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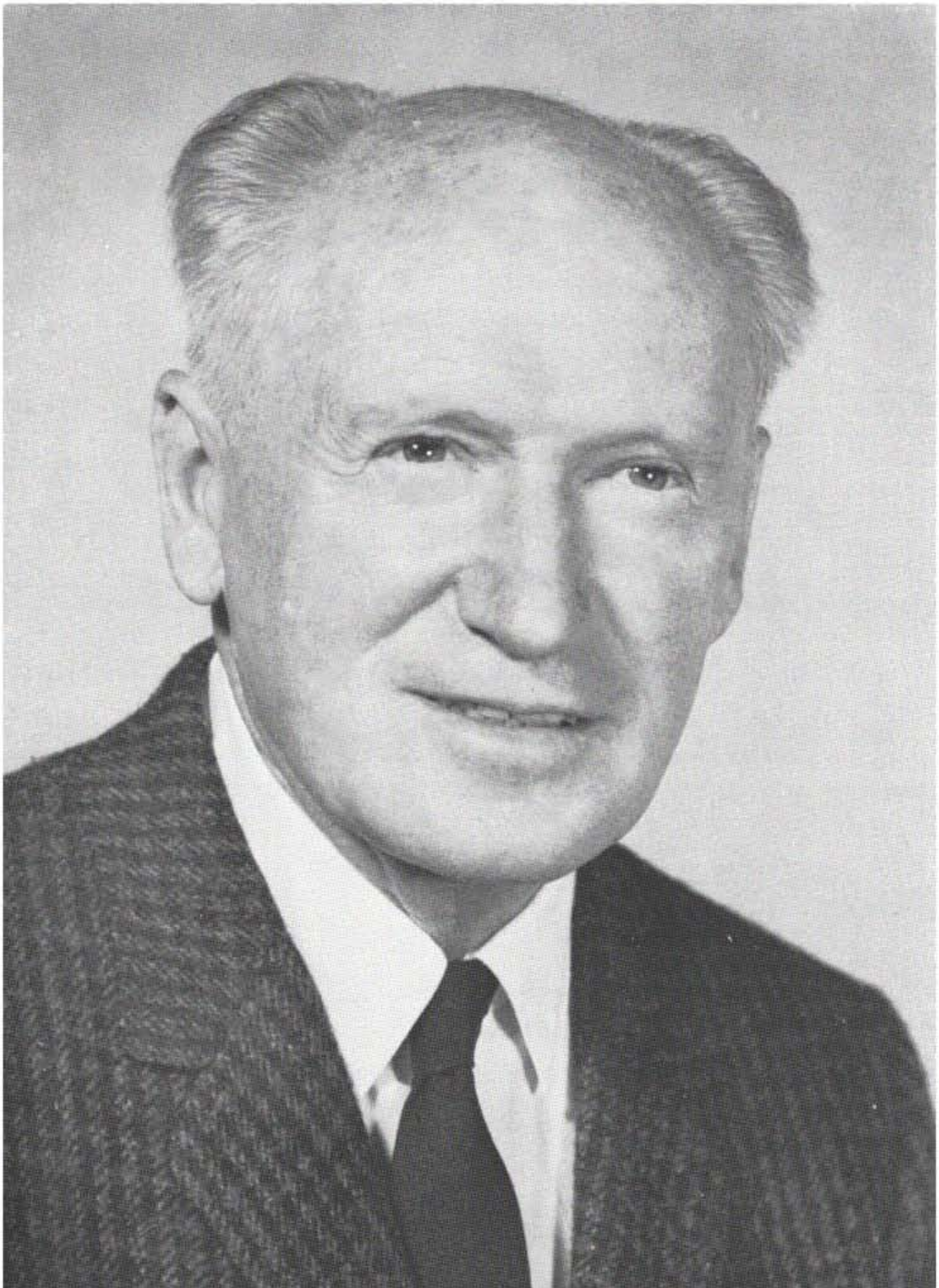

Pierre Delattre

PAPERS IN LINGUISTICS AND PHONETICS TO THE MEMORY OF

PIERRE DELATTRE

edited by

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PREFATORY NOTE

It had been the desire of a few former students of Pierre Delattre or linguists and phoneticians whose career he had profoundly influenced to present to him on the occasion of his sixty-fifth birthday a collection of papers in linguistics and phonetics that would reflect the breadth of his research interests and pedagogical and administrative experience. But after delays in publication and his untimely death, the efforts of the Editorial Committee were turned in profound sorrow to the preparation of this memorial volume.

The broad scope of the contributions to this memorial volume bears witness to Pierre Delattre's profound influence in a large variety of areas of scholarly endeavor. While limitations of space and our attempts — alas, too successful in retrospect — to keep the preparation of the originally intended Festschrift secret to the *hommagé* reduced the potential number of contributors, we hope that the authors of the papers of this volume will bear testimony for all those who, touched by Pierre Delattre's magnetic energy and enthusiasm or influenced by his searching studies, would have liked to express their esteem and gratitude.

The Editorial Committee

CONTENTS

PIERRE DELATTRE

Pierre Delattre died on July 11, 1969 in Santa Barbara after a strenuous game of tennis with his wife and two sons, a most fitting death for this dynamic modern Renaissance man who enjoyed every moment of life to the fullest and committed himself totally, whether it be at the piano keyboard, in the concert hall, on the mountain trail, or behind the net.[1] Although nearing the compulsory retirement age of the University of California system, he was deeply engaged in his Speech Synthesis Project and the organization of a graduate program that would harmonize literary and linguistic studies and train teacher-scholars of French who would follow him in delicately balancing scientific inquiry with a tolerant and rich humanism. By the last decade of his academic and scientific career, Pierre Delattre had achieved indisputable international prominence in the field of experimental phonetics and French linguistics, recognized by numerous honors including designation as Fellow of the Acoustical Society of America — a significant honor for a non-physicist — and the award of the title of Chevalier de la Légion d'Honneur by the French government. But this intense and devoted teacher of French could not have practiced his craft for nearly forty years without leaving an indelible mark, and indeed there is scarcely any teacher of French in this country who has not been influenced, directly or indirectly, by Pierre Delattre's theory and practice of applied French phonetics as well as his ideas about foreign language (FL) pedagogy in general.

Delattre was born in the town of Roanne in central France on October 21, 1903, the thirteenth child of a Huguenot minister, and the austere character of his native Calvinist milieu accounts for his capacity for long hours of hard work impervious to external distractions. Very early he demonstrated musical talent and eventually became an accomplished pianist and fair composer of short pieces. His attachment to music was to remain with him throughout his life, and it no doubt explains his strong interest in intonation and other prosodic features. After completing secondary school studies in France, he emigrated to the Detroit area where, together with his brother André, who was to become a leading specialist in eighteenth century French literature, he enrolled at the University of Michigan. While preparing his Ph.D. he

[1] We should like to thank Mme Pierre Delattre, Simon Belasco, and Fred Eddy for making available to us biographical and bibliographical material.

taught French at Wayne State University; he also studied at the Institut de Phonétique of the Sorbonne and obtained a certificate in phonetics. In 1941 he joined the faculty of the University of Oklahoma and in 1944–45 launched an experimental course which applied some of the procedures of the Army Language School method at the University of Oklahoma. The most decisive step in his career was his acceptance of a post at the University of Pennsylvania in 1947 which placed him in propinquity to acousticians at MIT, Bell Telephone Laboratories, and Haskins Laboratories and led to his participation in research utilizing the Pattern Playback devised by F. S. Cooper at the latter institution. At Pennsylvania Delattre also became associated with a major graduate program in Romance languages and eventually attracted several disciples to French phonetics who went on to attain scholarly and academic distinction. Except for Delattre there was no director of serious French linguistic studies in this country between the late thirties and early fifties. From 1941 until 1957 he directed the remedial phonetics program at the Middlebury College French Summer School. In 1953 he moved west to the University of Colorado, and in 1961 he established his Speech Synthesis Project which he moved to the University of California, Santa Barbara in 1964. No doubt these younger universities provided a greater outlet for his infinite creative energy than the tradition-bound Ivy League institution, but also Colorado and California gave him more opportunity to participate in sports which he enjoyed with as much exuberance and intensity as he did his research and teaching. We recall that during the last International Congress of Phonetic Sciences in Prague where he was invited to deliver one of the plenary session papers he managed to squeeze in attendance at a soccer game between two of Czechoslovakia's best teams, a feat that required finding his way without guides and using Prague's complex trolleycar system with a very rudimentary knowledge of the language no doubt enriched in advance with suitable basic sentences required for the expedition.

Delattre began his career in articulatory French phonetics with a strong commitment to practical applications to the teaching of French to American speakers. Following the publication of *La durée des voyelles en français: Etudes expérimentales sur la durée des E d'un Français* in 1939, based in part on his Michigan doctoral dissertation, he published more than forty articles on various aspects of French articulatory phonetics and pedagogical application primarily in the *French Review*, the journal of the American Association of Teachers of French. In fact, his regular annual contribution, presented with great clarity and without condescension, was for nearly a decade almost the only opportunity the relatively unsophisticated audience of that journal had to gain accurate information about matters linguistic.

Delattre's approach to remedial phonetics was heavily influenced by the early articulatory phoneticians: Rousselot, Passy, and Jones, and it was not until relatively late (in *Comparing the Phonetic Features of English, French, German and Spanish*, for instance) that he worked explicitly with the notion of the phoneme. Rather than claiming to predict very specific points of phonological interference by the comparison of the phonemic inventories of the native and target language, Delattre held that the inaccurate pronunciation of the target language stemmed from interference of the native articulatory set. Differences in the phonological systems of French and English — phonemic or allophonic, segmental or prosodic — according to him had their source in contrasts between the two languages in three articulatory modes: (1) tense vs. lax; (2) fronted vs. backed; (3) opening vs. closing. Since individual features of the target language were determined by the interplay of the articulatory modes, it was necessary for the learner to acquire the latter before he could master individual features. Thus, the first stage in Delattre's method of remedial phonetics was articulatory conditioning undertaken independently of the functional use of language or the manipulation of grammatical features and lexicon. Consider the following two practice sentences from *Les Difficultés phonétiques du français*, which, together with its companion volume *Principes de phonétique française*, gave Delattre's method wide dissemination: (1) *Zéro! pour avoir osé ôter un mégot du métro*; (2) *Un homme éminent n'amène aucun ennui*. Sentence (1) is designed to train the learner in producing steady-state vowels by having him repeat alternately a front unrounded and a back rounded vowel in an extended series of syllables rather than, for example, contrast steady-state French vowels and glided English near-equivalents: *gué/gay*; *l'eau/low*. Sentence (2) provides training in open vs. close syllabification, one of the manifestations of the contrast between an opening and a closing mode of articulation, as well as the non-nasalization of vowels preceding nasal consonants which is, within Delattre's scheme, simply a consequence of open syllabification. During the fifteen year period when contrastive analysis of phonemic inventories and minimal pair or near-equivalent contrast drills derived directly from these analyses became one of the basic marks of audiolingual oriented FL teaching, Delattre's method was in relative disfavor with many leading FL teaching methodologists — but not, it must be pointed out, with rank and file practitioners. But now that the linguistic and psychological underpinnings of contrastive analysis theory are seriously questioned, it becomes more apparent that Delattre's reliance on the notion of articulatory set has two advantages. First, it deals with entities directly linked to articulatory motions rather than abstract linguistic units, and is thus compatible with a weak version of linguistic interference theory anchored in physiology, namely that articulatory habits of the native language deeply ingrained after many years of practice will inhibit the acquisition of a different set of habits. Second, since an articulatory mode subsumes a variety of target language features, the remedial phonetician needs to concentrate on intra-systemic relations rather than comparing native and target language step-by-step, which is more in harmony with the structuralist view of language as "*un système où tout se tient*".

One of the most troublesome aspects of French for the foreign learner is the alternation in the surface form of morphemes subsumed by traditional optional liaison and elision but compounded by dialect and stylistic variation. An important task for the applied French linguist is the elaboration of pedagogical norms whereby the ragged edges that the language shows in normal use by a complex and heterogeneous linguistic community are streamlined to make the principles that underlie the variable behavior of its speakers more readily accessible to foreign learners. A pedagogical norm cannot, however, be an ad hoc simplification of linguistic facts but must express some significant generalization about them. Delattre's research was motivated by the search for generalizations that relate various aspects of a phonological system — physiological, acoustic, linguistic, and psychological — and it comes as no surprise that without having discussed the notion explicitly he formulated powerful pedagogical norms for French pronunciation and worked out practical procedures to apply them in the classroom.

French shows partial complementation between members of the mid vowel pairs [e]/[ɛ], [ø]/[œ], and [o]/[ɔ], such that, except for contrasts of the type *gué/guet*, *jeûne/jeune* and *paume/pomme* and considerable free variation in medial syllables in certain styles of the prestige Paris dialect, the high-mid member of each pair occurs in an open syllable and the low-mid member in a checked syllable. While this partial complementation had been observed previously, notably by Passy (1887), it was Delattre who formulated it most concisely as a variable rule termed the *Loi de Position* ("en syllable fermée, la voyelle tend à s'ouvrir; en syllabe ouverte, la voyelle tend à se fermer") which, while it did not sacrifice observational adequacy since it was not stated categorically, provided foreign learners with a simple basis for pronunciation. "Exceptions" to the *Loi de Position* were progressively introduced, for example the use of high-mid [ø] and [o] before [z], so that the learner's pronunciation more closely approximated that of prestige speakers. Interestingly, Delattre also viewed the *Loi de Position* as expressing a natural tendency of French and considered pronunciations which constituted exceptions to it "une réaction savante et contre-nature (contre les tendances phonétiques du français) imposée par les grammairiens" (1948:22). In this instance his claims were not altogether correct since the use of [ɛ] in final open syllables and of [ɔ] in medial open syllables is characteristic of working class Paris adolescents (Léon, 1972), and Delattre's assertions were perhaps influenced by his own pronunciation habits in which indeed [ɛ] seldom occurred in final open syllables. Nonetheless, they reflect his idea that the function of the phonetician was to transcend the collection of data and to search for the small set of great principles, revealed really by exceptional insight, that underlie speech and distinguish one language from another, and in this regard his attitude joins that of present-day generative phonologists.

Delattre's involvement in FL pedagogy transcended remedial phonetics and led him to undertake one of the earliest and most notable comparison experiments. During the academic year 1944–45 he decided to test the Army Language Method assertion that an initial concentration on listening and speaking while denying reference to the written word was more efficient than the traditional immediate exposure to spelling. At the University of Oklahoma, he divided a beginning class into an experimental group exposed to an innovative treatment and a control group following the traditional eclectic approach. Both groups were taught by the same instructor so that the dependent variable was limited to availability or non-availability of the written word and the use of materials and procedures compatible with these two approaches. Students in the experimental group demonstrated superior proficiency in auditory comprehension and speaking and slightly better ability in writing, but the long-range importance of the experiment lies not in the demonstration that an extended prereading period leads to more efficient acquisition of audio-lingual skills since we now know that even comparison experiments with considerably more elaborate research fail to isolate as many significant variables as they control. Rather, it showed nearly two decades before programmed self-instructional courses were launched that a significant responsibility for learning can be assumed by the students directly. Students had access to a phonograph and discs prepared daily by Delattre and practiced material presented previously in class. In this way contact with the spoken language was multiplied several fold, at least for assiduous students, and much of the drill was taken over by an electro-mechanical component which could supplement and, indeed, function independently of the classroom teacher. Another innovative feature of the experimental treatment that antedated programmed instruction was a graded presentation of phonological features to reduce initial articulatory difficulty to a minimum. The first sentence students practiced, *La belle demoiselle qui passe là-bas est la voisine de Jeanne*, artfully combined only five of the fifteen vowels of French and avoided such difficult articulations — for English speakers — as *r*, front rounded vowels, and unglided final [e], [o] and [u], and thus provided a facilitative framework within which the student acquired French prosodic habits of even-stressed syllabic rhythm and sustained statement intonation. While Delattre was a precursor of programmed instruction, he never would have accepted attempts to teach the spoken language, and particularly pronunciation, by means of total self-instruction. For him, language was literally SPEECH, and he would not have accepted the extensive preliminary training in auditory comprehension contained in all current programmed audio-lingual language courses, nor for that matter would he accept any FL program that did not aim at the attainment of functional bilingualism:

> ... since we understand the sounds of a new language not just by ear but by direct reference to articulatory gesture of which we have already acquired the correct HABIT ... it seems that the earlier we enter the production phase the better we can discriminate among the phonemes of a target language (1966:9).

Delattre's appointment to the French Department of the University of Pennsylvania was a momentous occasion, not only in his personal career, but also in the history of Acoustic Phonetics, for it brought him into contact with the principal new technological advances that were to play important roles in this new interdisciplinary science. The Bell Telephone Laboratories had produced the sound spectrograph, which for the first time performed a running Fourier analysis of the acoustical wave form and provided a coherent visual representation of speech samples. From spectrograms, hypotheses could be made as to what aspects of the total speech signal convey phonemic information. However analysis constitutes only one half of the investigative processes of experimental sciences; the hypotheses must be tested by synthesis. An additional research tool was clearly indicated, namely a device that would convert spectrograms, real or hand-painted, into sound. Delattre began visiting the Bell Telephone Laboratories regularly, at his own expense, in order to familiarize himself with spectrographic analysis. It was there that he learned that F. S. Cooper, of the Haskins Laboratories in New York, had developed a successful synthesizer. Actually, Cooper, a physicist, and his colleague, A. M. Liberman, a psychologist, had been concerned with developing a reading device for the blind, and had, from that project, become interested in discovering the acoustic cues for speech. Excited by the research possibilities offered by this equipment, Delattre began going regularly to New York to visit the Haskins Laboratories. "*Vini, vidi vici!*" might very well have been attributed to Delattre, for that is precisely what happened, and Cooper and Liberman soon asked him to become part of their research team. Together, they made the first major breakthroughs in acoustic phonetics, methodically discovering the principal perceptual cues for phonemes, and developing a 'motor' theory of speech perception. According to the latter, the acoustic level is not the fundamental one, but rather speech is conceived as a complex of articulatory (motor) patterns, made up of units of positions and movements. These workers claimed that speech recognition involves a proprioceptive feedback in which the acoustic signals are referred back to the articulations that are their genesis. If the acoustic level were the fundamental one, that is, if the phoneme were conceived as an acoustic rather than as an articulatory event, we would expect to find a one-to-one relation between the two. On the contrary, a simpler relationship appears to exist between perception and articulation than between perception and the acoustic stimulus.

Indications to this effect are numerous and dramatic. A good example is the role of the burst in identifying the voiceless stops: The frequency of the burst for /k/ varies with that of the second formant of the associated vowel — it is relatively high for /ki/ and low for /ku/ —, and when a burst appropriate for /ki/ is paired with /u/ the result is perceived as /tu/. Thus a number of bursts at widely separated frequencies, but paired with appropriate vowels, will be perceived as the linguistically constant /k/ — it is noted that they are normally produced in all contexts with roughly the SAME articulation —, while a given burst paired with different vowels may be heard as DIFFERENT consonants. The same lack of correspondence is observed between formant transitions and perceived phonemes, and the "Locus Theory" represents an attempt to find constant values on the acoustic level for each place of articulation. Vowel–consonant transitions do not show a constant relation to consonant class either — second formant transitions for /d/, for example, may point up, down, or straight, depending on the identity of the contiguous vowel. However, an extrapolation of their curves leads to a single point where they intersect. For dentals, it is approximately at about 1800 H_z, for labials it is at about 700 H_z, and for velars with all but the back vowels, it is around 3000 H_z. Those points, or 'loci', can thus be considered as corresponding to articulation. Although spectrograms of real speech show considerable variation in this respect, the best results obtained with synthetic speech are those which follow this principle. As a result of this and other discoveries, the Haskins Laboratories soon became an international focal point for work in acoustic phonetics, and Delattre became recognized as an authority in this field.

Once the major acoustic cues had been specified, he turned his attention to comparative phonetics. When he moved to the University of Colorado, he obtained an Office of Education grant to build a laboratory, conceived on the basis of an original three-way research technique, involving spectrographic analysis, speech synthesis, and cineradiography, which permitted relating the elements of the acoustic signal to the articulatory phenomena that they represent. It was in the latter that Delattre looked for the broad generalizations that would explain not only systemic relations at the synchronic level but also the direction of linguistic change. He had shown an early interest in diachronic studies and had published several articles on sound changes, for example "A contribution to the history of 'R grasseyé'" (1944) and "Stages of Old French phonetic changes observed in Modern Spanish" (1946).

Typical of what might be considered his mature work in experimental phonetics was his study of nasalization published in one of his last articles, "Divergences entre nasalités vocaliques et consonantiques" (1970). Spectrographic analyses reveal two types of vocalic nasalization. In the first type Delattre labelled "nasalisation par annulation" (cancellation) and characteristic of the French nasal vowels [ẽ], [ã], [œ̃], [ɔ̃], there is a decrease in the amplitude of the first formant while the second formant value remains comparable to that of corresponding oral vowels. In the second type, there is a spread of formant one so that, although its amplitude is not necessarily reduced, it is spread over more harmonics. This type of vocalic nasalization, termed "nasalisation par amortissement" (damping), is found in English vowels preceding nasal consonants as in *Sam* and *thin* and in the high and high-mid nasal vowels of Portuguese. X-ray film studies show that the two types of vowel nasalization correspond to two different articulatory configurations: nasalization by cancellation is produced not only by a lowering of the velum, which also occurs in the production of nasalization by damping, but by the adjustment of the volume of the pharyngeal cavity to that of the velic cavity formed in the upper pharynx above the velum. After noting that all four French nasal vowels have pharyngeal cavities of equal volume and show identical first formants, Delattre suggested that their diachronic evolution from sequences of high and high-mid vowels followed by a nasal consonant is explained by the fact that low and low-mid vowels have pharyngeal cavities that produce maximal perceptible nasalization. He hypothesized that, in turn, this evolution is explained by the loss of implosive consonants that changed the syllabic structure of French between the Middle Ages and the 16th century (Martinet 1965) and led to the phonemicization of nasal vowels: "une fois libérées de la tyrannie des consonnes nasales subséquentes, les voyelles nasales françaises ont eu libre cours pour évoluer vers des positions articulatoires plus favorables à la distinction orale/nasale" (1970:70).

Delattre never drew a sharp distinction between pure and applied research, and he did not leave the application of his use of a variety of experimental techniques in phonetics to less skilled and less knowledgeable interpreters. Indeed, much of his time and energy during his mature period was devoted to the improvement of FL teaching. In the preface to *Comparing the Phonetic Features of English, French, German and Spanish* he states:

It occurred to us that the same techniques as, for instance, that which was used at Haskins to study the acoustic correlates of speech perception could be applied to the study of foreign accents described in terms of phonetic features which distinguish one language from another. Thus the latest electronic techniques of speech analysis and our experience in artificial speech synthesis should serve a practical purpose — better teaching of foreign languages.

Pierre Delattre was a generous and affable host and displayed a charming and sparkling Gallic wit that one would hardly suspect in someone with such austere antecedents, and colleagues from the humanities who knew of his strong attachment to music and literature had difficulty imagining him as the white-smocked scientist surrounded by complex machines. But Delattre was and considered himself a humanist and he had always been enchanted by the esthetic qualities of the principal object of his study, French sounds:

French ... reveals a rich and varied system of vowels and consonants in which frontal resonance dominates, open syllables that are proud of their vowels, oxytonic accentuation that emphasizes the last syllables of sense groups not by heavy marks of intensity but by restrained increases in length, an intonation capable of contrasting the lightest shade of syntactic meaning, a rhythm of equal syllables which recalls a string of pearls ... (1966b:6).

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REFERENCES

Delattre, Pierre

1939 *La durée des voyelles en français: Etude expérimentale sur la durée des E d'un Français* (Paris: d'Artrey).

1944 "A contribution to the history of 'R grasseyé", *Modern Language Notes* 14: 562–64.

1946a *Principes de phonétique française à l'usage des étudiants anglo-américains* (Middlebury, Vermont: The College Store).

1946b "Stages of Old French phonetic changes observed in Modern Spanish", *PMLA* 61: 7–41.

1947 "A technique of aural-oral approach, report on a University of Oklahoma experiment in teaching French", *French Review* 20: 238–50; 311–24.

1948a *Les difficultés phonétiques du français* (Middlebury, Vermont: The College Store).

1948b "Un triangle acoustique des voyelles orales du français", *French Review* 21: 477–84.

1951 "The physiological interpretation of sound spectrograms", *PMLA* 66: 864–75.
1955 "Les attributs acoustiques de la nasalité vocalique et consonantique", *Studia Linguistica* 8: 103–09.
1958 "Les indices acoustiques de la parole: premier rapport", *Phonetica* 2: 108–18; 226–51.
1965a "La nasalité vocalique en français et en anglais", *French Review* 39: 92–109.
1965b *Comparing the Phonetic Features of English, German, Spanish and French* (Heidelberg: Julius Groos Verlag and Philadelphia: Chilton Books).
1966 *Studies in French and Comparative Phonetics* (The Hague: Mouton).
1968 "La radiographie des voyelles françaises et sa corrélation acoustique", *French Review* 42: 48–65.
1970 "Divergences entre nasalités vocaliques et consonantiques", *Word* 24: 64–72. (*Linguistic studies presented to André Martinet on the occasion of his sixtieth birthday*, II).

Léon, Pierre,
1972 "Etude de la prononciation de *e* accentué chez un groupe de jeunes Parisiens", in *Papers in Linguistics and Phonetics to the Memory of Pierre Delattre* (The Hague: Mouton).

Liberman, A. M. and F. S. Cooper,
1972 "In search of distinctive features", in *Papers in Linguistics and Phonetics to the Memory of Pierre Delattre* (The Hague: Mouton), 329–38.

Martinet, André,
1965 "Les voyelles nasales du français", *Linguistique* 1: 117–22.

PUBLICATIONS OF PIERRE DELATTRE

BOOKS

1. *La durée des voyelles en français: Etude expérimentale sur la durée des E d'un Français* (Paris: d'Artrey, 1939).
2. *Principes de phonétique française à l'usage des étudiants anglo-saxons* (Middlebury, Vermont: The College Store, 1946).
3. *An Introduction to French Speech Habits* (with a 10″ L.P. record) (New York: Henry Holt and Company, Inc., 1947).
4. *Les Difficultés phonétiques du français* (Middlebury, Vermont: The College Store, 1948).
5. *Advanced Training in French Pronunciation* (with a 12″ L.P. record) (Middlebury, Vermont: The College Store, 1949).
6. *Premier manuel: Grammaire et civilisation françaises* (with a 12″ L.P. record, with D.W. Alden) (New York: Appleton-Century-Crofts, 1954).
7. *Phonetic Readings of Songs and Arias* (with B. Coffin, R. Errolle, and W. Singer) (Boulder: Pruett Press, 1964).
8. *Comparing the Phonetic Features of English, German, Spanish and French* (Heidelberg: Julius Groos Verlag or Philadelphia: Chilton Books, 1965).
9. *Studies in French and Comparative Phonetics* (The Hague: Mouton, 1966).
10. *Word-by-Word Translations of Songs and Arias* (with B. Coffin and W. Singer) (New York: The Scarecrow Press, 1966).

ARTICLES

1. "Durée consciente et durée inconsciente", *French Review* 12 (1938) 49–50.
2. "Investigating vowel duration in French", *Papers of the Michigan Academy of Science, Arts, and Letters* 23 (1938) 517–24.
3. "L'accent final en français: accent d'intensité, accent de hauteur, accent de durée", *French Review* 12 (1938) 3–7.

4. "Remarques sur l'enseignement de la durée des voyelles françaises", *Le Maître Phonétique* 3 (1938) 66–67.
5. "L'*e* muet dans la coupe syllabique", *Le Français Moderne* 7 (1939) 154–58.
6. "Durée vocalique et consonnes subséquentes", *Le Maître Phonétique* 3 (1939) 41–44.
7. "Accent de mot et accent de groupe", *French Review* 13 (1939) 141–46.
8. "Le mot est-il une entité phonétique en français", *Le Français Moderne* 8 (1940) 47–56.
9. "Anticipation in the sequence: vowel and consonant-group", *French Review* 8 (1940) 314–20.
10. "Tendances de coupe syllabique en français", *Publications of the Modern Language Association of America (PMLA)* 55 (1940) 579–95.
11. "La force d'articulation consonantique en français", *French Review* 14 (1941) 220–32.
12. "Paul Passy, or the return to elementals", *Books Abroad* 16 (1942) 241–46.
13. "Travaux d'étudiants au laboratoire de phonétique expérimentale de l'école française de Middlebury", *French Review* 16 (1943) 504–10.
14. "La leçon de phonétique de Maurice Chevalier", *French Review* 17 (1943) 99–104.
15. "L'aperture et la syllabation phonétique", *French Review* 17 (1944) 281–85.
16. "A foreigner views basic English", *Books Abroad* 18 (1944) 115–20.
17. "La syllabation ouverte par la méthode compensatrice", *French Review* 17 (1944) 371–76.
18. "Que faut-il penser de l'anglais basique", *Le Recueil* 14 (1944) 1–9.
19. "International phonetics, a founder and pioneer — Paul Passy", *The French Forum* 7 (1944) 289–90.
20. "Vers la méthode phonétique intégrale pour débutants", *French Review* 18 (1944) 109–15.
21. "A contribution to the history of 'R grasseyé'", *Modern Language Notes* 14 (1944) 562–64.
22. "Prononciation graphique et prononciation phonétique, I. Les Consonnes", *French Review* 18 (1945) 219–226.
23. "Prononciation graphique et prononciation phonétique, II. Les Voyelles", *French Review* 18 (1945) 285–96.
24. "Spanish is a phonetic language", *Hispania* 28 (1945) 511–17.
25. "Tout va très bien, Madame la Marquise, transcription commentée", *French Review* 19 (1945) 125–29.
26. "Stages of Old French phonetic changes observed in Modern Spanish", *Publications of the Modern Language Association of America (PMLA)* 61 (1946) 7–41.
27. "L'enseignement de l'*R* français", *French Review* 19 (1946), 428–33.
28. "Pour imiter un disque de français parlé", *French Review* 20 (1946) 43–48.
29. "A technique of aural–oral approach, report on a University of Oklahoma

experiment in teaching French", *French Review* 20 (1947) 238–50 and 311–24.
30. "La leçon de phonétique de Charles Boyer", *French Review* 20 (1947) 396–98.
31. "Broad transcription for typing in American English", *Le Maître Phonétique* 3 (1947) 27–28.
32. "La liaison en français, tendances et classification", *French Review* 21 (1947) 148–57.
33. "La leçon de phonétique de Charles Trenet", *French Review* 21 (1948) 249–59.
34. "Phonetics in beginning language study", *The Modern Language Journal* 32 (1948) 373–77.
35. "Un triangle acoustique des voyelles orales du français", *French Review* 21 (1948) 477–84.
36. "La leçon de phonétique de Farrebique", *French Review* 22 (1949) 323–28.
37. "Le jeu de l'*E* instable de monosyllabe initial en français: I. Un seul monosyllabe", *French Review* 22 (1949) 455–59.
38. "Le jeu de l'*E* instable de monosyllabe initial en français: II. Deux monosyllabes", *French Review* 23 (1949) 43–47.
39. "Le surcomposé réfléchi en subordonnée temporelle", *Le Français Moderne* 18 (1950) 95–108.
40. "The use of the pattern playback in studies of vowel color by synthesis", *Journal of the Acoustical Society of America* 22 (1950) 678.
41. "Le jeu de l'*E* instable intérieur en français", *French Review* 24 (1951) 341–51.
42. "The physiological interpretation of sound spectrograms", *Publications of the Modern Language Association of America (PMLA)* 66 (1951) 864–75.
43. "Des progrès actuels de la phonétique", *French Review* 25 (1951) 42–46.
44. "Voyelles synthétiques à deux formants et voyelles cardinales" (with A. M. Liberman and F. S. Cooper), *Le Maître Phonétique* 96 (1951) 30–36.
45. "Some suggestions for language teaching methods arising from research on the acoustic analysis and synthesis of speech" (with F. S. Cooper and A. M. Liberman), *Report of the Third Annual Round Table Meeting on Linguistics and Language Teaching*, Monograph Series 2 (1952) 31–47.
46. "The role of selected stimulus-variables in the perception of the unvoiced stop consonants" (with A. M. Liberman and F. S. Cooper), *The American Journal of Psychology* 65 (1952) 497–516.
47. "Some experiments on the perception of synthetic speech sounds" (with F. S. Cooper, A. M. Liberman, J. M. Borst, and L. J. Gerstman), *The Journal of the Acoustical Society of America* 24 (1952) 597–606.
48. "An experimental study of the acoustic determinants of vowel color; observations on one- and two-formant vowels synthesized from spectrographic patterns" (with A. M. Liberman, F. S. Cooper, and L. J. Gerstman), *Word* 8 (1952) 195–210.
49. "Les modes phonétiques du français", *French Review* 27 (1953) 59–63.
50. "The role of consonant-vowel transitions in the perception of the stop and nasal

consonants" (with A. M. Liberman, F. S. Cooper and L. J. Gerstman), *Psychological Monographs* 68 (1954) 1–13.

51. "Lecture et prononciation en seconde année de français", *French Review* 27 (1954) 472–74.
52. "Acoustic loci and transitional cues for consonants", (with A. M. Liberman and F. S. Cooper), *The Journal of the Acoustical Society of America* 27 (1955) 769–73.
53. "Les attributs acoustiques de la nasalité vocalique et consonantique", *Studia Linguistica* 8 (1955) 103–109.
54. "... Sur les origines de la prononciation française", *Le Bayou* 62 (1955) 316–18.
55. "Les facteurs de la liaison facultative en français", *French Review* 29 (1955) 42–49.
56. "Tempo of frequency change as a cue for distinguishing classes of speech sounds" (with A. M. Liberman, L. J. Gerstman, and F. S. Cooper), *Journal of Experimental Psychology* 52 (1956) 127–37.
57. "La fréquence des liaisons facultatives en français", *French Review* 30 (1956) 48–54.
58. "The Celtic element in the French language", *Bulletin of the Colorado Congress of Modern Language Teachers* 9 (1956) 4–6.
59. "Speech Synthesis as a research technique" (with F. S. Cooper, A. M. Liberman, and L. J. Gerstman), *Proceedings of the VIIth International Congress of Linguists (1952)*, London, International University Booksellers Ltd., (1956) 545–61 plus 9 figures.
60. "Acoustic cues for the perception of initial /w, j, r, l/ in English" (with J. D. O'Connor, L. J. Gerstman, A. M. Liberman, and F. S. Cooper), *Word* 13 (1957) 24–43.
61. "La question des deux '*A*' en français", *French Review* 31 (1957) 141–48.
62. "A propos des corrélatifs acoustiques de la distinction entre voyelle et consonne", *Studia Linguistica* 11 (1957) 78–83.
63. "Effect of third-formant transitions on the perception of the voiced stop consonants" (with K. S. Harris, H. S. Hoffman, A. M. Liberman, and F. S. Cooper), *The Journal of the Acoustical Society of America* 30 (1958) 122–26.
64. "Unreleased velar plosives after back-rounded vowels", *The Journal of the Acoustical Society of America* 30 (1958) 581–82.
65. "Some cues for the distinction between voiced and voiceless stops in initial position" (with A. M. Liberman and F. S. Cooper), *Language and Speech* 1 (1958) 153–67.
66. "Vowel color and voice quality — an acoustic and articulatory comparison", *The Bulletin of the National Association of Teachers of Singing* 15 (1958) 4–7.
67. "Les indices acoustiques de la parole: premier rapport", *Phonetica* 2 (1958) 108–18 and 226–51.
68. "Acoustic cues in speech", *Haskins Laboratories Report* (1958) 2–39.

69. "Rapports entre la durée vocalique, le timbre et la structure syllabique en français", *French Review* 32 (1959) 547–52.
70. "Minimal rules for synthesizing speech" (with A. M. Liberman, F. Ingemann, L. Lisker, and F. S. Cooper), *The Journal of the Acoustical Society of America* 31 (1959) 1490–99.
71. "Sommes-nous préparés pour l'enseignement de la langue?" *French Review* 33 (1960) 483–90.
72. "Testing audio equipment by ear", *Audiovisual Instruction* 5 (1960) 156.
73. "Un cours d'exercices structuraux et de linguistique appliquée", *French Review* 33 (1960) 591–603.
74. "Testing students' progress in the language laboratory", *International Journal of American Linguistics* 26 (1960) 77–93.
75. "Testing students' progress in the language laboratory", *Automated Teaching Bulletin* 1 (1960) 21–31.
76. "Comment tester la facilité de parole dans un laboratoire de langue", *Le Français dans le Monde* 1 (1961) 36–38.
77. "La leçon d'intonation de Simone de Beauvoir, étude d'intonation déclarative comparée", *French Review* 35 (1961) 59–67.
78. "Testing the oral production of language students", *The College Language Laboratory* 5 (1961) 25–43.
79. "Un cours d'exercices structuraux et de linguistique appliquée", *NDEA Anthology*, Boston, Heath (1961) 59–72.
80. "La fréquence des liaisons facultatives en français", *NDEA Anthology*, Boston, Heath (1961) 90–97.
81. "A comparative study of declarative intonation in American English and Spanish" (with C. Olsen and E. Poenack), *Hispania* 45 (1962) 233–41.
82. "An experimental study of the effect of pitch on the intelligibility of vowels" (with J. Howie), *The Bulletin of the National Association of Teachers of Singing* 18 (1962) 6–9.
83. "Some factors of vowel duration and their cross-linguistic validity", *The Journal of the Acoustical Society of America* 34 (1962) 1141–42.
84. "Le français et les laboratoires de langue", *Esprit* 30 (1962) 595–604.
85. "Formant transitions and the perception of consonants", *Haskins Laboratories Reports* 30 (1962) 1–23.
86. "Le jeu des transitions de formants et la perception des consonnes", *Proceedings of the Fourth International Congress of Phonetic Sciences, Helsinki 1961*, The Hague, Mouton (1962) 407–17.
87. "Une technique 'audio-linguale' d'initiation au français", *Le Français dans le Monde* 2 (1962) 15–17.
88. "Quality in tape recording and voicing", *International Journal of American Linguistics* 29 (1963) 55–59.
89. "Voyelles diphtonguées et voyelles pures", *French Review* 37 (1963) 64–76.

90. "Research techniques for phonetic comparison of languages", *International Review of Applied Linguistics in Language Teaching (IRAL)* 1 (1963) 85-97.
91. "Comparing the prosodic features of English, German, Spanish and French", *International Review of Applied Linguistics in Language Teaching (IRAL)* 1 (1963) 193-210.
92. "Some experiments on the perception of synthetic speech sounds" (with F. S. Cooper, A. M. Liberman, J. M. Borst, and L. J. Gerstman), *New Selected Works of Physics #28*, Tokyo, Japanese Physics Association (1963) 32-41.
93. "Acoustic loci and transitional cues for consonants" (with A. M. Liberman and F. S. Cooper), *New Selected Works of Physics #28*, Tokyo, Japanese Physics Association (1963) 42-46.
94. "Minimal rules for synthesizing speech" (with A. M. Liberman, F. Ingemann, L. Lisker, and F. S. Cooper), *New Selected Works of Physics #28*, Tokyo, Japanese Physics Association (1963) 47-56.
95. "French prepositional patterns in linking a verb to an infinitive object", *The Modern Language Journal* 48 (1964) 29-35.
96. "Classifying speech sounds by their source", *In Honour of Daniel Jones*, edited by David Abercrombie, London, Longmans, Green and Company (1964) 46-52.
97. "French phonetics for the singer", *Phonetic Readings of Songs and Arias*, Boulder, Pruett Press (1964) 252-54.
98. "Formant transitions and loci as acoustic correlates of place of articulation in American fricatives" (with A. M. Liberman and F. S. Cooper), *Studia Linguistica* 16 (1964) 104-21.
99. "Comparing the vocalic features of English, German, Spanish and French", *International Review of Applied Linguistics for Language Teaching (IRAL)* 2 (1964) 71-97.
100. "Le son du français, impressions et réalité", *Le Français dans le Monde* 4 (1964) 13-16.
101. "Le jeu des prépositions dans l'enchaînement des verbes en français", *French Review* 38 (1964) 67-81.
102. "German phonetics between English and French", *Linguistics* 8 (1964) 43-55.
103. "Comparing the consonantal features of English, German, Spanish and French", *International Review of Applied Linguistics for Language Teaching (IRAL)* 2 (1964) 155-203.
104. "La synthèse acoustique de la parole", *Bulletin de la Société des Professeurs Français en Amérique* 18 (1964) 13-26.
105. "De la hiérarchie des indices acoustiques pour la perception de la parole", *Proceedings of the Fifth International Congress of Phonetic Sciences, Münster 1964*, edited by E. Zwirner and W. Bethge, Basel, S. Karger (1964) 244-51.
106. "Change as a correlate of the vowel-consonant distinction", *Studia Linguistica* 18 (1965) 12-25.

107. "Some characteristics of German intonation for the expression of continuation and finality" (with E. Poenack and C. Olsen), *Phonetica* 13 (1965) 134–61.
108. "La nasalité vocalique en français et en anglais", *French Review* 39 (1965) 92–109.
109. "Some sound changes in the light of spectrographic analysis and synthesis", *Omagiu Lui Alexandru Rosetti*, Bucharest, Editura Academiei Republicii Socialiste România (1965) 163–65.
110. "Oklahoma revisited", *Advances in Teaching of Modern Languages*, edited by G. Mathieu, Oxford and New York, Pergamon Press (1966) 1–10.
111. "Les attributs physiques de la parole et l'esthétique du français", *Revue d'Esthétique* 3–4 (1966) 250–54,
112. "La notion de structure et son utilité", *Le Français dans le Monde* 41 (1966) 7–11.
113. "Les dix intonations de base du français", *French Review* 50 (1966) 1–15.
114. "A comparison of syllable length conditioning among languages", *International Review of Applied Linguistics for Language Teaching (IRAL)* 4 (1966) 183–98.
115. "Acoustic or articulatory invariance?" *Glossa* 1 (1967) 1–25.
116. "La nuance de sens par l'intonation", *French Review* 41 (1967) 326–40.
117. "Language learning and linguistic interference", *Dimension: Languages* 2 (1967) 27–33.
118. "Principles of language instruction at the college level", *Dimension: Languages* 2 (1967) 120–26.
119. "Tempo of frequency change as a cue for distinguishing classes of speech sounds" (with A. M. Liberman, L. J. Gerstman, and F. S. Cooper), *Readings in Acoustic Phonetics*, edited by Ilse Lehiste, Cambridge, M.I.T. Press (1967) 159–69.
120. "Some experiments on the perception of synthetic speech sounds" (with F. S. Cooper, A. M. Liberman, J. M. Borst, and L. J. Gerstman), *Readings in Acoustic Phonetics*, edited by Ilse Lehiste, Cambridge, M.I.T. Press (1967) 273–82.
121. "Acoustic loci and transitional cues for consonants" (with A. M. Liberman and F. S. Cooper), *Readings in Acoustic Phonetics*, edited by Ilse Lehiste, Cambridge, M.I.T. Press (1967) 283–87.
122. "Minimal rules for synthesizing speech" (with A. M. Liberman, F. Ingemann, L. Lisker, and F. S. Cooper), *Readings in Acoustic Phonetics*, edited by Ilse Lehiste, Cambridge, M.I.T. Press (1967) 333–42.
123. "The role of duration in the identification of French nasal vowels" (with M. Monnot), *International Review of Applied Linguistics in Language Teaching (IRAL)* 6 (1968) 267–88.
124. "La radiographie des voyelles françaises et sa corrélation acoustique", *French Review* 42 (1968) 48–65.
125. "Duration as a cue to the tense/lax distinction in German unstressed vowels" (with M. Hohenberg), *International Review of Applied Linguistics in Language Teaching (IRAL)* 6 (1968) 367–90.
126. "From acoustic cues to distinctive features", *Phonetica* 18 (1968) 198–230.

127. "A dialect study of American *R*'s by X-ray motion picture" (with Donald C. Freeman), *Linguistics* 44 (1968) 29–68.
128. "Syntax and intonation: a study in disagreement", *Study of Sounds* 14 (1969) 21–40.
129. "Syllabic features and phonic impression in English, German, French and Spanish" (with Carroll Olsen), *Lingua* 22 (1969) 160–75.
130. "L'intonation par les oppositions", *Le Français dans le Monde* 64 (1969) 6–13.
131. "Two notes on Semitic laryngeals in East Gurage" (by Robert Hetzron with contribution by P. Delattre), *Phonetica* 19 (1969) 69–81.
132. "L'/R/ parisien et autres sons du pharynx", *French Review* 43 (1969) 5–22.
133. "Syntax and intonation: a study in disagreement", *Modern Language Journal* 54 (1970) 3–9.
134. "A cross-language study of the i/j distinction" (with Marie-Thérèse Delyfer), *English as a Second Language — Current Issues* (Robert C. Lugton, Ed.) [Language and the Teacher: A Series in Applied Linguistics #6]. Philadelphia: Center for Curriculum Development, Inc., (1970) 63–87.
135. "Divergences entre nasalité vocalique et consonantique", *Linguistic Studies Presented to André Martinet*, Part II (Indo-European Linguistics) [*Word* 24 (1968) 64–72; published in 1970].
136. "Coarticulation and the locus theory", *Studia Linguistica* 23 (1969) 1–26.
137. "La théorie celtique et les substrats", *Romance Philology* 23 (1970) 480–91.
138. "An acoustic study and articulatory study of vowel reduction in four languages", *International Review of Applied Linguistics for Language Teaching (IRAL)* 7 (1969) 295–325.
139. "First-formant transitions as a cue to place of articulation", *Journal of the Acoustical Society of America* 46 (1969) 110A.
140. "Rapports entre la physiologie et la chronologie de la nasalité distinctive", *Proceedings of the X International Congress of Linguists, Bucharest*, IV (1970) 221–27.
141. "Pharyngeal features in the consonants of Arabic, German, Spanish, French and American English", *Phonetica* 23 (1971) 129–55.
142. "Consonant gemination in four languages: an acoustic, perceptual, and radiographic study", *International Review of Applied Linguistics for Language Teaching (IRAL)* 9 (1971) 31–52.

REVIEWS

1. George Gougenheim, *Système grammatical de la langue française*, *French Review* 13 (1940) 236–38.
2. Henri Malhiac, *Analyse et enregistrement de la voix parlée et chantée*, *Language* 30 (1954) 597–98.
3. F. D. Eddy, *French for Children*, *Bulletin of the Colorado Congress of Foreign Language Teachers* 9 (1958) 13–14.

4. L. Kaiser, *Manual of Phonetics*, *Romance Philology* 13 (1959) 80–83.
5. Jean-Claude Lafon, *Message et phonétique: Introduction à l'étude acoustique et physiologique du phonème*, *The Journal of the Acoustical Society of America* 34 (1962) 995.
6. William G. Moulton, *The Sounds of English and German*, *International Review of Applied Linguistics in Language Teaching (IRAL)* 1 (1963) 142–45.
7. *Diagnostical Procedures of Voice and Hearing Dysphonia*, *Reports of the 12th Congress of Logopedics and Phoniatrics, 1962*, *The Journal of the Acoustical Society of America* 35 (1963) 1069–70.
8. Alf Lombard, *Le Rôle des semi-voyelles et leur concurrence avec les voyelles correspondantes dans la prononciation parisienne*, *Romance Philology* 18 (1965) 462–64.
9. Georges Straka, *Travaux de linguistique et de littérature publiés par le Centre de philologie et de littératures romanes de l'Université de Strasbourg, I*, *Romance Philology* 19 (1965) 73–81.
10. George Scherer and Michael Wertheimer, *A Psycholinguistic Experiment in Foreign-Language Teaching*, *Harvard Educational Review* 35 (1965) 533–36.
11. Bertil Malmberg, *Phonetics*, *Romance Philology* 20 (1967) 246–50.
12. A. Moles and B. Vallancien, *Phonétique et phonation*, *The Journal of the Acoustical Society of America* 42 (1967) 1107.
13. Jean-Denis Gendron, *Tendences phonétiques du français parlé au Canada*, *Language* 44 (1968) 852–55.
14. W. Zwanenburg, *Recherches sur la prosodie de la phrase française*, *Romance Philology* 22 (1968) 209–12.
15. G. Straka, *Travaux de linguistique et de littérature* I: II: *Linguistique et philologie*, *Romance Philology* 23 (1970) 92–97.
16. David Abercrombie, *Elements of General Phonetics*, *General Linguistics* 9 (1969) 118–22.
17. Boudreault, *Rythme et mélodie de la phrase parlée en France et au Québec*, *Romance Philology* 25 (1971) 121–23.
18. Péla Simon, *Les Consonnes françaises*, *Romance Philology* 24 (1970) 332–37.
19. Y. Lebrun, *Anatomie et physiologie de l'appareil phonatoire*, *Phonetica* 21 (1970) 126–28.

BIBLIOGRAPHY

1. A critical bibliography of phonetics (with S. Belasco, J.-P. Vinay, and H. E. Collins) in *American Speech* 33 (1958), 63–69.
2. A critical bibliography of phonetics (with S. Belasco and J.-P. Vinay) in *American Speech* 33 (1958), 212–22.
3. A critical bibliography of phonetics (with S. Belasco and H. E. Collins) in *American Speech* 34 (1959), 55–63.

4. A critical bibliography of phonetics (with S. Belasco and H. E. Collins) in *American Speech* 34 (1959), 214–21.
5. A critical bibliography of phonetics (with S. Belasco and A. Valdman) in *American Speech* 35 (1960), 66–72.
6. A critical bibliography of phonetics (with S. Belasco and A. Valdman) in *American Speech* 35 (1960), 226–35.
7. A critical bibliography of phonetics (with S. Belasco and A. Valdman) in *American Speech* 36 (1961), 69–77.
8. A critical bibliography of phonetics (with S. Belasco and A. Valdman) in *American Speech* 36 (1961), 215–23.
9. A critical bibliography of phonetics (with S. Belasco and A. Valdman) in *American Speech* 37 (1962), 62–70.
10. A critical bibliography of phonetics (with S. Belasco and A. Valdman) in *American Speech* 37 (1962), 222–29.
11. A critical bibliography of phonetics (with S. Belasco and A. Valdman) in *American Speech* 38 (1963), 66–75.
12. A critical bibliography of phonetics (with S. Belasco and A. Valdman) in *American Speech* 39 (1964), 64–74.
13. A critical bibliography of phonetics (with S. Belasco and A. Valdman) in *American Speech* 39 (1964), 226–34.
14. A critical bibliography of phonetics (with S. Belasco and A. Valdman) in *American Speech* 40 (1965), 68–73.
15. A critical bibliography of phonetics (with S. Belasco and A. Valdman) in *American Speech* 40 (1965), 218–23.
16. A critical bibliography of phonetics (with S. Belasco and A. Valdman) in *American Speech* 41 (1966), 225–34.

RECORDS

1. 1–10″ L.P. record for *Introduction to French Speech Habits* (New York: Henry Holt and Company, Inc., 1947).
2. 1–12″ L.P. record of the complete material in *Advanced Training in French Pronunciation* (selections from *Les Difficultés Phonétiques du Français*) (Middlebury, Vermont: The College Store, 1949).
3. 1–12″ L.P. record for *Premier Manuel: Grammaire et Civilisation Françaises* (New York: Appleton-Century-Crofts, 1954).

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TONAL EXPERIMENTS WITH WHISPERED THAI[1]

In so-called tonal languages it is the general consensus among linguists and phoneticians that the feature used to distinguish most, if not all, of the tonal phonemes is pitch variation. The question arises as to what happens in whispered utterances of such a language, where there is no vocal fold vibration to produce a fundamental frequency that varies according to the levels or contours prescribed by the phonological system. In some languages, such as Swedish, tonal oppositions are restricted to certain points in the utterance and may in fact be conditioned syntactically to some extent; the question of the preservation of tonal oppositions is more intriguing in a language like Thai, in which every syllable has a tone as part of its phonemic make-up.

This problem has interested a number of phoneticians working on a variety of languages. In an investigation of Mandarin Chinese, Charles Boardman Miller (1934) found that its four tonal phonemes are readily identified in whispered speech. He concluded that this was done through extensive help from the context as well as changes in energy indicating variations in pitch. Miller's experimental design, however, apparently provided no tests in which tone itself was the only variable. Panconcelli-Calzia (1955) maintains that in tonal languages context makes comprehension of longer whispered utterances possible, but he just about rules out comprehension of isolated words. Where others have claimed that whispered tones are indeed audible,[2] he advances two thoughts: either they were not dealing with a genuinely voiceless whisper,[3] or the semantic function of tones has been exaggerated. In a rejoinder, Giet (1956) reaffirms his stand that tonal distinctions are maintained in

[1] This work was inspired by a long conversation with Pierre Delattre who was at the time looking at other aspects of whispered speech (Delattre, Liberman and Cooper 1959). Early versions were presented as oral papers at the Seventy-Third Annual meeting of the Modern Language Association of America, December, 1958 and the Fifty-Eighth Meeting of the Acoustical Society of America, October 1959 (Abramson, 1959).

[2] E.g. Giet, 1950: p. 95.

[3] This is indeed something to be guarded against in such discussions. In true whisper the glottis may be somewhat narrowed but the folds do not pulsate (von Essen, 1962: 35). In stage whisper, although the cartilaginous glottis is open to allow turbulent air through, the membranous folds will be sufficiently approximated to allow for the breathy phonation known as murmur (Zemlin, 1964: 165); this quasi-periodicity, albeit mixed with noise, can of course carry tonal information.

whispering and rendered perceptible, though less clearly so, through the substitution of other phonic features for pitch. The two substitutes in REAL Chinese whispering, he says, are changes in vowel color as well as increases in air flow for high tones and decreases in air flow for low tones. Addressing himself to this controversy, Meyer-Eppler (1957) supports Giet with spectrographic evidence of upward shifts in some vocalic formant frequencies for higher pitch, as well as an increase in intensity accompanied by noisy components in the gaps of the higher spectral regions for whispered German.[4]

Further work on tonal distinctions in whispered Mandarin was done by Wise and Chang (1957), who found that in tests with paired utterances minimally distinguished by tone, listeners were able to identify no more than 62% of the critical words. Kloster Jensen (1958), however, obtained somewhat higher recognition scores for Mandarin; they ranged from 73% to 85%, so he concluded that phonemic tones are reflected somehow in whispered speech.[5] Two rather recent studies show on the one hand very little tonal information transmitted for whispered Vietnamese (Miller, 1961) and, on the other hand, considerable information on the word accents of whispered Swedish (Segerbäck, 1966).

The foregoing claims and counterclaims, as well as the mixed experimental results, made it seem desirable to tackle the problem of the perception of phonemic tones in whispered speech with yet another language. The Thai language appears to be a good choice for this purpose because it has been clearly established (Abramson, 1962) that pitch movements furnish the dominant cues for the identification of the phonemic tones. Standard Thai or Siamese is the national language of Thailand and the regional dialect of the central plains including Bangkok. It is usually said to have five tones: middle, low, falling, high and rising. Spectrographic measurements of fundamental frequencies show that the mid tone starts near the middle of the speaker's voice range and remains level; if it occurs before a pause, it drops slightly at the end. The low tone starts just below the middle of the voice range, drops gradually and levels off somewhat above the bottom of the range. The falling tone starts rather high and drops rapidly to the bottom of the range. The high tone starts above the middle and rises slowly; before a pause, in certain phonetic environments, it drops slightly toward the end and shows concomitant laryngeal constriction with irregular pulsing. The rising tone starts quite low and rises rapidly to the top of the voice range.[6]

The plan of this study was to see whether in fact Thai tones could be identified in whispered speech, and then, using equipment not available to previous investigators, to see whether such information as is transmitted is also available in normally phonated speech. After all, one might argue that the mixed results from Mandarin

[4] Meyer-Eppler does not take German to be a tonal language but asserts that the prosodic distinction between a question and a statement is analogous.

[5] Kloster Jensen's study included similar experiments with Norwegian, Slovenian and Swedish.

[6] For more details see Abramson, 1962, especially Tables 3.2–3.3 and Figures 3.3–3.6. These statements are for citation forms; a full allophonic description would have to take at least tonal environment and sentence intonation into account.

suggest that some speakers go through special maneuvers to compensate for the missing pitch information, while others simply supply the usual instructions to their speech production mechanisms minus fundamental frequency control.

The most severe test of the phonological distinctiveness of tonal features would seem to be one in the context-free condition of isolated monosyllabic words. Before proceeding to whispered speech then, it was necessary to establish that the tones could be distinguished in phonated speech without any help from verbal context. Perception tests were prepared for each of four sets of tonally differentiated words in which each word was pronounced five times by a male native speaker of Thai. All the stimuli were presented in a random order to eleven native speakers, including the informant. Two tests gave five choices, one gave four, and the last gave three. Most of the subjects scored 100% on all the tests. There were a few scattered errors. Although these results indicate that all five tones are readily identified in isolation, R. B. Noss (1954, section 1.1.2) claims that the mid and low tones are not distinguishable in isolation but require an environment where relative pitch criteria are available. In a recent private communication, Noss has clarified this point by describing perception tests of his that do indeed strongly suggest that the tonal opposition in question is somewhat unstable in isolation. The informant used in the present study,[7] he goes on to say, must have produced optimal maximally differentiated contours that the listeners had no difficulty in identifying. To reconcile the apparent conflict, it may be necessary to view the distinction between the mid and low tones as an unstable one, or at least a facultative one, in isolation. This is obviously an important observation to take into account when considering the identifiability of whispered tones in isolated words.

The sets of words so well identified in phonated speech were once again recorded five times each by the same informant in a whisper. Great care was taken to insure that the speaker used true whisper. Neither auditorily nor spectrographically could any laryngeal pulses be detected. The recordings were randomized into test tapes and played to the eleven subjects used for the base line test; for two of the four tests, only eight of the subjects were available. The results are given in the form of confusion matrices in Tables 1 through 4. The words and brief glosses are given in each table. In Table 1, the words are also labelled as to tone to facilitate the reading of the tonal symbols in the rest of the tables. The convention of using double vowel symbols to represent distinctive length is followed here.

The mean recognition scores of Tables 1 through 4 show a sharp drop in identifiability of whispered isolated words as compared with normally phonated words. The individual scores ranged from 73.3% for the informant himself in Table 4 down to two instances of 5% in Table 2. Examination of the confusion matrices suggests that more information has been transmitted than indicated by the overall scores. Indeed, the pattern of responses might make one suspect the existence of a marginal tonal

[7] The informant and base line tests described here are the same as those found in Abramson, 1962: 128.

TABLE 1

Confusion of Matrix of Tones in Words

Number of subjects: 11
Percent Identification

	Whispered				
	Mid	Low	High	Falling	Rising
Heard					
Mid	*14.5*	14.5	23.6	16.4	7.3
Low	9.1	*54.5*	14.5	10.9	7.3
High	27.1	5.5	*40.0*	20.0	12.8
Falling	5.5	7.3	9.1	*52.7*	3.6
Rising	43.7	18.2	12.8	0	*69.0*
N:	55	55	55	55	55

Heard as intended: 46.2%

Words

/naa/ 'field' (Mid tone)
/naà/ 'custard apple' (Low tone)
/naá/ 'mother's younger sibling' (High tone)
/naâ/ 'face' (Falling tone)
/naǎ/ 'thick' (Rising tone)

TABLE 2

Confusion Matrix of Tones in Words

Number of subjects: 8
Percent Identification

	Whispered				
	Mid	Low	High	Falling	Rising
Heard					
Mid	*42.5*	35.0	37.5	52.5	20.0
Low	52.5	*52.5*	60.0	35.0	67.5
High	5.0	0	*2.5*	0	0
Falling	0	12.5	0	*12.5*	7.5
Rising	0	0	0	0	*5.0*
N:	40	40	40	40	40

Heard as intended: 23%

Words

/k'aj/ 'dried sweat'
/k'àj/ 'egg'
/k'áj/ 'to scoop out'
/k'âj/ 'fever'
/k'ǎj/ 'to unlock'

TABLE 3

Confusion Matrix of Tones in Words

Number of subjects: 11
Percent Identification

	Whispered			
	Mid	Low	High	Falling
Heard				
Mid	*12.7*	40.0	31.0	26.4
Low	61.8	*18.2*	9.1	20.8
High	9.1	5.5	*12.7*	11.6
Falling	16.3	36.4	47.2	*41.5*
N:	55	55	55	55

Heard as intended: 21.3%

Words

/lom/ 'wind'
/lòm/ 'mud'
/lóm/ 'to fall'
/lôm/ 'shipwreck'

TABLE 4

Confusion Matrix of Tones in Words

Number of subjects: 8
Percent Identification

	Whispered		
	Mid	Low	High
Heard			
Mid	*57.5*	42.5	52.5
Low	37.5	*57.5*	27.5
High	5.0	0	*20.0*
N:	40	40	40

Heard as intended: 45%

Words

/p'ææ/ 'raft'
/p'æ̀æ/ 'to spread'
/p'ǽæ/ 'to be defeated'

system whose categories do not coincide exactly with those of the normal tonal system. It is however hard to see a consistent breakdown into categories. Note, for example, the rather different treatment of the rising tone in Tables 1 and 2 even though in both tests there are five response choices.[8]

[8] Chi-square tests show that the overall distribution of responses is significantly different from chance at the 1% level of confidence in Tables 1 and 3; it is barely significant at the 1% level in Table 4 and not significant in Table 2.

The data of Tables 1 through 4 hint that the context-free conditions of the first four tests may have been too severe to allow a by-system of whispered reflexes of tonal categories to emerge clearly, although such a system, without too much of a stretch of the imagination, may seem to be incipient in the matrices. Four more tests were prepared with sets of two and three tonally differentiated words embedded in sentence frames and randomized on magnetic tape. Because of grammatical and semantic constraints, we could not at that time think of any sentence that would accomodate five tonally differentiated words. The confusion matrices for these tests are displayed in Tables 5 through 8. The sentences, key words and glosses are given in the tables. The sentence environments seemed to induce a slight improvement in perception, although it is difficult to quantify the difference.[9] For three of the eight subjects there was a startling improvement. In the test underlying Table 5, one subject had 90% correct.[10] All the other subjects, however, ranged from 40% to 60%, thus accounting for the poor resolution of Table 5. The somewhat better resolution of Table 6 is accounted for by the 100%, 80% and 70% achieved by three other subjects. Once we move to a three-way choice in Tables 7 and 8, we do not find such high individual scores. In Table 7 individual scores range from 33.3% to 60%, and in Table 8 from 33.3% to 80%, the latter achieved by the informant himself. It seems reasonable to infer from these findings that, given a sufficiently long linguistic context, some Thai speakers at least are moderately successful at using phonic features other than pitch to distinguish phonemic tones perceptually.

At this point the question arose as to whether the concomitant features associated with the distinctive pitch contours were simply not as audible in whisper as in phonated speech. To test such a hypothesis it was necessary to expose the subjects to voiced speech which presumably retained the concomitant features but was neutral as to pitch. This was done by passing the sets of spoken words through an 18-channel vocoder at a constant fundamental frequency, i.e., a monotone, of 130 cps.[11] Although some of the concomitant features, e.g., the abrupt amplitude drop of the falling tone, were quite detectable by ear, the four tests yielded no discrimination at all. That is, the eleven subjects either showed chance distributions of responses or assigned nearly all the stimuli to the mid tone when it was one of the response choices. It would seem that the presence of pitch, even if it was a monotone, was too great

[9] Chi-square tests show that the overall distribution of responses is significantly different from chance at the 1% level of confidence in Tables 7 and 8; it is barely significant at the 1% level in Table 6 and not significant in Table 5.

[10] Interestingly enough, the informant correctly identified only 50% of his own productions in this test.

[11] The vocoder is a machine that processes speech, first by analyzing it and then by resynthesizing it. The analyzer separates the speech signal into information about its voiced and voiceless characteristics and its spectrum information, or roughly, into information about activity at the vocal folds versus information about articulation. The synthesizer supplies its own voiced sounds in the form of a buzz and its own voiceless sounds in the form of a hiss. These sounds are shaped by the spectrum information from the analyzer. The result is highly intelligible speech, but with a voice quality that is characteristic of the machine (Dudley, 1939).

TABLE 5

Confusion Matrix of Tones in a Sentence
Number of subjects: 8
Percent Identification

	Whispered	
	Low	Falling
Heard		
Low	*30.0*	32.5
Falling	70.0	*67.5*
N:	40	40

Heard as intended: 48.8%

Sentence frame: /p'ǒm rúu wâà k'un c'ɔ̌ɔp______dii/
'I know you like good______.'
Key words: /k'àaw/ 'news'
/k'âaw/ 'rice'

TABLE 6

Confusion Matrix of Tones in a Sentence
Number of subjects: 8
Percent Identification

	Whispered	
	High	Rising
Heard		
High	*47.5*	15.0
Rising	52.5	*85.0*
N:	40	40

Heard as intended: 67.5%

Sentence frame: /p'ǒm mii______hòk tua/
'I have six______.'
Key words: máa 'horse(s)'
mǎa 'dog(s)'

a distraction for any kind of tonal identification based on other features. The experiment was repeated by resynthesizing phonated versions of the sentences used for Tables 5 through 8 on vocoder buzz to make sure, once again, that the lack of a carrier frame was not dulling the sensitivity of the subjects to such cues as were present in the key words. There was no sharpening of discrimination at all; the results were the same as for the isolated words. These findings are consistent with those of another experiment (Abramson, 1962:131–33 and Figure 3.11), in which the optimum contour for each of the five tones was artificially imposed on each member of a set of five

TABLE 7

Confusion Matrix of Tones in a Sentence

Number of subjects: 8
Percent Identification

	Whispered		
	Low	Falling	Rising
Heard			
Low	*17.5*	52.5	5.0
Falling	5.0	*30.0*	10.0
Rising	77.5	17.5	*85.0*
N:	40	40	40

Heard as intended: 44.1 %

Sentence frame: /pen______/
'It is a______.'
Key words: /sìa/ 'mat'
/sîa/ 'upper garment'
/sǐa/ 'tiger'

TABLE 8

Confusion Matrix of Tones in a Sentence

Number of subjects: 8
Percent Identification

	Whispered		
	Mid	High	Falling
Heard			
Mid	*50.0*	27.5	40.0
High	37.5	*52.5*	10.0
Falling	12.5	20.0	*50.0*
N:	40	40	40

Heard as intended: 50.8 %

Sentence frame: /raw cà paj duu______k‘ɔ̌ɔŋ k’un/
'We will go look at your______.'
Key words: /naa/ 'field'
/náa/ 'mother's younger sibling'
/nâa/ 'face'

tonally differentiated words for identification by Thai listeners. This was done with the Haskins Laboratories' Intonator, a device that enables one to pass speech through the vocoder while at the same time substituting a new fundamental frequency contour for the original one. Ten Thai subjects made nearly perfect identifications of all members of the /naa/ set of words (listed in Table 1) in terms of the synthetic tones rather than the tones of the original unvocoded productions.[12] It is interesting to note that the experimenter himself, in taking this test, was able to recognize nearly all instances of syllables originally spoken on the falling and rising tones by listening for allophonic variations in duration and changes in the course of intensity; yet the native speakers of Thai apparently ignored these features and attended only to the fundamental frequency movements.

Even while providing some interesting information in their own right, the vocoder monotone experiments did not answer the questions for which they were designed. To determine whether the concomitant features of the tones might not be more audible in phonated speech than in whisper it was apparently necessary to strip away the voice and thus remove the distracting impression of pitch. This was done by passing both the isolated words and the sentences through the vocoder once again, but this time with the buzz generator turned off. The outputs of the analyzing channels were modulated instead upon hiss to produce vocoder 'whispering'. In these tests the subjects were told that someone else had done the whispering. The word data are displayed in Tables 9 through 12, and the sentence data [13] in Tables 13 through 15. As we look at the word data in Tables 9 through 12, we find that overall recognition is somewhat better than for the isolated whispered words in Tables 1 through 4.[14] The confusion matrices show that some of the tones, in particular the rising tone, are perceived rather well on vocoder hiss. Also, as before, certain subjects did much

TABLE 9

*Confusion Matrix of Tones in Words**

Number of subjects: 9
Percent Identification

	Resynthesized on Vocoder Hiss				
	Mid	Low	High	Falling	Rising
Heard					
Mid	*13.3*	20.0	0	2.2	0
Low	0	*66.7*	0	0	0
High	60.0	0	*75.5*	26.8	0
Falling	8.9	4.4	2.2	*71.0*	0
Rising	17.8	8.9	22.2	0	*100*
N:	45	45	45	45	45
					Heard as intended: 71.6%

* The same as in Table 1.

[12] Each of the five words, of course, had the synthetic version of its own original tone imposed upon it as well as those of the other four tones making twenty-five stimuli in all. These were recorded four times and randomized into a test order of 100 items.

[13] The sentences of Table 7 were not used for this part of the study.

[14] Tables 9 through 12 are all significant at the 1% level.

TABLE 10

*Confusion Matrix of Tones in Words**

Number of subjects: 9
Percent Identification

	Resynthesized on Vocoder Hiss				
	Mid	Low	High	Falling	Rising
Heard					
Mid	*17.8*	15.6	22.1	24.4	6.7
Low	26.7	*82.3*	28.9	24.4	11.1
High	6.7	0	*0*	0	0
Falling	8.9	2.2	13.3	*51.2*	0
Rising	40.0	0	35.6	0	*82.3*
N:	45	45	45	45	45

Heard as intended: 46.7%

* The same as Table 2.

TABLE 11

*Confusion Matrix of Tones in Words**

Number of subjects: 9
Percent Identification

	Resynthesized on Vocoder Hiss			
	Mid	Low	High	Falling
Heard				
Mid	*35.6*	28.0	20.0	15.8
Low	28.9	*72.0*	15.6	15.8
High	24.5	0	*40.0*	9.1
Falling	11.1	0	24.5	*59.0*
N:	45	43	45	44

Heard as intended: 51%

* The same as Table 3.

better than the others. For example in Table 9, two subjects achieved identification scores of 88% and 80% respectively, while the rest ranged from 64% to 52%. In Tables 10 through 12 the individual scores ranged from 75% down to 6.6%. The sentences also show a somewhat sharper patterning of responses on vocoder hiss than do their whispered counterparts.[15] Table 13 makes it dramatically evident that at least some tonal oppositions in suitable sentence contexts can be reliably distinguished.

[15] Table 13 is significant at the 0.1% level and Table 15 at the 1% level. The distribution of responses in Table 14 is not significantly different from chance.

TABLE 12

*Confusion Matrix of Tones in Words**

Number of subjects: 9
Percent Identification

	Resynthesized on Vocoder Hiss		
	Mid	Low	High
Heard			
Mid	*33.4*	48.8	27.3
Low	4.4	*42.3*	9.1
High	62.2	8.9	*63.6*
N:	45	45	44
			Heard as intended: 45.9%

* The same as Table 4.

TABLE 13

*Confusion Matrix of Tones in a Sentence**

Number of subjects: 6
Percent Identification

	Resynthesized on Vocoder Hiss	
	Low	Falling
Heard		
Low	*91.7*	2.8
Falling	8.3	*97.2*
N:	36	36
		Heard as intended: 94.4%

* The same as in Table 5.

TABLE 14

*Confusion Matrix of Tones in a Sentence**

Number of subjects: 6
Percent Identification

	Resynthesized on Vocoder Hiss	
	High	Rising
Heard		
High	*58.3*	47.2
Rising	41.7	*52.8*
N:	36	36
		Heard as intended: 55.7%

* The same as Table 6.

TABLE 15

*Confusion Matrix of Tones in a Sentence**

Number of subjects: 6
Percent Identification

	Resynthesized on Vocoder Hiss		
	Mid	High	Falling
Heard			
Mid	*36.2*	30.6	8.3
High	11.0	*36.2*	8.3
Falling	52.8	33.3	*83.4*
N:	36	36	36
			Heard as intended: 51.8%

* The same as Table 8.

Table 14, with its chance distribution of responses, is in fact less good than its whispered counterpart in Table 6. This is more apparent in the treatment of the rising tone than in the overall scores. Pending instrumental examination of the stimuli, we can only speculate that the speaker may have considerably enhanced the concomitant features in that particular rendition of whispered /mǎa/. Table 15 indeed shows a patterning of responses — but one that is somewhat different from that of its whispered counterpart in Table 8. It is hard to decide that there is an improvement throughout the confusion matrix, even though the falling tone in particular is now identified correctly 83.4% of the time.

The results of the research presented here indicate that in the context-free setting of isolated words, whispered Thai tones cannot be well identified. As Hockett (1955:17–18) points out in discussing by-systems and marginal cases at the boundaries of language that should not be allowed to complicate one's phonologic analysis, "A whispered utterance mocks the phonologic structure of the same utterance spoken in the normal way, but almost always omits certain contrasts which are functional in normal speech." The responses to the whispered sentences, however, suggest that when the concomitant features of tonal phonemes are embedded in a sufficiently long phonic environment, at least some Thai speakers can do reasonably well at identifying certain tones. The vocoder buzz experiments, both for words and sentences, convincingly demonstrate that these concomitant features are really redundant and probably can never function distinctively in the presence of distracting pitch. This conclusion is supported by parallel work done on the tonal contours of Thai (Abramson, 1962). But the vocoder hiss experiments show that the concomitant features are indeed present in phonated speech and, once the distracting voice is stripped away, are somewhat more audible than in whispered speech.

The poor transmission of tonal features in whispered speech did not seem to warrant a detailed instrumental analysis of the concomitant features for the present natea speecn, tne wnoie iarynx is iikeiy to rise ana iaii witn great cnanges in :hus shortening and elongating the pharyngeal tube; such changes in the length vocal tract will of course affect formant frequencies and thus sometimes, if ormant shifts exceed the psychoacoustic thresholds, cause changes in vowel (Parmenter, Treviño and Bevans, 1933). Auditory phonetic analysis suggests is happens in Thai, but no quantitative data are available. For this to have ect in whispered speech, it is necessary to suppose that the speaker replicates :tions' that he sends in phonated speech to the extrinsic muscles of his larynx :rhaps, muscles of the tongue to make adjustments in vocal tract configuration litate large pitch changes.[16]

ould seem that in Thai and no doubt other tonal languages[17] whispered comition can be ambiguous in short utterances with low redundancy. In longer ices or in short utterances embedded in a conversation or a particular situaie high contextual redundancy plus the tonal distinctions that whispering does e, combine to make whispered communication quite feasible.

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REFERENCES

on, Arthur S.,
"Vocoder Output and Whispered Speech in a Tone Language: Thai", *J. Acoust. Soc. Am.* 31 (1568) A.
The Vowels and Tones of Standard Thai: Acoustical Measurements and Experiments (= *Bloomington: Indiana U. Res. Center in Anthro., Folklore and Linguistics*, Pub. 20).
:, Pierre, Alvin M. Liberman and Franklin S. Cooper,
"Whispered Vowel and [h]: an Acoustic and Articulatory Comparison" (A paper presented at the Ann Arbor, Mich. meeting of the Linguistic Society of America, July 29, 1959).
, Hower,
"Remaking Speech", *J. Acoust. Soc. Am.* 11:169–75.
en, Otto,
Allgemeine und angewandte Phonetik (Berlin Akademie-Verlag).
ranz,
Zur Tonität nordchinesischer Mundarten (Wien-Mödling, Missionsdruckerei St. Gabriel).
"Kann man in einer Tonsprache flüstern?", *Lingua* 5: 372–81.

t this kind of replication happens for voicing distinctions has been at least tentatively estaby transillumination of the larynx (Malécot and Peebles, 1965; Lisker, Abramson, Cooper and 1969).

; statement may not be completely true of a language in which one or more tones are charac-by prominent non-pitch features, such as strong glottal stop. This kind of thing may at least explain the mixed observations of some of the sources cited.

Hockett, Charles F.,
1955 *A Manual of Phonology* (Baltimore, Waverly Press).
Kloster Jensen, Martin,
1958 "Recognition of word tones in whispered speech", *Word* 14: 187–96.
Lisker, Leigh, Arthur S. Abramson, Franklin S. Cooper and Malcolm H. Schvey,
1969 "Transillumination of the larynx in running speech", *J. Acoust. Soc. Am.* 45: 1544–46.
Malécot, André and K. Peebles,
1965 "An Optical Device for Recording Glottal Adduction-Abduction During Normal Speech", *Z.f. Phonetik, Sprachwissenschaft u. Kommunikationsforschung* 18: 545–50.
Meyer-Eppler, E.,
1957 "Realization of Prosodic Features in Whispered Speech", *J. Acoust. Soc. Am.* 29: 104–06.
Miller, Charles Boardman,
1934 "An Experimental-Phonetic Investigation of Whispered Conversation, Considered from the Linguistic Point of View" (Ph.D. dissertation, Hamburg University).
Miller, John D.,
1961 "Word Tone Recognition in Vietnamese Whispered Speech", *Word* 17: 11–15.
Noss, Richard B.,
1954 "An Outline of Siamese Grammar" (Ph.D. dissertation, Yale University).
Panconcelli-Calzia, G.,
1955 "Das Flüstern in seiner physio-pathologischen und linguistischen Bedeutung", *Lingua* 4: 367–78.
Parmenter, C.E., S.N. Treviño and C.A. Bevans,
1933 "The Influence of a Change in Pitch on the Articulation of a Vowel", *Language* 9: 72–81.
Segerbäck, Börge,
1966 *La réalisation d'une opposition de tonèmes dans des syllabes chuchotées: étude de phonétique expérimentale.* (= *Travaux de l'Institut de Phonétique de Lund*, IV) (Lund: Gleerup).
Wise, C.M. and L.P.H. Chang,
1957 "Intelligibility of Whispering in a Tone Language", *JSHD* 22: 335–38.
Zemlin, Willard R.,
1964 *Speech and hearing science: anatomy and physiology* (Champaign, Ill.: Stipes).

SIMON BELASCO

PHONEMICS AS A DISCOVERY PROCEDURE IN SYNCHRONIC DIALECTOLOGY

In recent years, the development of generative grammar has seriously brought into question the value of positing classical — sometimes called taxonomic or autonomous — phonemics as a separate level of linguistic structure. It is maintained that such a level is not incorporable into a descriptively adequate grammar, since it denies that phonetic processes are in part dependent upon syntactic and morphological structure (Chomsky, 1964:110–11; Chomsky and Halle, 1968:114–19; Postal, 1968: 240–44).

Following Postal, we shall call the autonomous approach: P1, which is the view that NO information about word and morpheme boundaries, morphological and syntactic categorizations, morphophonemic alternation, etc. is relevant for the determination of phonological structure. The alternative view, where SOME reference to non-phonetic morphophonemic and/or superficial grammatical structure is relevant will be termed the non-autonomous approach: P2. Another possibility, the inseparable approach: P3, is the view that ALL grammatical information is relevant in a phonological analysis. Since P3 has never really been maintained by anyone, it will not be mentioned any further in this study.

Let us assume that P2 is the correct approach. As part of such an approach, generative phonology posits two levels: one 'systematic phonemic' — most recently termed a "phonological representation" (Chomsky and Halle: 1968:11) — and the other 'systematic phonetic' — also called a 'phonetic representation'. Roughly speaking, the output of the syntactic component (a proper labeled bracketing of a string of formatives) is connected to the phonological component by the application of a series of 'readjustment rules'. The result of this operation is the creation of the systematic phonemic level, the entire process being called a 'surface structure'. A system of phonological rules relates surface structures to phonological representations. In other words, the systematic phonetic level is derived from the systematic phonemic level by a set of fixed rules that apply in a fixed manner determined by the labeled bracketing of the surface structure. No linguistic significance is assigned to an intermediate 'classical phonemic' level between the systematic phonemic and the systematic phonetic levels.

The case against an intermediate 'autonomous' level is best exemplified by the arguments set forth by Paul Postal (1968:7–24). Briefly, they go something like this. All linguists agree that a phonological analysis should distinguish free variants from contrasting utterances. Given two utterances, such as [bin] and [pin], that may occur in two different languages, it is not possible to infer whether these utterances contrast or are in free variation in either language from their phonetic representations alone.

A systematic, i.e., generative, grammar assigns two distinct phonetic representations, such as [kat] and [kaḷ], to the same free variation set, making them noncontrastive utterances, just in case the phonological rules derive them from "the same single input systematic phonological representation and not otherwise" (Postal, 1968: 14). Thus, omitting certain irrelevant details, Table 1 shows that the systematic

TABLE 1

(After Postal, 1968)

Systematic Phonemic	*Autonomous Phonemic*	*Systematic Phonetic*
a. *#kat#*	c. /kat/	b. [kat] b'. [kaḷ]
	#t# Sys. Phonemic	
	[t] [ḷ] Sys. Phonetic	

phonetic representations b. [kat] and b'. [kaḷ] may be directly related to the systematic phonemic representation a. *#kat#*, i.e., they are in free variation and are non-contrastive, without the mediation of the autonomous phonemic representation c. /kat/. Table 2 illustrates an objection by Postal (1968:20–22) to Sydney Lamb's (1964:75–76) claim that autonomous representations are essential in order to indicate the lack of voiced : voiceless contrast in final position in certain Russian utterances. According to Postal, items b1. [...ot...] and b2. [...ot...] are free variants because they are phonetically identical, whereas b3. [...ada...] and b4. [...ata...] are contrastive "because there is no single systematic structure to which they may be assigned" (Postal, 1968:24). In other words, the feature 'voice' is predicted as distinctive or contrastive in intervocalic (but not in final) position because the phonological rules do not derive systematic phonetic intervocalic [t] and [d] from some SINGLE systematic intervocalic phoneme. Since the facts concerning free variation and contrast can be read off directly from the two systematic levels, then autonomous representations such as c3. /...ada.../ and c4. /...ata.../ are redundant. As long as no motivation exists for reading the facts off from one level instead of two levels, there are once again "no grounds whatever for including autonomous phonemic representation in a linguistic description" (Postal, 1968:22).

If circumstances turned out to be as typical and as simple as those depicted in Tables 1 and 2, then investigations in synchronic dialectology would be a relatively easy matter. In the first place, a dialectologist cannot wait until he has made an

TABLE 2

(After Lamb and Postal)

Systematic Phonemic	*Autonomous Phonemic*	*Systematic Phonetic*
a1. ...*od*...	c1. /...ot.../	b1. [...ot...]
a2. ...*ot*...	c2. /...ot.../	b2. [...ot...]
a3. ...*ada*...	c3. /...ada.../	b3. [...ada...]
a4. ...*ata*...	c4. /...ata.../	b4. [...ata...]

d *t*	*d*	*t*	Sys. Phonemic
[t]	[d]	[t]	Sys. Phonetic

exhaustive analysis of the syntactic, if not the semantic, structure of a language before he learns the facts about free variation and contrast.[1] In the second place, even if he intends to incorporate P2 in a finalized version of a total linguistic description, he is still faced with the necessity of developing an effective discovery procedure that leads from the accumulated phonetic data to the best phonemic system.

To show that the circumstances are more complicated than those depicted in Tables 1 and 2, let us first compare the systematic phonetic data in Table 2 with the phonetic data in Table 3, representing an American dialect which we may call South Philadelphianese. In Table 2 the phonetic data show BOTH [t] and [d] in intervocalic position but ONLY [t] in final position. In Table 3 there is no phonetic [s] or [z] that occurs

TABLE 3

(After Belasco)

Phonetic Data for South Philadelphianese (circa 1930)

Final Position	*Intervocalic Position*	*Initial Position*
becauṣe [...s]	partiṣan [...s...]	zeppelin [z...]
becauṣe [...z]	partiṣan [...z...]	zeppelin [s...]
fuṣṣ [...s]	citiẓen [...s...]	sink [s...]
fuẓẓ [...z]	citiẓen [...z...]	sink [z...]
cloṣe [...s]	Joṣeph [...s...]	sip [s...]
cloṣe [...z]	Joṣeph [...z...]	sip [z...]
Japan̲ese [...s]	reṣourceful [...s...]	soup [s...]
Japan̲ese [...z]	reṣourceful [...z...]	soup [z...]
	razor [...z...]	sue [s...]
	racer [...s...]	zoo [z...]
	cussin' [...s...]	zip [z...]
	cousin [...z...]	sit [s...]
	classy [...s...]	
	jazzy [...z...]	

[1] Establishing MEANINGFUL communication with NON-SOLICITED informants can be a matter of life and death in the field. The possibility of eventually formulating a completed linguistic description may depend upon how rapidly such factors as contrastive and freely varying utterances are determined. For dramatic incidents suggesting what problems may be involved, see Wallis, 1960.

in one environment ONLY, i.e., phonetic [s] and [z] occur in BOTH final AND intervocalic position.[8] Then some procedure must be established to show that phonetic [s] and [z] in the two pronunciations of utterances such as *because*, *partisan*, *citizen*, *Joseph* derive from some SINGLE systematic phoneme in each of the two environments: final and intervocalic; whereas phonetic [s] in *fuss*, *cussin'*, *classy* only derives from systematic phonemic *s* in final and intervocalic position, and phonetic [z] in *fuzz*, *cousin*, and *jazzy* only derives from systematic phonemic *z* in these same two environments.

To a dialectologist familiar with English, this may not present a major problem. There is nothing to prevent a language, however, from having two or more series of words that DO NOT constitute a predictable subdivision of the lexicon, such as [+native] or [+Romance] words, where two phones may be in free variation in the words of one series, and may contrast in the words of another series in exactly the same environments. The problem of assigning phonetic data to systematic phonemic structure is even more difficult when the dialectologist is confronted by utterances involving sandhi variation in a strange language. Some idea of the problem may be gotten from the examples in Table 4. These examples are typical of certain English dialects.

TABLE 4

Phonetic Data for South Philadelphianese

a. *Amina* [aminə] as in *Amina* (*I am going to*) go.
b. *Whadiya* [wʌdijə] as in *Whadiya* (*What do you*) want?
c. *Whadya* [wʌdjə] as in *Whadya* (*What did you*) want?
d. *Whacha* [wʌčə] as in *Whacha* (*What do you*) say, Joe?
e. *Whaja* [wʌǰə] as in *Whaja* (*What did you*) say, Joe?

For example, item a. [aminə] is not usually identifiable out of context. Item b. [wʌdijə] (present tense) is distinguished from item c. [wʌdjə] (past tense) by the occurrence of phonetic [i] in the former. Item d. [wʌčə] (present tense) is distinguished from item e. [wʌǰə] (past tense) by the occurrence of phonetic [č] in the former and phonetic [ǰ] in the latter. Note that items d. and e. ([wʌčə] : [wʌǰə]) differ by only one phone and ARE contrastive. On the other hand, items c. and e. ([wʌdjə] : [wʌǰə]) differ by only one phone and ARE NOT contrastive. Note further that TWO DIFFERENT SEQUENCES pronounced 'ideally' as 'what do you' and 'what did you' may as a result of sandhi variation have phonetic representations that constitute a minimal pair [wʌčə] : [wʌǰə], whereas A SINGLE SEQUENCE pronounced 'ideally' as 'what do you' normally DOES NOT have sandhi representations that constitute a minimal pair [wʌdijə] [wʌčə].

When a dialectologist works with unfamiliar languages, he encounters morphophonemic problems of far greater magnitude. Assigning phonetic utterances to systematic phonemic structure is not impossible, but he will have to rely on some dis-

[8] To facilitate the exposition, we shall omit the phonetic data relating to [s] and [z] in initial position.

covery procedure that will enable him to determine free variation and contrast between utterances, on a level lower than the still-to-be-determined systematic phonemic level, meeting the conditions of descriptive and explanatory adequacy. This is not to say that such a lower level may not be eliminated in the later stages of a completed linguistic description.

When I say a lower level, I do not mean the phonemic level that is identical to the notion widely held by classical phonemicists. In 1959, I pointed out that phonemic analysis of complex distributional data may not be effectively carried out solely on the basis of complementary distribution, phonetic similarity, and pattern congruency (Belasco, 1959:269). Too often complications arise when more than one phonemic grouping is possible with phonetically similar phones in free variation or complementary distribution. A case in point (cf. Table 5) is Bernard Bloch's phonemic grouping

TABLE 5

(After B. Bloch)

Japanese Conservative Dialect

Contrast	*Free Variation*	*Complementary Distribution*
[f] : [x̲]	[f] : [h] [h̲] : [x̲]	[h] : [h̲] [f] : [h̲]
	[f] + [h] + [h̲] = /h/ [x̲] = /x/	

of "spirants" in one of his celebrated "Studies in Colloquial Japanese" (Bloch, 1950: 113). A short voiceless bilabial or labiodental spirant [f], a short voiceless glottal spirant [h], and a short voiceless palatalized glottal spirant [h̲] are all grouped in the same phoneme /h/ on the basis of phonetic similarity. The phone [f] is in free variation with the phone [h] which is in complementary distribution with the phone [h̲]. However, there is a short prevelar spirant [x̲] which is said to contrast with the phone [f] and therefore is assigned to a different phoneme /x/ — despite the fact that phone [x̲] is always in free variation with phone [h̲]. In other words, all four phones are phonetically similar, i.e., they are spirants, and [h̲] is grouped with [f] and [h] because they are all "strongly pulsed voiceless onsets of a following vowel or semivowel", (Bloch, 1950:94), whereas [x̲] is "produced with contact between the back of the tongue and the forward part of the soft palate" (Bloch, 1950:113). But such phonemic grouping is untenable, since [x̲], which varies freely with [h̲], contrasts with [f], which varies freely with [h].[3] The procedure we intend to propose will rightly group [f] and [h] as allophones of one phoneme, and [x̲] and [h̲] as allophones of a different phoneme.

[3] Equally untenable is the position taken by Austin (1957: 542), wherein he maintains that his unidimensional principle requires that phonetically similar phones grouped as allophones "have point of articulation or manner of articulation in common, but never both". For a discussion of this point relating to Bloch's grouping of spirants, see Belasco, 1959: 278, footnote 16.

This procedure DOES NOT make the claim that two phonetically similar phones that share no environments, i.e., that are in complementary distribution, are necessarily allophones. There is no basis for recognizing the principle of complementary distribution as scientifically motivated. It is for the most part arbitrary and without empirical justification. Nor do we claim that two phonetic representations which are free variants necessarily have identical phonemic representations. They may contain non-contrasting segments. The term 'non-contrasting' is used here in a special sense. Two NON-CONTRASTING phones are not necessarily allophonic. The term implies free variation but does not imply that two phones cannot contrast elsewhere in the same or different environments. Two segments which are allophonic are NON-CONTRASTIVE. Thus, non-contrasting phones may be either allophonic segments or freely varying non-allophonic segments. It is then possible to refer to a state of free variation between two phones without involving their phonemic status.

A comparison of two utterances, such as [bin] : [pin] or [nip] : [nip'], that appear to differ by one feature, [lax] : [tense] or [non-aspirated] : [aspirated], may or may not constitute a minimal pair. Actually, any difference between two phones in a comparison may be placed in one of three mutually exclusive categories. Either the differences are (1) distinctive or (2) non-distinctive. If they are non-distinctive, they may be sub-categorized as (2a) allophonic or (2b) irrelevant.

There has been much discussion in the literature recently concerning linguistic universals, both substantive and formal. It is fashionable to speak of a theory of universal phonetics that specifies the class of possible phonetic representations of sentences "by determining the universal set of phonetic features and the conditions of their possible combinations" (Chomsky and Halle, 1968:4–5). Suppose we assume that a universal set of phonetic features does exist. It is a fact that all human societies communicate by speaking rather than — let us say — by tweaking the ears or blowing through the nose. The number of possible speech sounds that can be made are confined within the vocal apparatus to all possible movements of all possible organs involved in articulation. Since all languages past, present, and future are not available for analysis, we cannot be certain of all the possible combinations of speech sounds. Nor can we be certain that a complete inventory of the set of phonetic features has yet been made.[4]

What is common to all language is the fact that each sound or sequence of sounds is uttered as part of a time continuum. As such, speech is linear. Linguists have adopted the practice of dividing sequences of sounds into discrete elements for convenience of reference, and then they compare two or more sequences to determine

[4] One only has to consider how many times distinctive feature theory and its relation to acoustic and articulatory correlates has undergone revision to appreciate the fact that the theory has yet to be stated in definitive form. (cf. footnotes and references in Postal 1968; Chomsky and Halle 1968). The recent concept of MARKEDNESS resembles a probabilistic criterion more than a universal criterion, e.g., the unmarked member of a pair of segments (1) OCCURS MORE FREQUENTLY, (2) MOST LIKELY OCCURS FIRST in language acquisition, (3) APPEARS OFTEN in neutralized environments (cf. Schane, 1968: 714–15).

where they differ and where they are the same.[5] The factors of free variation and contrast apply to selected points or positions within paired continua.

We shall adopt this procedure as well as the test of segment substitutability, which involves the commutation of phonetically similar segments in common environments, of paired or phonetically similar utterances, to determine whether the original utterances undergo a change in meaning. If a change in meaning DOES occur in one of two compared utterances, then the phones are CONTRASTIVE. If no change in meaning occurs, the phones are NON-CONTRASTING. In the event that two phones share no common environment, their status may be ascertained from the relationship with some third phone with which they DO share a common environment. Despite claims to the contrary (Postal, 1968:28), we shall maintain that the discovery of phonetically minimal pairs does permit a conclusion about underlying phonological contrast. However, following Chomsky (1964:97), we shall insist that the notion of minimal pair be defined only in terms of a completed phonemic analysis. Thus the basis for allophony is inherent not only in the relationship between two phones, but between one phone and every other phone in the dialect undergoing analysis. This means that all environments have to be taken into consideration. Furthermore no segment is an allophone of a phoneme $\underset{\sim}{x}$ if it contrasts with any allophone of /x/ or if it is allophonic with any segment which contrasts with an allophone of /x/. Thus, the determining factor that allophony exists between two phones is NOT that they are phonetically similar, or in free variation, or in complementary distribution. The determining factor is ABSENCE OF CONTRAST BETWEEN PHONES.

We can make this claim because a phonological system is a closed system that is limited to a set of universal relationships existing between the range of one segment and the range of every other segment in the system. We use the term RANGE here to mean the total number and kinds of environments in which a phonetic segment, i.e., a phone, occurs. The environments of phones are made up of phones. It is subsumed that phones are composed of phonetic features. When one phone in an utterance appears to be different from a phone in another utterance and the phones share a common environment, then the difference is either distinctive, non-distinctive allophonic, or non-distinctive irrelevant.

Table 6A is in the form of a matrix and illustrates the universal relationships for a phonological system. The rows labeled 'identical', 'mixed y', 'mixed z', and 'different' indicate the possible 'general' 'relationships' between the ranges of any pair of phones. The circles are called Euler circles or Venn diagrams. The letters *a* and *b* represent phones. When phones *a* and *b* occur in a single circle, it means that their ranges are exactly the same, i.e., the phones have identical environments. The

[5] Few linguists, if any, harbor the illusion that phones or phonemes may be isolated as discrete entities, either from an articulatory or an acoustic point of view. Speech-sound investigations experimenting with bursts of noise, consonant-vowel transitions, variations in formant intensity, etc., belie any such notion. For some discussion, see Joos, 1948; Schatz, 1954; Liberman *et al.*, 1954; Delattre *et al.*, 1955, 1967; Moulton, 1968.

TABLE 6A

The Universe for a Phonological System

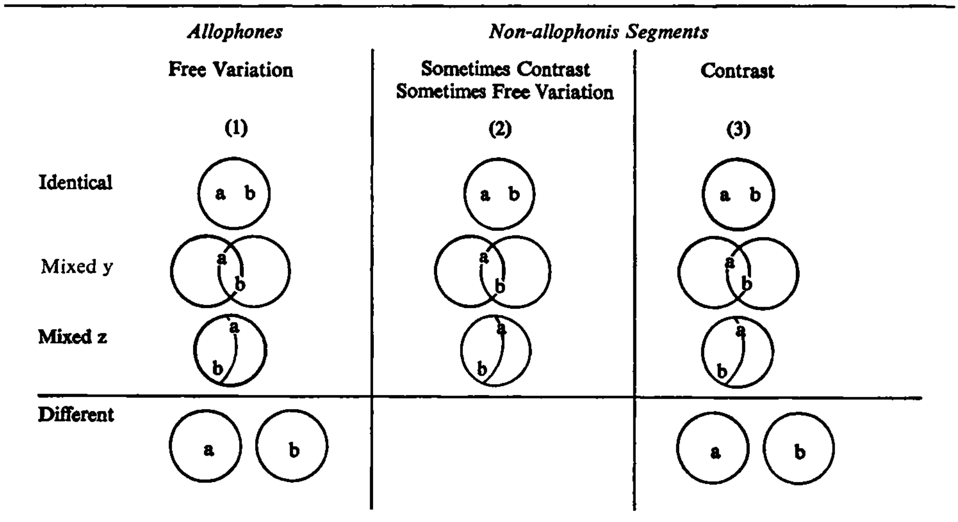


TABLE 6B

	Allophonic	Non-allophonic Segments	
	(1)	(2)	(3)
Identical	Intersection x	Saturation x	Correspondence
Mixed y	Intersection y	Saturation y	Overlapping
Mixed z	Intersection z	Saturation z	Incorporation
Different	Complementation		Isolation

set of environments shared by two phones is termed the PARS COMMUNIS; the set of environments not shared make up the PARS PROPRIA.[6] Thus the phones *a* and *b* share a *pars communis*, but neither has a *pars propria* when their ranges are 'identical'. When their ranges are in 'mixed y' relationship, *a* and *b* share a *pars communis* and each phone has a *pars propria*. In 'mixed z' relationship, *a* and *b* share a *pars communis*, but only *a* has a *pars propria*. Of course the relationship is still 'mixed z' if *b* is assigned the *pars propria* instead of *a*, provided *a* and *b* still share a *pars communis*. When the ranges of *a* and *b* are 'different', they each have a *pars propria* and share no *pars communis*.

The test of segment substitutability (or commutation test) can only be performed

[6] The terms *(pars) communis, propia*, as well as coincident, overlapping, and relative distribution are used in Bloch 1953, but not in the way we use them.

when two phones have at least one environment in common, i.e., when the ranges of two phones are either in 'identical', 'mixed y', or 'mixed z' relationship. For the time being, let us restrict our remarks to these three relationships, omitting the relationship 'different' from the discussion.

Table 6A applies to the ranges of phones in a 'complete' corpus. The numbers 1, 2, 3 (precise relationships) above the columns indicate the allophonic status of the phones AFTER the test of segment substitutability has been applied to ALL utterances in the corpus in which the phones have one or more environments in common. Thus, 3 means that for a given dialect every time phone *a* in one utterance has been substituted for phone *b* in another utterance or vice-versa, the utterances in question have changed meaning. For example, if the [s] in [fʌs] is replaced by the [z] in [fʌz], then the meaning of this word changes. It makes no difference what the word originally meant. It has a different meaning as a result of the substitution test. This is then a case of CONTRAST, and the phones *a* and *b* are not members of the same phoneme, i.e., are not allophones.

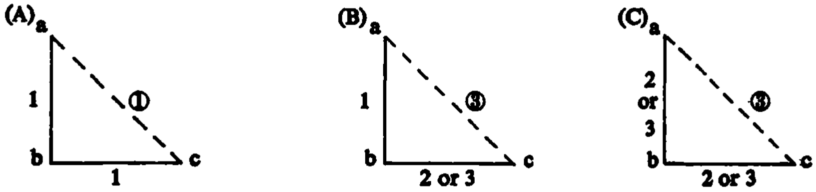
There is an important point to be made here. The substitution of [z] for [s] could have resulted in gibberish, in which case there WOULD NOT have been contrast. For example, the [s] in [kriys] *crease*, when replaced by [z], would result in the word [kriyz] **creaze* — a nonsense word. This would not represent a case of contrast. The word is just declared as gibberish and omitted from consideration. Nevertheless, to qualify for status 3, i.e. contrast, all the examples of the commutation test either produce contrast, i.e., produce a change in meaning, or result in gibberish but NEVER in free variation. The feature responsible for contrast in this instance, is VOICE, i.e., the distinctive difference is due to the opposition [−voice] : [+voice] IN ALL THE ENVIRONMENTS THAT THE PHONES SHARE.

For the column headed 2, the commutation test for all utterances of a given dialect must result in BOTH contrast AND free variation, and possibly gibberish. For example, a complete inventory of the utterances involving commutation of [s] and [z] in the environments shared might produce CONTRASTS such as [fʌs] : [fʌz] (*fuss* : *fuzz*), [reysɨr] : [reyzɨr] (*racer* : *razor*), [suw] : [zuw] (*sue* : *zoo*) AND FREE VARIATION such as [biykəs] : [biykəz] (*because*), [sitisin] : [sitizin] (*citizen*), [suwp] : [zuwp] (*soup*), and possibly gibberish [klæsiy] : *[klæziy], *[ǰæsiy] : [ǰæziy]. The last two pairs of utterances will have no bearing on the allophonic status of phones [s] and [z] and will of course be discarded. When the ranges of two phones of a dialect indicate either status 2 or 3, the phones are non-allophonic and are NOT grouped in the same phoneme. Note that CONTRAST is the determining factor here, NOT FREE VARIATION.

For the column headed number 1, no contrast of any sort ever obtains. Every case of commutation will produce free variation, and possibly gibberish, in every environment shared by two phones. THEN and ONLY THEN can the phones be said to be allophones of the same phoneme.

Let us return to the general relationship in Table 6A, which shows the ranges of the phones *a* and *b* to be different, i.e., they never share a pars communis. In the event that two phones do not share a single environment, their status may be ascertained by the triangle method indicated in Table 7. The solid lines in triangles A, B, and C indicate the allophonic status of phones which have already been ascertained by the commutation test. The broken line connects two phones which do not share a common environment. Another possibility exists with the broken line which we shall discuss later. Thus, for triangle A in Table 7, phones *a* and *b* have the relationship 1

TABLE 7



(only free variation, no contrast), phones *b* and *c* have the relationship 1, therefore phones *a* and *c* have the relationship ①. For triangle B, phones *a* and *b* have the relationship 1, phones *b* and *c* may have either the relationship 2 (BOTH free variation AND contrast) or 3 (contrast but no free variation), therefore phones *a* and *c* have the relationship ③.[7] For triangle C, it is not possible to establish the relationship between phones *a* and *c* because phone *a* is non-allophonic with *b*, and *b* is non-allophonic with *c*, therefore the status of phone *c* is in doubt. In order to use the triangle method, AT LEAST ONE of the legs of the triangle with a solid line must indicate the relationship 1.

Let us return to the problem involving the Japanese spirants. Table 5 shows that [h̲] shares no common environment with [h] or [f], and according to Bernard Bloch [h̲] varies freely IN EVERY WORD with phone [x̲]. Phone [x̲] contrasts with phone [f] which varies freely with phone [h]. Thus if allophones of a phoneme may never contrast, then the relationships between the spirant phones are correctly shown by the triangles in Table 8. In triangle A of Table 8 [h̲] and [x̲] are allophonic, [x̲] and

TABLE 8

(After Belasco 1959)

Japanese Conservative Dialect

[7] The precise relationship involving the broken line of the triangle can never be ②, since the pair of phones involved cannot share at least one environment and never therefore be in free variation.