steeply from that high level to a very low one for the unstressed syllables that may follow. In spite of the resemblance to German, it is quite different because in Spanish the fall is on the stressed syllable itself and the unstressed syllables which follow remain closely connected to it.

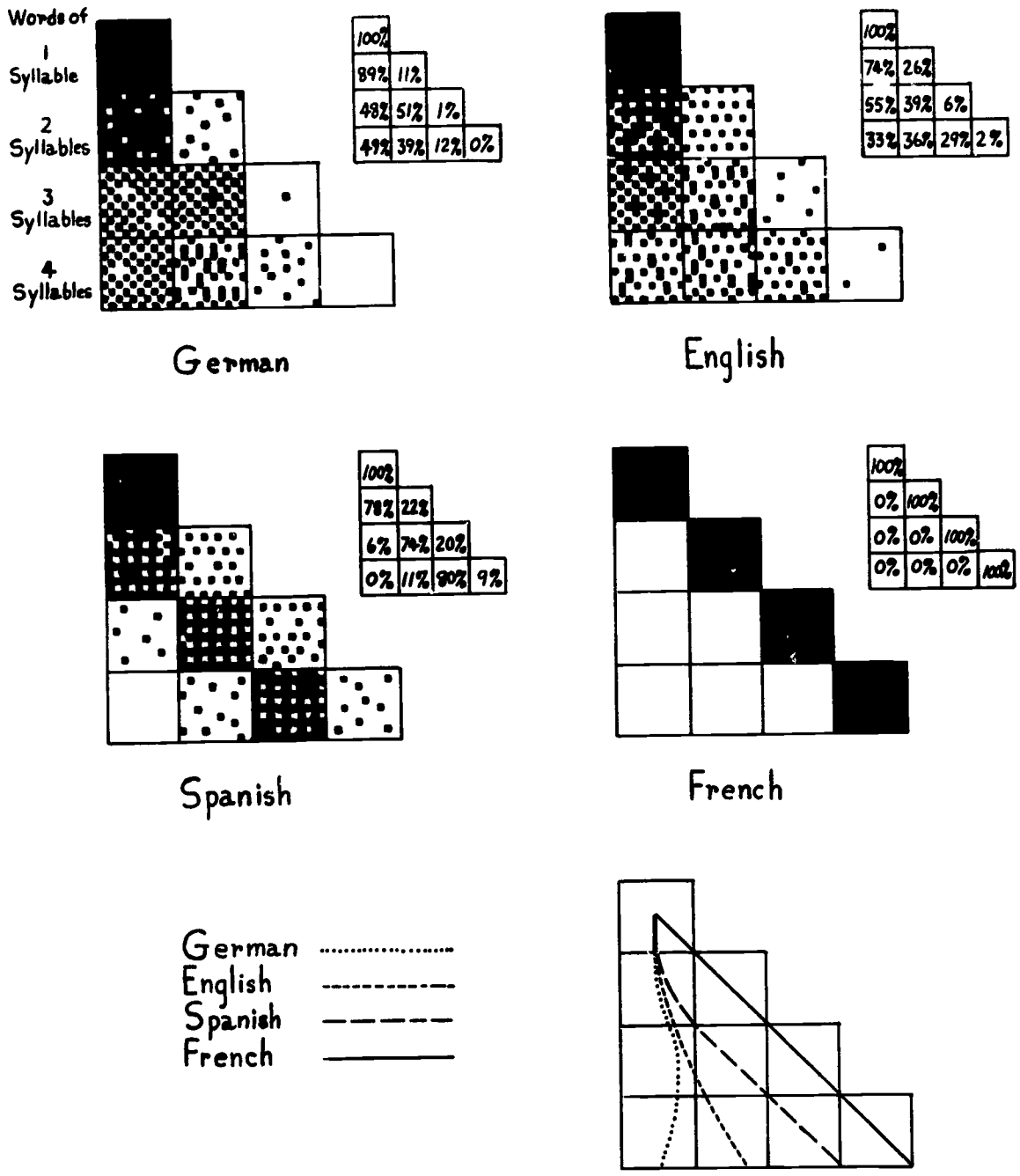
In French the pattern of finality begins on the first syllable of the last minimal sense group, not on the last stressed syllable, as in the three other languages; and it begins lower than the preceding continuation rise had ended unless there is "accent d'insistance."

Unlike the case of the three other languages, the shape of the finality curve is convex in French. This is in direct contrast with the typically concave ending shape of English finality.

5. The contrast between continuation and finality is not so clearly realized in English as in the other languages. Both continuation and finality have falling shapes; the difference is often merely a matter of degree in the slope or of frequency range. This explains why foreigners constantly mistake an American continuation for a finality. They find it unambiguous only when the rising hook is clearly voiced, and this occurs much less than the majority of the time.

In the three other languages the contrast "continuation/finality" is quite unambiguous: continuation rises, finality falls. This is clearest in Spanish: not only is the fall on the last stressed syllable, but the preceding unstressed syllable unmistakably announces that fall by a high pitch. In French there is no ambiguity

Figure 4. A comparison of the place of stress in German, English, Spanish and French *words.*



Let us first consider each language from the point of view of variability in the place of stress. Greater variability can be seen by the degree to which the dots are scattered over the triangle, while more predictable stress is shown through a concentration of dots in a specific area. With this in mind, we see that, of the four languages, English has the greatest variability in stress position; it shows a scattering of dots over a wide area. German has a slightly greater concentration of blackness (stress position) than English, but still considerable variability of

either, but nothing warns you clearly ahead of time; only the last syllable (always stressed) contains the definite slope of finality. In German the stressed syllable of the final sense group begins with a rising S-shape somewhat similar to that of continuation; it is only the following unstressed syllables that clearly indicate finality.

II. NON-DECLARATIVE INTONATION

In comparing among our four languages the typical pitch shapes for such attitudes as command, interrogative question (rising), information question (falling), implication, and parenthesis, we use the same electronic techniques of spectrographic analysis and synthesis, but the material is quite different. Extemporaneous speeches by good speakers do not frequently contain such intonations. We have to use, on one hand, extemporaneous discussions recorded from symposia, interviews, or radio programs; and on the other hand, recorded conversations in which we create schemes to elicit responses with varied intonations from native subjects. No results can be reported at this time.

III. THE PLACE OF LOGICAL STRESS IN THE WORD

In teaching a language, it is necessary to know: a) the characteristic place of stress; b) how variable or predictable this place is. This is related to stress patterns in words and in sense groups. For practical purposes of cross-linguistic comparison, we must first limit our investigation to *primary* stress in words.

A preliminary study of the position of primary word stress was made through an analysis of contemporary short story texts. Short stories in French, Spanish and German were used, with a translation of these three texts as an example of English.

Our statistics are based on running words from texts of five to eight pages in length, and not on vocabulary count. There were approximately 1500 words analyzed for both French and Spanish and 2400 for German. The larger number of English words (5800) is due to the fact that all three translations representing the other language texts were used.

Fig. 4 presents the results of our study in schematic form. Because of the small number of polysyllabic words of five or more syllables in our count, we have limited our comparison to words of one through four syllables. In the figure, syllable position within words reads from left to right. For each language, we give percentages of stress for each syllable position. The percentages are given in the small reference triangles to the upper right of the major triangles. In the large triangles the percentages have been converted into a density presentation, where each small blackened square represents about one percent.

position. On the other hand, Spanish shows a definite tendency for fixed stress position with only light scattering around a dark nucleus. French, as can be readily seen, has a completely fixed place of stress. Thus, a comparison of the four languages reveals a clear progression: freedom of stress position is greatest in English; it is somewhat less marked in German; a tendency toward a fixed position appears in Spanish; and a completely fixed position is reached in French.

Let us now compare the place of stress in the four languages. It varies according to the number of syllables. In words of two syllables, the tendency toward stress on the first syllable is greatest in German, less in Spanish, less again in English, and absent in French. In words of three syllables, the tendency toward stress in the first syllable is greatest in English, less in German, still less in Spanish, and absent in French. In words of four syllables, the tendency toward stress in the first syllable is greatest in German, less in English, less again in Spanish, and absent in French. The tendency in four-syllable words coincides with the general tendency as summarized in the lower right-hand corner of Fig. 4. On the whole, German tends to place the stress on the first syllable. English does also, but to a lesser degree. Spanish strongly tends to have it on the penult, and French has it without exception on the ultima.

The correlation between place of stress and variability is not complete:

Tendency toward placing the stress near the beginning decreases in the order: German: English, Spanish, French.

Tendency toward varying the place of stress decreases in the order: English, German, Spanish, French.

IV. THE PLACE OF LOGICAL STRESS IN THE SENSE GROUP

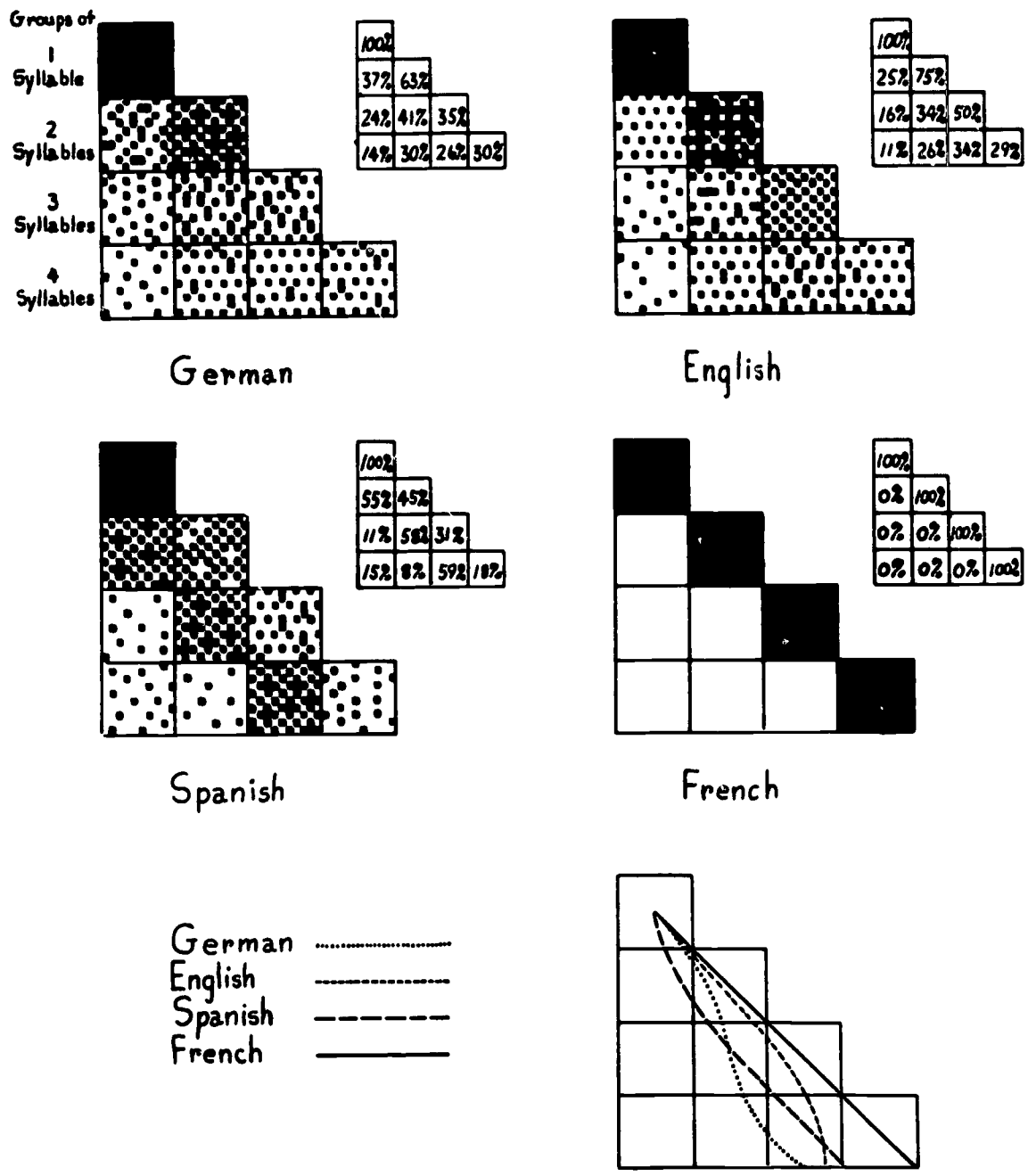
Here we present a preliminary comparison among the four languages of the place of primary stress (only) in short *sense groups*. A further comparison between the word patterns of Part III and the sense group patterns of this part will be instructive.

The same three short story texts and their English translations were used for our analysis of sense groups as for our study of word stress. They were divided into sense groups as nearly as possible on the same principle for each of the four languages. The statistical results of primary stress patterns are presented in schematic form in Fig. 5. The sense groups had to be very short, for no practical patterns could emerge from longer divisions.

1. The scattering of dots is considerably greater in Fig. 5 than it was in Fig. 4. This means that sense group patterns of rhythm do not recur as regularly as word patterns of rhythm. It could have been expected.

2. The second result was quite unexpected. Whereas Spanish stress remains on the penult syllable, in sense groups as in words, (although in a less conclusive

Figure 5. A comparison of the place of stress in German, English, Spanish and French *sense-groups.*



manner), English and German stresses are severely drawn toward the end of the sense group – and slightly more so in English than in German.

In English, two-syllable *words* have the stress mainly on the first syllable; two-syllable *groups* have the stress mainly on the second syllable. Three-syllable words have the stress mainly on the first syllable; three-syllable groups have the stress mainly on the third syllable. Four-syllable words have their stress mainly on the first two syllables; four-syllable groups have it mainly divided among the last three syllables.

In German, two-syllable words have their stress on the first syllable; two-syllable groups have it mainly on the second syllable. Three-syllable words have their stress divided between the first two syllables; three-syllable groups have it mainly divided between the last two syllables. Four-syllable words have their stress mainly on the first syllable; four-syllable groups have it mainly divided among the last three syllables.

As summarized in the lower right-hand corner of Fig. 5, the place of stress in sense groups is as a whole near the end of the group in all four languages, with Spanish the least close to the end (near the penult syllable), then German, then English, then French (on the last syllable).

Examples of the most characteristic patterns of rhythm for each length of words and each length of sense groups follow.

	Word	*Sense Group*
	Spanish	
1 syllable	*sé*	*que*
2 syllables	*fue*ron	la *tez*
3 syllables	mo*men*tos	en *ca*sa
		al vol*ver*
4 syllables	ino*cen*tes	a la *puer*ta
		del cora*zón*
		fué pre*ci*so
	German	
1 syllable	*Milch*	*Ach*
2 syllables	*Fin*ger	er *sass*
3 syllables	*hef*tiger	be*seelt* war
	be*trog*en	wie der *Wind*
4 syllables	*ein*geschlummert	ge*stan*den war
		zu er*war*ten
		auf seinen *Wunsch*
	English	
1 syllable	*give*	*first*
2 syllables	*flo*wers	with *light*
3 syllables	*pos*sible	of the *past*
4 syllables	in*ha*bited	at the *cor*ner
	*me*lancholy	dis*tress*ing *scenes*
	French	
1 syllable	*choses*	*certes*
2 syllables	tris*tesse*	en *moi*
3 syllables	impres*sions*	et la *perte*
4 syllables	débarras*ser*	de la na*ture*

V. THE NATURE OF LOGICAL STRESS

Stress being what makes a syllable stand out, our experiments have concentrated on separating the acoustic elements that cause a syllable to be linguistically perceived as prominent. At this point we find that syllabic prominence is related to variations in:

a) vowel intensity
b) vowel duration
c) consonant duration (length of closure—it correlates with a subjective impression of consonant intensity)
d) consonant intensity (energy in the noise of burst, as in [p] sound, or the noise of friction, as in [s] sound)
e) syllabic pitch (fundamental frequency variation)

In synthesis, any of these five factors can be studied in isolation, and any combination of the five can be produced. Research by playback and voback is very promising, but we have only exploratory results to report here.

When we synthesize an utterance like *nice party* and reverse the ratios of a, b, c, e, one at a time in the two syllables of *party,* that is, when we successively give the syllable *ty* the vowel intensity, the vowel duration, the consonant duration, or the syllabic pitch of *par,* and conversely, the impression of stress unambiguously shifts from *par* to *ty.* However, it does not sound equally like "American stress" in each case.

Such experiments can be repeated with words that change meaning when the stress is shifted, such as *súspect* (noun) which becomes *suspéct* (verb). The advantage of such words is that they can be judged phonemically by naive listeners who, instead of answering the question, "Which syllable is stressed?", answer the question. "Is it a noun or a verb?" Such words, unfortunately, never have comparable consonants—belonging to the same class—such as /p/ and /t/ in the word *party.*

Preliminary experiments on complete sentences (synthesized) indicate that in English, German, and Spanish, the main factor of syllabic prominence is a combination of vowel intensity and consonant closure duration, whereas in French it is vowel duration. We also have indications that vowel duration plays a greater role in German stress and a smaller role in Spanish stress than in English stress. And pitch is important in all four, perhaps more in English than in the three target languages.

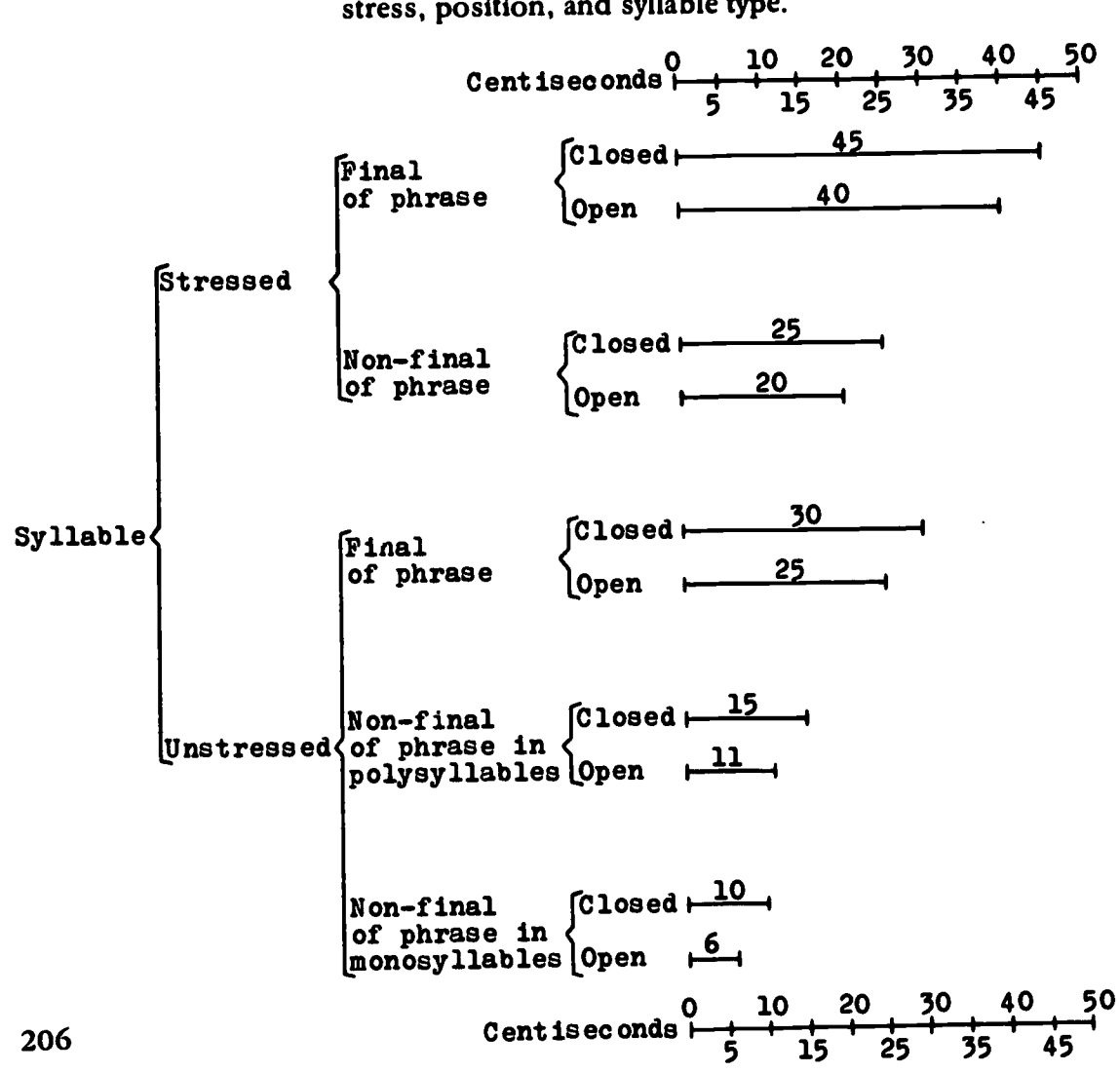
Our aim is to discover in what proportion the five ingredients a, b, c, d, e, must be mixed to produce a *characteristic* stress in each of the four languages. This will involve a great number of experiments by synthesis, with judgement tests by native speakers of each language.

The nature of stress has been one of the most investigated problems of phonetics. But all previous investigations have failed to include the factor of consonants which is being taken into account here. Pitch changes may supersede increases

1. Stressed syllables that are not final in a phrase,
   a) open syllables: 20 centiseconds;
   b) closed syllables (more consonants): 25 cs.
2. Stressed syllables that are final in a phrase,
   a) open syllables: 40 cs;
   b) closed syllables: 45 cs.
3. Unstressed syllables of monosyllables that are not final in a phrase (mainly words like *the, we, of, than),*
   a) open syllables: 6 cs;
   b) closed syllables: 10 cs.
4. Unstressed syllables of polysyllables that are not final in a phrase,
   a) open syllables: 11cs;
   b) closed syllables: 15 cs.
5. Unstressed syllables that are final in a phrase,
   a) open syllables: 25 cs;
   b) closed syllables: 30 cs.

This is shown in Figure 6.

Figure 6. Approximate variations of English syllable length when conditioned by stress, position, and syllable type.



of vowel intensity, but they do not supersede so easily a combined increase of consonant duration-intensity and vowel duration-intensity as they occur in speech.

VI. THE PLACE OF EMPHATIC STRESS

Special emphasis on a word tends to shift the stress toward the beginning of the word if it is not there already. This is a regular process in French where *impossibilité* in logical stress becomes *IMpossibiiité* or *imPOssibilité* in emphatic stress, depending on how emotive the reason for emphasis is. The tendency also exists in English, German, and Spanish, where the stress is occasionally shifted to an earlier syllable for emphasis on the word. We are comparing the extent of this phenomenon in the four languages. Habitually, however, English, German, and Spanish, unlike French, keep emphatic stress on the same syllable as logical stress.

VII. THE NATURE OF EMPHATIC STRESS

Here, the ratios between a) vowel intensity, b) vowel duration, c) consonant duration, d) consonant intensity, and e) syllabic pitch will not be the same as for logical stress. The role of vowel duration is expected to be reduced and that of consonant duration to be increased. Pitch variations may also play a more important role. We hope to find how these factors will vary from language to language.

VIII. VARIATIONS IN SYLLABLE WEIGHT

Syllable weight, like stress, is a combined function of loudness, pitch, and length, which can be measured by intensity (decibels), frequency (cycles), and duration (centiseconds). We have already spoken of the nature of stress. Here we wish, if possible, to go a step further and compare among the four languages not only what makes the stressed syllables stand out, but also how the unstressed syllables behave in regard to each other and in regard to the stressed ones; in regard to their position in the phrase and in regard to their grammatical function. This will involve measuring variations of intensity, frequency, and duration of *all* the syllables along the phrase. In the end it should yield comparative schematic representations of prosodic features that will show at a glance the all-important differences in the distribution of intensity, frequency, and duration along the sentence.

Our first exploration is limited to variations of *syllable length* in English. We have measured the syllables of five minutes of extemporaneous speech by Margaret Mead—over 3000 syllables in all.

Very roughly, five main categories of *syllable* duration emerge. Results are given here in round numbers.

It is interesting to note that final unstressed syllables are on the average equal to or perhaps even longer than non-final stressed ones. One must note, however, that the long final unstressed syllables have comparatively low vowel intensity and short consonant closure to compensate for their long duration. Therefore, long syllabic duration does not exclusively correlate with heavy syllabic weight in English, as strong vocalic intensity and long consonant closure regularly do.

IX. INTERNAL JUNCTURE AND SYLLABICATION

Languages differ in their junctural habits, especially in regard to internal juncture (for instance, in connected word separation: *it swings/its wings, a nice man/an ice man)* and syllabication (syllable separation within a word: compare French *inabilite* to English *inability;* every syllable of the French word is more open, shows less consonant anticipation, than the corresponding syllable of the English word). Here we shall limit our discussion to internal juncture in the consonant-vowel or vowel-consonant sequences. In English, this type of transition can be distinctive (it can function so as to produce a change of meaning) by its presence or absence: *an aim* [ən + eim], *a name* [əneim]; *an ice man* [ən + aismæn], *a nice man* [ənaismæn]; or by its change of place: *great eye* [greit + ai], *gray tie* [grei + tai]; *house ad* [haus + æd], *how sad* [hau + sæd].

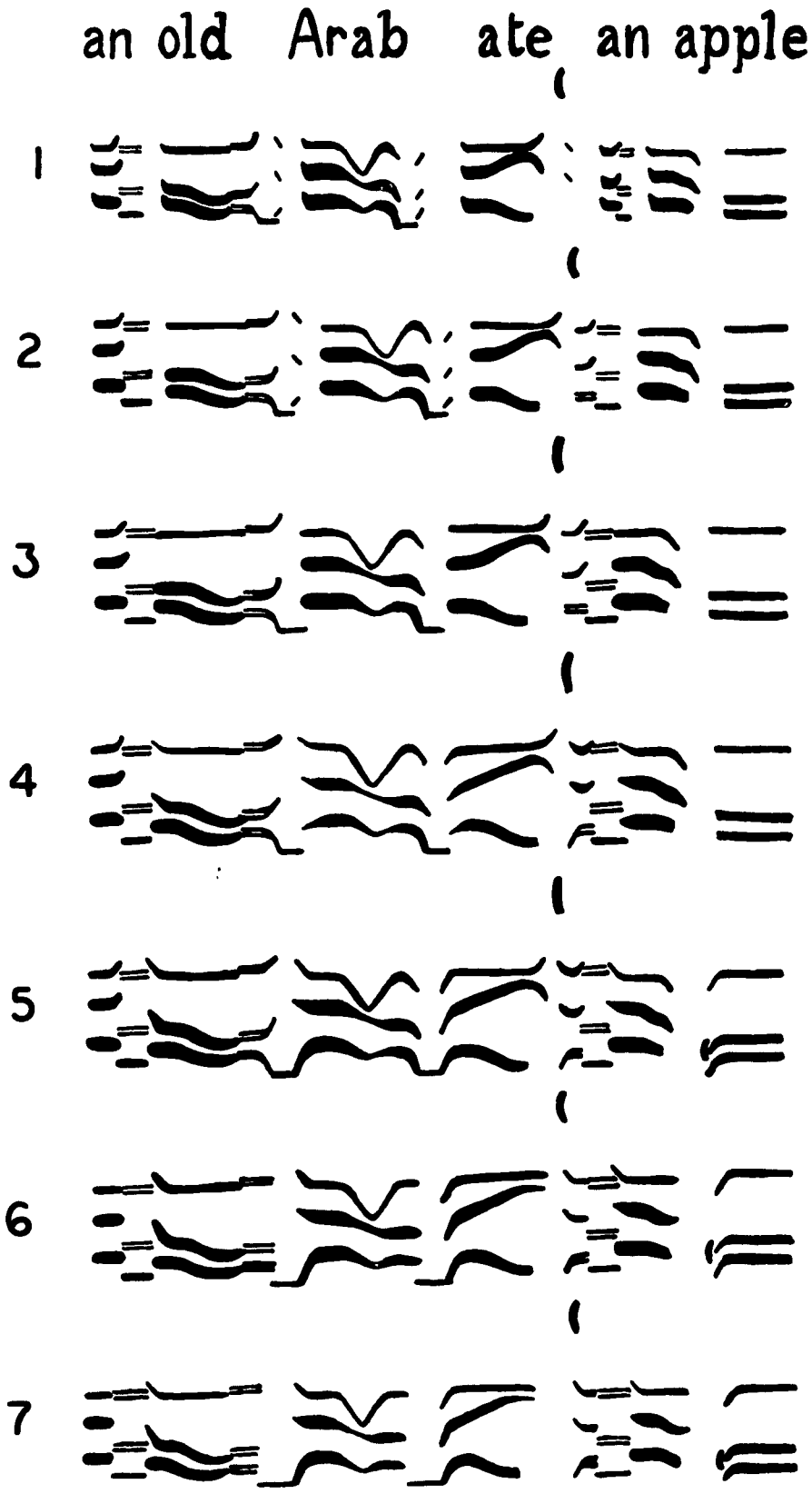
In German, internal juncture can also be distinctive: *zu meinen* is different from *zum einen, wo leben* from *wohl eben.*

But in French and Spanish, internal juncture is not distinctive (at least at a normal rate of speech): *du nôtre* is not different from *d'une autre, les rues sont finies* from *les Russes ont fini, un nain valide* from *un invalide; la sabes* from *las aves, helado* from *el hado, enojo* from *en ojo.* Thus, a Frenchman or a Spaniard would tend to pronounce *an ice man* like *a nice man;* and an American would tend to pronounce *un invalide, el hado* with plus junctures between words.

To begin our investigation of internal juncture and its perception, we have done a basic experiment, using a speech synthesizer. Having found on spectrograms and by synthesis that the most recurring difference between close and open syllabication is in the formant transitions which reflect the closing of the articulators, as for the /n/ of *an aim* (arresting transitions) versus the /n/ of *a name* (releasing transitions), we synthesized seven versions of the sentence *An old Arab ate an apple* with seven degrees of close-to-open syllabication, realized by seven degrees of formant transition angles.

Fig. 7 offers spectrographic patterns of this sentence as they are needed for synthesis. In the first line, all the syllables are closed, from the [n] of *an* to the [p] of *apple.* Let us look at the /b/ of *Arab* as a typical example of the others. The closing articulation movement is seen by the three formants pointing down before complete closure is marked by a silence. Then little falling hooks start the for-

Figure 7. Seven spectrographic realizations of internal juncture produced by variations in the degree of arresting (final) and releasing (initial) formant transitions.



mants of *ate*. These hooks are heard as a glottal stop. Arresting transitions on /b/ of *Arab* followed by a glottal stop explosion on /ei/ of *ate* was identified as closed syllabication followed by very sharp vocalic onset as in German.

The second line is similar, but it does not show the hooks of glottal stops at the beginning of *ate*. The vocalic attack is less sharp. This was identified as closed syllabication followed by fairly sharp onset as in English.

In the third line, the closure gaps are decreased but the onsets are still brusque. This does not sound English, or German or anything else, meaning that in English or German, if the onset is sharp, a sufficient closure (silence) time is required to precede it; it is the time during which the glottis is closed.

In line 4, there is again complete /b/ closure with maximal arresting transitions at the end of *Arab;* then at the onset of *ate* we see very reduced /b/ transitions with gradually increasing intensity. This is identified as good English or German closed syllabication followed by *smooth* vocalic onset – the most usual realization of closed syllabication in English, as well as the most difficult to imitate for a Spaniard or a Frenchman.

In line 5, complete transitions are seen, both preceding and following the /b/ closure. The arresting and the releasing transitions are about equal and the closure time is relatively short. This makes syllabication of the sentence sound rather Spanish.

In line 6, we see no arresting transitions before the /b/ closure, but complete ones after the /b/. Only the releasing transitions are kept, and closure time is still short. Here the conditions of line 2 are practically reversed. This makes syllabication of the sentence sound clearly French.

In line 7, the transition conditions are the same as in line 5, but the length of closure is increasing. Syllabication sounds even more French.

This experiment confirms that the main factor of syllabication is in the combined degrees of arresting and releasing of the formant transitions that precede and follow the consonant closure. The secondary factors seem to be in the duration of consonant closure and in the relative offset and onset intensities of the arresting and releasing transitions. Others may appear, such as aspiration. For instance, whereas the /t/ of *gray tie* is aspirated and strong (mainly by its long closure), the /t/ of *great eye* is unaspirated and weak (mainly by its short closure).

Although this experiment is but a first step in a long series, a tentative comparison of syllabication for the type *ab a (an aim, zum einen, d'une autre, las aves)* among the four languages might be made here.

In English, maximally *arresting* consonant transitions always precede the closure. The onset of the following vowel can be either *very sharp* with glottal stop closure and transitions, *fairly sharp* with glottal closure but no marked glottal stop transitions, or *smooth* with no glottal closure, much reduced (1/3 of arresting) releasing consonant transitions, and very gradual intensity increase.

German has the same three types but uses the very sharp onset more frequently.

In Spanish, the arresting and releasing transitions are somewhat equal.

In French, the arresting transitions are very weak (from zero to 1/3 of releasing), and the releasing transitions are maximal. Closure time is longer than for the "smooth" type in English or for the normal type in Spanish.

Further experiments will include comparison of intervocalic consonants *in the word,* where differences are of the same type as between words but much more subtle and, in addition, more dependent on the place of stress.

Next in importance, for comparative teaching purposes, is the case of phonetic realization of internal juncture for a sequence of two vowels, as in *stay out, die Uhr, là aussi, una isla.*

Here Spanish is markedly different from the three other languages.

In English, the second vowel may have a sharp onset or a smooth one.

In German the sharp onset, with glottal stop, is much more frequent than in English, but the smooth onset is also heard.

In French, the smooth onset of the second vowel is the rule. There is no voice interruption between the two vowels, only a reduction of intensity.

In Spanish the smooth onset is also the rule; but, in addition, *the first vowel, if unstressed and not closer than the second, tends to fall (sinalefa): busc (a) una, cuart (o) oscuro; if unstressed and closer than the second, it tends to become a semi-vowel: ni una vez, su amigo.*

The acoustic and articulatory features of this type of juncture will be studied experimentally and statistically.