SPECIAL ARTICLES

VOCAL PITCH DURING SIMULATED EMOTION

THE present report is limited to consideration of the pitch of the voice during simulated emotion. It differs from previous studies in two respects: (1) Identical reading materials were used in simulations of all emotions studied; (2) the effectiveness of the simulations was measured.

The test passage, "There is no other answer. You've asked me that question a thousand times, and my reply has always been the same. It always will be the same," was read by six competent amateur male actors to portray each of the following emotional states: Contempt, anger, fear, grief and indifference. Phonograph records of the readings were cut. The recordings were played before a group of 64 observers, in whose hands had been placed lists of twelve emotional states, among which appeared the five being studied, as follows: Amusement, anger, astonishment, contempt, doubt, elation, embarrassment, fear, grief, indifference, jealousy, love. The observers were asked to select from the list the term which named most accurately the emotion being simulated as each recording was played. A random order of presentation was used. From these judgments it was possible to rate the portrayals in terms of the percentage of the observers able to identify them.

Measurements of the fundamental sound wave frequencies employed were made from the phonograph recordings by phono-photographic techniques. The results of the analysis are presented in Table I. It will be understood that the measure listed as median pitch level in this table is the median fundamental frequency employed. It is referred to as "pitch level" to distinguish it from the concept of frequency level in octaves above 16.35 c.p.s., and because it is a term in common use among students of speech. The nearest musical tone is that on a musical scale where A = 440 c.p.s. Measures of range were computed by means of the relation $N_{Tones} = 19.92 \log_{10} \frac{f_1}{f_0}$, where f_1 is the higher and f_0 the lower frequency.

TABLE I

AVERAGE MEASURES OF PITCH

	Contempt	Anger	Fear	Grief	Indifference
Percentage of correct judgments	84	78	66	78	88
Median pitch level [cycles per second]	124.3	228.8	254.4	135.9	108.3
Nearest musical tone	B_1	$A_2^\sharp$	C_3	$C_2^\sharp$	A_1
Total pitch range [tones]	10.5	10.3	11.2	9.0	7.8
Mean inflectional range [tones]	2.2	2.6	2.3	1.7	2.0
Rate of pitch change [tones per second]	16.8	25.6	19.0	15.6	16.6

That the simulations studied were characteristic of the emotional states is readily observed from the high percentage of correct identifications, as seen in Table I. Further reference to this table and to Fig. 1 shows that striking differences obtain between the median pitch levels measured for the different emotions. It will be observed that indifference employs a lower pitch level than any of the other readings and that each emotion appears to have a characteristic comparative pitch level different from other portrayals. A significant

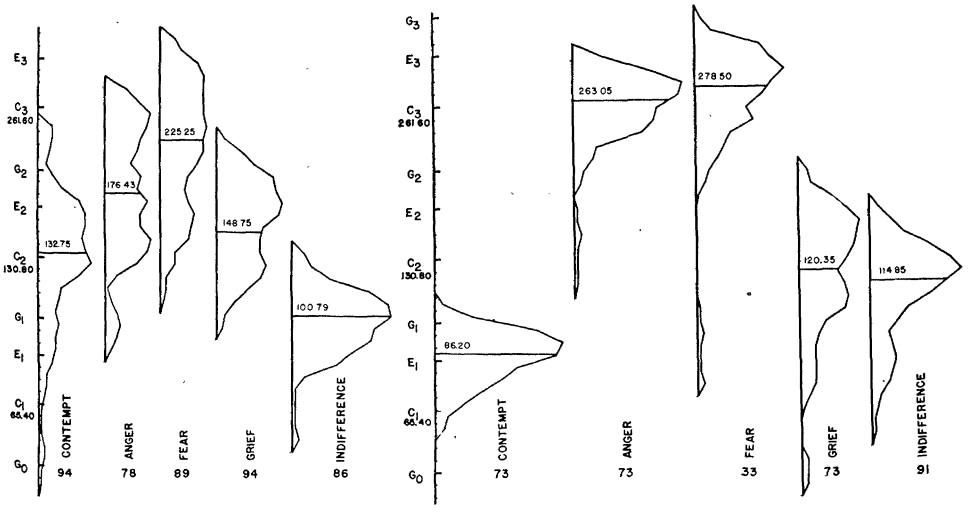

FIG. 1. Distributions of pitches used. The ordinate is pitch in semi-tone intervals; the abscissa, in the case of each distribution, is percentage of cases. Left, effective actor; right, ineffective actor. Medians indicated by horizontal lines across each distribution and labeled in cycles per second. Lower numbers show percentage of observers making correct identification.

fact is that pitch levels for indifference, contempt and grief are in the neighborhood of C_2, while those for anger and fear are approximately one octave higher at C_3.

Indifference employs the narrowest total pitch range, about an octave, with grief using a range of one and one half octaves, and contempt, anger and fear approximately two octaves. The distribution of pitches used within these ranges is observed from the graphs of the effective readings in Fig. 1 to approximate a normal distribution.

The mean extent of inflections (*i.e.,* frequency modulations either upward or downward) is seen to vary from one third to approximately one half an octave in extent. Grief employs the narrowest inflectional range and anger the widest, with the other emotions falling within the interval which separates these extremes.

An additional means of distinction between emotions is afforded by a measure of the rapidity with which pitch changes per unit of time during inflections. An expression of the rate of this change is given in tones per second by dividing the pitch range in tones of a given inflection by its duration in seconds. As with inflectional range, anger and grief are the extremes, with anger using the fastest rate of pitch change and grief the slowest, the difference being ten tones per second. The speed of pitch change for contempt and indifference is slightly more rapid than for grief, while fear exceeds this value by approximately two tones per second.

Fig. 1 presents distributions of the pitches used by typical effective and ineffective actors. It is interesting to note that the ineffective actor deviates markedly from the effective performer in all but indifference, in which both were judged as being highly effective. Examination of the figure shows that pitch levels for the poor readings are not defined as clearly as those for the better readings. The median pitch levels in anger and fear are almost identical, as are those in grief and indifference, while contempt, contrary to the effective as well as average measures, employs a pitch level which is considerably lower than other attempts by this actor. The latter's simulation of contempt uses also an extremely narrow pitch range of less than one octave, and the extremely wide ranges of his fear and grief are due to the presence of a few very low pitches. The above deviations represent the typical differences between effective and ineffective portrayals. It is probable that the ineffectiveness is the result, to some degree at least, of these extreme deviations from the average and effective simulations.

One striking result regarding pitch in emotional speech was obtained by computation of the total pitch range employed by each actor in portraying all five emotions. It was found that five of the six actors used a total pitch range of over three octaves.

From the above data it is possible to characterize each emotion comparatively on the basis of pitch usage alone, as follows:

(1) Contempt. (a) Low median pitch level (124.3 c.p.s.), but (b) wide total pitch range (10.5 tones).

(2) Anger. (a) High median pitch level (228.8 c.p.s.), (b) wide total pitch range (10.3 tones), (c) widest mean inflectional range (2.6 tones), (d) most rapid pitch change (25.6 tones per second).

(3) Fear. (a) Highest median pitch level (254.4 c.p.s.), (b) widest total pitch range (11.2 tones).

(4) Grief. (a) Low median pitch level (135.9 c.p.s.), (b) narrow total pitch range (9.0 tones), (c) narrowest mean inflectional range (1.7 tones), (d) slowest pitch change (15.6 tones per second).

(5) Indifference. (a) Lowest median pitch level (108.3 c.p.s.), (b) narrowest total pitch range (7.8 tones).

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PHOSPHORUS METABOLISM OF CHICKS AFFLICTED WITH PEROSIS

PEROSIS (slipped tendon) in chicks was first described by Hunter and Funk.[1] It has been studied by a number of investigators, and recently Wilgus, Norris and Heuser[2] have shown that the affliction can be corrected by raising the level of manganese in the ration. This observation has been confirmed by a number of investigators.[3]

The disorder is characterized by a bowing of the legs in the tibia—metatarsal joint, enlargement with a tendency toward flattening of the joint and finally slipping of the Achilles tendon from its normal position. Perosis has been produced by the feeding of high levels of calcium phosphate—3 to 5 per cent. of the ration. Our ration[4] for producing this condition is given in Table 1.

The addition of 50 mg of manganese as $MnSO_4 \cdot 4H_2O$ per kilo of the above rations protects the chicks from perosis. Injection of 1, 3, 10 or 50 mg of manganese per week, in two equal doses, also protects on ration 604. No data involving injection are as yet available with ration 610. Rice bran fed at the level of 15 or 20 per cent. protected on ration 604. Auto-

[1] J. E. Hunter and E. M. Funk. *Proceedings* of the 22nd annual meeting of the Poultry Science Association, Macdonald College, Quebec, p. 45, 1930.

[2] H. S. Wilgus, Jr., L. C. Norris and G. F. Heuser. SCIENCE, 84: 252, 1936; *Jour. Nutrition,* 14: 155, 1937.

[3] V. G. Heller and R. Penquite, *Poultry Science,* 16: 243, 1937. M. Lyons, W. M. Insko, Jr., and J. H. Martin, *Poultry Science,* 17: 12, 1937. M. Lyons and W. M. Insko, Jr., *Ky. Agr. Exp. Station Bull.,* 371, 1937. P. J. Schaible, S. L. Bandemer and J. A. Davidson, *Poultry Science,* 16: 367, 1937.

[4] L. E. Clifcorn, C. A. Elvehjem and E. B. Hart, *Poultry Science,* 17: 28, 1938.