

which is equivalent to the two forms

$$p(g_1) = \frac{2(3+\theta^2)^{5/2}}{27\sqrt{3}(1+|\theta|)^2(\theta^2-1)}$$

for $-3 \leq \theta \leq -1$; $1 \leq \theta \leq 3$
and $-\infty \leq \theta \leq -3$; $3 \leq \theta \leq \infty$. } (13)

Substituting

$$\theta = \sqrt{3} \tan \alpha \quad (14)$$

it is seen that these forms reduce to

$$p(g_1) = \frac{1}{\sqrt{12}\sqrt{3-g_1^2}\cos^2\alpha}$$

for $-\sqrt{3} \leq g_1 \leq \sqrt{3}$ (15)

where α lies between $-\frac{\pi}{6}$ and $+\frac{\pi}{6}$ and satisfies the equation

$$\sin 3\alpha = -\frac{g_1}{\sqrt{3}} \quad (16)$$

NORMAL DISTRIBUTION

William R. Thompson (1935) has shown that

$$p(\tau_i) = \frac{1}{\pi\sqrt{2-\tau_i^2}} \text{ for } -\sqrt{2} \leq \tau_i \leq \sqrt{2} \quad (17)$$

$$\therefore p(g_1) = \frac{1}{\pi\sqrt{3-g_1^2}} \text{ for } -\sqrt{3} \leq g_1 \leq \sqrt{3} \quad (18)$$

a result established by Fisher (1930). Comparing the distributions of g_1 for the rectangular and normal distributions it is seen that

$$p(g_1) \text{ rectangular} \begin{cases} > \\ < \end{cases} p(g_1) \text{ normal}$$

according as $|g_1| \begin{cases} \leq \\ > \end{cases} 1.3887$.

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ON DEFINING THE α -PHONEME

FOLLOWING Professor E. W. Scripture,¹ the term 'phoneme' is applied here to 'one of a group of similar speech sounds'. It is certainly a matter of fundamental importance to be able to define precisely the positive qualities (let us call them V and C) which characterise the vowel and consonant phonemes. Linguistics has not yet been able to arrive at these. It is because of this failure that Professor E. W. Scripture clearly points out the absolute necessity for a further work in *vowel analysis*; also, it is on account of this failure alone that certain phonemes are taken to be diphthongs

which in reality turn out to be only long vowels in which the change is considerable.² Our normal expectation is that V and C must be mutually exclusive, i.e., no sound-profiles can have both V and C. It is clearly seen from the phenomenon of the occurrence of the phoneme traditionally known as the *Aytam* in certain speech-forms in Tamil,³ that V and C are not *exhaustive* characters of speech-sound-profiles. It is not true that a sound-profile must be either V or C. The *Aytam* is both not-V and not-C.

In the speech-forms where the *Aytam* occurs, it is preceded by a vowel (*the necessary condition*) and followed by a consonant (*the sufficient condition*). That is, in the actual articulation of certain Tamil words in the stream of speech, consisting of an integral part with a vowel, followed by a consonant, the *Aytam* occurs. In each such word, the sound-profiles which occur successively may be taken as an infinite class, densely ordered, which has initially the vowel-character, then a transitional character, and finally the consonantal character. For, a vowel is made up of a series of adjacent vibration profiles⁴ the analysis of which show that all the frequencies from zero to infinity are present to a greater or less degree. 'The profile is, therefore, not a sum of a few discrete free vibrations as ordinarily supposed but an integration of an infinite number of such vibrations differing infinitely little from one another.'⁵ Any spoken language consists of a succession of speech-sounds more or less overlapped⁶ and these sounds can be grouped on the principle of similarity. The view that the speech is made up of a series of independent elements is erroneous.⁷ 'Not only must we say that every individual sound changes from beginning to end but we must assert that each one develops out of the preceding sound and into the following one. There are no well-defined limits between neighboring sounds—not only because the limits are vague, but also because there are no independent sounds to be limited.'⁸

In this connection attention must be drawn to Professor Scripture's analysis of 'to race' (in plate VIII facing page 40). 'As the [t]-closure is opened, the vibrations appear in line 102. Are these weak vibrations to be reckoned to the vowel vibrations that occupy the rest of the line? Or are they to be treated as a "glide" from [t] to the vowel?' These are legitimate questions. But Professor Scripture does not appear to answer them. On the contrary, he appears to be merely to follow an arbitrary procedure in placing the beginning of the vowel at the point where the vibrations reach half a millimeter amplitude. Similar is his treatment with regard to other sounds as well (page 44). He himself admits that nowhere in the whole sequence is there any sudden change, nowhere any possibility of assigning limits. 'We must conclude that there are no such limits and that the sound changes gradually throughout.'

In this connection, it is interesting also to note that according to A. Tanakadate⁹ the record of any single syllable of the Japanese sound elements, e.g., that represented by the

Kana (*ku*) or (*ke*) presents three characteristic portions. The beginning corresponds to the consonant *k*, the end corresponds to the vowel *u*; and there is an intermediate portion between the two where the amplitude of the oscillations is reduced to an insignificant amount. This middle portion does not play any important part in the formation of sound quality, or the Japanese Phoneme. Cutting away this part or lengthening it artificially does not change the reproduced quality of the sound or sound value. The same holds when the consonant is followed by any other vowel.'

It must be also remarked here that a change-point is ordinarily conceived to be any point at which any organ changes from one type of function to another and an α -sound is also similarly conceived to be a segment between two successive change-points.¹⁰ But an α -sound is quite different from the α -phoneme (the *Aytam*). The latter is a speech-sound of a group while the former is merely a sound. Failure to recognise this distinction will lead to much needless confusion. But it is clear that there are no ascertainable change-points. All the laboratory investigations lead to the conclusion that it is certain that there are no definite change-points. It is also clear that we are dealing with *macrophonic* speech here.¹¹

If we know the defining characters V and C, then we could give a rigorous definition of the *Aytam* by means of Dedekind sections, namely, we have a Dedekind section in which the lower segment consists of V (i.e., vowel sound-profiles) and the upper segment of not-V; we have also a second Dedekind section in which the lower segment is composed of not-C (non-consonantal sound-profiles) and the upper segment of C. The interval between the two section-points is the *Aytam* (the α -phoneme).

The *distances* between the vowel, the α -phoneme and the consonant in each of our ordered classes have to be measured, and on the basis of the three *physical assumptions* stated already (in my paper on the sub-class of α -phoneme¹²) which are:—

- (1) In the *transitional*, the vowel and the consonant are always together; there is superimposition.
- (2) During the *transitional* as a consequence of superimposition the *masking effect* will be of importance.
- (3) If the *duration* of the consonant extends beyond the refractory period there is a chance for the *audibility* of the consonant, in case the preceding vowel has an *influence* on the following consonant; the properties of the α -phoneme have yet to be experimentally studied. It needs no over-emphasis here that as some kind of accent distribution is involved in the occurrence of our α -phoneme, the relation between quantity and stress,¹³ should not be lost sight of in our investigations.

The foremost advantage got by defining the α -phoneme can be easily seen to be the *conception* of a new 'bound' class (rather, a sub-class) of 'phoneme',¹⁴

Although the definition of the α -phoneme has so far been restricted by me only to certain speech-forms in Tamil, still as we meet with phonetic features in another Dravidian dialect Gōṇḍī similar to those that characterise the production of the *Aytam* in Tamil, I need hardly say that the formulation of the 'cut' conception may open up an altogether new vista. In Icelandic, too, we meet with a phoneme under conditions similar to those under which the *Aytam* seems to have appeared in old Tamil. In Kashmiri dialects, too, there appears to be a similar phenomenon.

The phenomenon of the *Aytam* (the α -phoneme) is, therefore, a strong pointer to the possibility of defining vowel and consonant phonemes by certain (so far undiscovered) positive characters V and C.¹⁵

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1 *Nature*, 1935, **136**, 261 and 644. 2 Scripture, Prof. E. W., *Researches in Experimental Phonetics*, pp. 43-45. 3 Sankaran, C. R., *Bulletin of the Deccan College Postgraduate and Research Institute (BDCRI.)*, **2**, 348-49. 4 Scripture, Prof. E. W., *Nature*, 1932, **130**, 275. 5 Wood, Alexander, *Acoustics*, **360**. See also Sankaran, C. R., *BDCRI.*, **4**, 124. 6 Scripture, Prof. E. W., *Nature*, 1935, **136**, 759. 7 —, *Ibid.*, 1935, **136**, 456. 8 —, *Researches in Experimental Phonetics*, pp. 42-43, 58-59; Andrade, M. J., *Language*, 1936, **12**, 2. 9 "A Study of Japanese Phonemes by means of Tone Films," *Proceedings of the Second International Congress of Phonetic Sciences*, 1936, **118**. 10 Hockett, C. F., *Language*, **18**, 5. 11 Scripture, Prof. E. W., *Nature*, 1933, **132**, 138. 12 Sankaran, C. R., *BDCRI.*, **4**, 55-56. 13 Heffner, R. M. S., *American Speech*, 1941, **16**, 204-7; Haugen, E., and Twaddell, W. F., *Language*, 1942, **18**, 230. 14 Sankaran, C. R., *BDCRI.*, **3**, 393. 15 I am indebted to Dr. R. Vaidyanathaswamy, Department of Mathematics, University of Madras, for the clarification of many ideas in the matter of application of Dedekind section idea in defining the α -phoneme.

RAMAN FREQUENCIES OF CALCITE

FOLLOWING the earlier work of Bhagavantam and Venkatarayudu,¹ one of us has recently given a satisfactory explanation for most of the prominent features of the Raman spectrum of sodium nitrate.² In this note, the case of calcite is dealt with on similar lines.

1065, 860, 680 and 1,407 cm.^{-1} are assumed to be the normal frequencies of the CO_3 -ion in solution and using the well-known equations for the frequencies of vibration in such a case, the following force-constants are evaluated:
 $K = 5.45 \times 10^5$, $K_1 = 1.75 \times 10^5$, $K_2 = 0.45 \times 10^5$,

$$K_3 = 3.33 \times 10^5.$$

In the crystal, besides altering the value of K_1 to 1.86×10^5 so as to take account of the surrounding structure, three additional constants representing effectively all the inter-ionic and other forces of the crystal are postulated and their values are given below:

$$K_4 = 0.22 \times 10^5, K_5 = 0.38 \times 10^5 \text{ and } K_6 = 0.16 \times 10^5.$$