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# The Localization of Sound by Wave Phase in the Open Ear

Henry M. Halverson

# THE IOWA PITCH RANGE AUDIOMETER

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The ideal apparatus for measuring the acuity of the ear should enable one to determine the faintest audible sound at each and every pitch within the tonal range. It should be easily and quickly operated and should be permanently standardized. The Pitch Range Audiometer is an approach to this ideal.

The essential parts of this audiometer are a variable frequency generator having a range of between 25 d.v. and 14,000 d.v., a motor for rotating this generator, a telephone receiver, and an electric tachometer for indicating the pitch of the tones produced. The complete range of tones is produced by varying the speed of the motor. Intensity measurements are secured by means of a small potentiometer with an empirically chosen increasing scale of 400 per cent installed in the circuit.

The practical use of the instrument has been demonstrated and verified in the otological clinic. It was used in the army vocational school in selecting radio operators. Unlimited opportunities are open for its use in the psychology of music, and for the basis of laboratory experiments, and other lines of practical scientific work.

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# THE LOCALIZATION OF SOUND BY WAVE PHASE IN THE OPEN EAR

HENRY M. HALVERSON

Wave phase localization may be studied under normal conditions; i.e, without the aid of conductors to the ears. Our apparatus consists of two telephone receivers connected in series from the same source. If the receivers are so energized as to produce a pure tone, the observer, by closing one ear and moving the head carefully from one source to the other, (the side of the head parallel to the axis of the receivers) will experience a series of "highs" and "lows" in intensity. These points of maximum and minimum intensity correspond exactly to the points of reinforcement and interference as obtain in the standing wave.

If now the observer, with both ears open, (the aural axis parallel with the axis of the receivers) moves slowly from one source to the other, he will be conscious of a median plane localization for each one-half wave length that he advances. These points in localization we call loops. Midway of these are other median localizations known as nodes. There is a fundamental difference between these nodes and loops. In the loop the phantom sound moves in the same direction in which the observer is moving, while in the node it moves in the opposite direction.

Following are some of the conclusions which we have reached:

1. If a rich tone is used the trained observer may localize, not only the phantom for the fundamental tone, but at least two or more of the overtones the phantoms of which have loops of relatively smaller dimensions may be localized independently of the overtone. This is particularly true of low tones of some 100 v.d.

2. The loops and nodes of any phantom always occur alternately for each one-fourth wave length of the phantom tone in the case of either a pure tone or a rich tone, and may be interpreted in terms of the conditions of the standing wave.

3. Wave phase effects obtain, not only in the line of the receivers, but practically anywhere within the range of audibility. We are as yet unable to say that these changes in phase are everywhere uniform. Present investigations seem to point to the fact that they are not uniform.

4. Wave phase effects are best obtained midway of the receivers. As we draw near either of the sources localization becomes more difficult.

5. The size of the loops varies directly with the wave length of the sounds used. The same is true of the nodes.

6. Wave phase effects in open air are best observed with tones ranging from 300 v.d. to 1200 v.d. This is because (1) tones within these limits present sharper differences in intensity at the nodes and loops; (2) the interaural distance hinders localization with tones of high pitch.

7. The flux in intensity from a loop to its adjacent node has been determined by means of the Seashore audiometer. Hence the differences in intensity which we had formerly observed are not at all subjective.

8. The intensity of the two sources may vary widely without affecting the wave phase effect.

9. By means of the standing wave it is possible to predict the relative intensity and localization of the phantom at any point on the line between the receivers.

# WHAT CONSTITUTES VOICE?

C. I. ERICKSON

I. General mechanism of voice production —
  A. Physiological
    1. Lungs
    2. Larynx
    3. Resonating Cavities
      a. Ventricles of the Larynx
      b. Lower pharynx
      c. Upper pharynx
      d. Oral cavity
      e. Nasal cavity
      f. Sinuses
    4. Muscles
      a. Ten expiratory muscles
      b. Laryngeal muscles
        (1). Five intrinsic
        (2) Four extrinsic or infrahyoid
      c. Supra-laryngeal muscles
        (1) Five pharyngeal
        (2) Four suprahyoid
        (3) Four maxillary
        (4) Eight lingual
        (5) Ten labial
        (6) Five palatal
        (7) Five nasal
  B. Psycho-physical
    1. Auditory imagery and sensations
    2. Kinaesthetic imagery and sensations
    3. Tonal memory
II. Basic factors —
  A. Pitch — its primary mechanism of control
    1. Physiological
      a. Vocal cords — variable as to weight, length, shape, tension, and condition
      b. Intrinsic laryngeal muscles
      c. Supra-laryngeal muscles
    2. Psycho-physical
      a. Pitch discrimination
  B. Intensity — its primary mechanism of control
    1. Physiological
      a. Lungs variable as to capacity and condition
      b. Resonating cavities — variable as to number used, size, shape, condition
      c. Expiratory muscles
      d. Supra-laryngeal muscles
    2. Psycho-physical
      a. Intensity discrimination
      b. Acuity of hearing

C. Timbre — its primary mechanism of control
  1. Physiological
    a. Resonating cavities
    b. Vocal cords
    c. Supra-laryngeal muscles
    d. Laryngeal muscles
  2. Psycho-physical
    a. Pitch discrimination
    b. Intensity discrimination
    c. Timbre discrimination

D. Volume — its mechanism of control
  1. Physiological
    a. The general mechanism of voice production
  2. Psycho-physical
    a. Intensity discrimination
    b. Timbre discrimination
    c. Extensity discrimination

E. Time — its mechanism of control
  1. Physiological
    a. The muscular mechanism of voice production
  2. Psycho-physical
    a. Time discrimination

## THE PERSONAL EQUATION IN MOTOR ABILITY

MARTIN L. REYMERT

In order to try out experimentally the common notion, that an individual will show a constant behaviour as to speed and accuracy in all kinds of motor performance — within his group — a series of reaction and motor tests were given to sophomores. The tests were: (1) Tapping in group (with pencil). (2) Individual tapping (on telegraph key). (3) Counting numbers orally. (4) Writing numbers. (5) Counting and writing as one combined activity. Simple bodily reactions of (6) the lips, (7) the jaws, (8) the index finger, (9) the head, (10) the elbow, (11) the thumb, (12) the foot. (13) Ergograph test.

Throughout this test series the individual behaviour was judged in terms of speed (time) and variability (mean variation). The raw-correlations (Spearman) have been pooled.

The main results:

1. There is a distinct personal equation as to speed throughout all tests — the intercorrelations here being positive, very high and very reliable (as judged by P. E.).

This result may have the bearing on motor tests for vocational selection, that one or two representative motor tests will suffice