added to the picture enables the viewer to track the speech gestures with good reference to the sounds. This can be realized by means of a vocoder used with a multitrack tape recorder to stretch the speech and maintain synchronization with the picture. A short film demonstration accompanies the paper. [This work was supported in part by Public Health Service research grant DE-01774, National Institute of Dental Research, National Institutes of Health, U. S. Department of Health, Education, and Welfare; and in part by contract SAE-8324 with the U. S. Office of Education.]

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J2. Cinéradiographic Studies of Speech: Procedures and Objectives. S. E. G. ÖHMAN, *Royal Institute of Technology, Stockholm, Sweden,* AND K. N. STEVENS, *Massachusetts Institute of Technology, Cambridge 39, Massachusetts.*—Simultaneous sound recordings and cinéradiographic films showing lateral views of the speech mechanism have been obtained for a variety of utterances generated by several speakers. Procedures are described for making frame-by-frame tracings from the films and for obtaining from these tracings quantitative data on the movements of the various speech-generating structures. Interpretation of these data is discussed in terms of several objectives: (1) obtaining further understanding of the relations between the positions of the articulatory structures, vocal-tract configurations, and acoustic outputs; (2) examining the dynamic properties of the various components of the articulatory mechanism and the interrelations among the movements of these components; and (3) gaining an understanding of the transformation from a discrete linguistic description of speech to the continuous motions of the articulatory structures. Attention in this paper is centered on the second of these objectives, and, in particular, data on the relative movements of various parts of the tongue and of the structures in the vicinity of the larynx for several vowel–consonant and consonant–vowel combinations are presented and discussed. A short film is shown to illustrate certain features of the data.

J3. Features of Coarticulation in VCV Utterances. S. E. G. ÖHMAN, *Royal Institute of Technology, Stockholm, Sweden.*—Spectrographic and cinéradiographic data on voiced stops in V–V context are presented. The data suggest that (1) the neural signals controlling the activity of the vocal structures during V–stop–V utterances do not occur as a discrete time sequence corresponding to the graphic sequence of phoneme symbols; (2) the articulatory response to the neural instruction for the stop is superimposed on the initial portion of the response to the instruction for the following vowel; (3) the vocal-tract-shape target for the stop is not unique and depends on the V–V context as a whole; and (4) the formant loci of a stop+vowel (vowel+stop) syllable may be shifted along the frequency scale by a preceding (following) vowel. Interpretation of the data in relation to a dynamical model of speech production are discussed.

J4. Vowel Identification and Phonetic Contexts. OSAMU FUJIMURA AND KAZUO OCHIAI (nonmember), *University of Electro-Communications, Chofu, Tokyo, Japan.*—Confusions in the perceptual identification of vowel samples taken out of various phonetic environments have been examined. Japanese words were uttered by a female speaker. The central portions of vowels within the words were electronically gated out for a 50-msec duration, including tapered ends. For each of five Japanese vowels, fifteen samples out of different environments were prepared, and 75 samples in total were arranged in randomized orders for forced-judgment-identification tests. The result showed a considerable amount of confusion for some vowels uttered in certain phonetic environments. Some appreciable effects upon the score were also observed when the subjects had been trained in different ways immediately preceding the listening tests. The result, in general, conforms with explanations in terms of articulatory movements, previously reported formant data, and some other factors that would influence the subjects' judgments.

J5. Electromyographic Study of Timing in Vowels. PETER F. MACNEILAGE (nonmember) AND GEORGE N. SHOLES (nonmember), *Haskins Laboratories, New York, New York.*—Patterns of electrical activity in the tongue musculature can be matched with the component features of a phonetic description of the vowels. When an English vowel is short and simple, e.g., /ɪ/, activity patterns are observed to occur more or less simultaneously. When a vowel is longer and more complex, e.g., /i, ɑɪ/, a particular activity pattern will occur earlier or later, depending on the vowel. But we find that some longer vowels, e.g., /e/, occupy a middle ground between vowels that are clearly simple, such as /i/, and those that are clearly diphthongs, such as /ɑɪ/. Theoretical commitments will determine whether these intermediate cases fall into one category or the other, or whether they illustrate yet a third category of diphthongizing vowels. We briefly explore some of the considerations that would lead to the last interpretation. [This investigation was supported in part by Public Health Service research grant DE-01774, National Institute of Dental Research, National Institutes of Health, U. S. Department of Health, Education, and Welfare.]

J6. Visarga Vowels. B. V. BHIMANI, *Bhimani Research Associates, Lexington, Massachusetts.*—Visarga is a class of vowels defined by Sanskrit phoneticians as ones that are coarticulated with "h" or aspiration. This class of vowels is not mentioned among most European and American vowel sounds and it has not been referred to in phonetic–acoustic studies. However, it could occur occasionally in any language, as in *December* spoken by an Englishman. For generation of visarga, the position of cheeks, tongue, and lips are the same as those for the vowel of its form. The only difference between a visarga and a normal vowel is that there is a steady flow of air from the vocal flaps for the former, whereas there is a significant periodic interruption of such a flow for the latter. The formant-frequency levels of both the above types of vowel sounds are expected to be approximately the same. However, the formant bandwidths of visarga vowels are wider than those of normal vowels, the energy in formants is lower for visarga than it is for normal vowels, and more fricative energy is expected with visarga than with normal vowels. [This work was supported by Air Force Cambridge Research Laboratories, U. S. Office of Aerospace Research, under contract No. AF 19(628)-2766.]

J7. Crosslanguage Study of Voicing in Initial Stops. LEIGH LISKER* AND ARTHUR S. ABRAMSON,† *Haskins Laboratories, New York, New York.*—In describing the phonemes of a language, phoneticians often find it useful to divide them into "voiced" and "voiceless" categories. For stop consonants, some languages are said to utilize aspiration in conjunction with voicing to yield two, three, or four categories, while in some few languages categories are said to be distinguished solely by differences in aspiration. Some phoneticians, moreover, speak of strongly articulated (fortis) and weakly articulated (lenis) categories. Earlier work has shown that the two English categories /ptk/ and /bdg/ can, in initial positions, be distinguished acoustically by a difference in the time interval between the burst that marks stop release and the onset of periodicity that reflects laryngeal vibration. This measure of voice-onset time was applied to eleven languages that vary in the number and phonetic description of their initial-stop categories. In all these lan-