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# DISCRIMINABILITY ALONG THE VOICING CONTINUUM: CROSS-LANGUAGE TESTS\*

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In psychoacoustic experiments with speech and speech-like stimuli it has been found that listeners' ability to detect differences along a physical continuum of variation depends on their assignment of the stimuli to linguistic categories. Data on stops in synthesized stop-vowel syllables show that the stimuli are distinguished only if they are assigned to different phonemes;<sup>1</sup> however, such studies have been confined to English. In going into cross-language testing,<sup>2</sup> we asked two questions: (1) Is discrimination sharpened at the margins of the labelling distribution for a phoneme? (2) Is discriminability shaped by specific language experience, or does it imply general phonetic categories? Voice onset time (VOT) is of interest here because many languages use VOT, in similar but not identical ways, to distinguish either two or three stop categories.<sup>3</sup>

For this study we used a set of the stimuli prepared for the identification experiments described in the accompanying paper. Using a parallel resonance synthesizer, we made 31 syllables consisting of labial stops plus a vowel of the type [a]. VOT varied in ten msec. steps from 150 msec. (—150) before the burst, to 150 msec. (+150) after the burst. We presented these variants in triads for discrimination. In each triad two stimuli were identical and one was different. The task was to decide whether the odd one was in first, second or third position. The triads were made by pairing stimuli at two-, three- and four-step intervals along the VOT continuum, thus comparing VOT differences of 20, 30 or 40 msec. Each comparison was arranged in six permutations

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<sup>1</sup> A. M. Liberman, K. S. Harris, H. S. Hoffman, & B. C. Griffith. "The Discrimination of Speech Sounds within and across Phoneme Boundaries", *J. Exptl. Psych.* 54 (1957), 358—368.

<sup>2</sup> See also K. N. Stevens, A. M. Liberman & M. Studdert-Kennedy, "Cross-Language Study of Vowel Perception".

<sup>3</sup> L. Lisker & A. S. Abramson, "A Cross-Language Study of Voicing in Initial Stops: Acoustical Measurements". *Word* 20 (1964), 384—422.

(AAB, ABA, BAA, etc.) for a total of 504 triads. Six randomly ordered test series were made with only one of the six permutations in each series. The six series were split into twelve tapes of 42 triads each. Over a three-month period these tapes were played, along with identification tests, to native speakers of Latin American Spanish, American English and Thai. We shall examine the pooled data of the subjects and then remove individual differences by focusing on single subjects.

For Spanish we must report that the results are unclear. The pooled data of the six subjects do show an increase in acuity of discrimination above chance level (33.3%) in the phoneme boundary region, but there are other peaks along the continuum. The Spanish subjects often failed to discriminate between variants that they consistently distinguished in the identification tests; therefore, we believe that these results neither support nor deny the hypothesis that discrimination is more acute in the region of the phoneme boundary. Rather it seems that our Spanish speakers were not well prepared for the task. We did not communicate with them very well despite instructions written in Spanish. We hope to establish better rapport with new subjects and repeat the experiment.

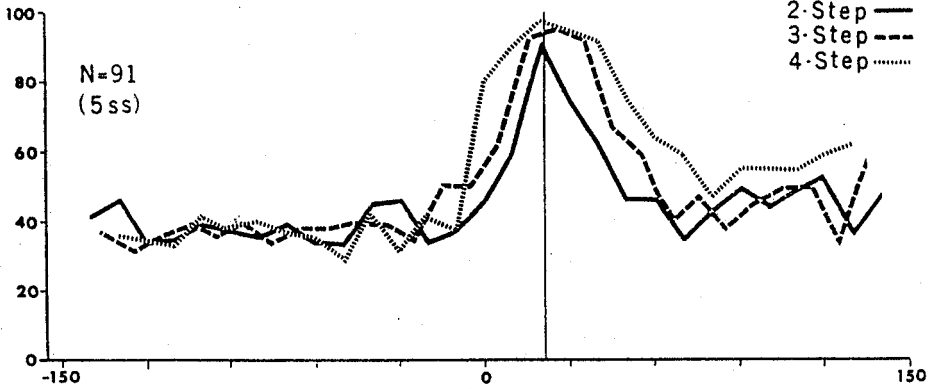
The English data (Fig. 1) are clear. In the pooled data and in the graphs for two single subjects, peaks of discrimination match the phoneme boundaries established by the identification tests and indicated by the vertical lines. Discrimination is acute at all three levels of difficulty. Indeed, subject LR reaches 100% at all three levels, although the peak is flattened to a plateau at 100% only for the four-step level. The small peak for extreme values of voicing lag requires comment. Possibly this portion of the VOT dimension is near the end of the range for English /p/, bordering on non-speech sounds. We might also speculate that this small peak reflects a boundary of another type, /p/ followed by /h/ across a morpheme or word boundary. This occurs in, e.g., "Is the mop hot?" Our stimuli were not designed for such a context, but the subjects may be vaguely aware of phonetic features appropriate to a word boundary. Furthermore, there is the possible effect of the changing duration ratio between voicing lag and vowel phonation. As lag increases, the syllable duration remains fixed, but the subject's judgment of length may change enough to affect his discrimination.

The responses of the Thai group and two individuals are shown in Fig. 2. Thai has three categories of labial stops on the VOT dimension. The phoneme boundaries, shown by the vertical lines, are well-matched by the discrimination peaks. In the pooled data the two phoneme boundaries are at  $-20$  and  $+40$  msec. For subject UJ they are  $-10$  and  $+45$  msec, and for OK,  $-35$  and  $+30$  msec. The differences in the boundaries are largely reflected by the discrimination peaks. The small peak at extreme values of lag cited for English is also apparent here, especially for UJ. The explanations offered for English can also be advanced for Thai.

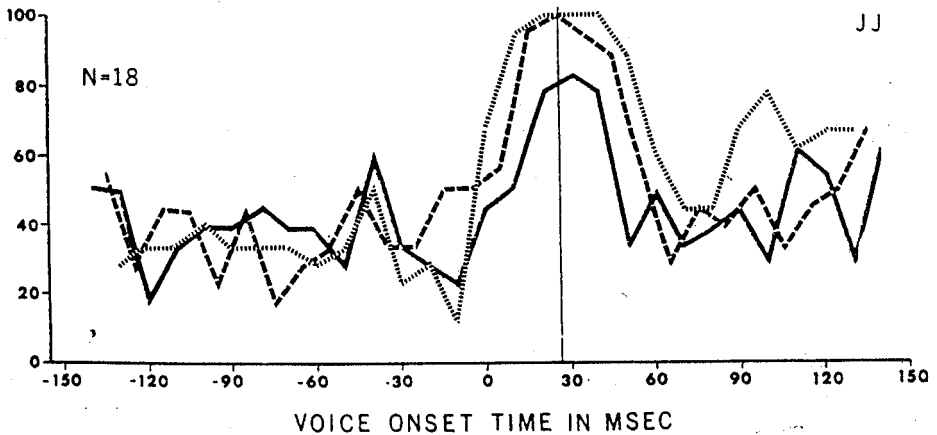
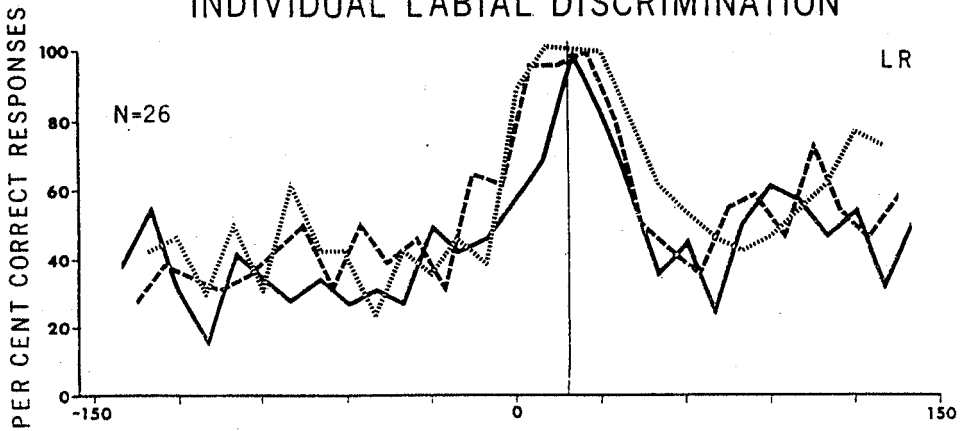
Our experiments give fairly clear answers to our questions. Although procedural problems have delayed the work on Spanish, the English and Thai data show sharpening of discrimination at the phoneme boundaries. For English at least, this might

# POOLED LABIAL DISCRIMINATION

## ENGLISH



## INDIVIDUAL LABIAL DISCRIMINATION

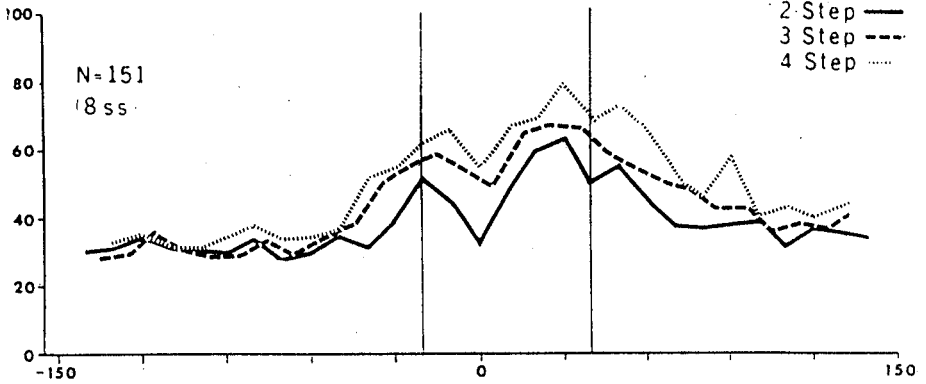


VOICE ONSET TIME IN MSEC

Fig. 1

# POOLED LABIAL DISCRIMINATION

## THAI



# INDIVIDUAL LABIAL DISCRIMINATION

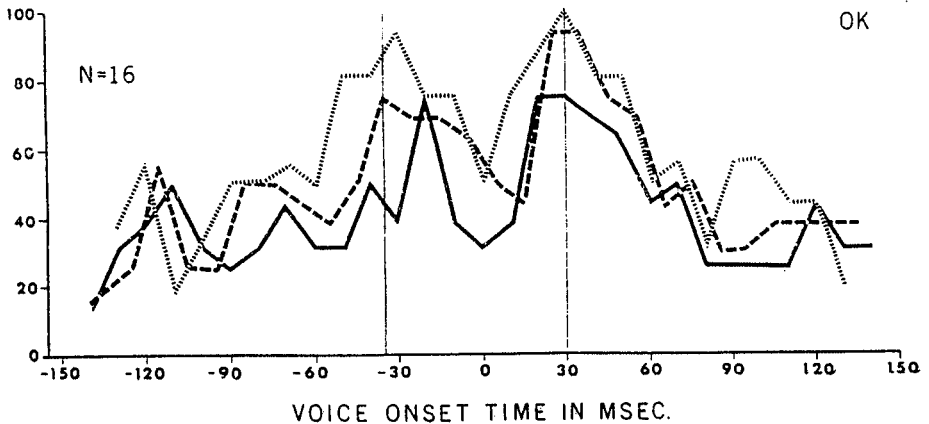
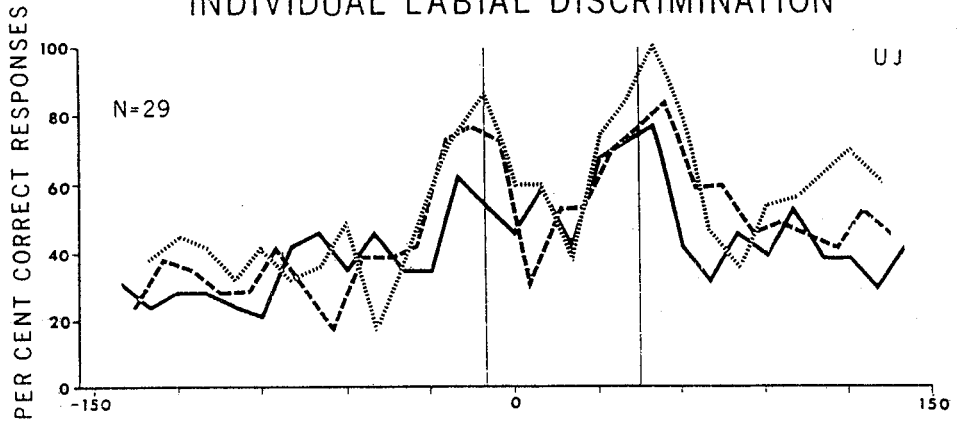


Fig. 2

have been predicted from the earlier work of Liberman *et al.*<sup>4</sup> Our data suggest that discriminability is basically determined by specific language experience. There is a large peak at the boundary between the two English phonemes. The three Thai phonemes are separated by two large peaks. In both languages, for the stimuli with long voicing lag, there is a tendency to show a sharpening of discrimination close to the margin of the labelling distribution that does not abut on another phonemic category. We hope to present a report soon on similar current experiments with apical and velar stops.

## DISCUSSION

*Fry:*

Were the Thai subjects whose individual results were given also used in collecting the analytical data? If so, was there any tendency for the data for these two speakers to be in step with their labelling results?

*Abramson:*

Ad Fry: No, these individual subjects were not in the United States when the analytical data were collected, nor were any of the speakers whose productions were examined for the first study still available to us at the time of the perception experiments. The possibility implied by your question cannot be ruled out until we have examined a sampling of stop productions of the present two subjects. We will try to do so soon. It would indeed be gratifying to find that the discrepancy between production and perception at one of the two boundaries is explained by individual differences in speech habits; however we doubt that this will happen.

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<sup>4</sup> A. M. Liberman, K. S. Harris, J. Kinney & H. Lane. "The Discrimination of Relative Onset Time of the Components of Certain Speech and Nonspeech Patterns". *J. Exptl. Psych.* 61 (1961). 379—388.