Identification and discrimination functions for pure tone auditory frequencies

JAMES KOPP and HARRY UDIN,
Claremont Graduate School, Claremont,
Calif. 91711

Subjects were instructed to identify auditory pure tone stimuli ranging in 4-Hz increments from B(480) to C(512) on the tempered musical scale with the labels "B" or "C." Discrimination data were then obtained for adjacent stimuli on the test continuum by the ABX method. In line with earlier studies it was found that identification probabilities were distributed in a step-like fashion across the continuum. Similarly, discrimination scores covaried systematically with identification probabilities. The fact that these data were obtained on a simple physical stimulus continuum is taken as support for the argument, put forth by Lane, that the identification-discrimination relationship does not require a model involving mediating vocal reproduction responses for its explication.

It has recently been shown that the probability of a correct discrimination between two stimuli is related to the probability with which the stimuli are associated with one or more than one identification response. When stimuli are presented sequentially for Ss to discriminate, the number of correct judgments between them is observed to be highly related to the extent to which each stimulus is associated with a different verbal label. Two stimuli which are usually given the same name by a S are poorly discriminated. Two stimuli which are named differently by a S are discriminated very well.

Studies directed at examining the identification-discrimination relationship are typically conducted over stimulus sets which range continuously between two extremes associated with two different naming responses. Naming probabilities plotted over the total stimulus continuum yield gradients in the form of mutually complementary step functions. Discrimination is best at the intersection of these two gradients where identification probabilities are most disparate, that is, where two adjacent stimuli were most likely to be named differently.

Liberman et al (1957, 1961, 1967), working with synthetic speech stimuli, have constructed a theory which accounts for the identification-discrimination relationship

with reference to a unique perceptual mechanism in which each stimulus is matched with a vocal articulatory response—that response which is necessary to reproduce the stimulus. By the Liberman model, incoming stimuli elicit the articulatory responses covertly. The subsequent overt discrimination response is based on proprioceptive feedback from the covert articulatory responses rather than the actual stimulus input. By this model, only speech stimuli, for which the S has matching articulatory responses, will yield the identification-discrimination correlation.

Lane and his associates (Cross & Lane, 1964; Lane, 1965; Cross, Lane, & Sheppard, 1965; Lane, 1967; Kopp & Lane, 1968) present data contravening the Liberman proposition. These investigators have shown that both step-like identification gradients and high correlations between identification and discrimination probabilities can be observed with stimuli (auditory intensities, visual angles, spectral hues) which cannot be produced by the S, for which there is no matching vocal articulatory response.

The Lane thesis is that the relationship between identification and discrimination results from a S's history of reinforcement with respect to labelling and might be expected to occur wherever there are well defined labelling responses associated with specific points on a stimulus continuum. Such is the case, for instance, with stimuli on the auditory frequency continuum. Overlying the frequency continuum is the musical scale in which successive doublings in frequency (octaves) are divided into 11 half-tone intervals. The study reported here compares naming probabilities with successive discrimination probabilities for auditory frequencies within one of these half-step intervals.

METHOD

Twenty Ss, ranging in age from 11 to 33 years, served as paid volunteers in individual experimental sessions of 1 h each. In the first part of the experiment, each S was presented with 20 tones. Ten of the tones corresponded to B(480) and another 10 to C(512) on the tempered musical scale (Henny, 1938). The tones were presented in random order and the S was instructed to push one of two buttons after each tone to identify it as either "B" or "C." During this phase, correct responses were reinforced by a brief flash of light on a panel in front of the S. In the second part of the experiment, the

S was instructed to continue responding as before but tones were presented at 484, 488, 492, 496, 500, 504, and 508, as well as 480 and 512 Hz. There were 10 presentations at each frequency; all presentations were randomized. During this phase no reinforcement was given. In the final phase, pairs of adjacent frequencies (480 and 484, 484 and 488, 488 and 492, etc.) were presented in "ABX" discrimination triads. Each triad was constructed so that the third stimulus was always a replication of one of the first two. There were thus four permutations per pair of stimuli, ABA, ABB, BAA, and BAB. Each possible triad was presented three times for a total of 12 triad presentations for any given stimulus pair. The S was instructed to press one of two buttons after each triad to indicate whether the third stimulus was identical to the first or to the second. In all phases tone duration was 1 sec. In the identification phase intertone intervals were 5 sec. In the ABX discrimination phase intertone intervals were 4 sec and intertriad intervals were 6 sec. The stimulus tones were generated from a beat frequency oscillator and recorded on electromagnetic tape. Tone frequencies were monitored on an electronic counter (Beckman, Model 5500). The tape recorded stimuli were presented to the Ss through a set of earphones (Knight KN876).

RESULTS AND DISCUSSION

Figure 1 presents identification and percent correct discrimination frequencies for the total group and for one representative S (2). In line with earlier work, it can be seen that the identification probabilities are distributed in a step-like fashion across the continuum. Similarly, the tendency is for discrimination scores to covary with identification probabilities, being high in the middle of the continuum, where there are large differences in the probability of two stimuli being assigned the same label, and remaining low at the extremes, where the naming probabilities are similar for adjacent stimulus pairs.

The magnitude of the relationship between identification and discrimination was assessed by transforming the identification scores to predicted discrimination scores according to the formula given by Liberman et al (1957). This formula states that:

$$P_{pred} = .5 + \frac{(P_A - P_B)^2}{2}$$

where P_{pred} indicates the predicted discrimination probability, P_A indicates the relative frequency with which a given identification response is assigned to Member A of a stimulus pair; and P_B indicates the relative frequency with which this same response is assigned to Member B of that pair.

Fig. 1. Mean identification, discrimination, and predicted discrimination functions for 20 Ss (left) and actual values for one representative S (right). Solid lines represent identification probabilities of one tone name ("B"). Probabilities of the other tone name ("C") are complementary to these values. Dashed lines represent obtained per cent correct ABX discriminations. Dotted lines represent the per cent correct ABX discriminations predicted from identification probabilities. There were 10 presentations of each stimulus value for identification, and 12 presentations of each stimulus pair for discrimination, per S.

It can be seen from Fig. 1 that the predicted and obtained values are very similar and tend to covary. The obtained values are somewhat higher overall, also in accord with earlier findings (Lane, 1965).

The observation that a direct functional relationship exists between identification probabilities and discrimination probabilities on the auditory frequency continuum corroborates earlier findings comparing naming and discrimination behavior in other sense modalities. The fact that these data were obtained over a simple physical continuum supports the Lane (1965) argument that the identification-discrimination relationship is not specific to speech stimuli and therefore does not require a special mechanism involving matching vocal articulation responses for its explication.

REFERENCES

- CROSS, D. V., & LANE, H. L. An analysis of the relations between identification and discrimination functions for speech and non-speech continua. University of Michigan Behavior Analysis Laboratory Progress Report No. 6, October 1964.
- CROSS, D. V., LANE, H. L., & SHEPPARD, W. C. Identification and discrimination functions for a visual continuum and their relation to the motor theory of speech perception. *Journal of Experimental Psychology*, 1965, 70, 63-74.
- HENNEY, K. *Principles of radio* (3d ed.). New York: Wiley, 1938.
- KOPP, J., & LANE, H. L. Hue discrimination related to linguistic habits. *Psychonomic Science*, 1968, 11, 61-62.
- LANE, H. L. The motor theory of speech perception: A critical review. *Psychological Review*, 1965, 72, 275-309.
- LANE, H. L. A behavioral basis for the polarity principle in linguistics. In K. Salzinger (Ed.), *Research in verbal behavior and some neurophysiological implications*. New York: Academic Press, 1967.
- LIBERMAN, A. M., HARRIS, K. S., HOFFMAN, H. S., & GRIFFITH, B. C. The discrimination of

speech sounds within and across phoneme boundaries. *Journal of Experimental Psychology*, 1957, 54, 358-368.

LIBERMAN, A. M., HARRIS, K. S., KINNEY, J.

A., & LANE, H. L. The discrimination of relative onset time of the components of certain speech and non-speech patterns. *Journal of Experimental Psychology*, 1961, 61, 379-388.

Cognitive and learning effects in the production of GSR conditioning data¹

D. McCOMB, *The University of Southampton, England*

The notion that GSR conditioning data are purely a function of S's awareness of relevant stimulus contingencies is challenged. An experiment is described in which, using a manifest task to disguise the true nature of the experiment from S, greater differential responding to the CS (in extinction) was seen in the case where Ss experienced conditioning trials having been informed previously of the CS-UCS contingency, than when this information was not followed by conditioning trials. The familiar finding of no conditioning without awareness is also supported.

Cognitive theorists (cf. Razran, 1955) have concluded from demonstrations of a "conditioning-like" phenomenon using GSR without a single pairing of CS and UCS (cf. Cook & Harris, 1937; Hilgard & Humphries, 1938) that an exclusively cognitive, perceptual phenomenon, something called "relational learning" (Razran, 1955) was being observed. Since, however, this occurs in the context of a classical learning paradigm, in which the pairing of

CS and UCS (actually or threatened) is present procedurally, the phenomenon described by Pavlov (1927) would seem to be relevant as well.

On the one hand these variables have been conceptualized as dichotomous (Mandel, 1966; Mandel & Bridger, 1967; Mowrer, 1938; Streiner & Sanford, 1968) while on the other, effects thought to be cognitive in nature (e.g., preparatory sets) are thought to be established and modified by the manipulation of parameters relevant to learning (Grings, 1960).

The present experiment was designed to permit a description of some functional relationships whereby so-called "cognitive" as well as learning variables exert control over the dependent variable.

METHOD

Subjects were seated in a darkened, sound-attenuated chamber and instructed to attempt to maintain a pointer on a moving irregular track by means of a steering wheel directly in front of them. GSR electrodes were attached to the palm and wrist of the nonpreferred hand. Mounted on the apparatus, containing a drum with the track described thereupon, were five horizontal, equally spaced lights of different colors (red, orange, blue, green, and white). A speaker