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Reasoning from recent psycholinguistic research, it was predicted that discrimination between two monochromatic stimuli would be poorer when they belong to the same color category, better when they belong to different color categories in the language of the observer. Accordingly, it was predicted that hue discrimination functions vary systematically from one language community to the next--to the extent that the different languages categorize the spectrum differently. Both predictions were supported by color labelling and discrimination measures obtained from speakers of English and Tzotzil, a Mayan language of Mexico. (See also AL 000 899.) (JD)

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HUE DISCRIMINATION RELATED TO LINGUISTIC HABITS[1]

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Reasoning from recent psycholinguistic research, it was predicted that discrimination between two monochromatic stimuli would be poorer when they belong to the same color category, better when they belong to different color categories in the language of the observer. Accordingly, it was predicted that hue discrimination functions vary systematically from one language community to the next--to the extent that the different languages categorize the spectrum differently. Both predictions were supported by color labelling and discrimination measures obtained from speakers of English and of Tzotzil.

Recent research in psycholinguistics (Lane, 1966; 1967) indicates that whenever a stimulus continuum is effectively partitioned into perceptual categories there are several behavioral consequences including: (a) the probability of assigning a stimulus to a given category tends toward zero or unity--that is, the distributions of identification probabilities over the continuum are step-like, with broad plateaus and sharp transitions; (b) the mean latency of identifying the stimuli is short over the plateaus, within categories, and long at the transition points, at category boundaries; (c) the accuracy of discriminating between two stimuli is poor if they both belong to the same category, better if they belong to different categories--that is, there is discrimination enhancement at category boundaries.

The effective partitioning of the stimulus continuum may be accomplished by the language community (Lane, 1965) presumably over years of verbal conditioning, or by the experimenter in the laboratory, working more rapidly and systematically (Cross & Lane, 1962; Lane & Moore, 1962; Cross, Lane, & Sheppard, 1965). Figure 1 illustrates the outcome of the former procedure, for an acoustic-phonetic continuum that ranged perceptually from /do/ to /to/.

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Insert Figure 1 about here

It has long been recognized that language habits similarly partition the color continuum (Ray, 1953). From what has been said above, we would expect that the relative probability of color names would be distributed stepwise as a function of wavelength and that their latencies would be short within color classes and long at class boundaries--both confirmed by Beare (1963). More interestingly, we would expect that the accuracy of discriminating two wavelengths would be poor within color categories and better across categories. Lane (1967) confirmed this expectation by superimposing the hue discrimination data of Laurens and Hamilton (1923) on the hue labelling data of Beare.

This result is striking because it suggests the possibility that hue discrimination may not depend exclusively on the inborn sensory mechanism of the observer but also on his linguistic habits. This brazenly Whorfian line of thought leads to the prediction that hue discrimination functions vary systematically from one language community to the next--to the extent that the different languages partition the hue continuum differently.

We first confirmed the correlation of hue labelling with hue discrimination by using English-speaking college students in four two-hour sessions. We then moved the apparatus to the anthropological field station in San Cristobal de las Casas, Chiapas, Mexico, where adult monolingual speakers of Tzotzil (a Mayan language) were recruited from a nearby Indian village for similar paid service. Next, we established that color categories in Tzotzil are different from those in English. Finally, we confirmed that the hue discrimination function of Tzotzil speakers is correlated with their color categories and thus differs from that of English speakers.

Method

The Tzotzil subjects were from the village of Nevenchauk near San Cristobal de las Casas. Access to these subjects was through a local informant who also served as a Spanish-Tzotzil interpreter during the actual experiment. Two subjects, one male and one female, participated; the male (Mariano) was 21 and the female (Petrona) 10 years of age. Both were monolingual in Tzotzil.

The American English subjects (MR and AA) were female college students at The University of Michigan.

Monochromatic stimuli for identification and discrimination were generated by passing "white" (3200°K) light through a continuous interference filter and thence through a 1mm vertical slit. This procedure produces relatively intense spectral stimuli with a half band-width of approximately 12 mμ over the entire range of visible wavelengths. Wavelength changes are produced by traversing the filter horizontally across the slit, the peak wavelength value in mμ being linear with the traverse distance in mm. Stimulus intensities ranged monotonically from 62 to 86 db (re: 10^{-10} Lambert) at the shortest and longest wavelengths respectively. These values are well above the photopic threshold. Subjects were seated in a completely darkened chamber, 2.5 ft. from a ground glass screen. The stimuli were projected upon the obverse side of the glass through the lens system of a standard slide projector. The resultant stimulus image consisted of a vertical rectangle, 3/4" x 5/16". The stimulus surround was rendered completely black by masking the screen with black posterboard. All stimulus events and concomitant responses were recorded on an 8-channel event recorder. During the labelling phase, response latencies were recorded by means of a multivibrator-counter arrangement which allowed temporal resolution to within 64 msec.

In the first part of the experiment the subject was provided with a telegraph key and instructed to report all hue changes, however slight, in the patch of light on the screen (sweep discrimination procedure). The experimenter then actuated a motor which moved the filter continuously across the slit at a slow fixed rate from right to left and back again. This yielded continually alternating ascending and descending sweeps of the spectrum from the violets (420 mμ) to the reds (645 mμ).

In the next phase, discrete wavelength values were presented tachistoscopically at 7.5 sec. intervals (stimulus duration = .75 sec.) according to a random protocol (hue identification procedure). The appropriate wavelengths were set manually by the experimenter by means of a dial micrometer fixed to the filter carrier. The subject was instructed to press one of several dimly illuminated buttons on a panel in front of him, each corresponding to one of the several most common color names extant in his language. For English speaking subjects the colors used were red, yellow, green, blue, and violet. Orange was eliminated on the basis of data published by Sternheim and Boynton (1966). For the Indian subjects the permissible color names were /cøh/, /yox/, /k'on/, and /ik'loan/. These four names were selected on the basis of a color naming experiment conducted by

Collier (1963) in which Tzotzil subjects assigned color names without restriction to Munsell color chips. In the Collier study, /¢oh/, /k'on/, /yox/, and /ik'loan/ were associated with peak relative frequencies of 60%, 65%, 85%, and 40% respectively. The peak frequencies for other names ranged from 20% to 30%.

In the third phase of the experiment pairs of adjacent stimuli from the identification phase were presented in "ABX" discrimination triads. The triads were constructed so that the third stimulus was always a replication of one of the first two, yielding four permutations per pair of stimuli: ABA, ABB, BAA, and BAB. Each possible triad was presented 24 times according to a random protocol. The subject was instructed to press one of two buttons to indicate whether the third stimulus was identical to the first or the second. In this phase the stimulus duration was again .75 sec. Stimulus onset occurred at 3 sec. intervals within triads. Triad onsets occurred at 19.5 sec. intervals.

The final phase consisted of a replication of the first phase in which the subject depressed a telegraph key to report the slightest hue change as the wavelength values were changed continuously over the spectrum.

Results and Discussion

Figures 2, 3, 4, and 5 present, for two English and two Tzotzil speakers, the obtained distributions of: identification probability, identification latency, sweep discrimination and ABX discrimination (cf. Figure 1). Also included are ABX discrimination values which would be predicted from the labelling probabilities assuming that the subjects labelled the stimuli during the ABX phase as they did during the actual labelling task (Liberman, Harris, Hoffman, & Griffith, 1957).

Insert Figures 2, 3, 4, & 5 about here

First it will be seen that, in accord with our initial generalization, the partitioning of the continuum into perceptual categories by the language leads to poorer discrimination within categories, better discrimination across categories; this is true for both measures of discrimination obtained from both language groups. Second, it will be noted that, because of this correlation between color categories and color discrimination, and because the color categories are different in the two language groups, color discrimination is different in the two language groups.

The hue labelling and hue discrimination functions obtained from English speakers are comparable to those reported by other investigators (Beare, 1963; Boynton, Schafer, & Neun, 1964; Laurens & Hamilton, 1923; Luria, 1966). These functions differ, however, from the hue labelling and correlated hue discrimination functions obtained from the Tzotzil speakers. We are led to infer that hue discriminability functions may vary systematically from one language community to the next--to the extent that color categories in the different languages partition the hue continuum differently.

Footnote

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Figure Captions

Fig. 1. The characteristics of identification probability and latency of discrimination accuracy along an acoustic continuum partitioned by the language community. From Lane (1967).

Figs. 2-5. Identification probability, identification latency, sweep discrimination and ABX discrimination measures as a function of wavelength for two English and two Tzotzil speakers. Each point on the functions is the mean of 10, 10, 40, or 24 stimulus presentations, respectively.

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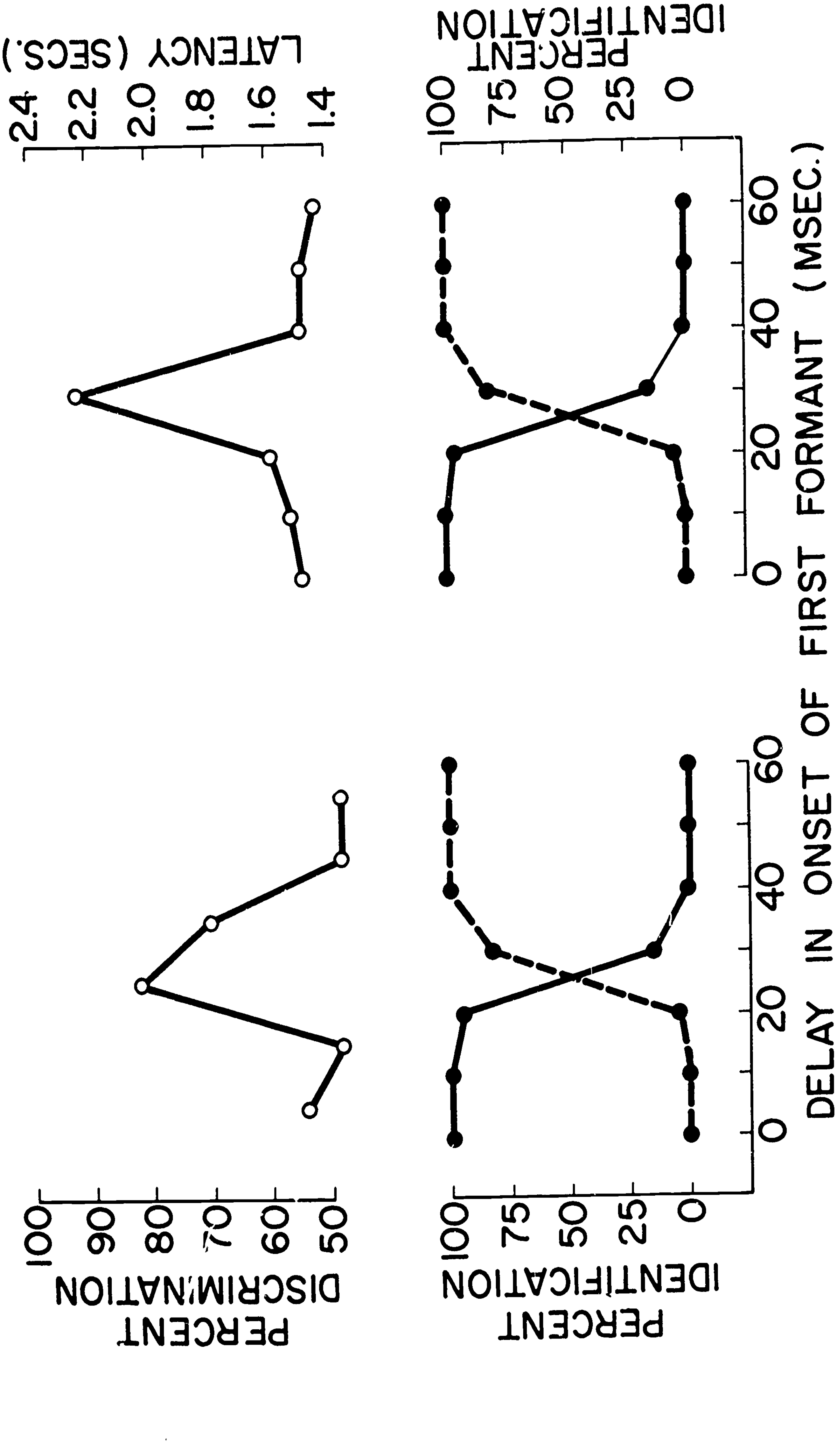

PERCENT DISCRIMINATION
100 90 80 70 60 50
PERCENT IDENTIFICATION
100 75 50 25 0
LATENCY (SECS.)
2.4 2.2 2.0 1.8 1.6 1.4
PERCENT IDENTIFICATION
100 75 50 25 0
0 20 40 60
0 20 40 60
DELAY IN ONSET OF FIRST FORMANT (MSEC.)

Figure 1

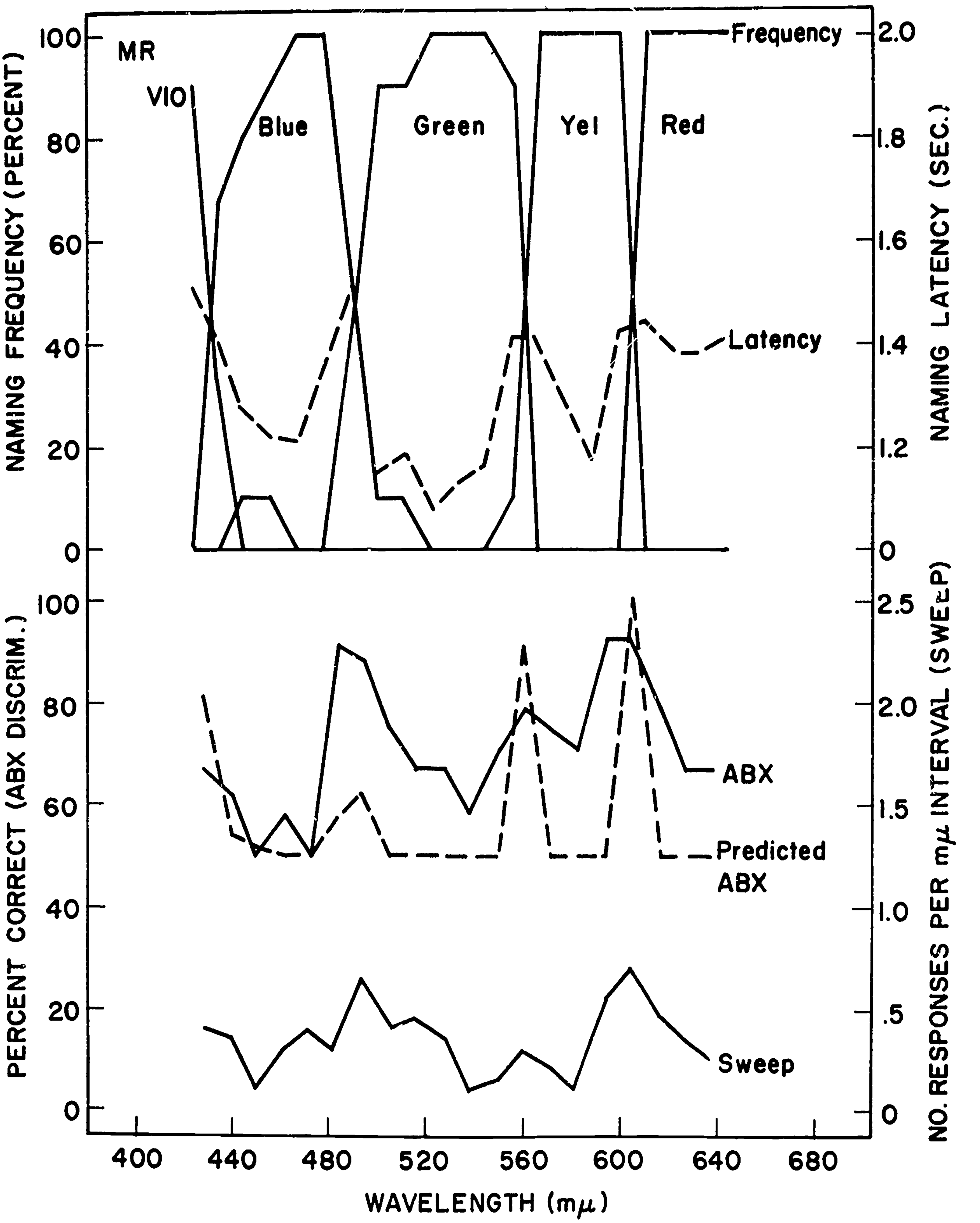

MR
VIO
Blue
Green
Yel
Red
Frequency
Latency
NAMING FREQUENCY (PERCENT)
NAMING LATENCY (SEC.)
100
80
60
40
20
0
2.0
1.8
1.6
1.4
1.2
0
PERCENT CORRECT (ABX DISCRIM.)
NO. RESPONSES PER mμ INTERVAL (SWEEP)
2.5
2.0
1.5
1.0
.5
ABX
Predicted ABX
Sweep
400
440
480
520
560
600
640
680
WAVELENGTH (mμ)

Figure 2

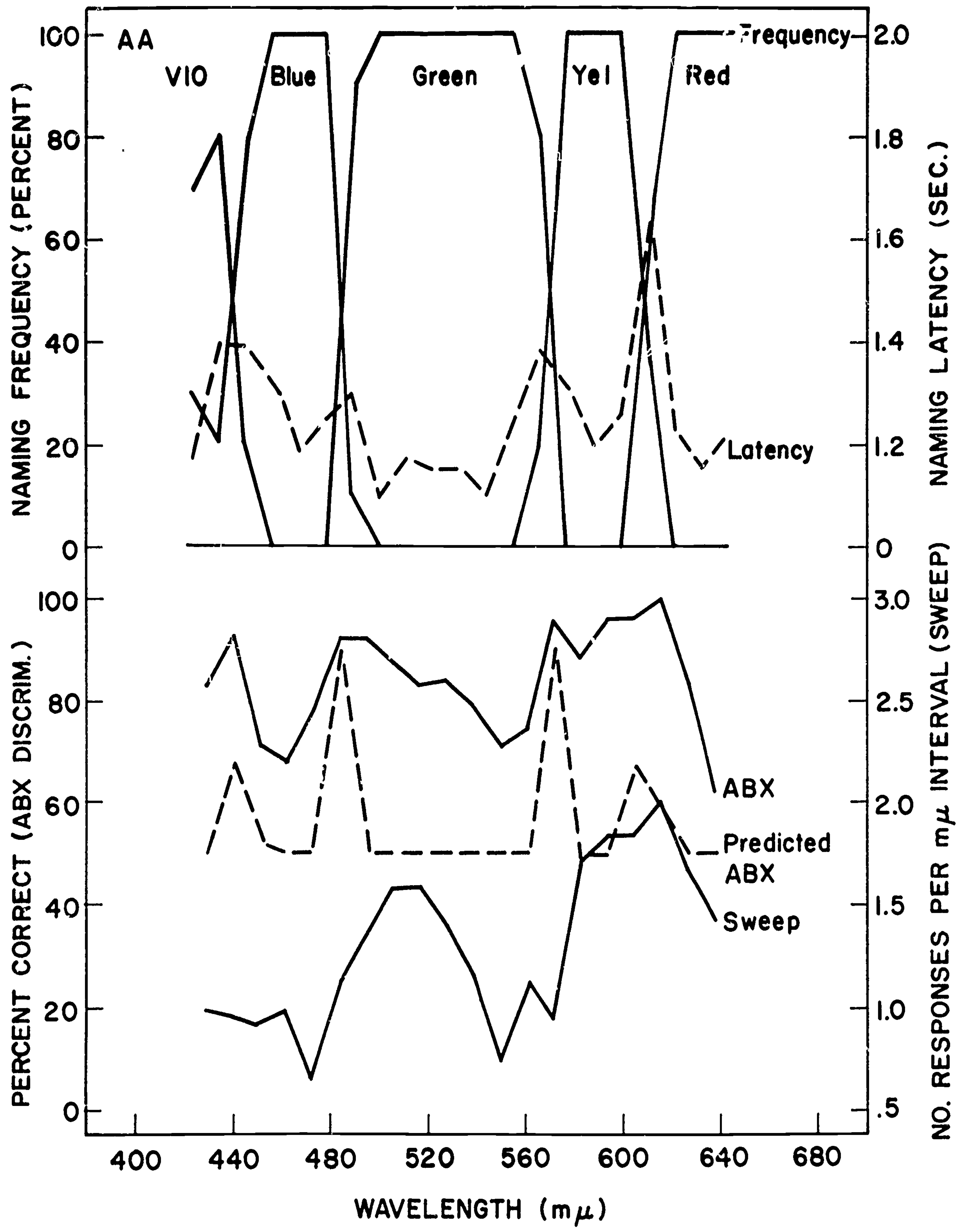
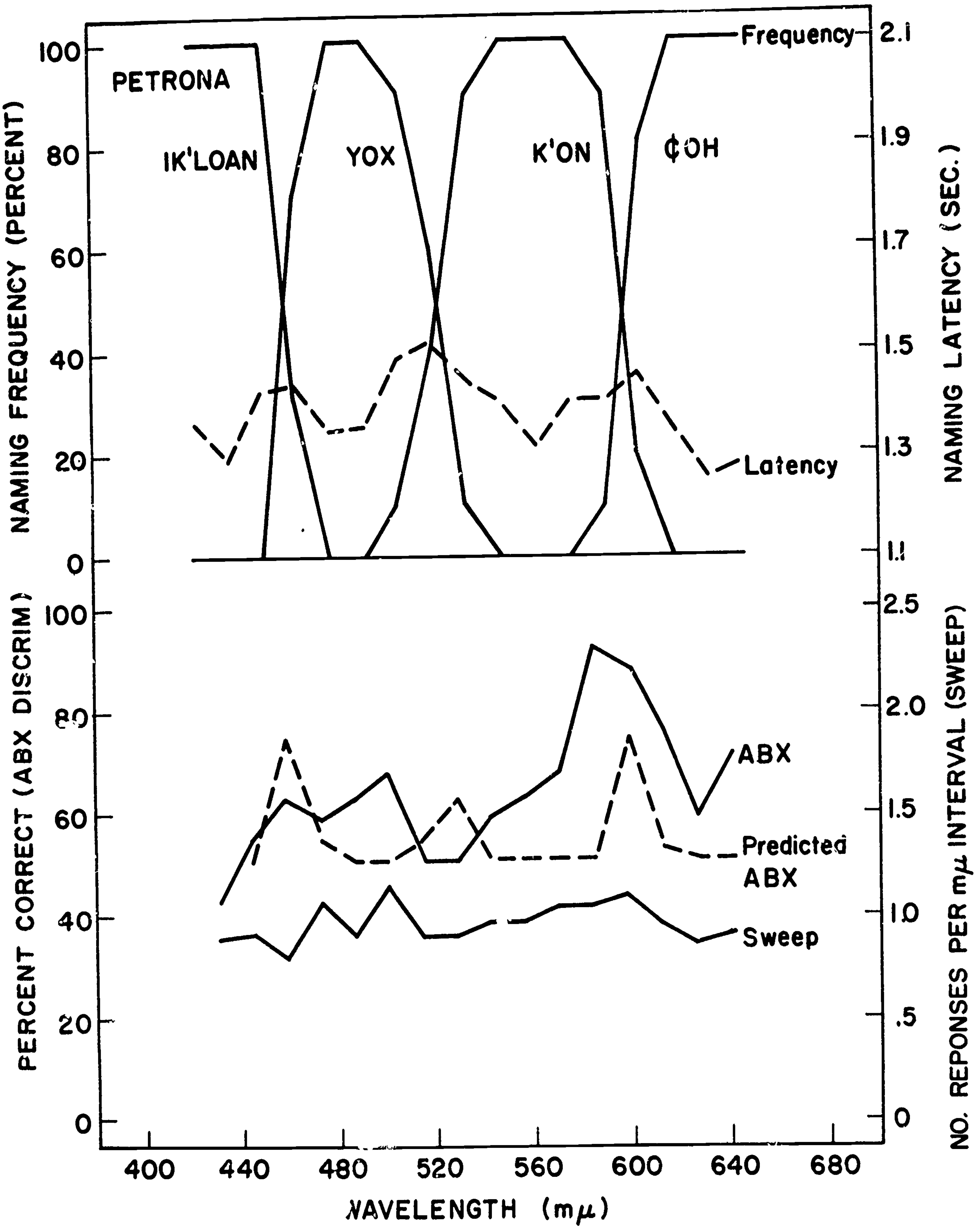
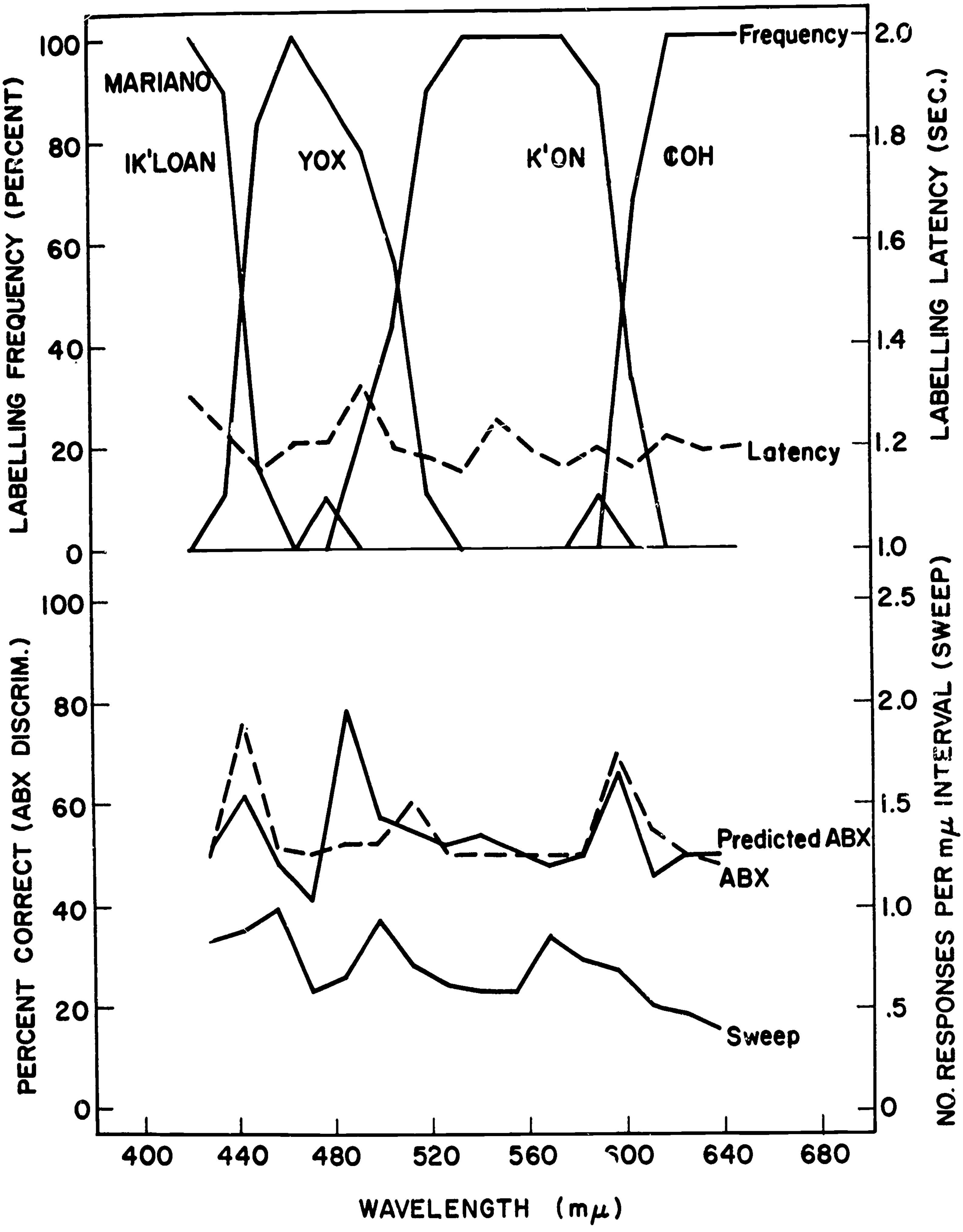

AA
VIO
Blue
Green
Yel
Red
Frequency
Latency
NAMING FREQUENCY (PERCENT)
NAMING LATENCY (SEC.)
100
80
60
40
20
0
2.0
1.8
1.6
1.4
1.2
0
ABX
Predicted ABX
Sweep
PERCENT CORRECT (ABX DISCRIM.)
NO. RESPONSES PER mμ INTERVAL (SWEEP)
3.0
2.5
2.0
1.5
1.0
.5
400
440
480
520
560
600
640
680
WAVELENGTH (mμ)

Figure 3



PETRONA
IK'LOAN
YOX
K'ON
¢OH
Frequency
Latency
NAMING FREQUENCY (PERCENT)
NAMING LATENCY (SEC.)
100
80
60
40
20
0
2.1
1.9
1.7
1.5
1.3
1.1
PERCENT CORRECT (ABX DISCRIM)
NO. REPONSES PER mμ INTERVAL (SWEEP)
ABX
Predicted ABX
Sweep
2.5
2.0
1.5
1.0
.5
0
400
440
480
520
560
600
640
680
WAVELENGTH (mμ)

Figure 4



Frequency
Latency
MARIANO
IK'LOAN
YOX
K'ON
COH
LABELLING FREQUENCY (PERCENT)
LABELLING LATENCY (SEC.)
100
80
60
40
20
0
2.0
1.8
1.6
1.4
1.2
1.0
Predicted ABX
ABX
Sweep
PERCENT CORRECT (ABX DISCRIM.)
NO. RESPONSES PER mμ INTERVAL (SWEEP)
2.5
1.5
.5
400
440
480
520
560
600
640
680
WAVELENGTH (mμ)

Figure 5