ence of a bodily attitude of quiet tension. Many observers of the behavior of animals in learning a maze have noted that they quickly acquire a bodily orientation towards the center, and tend to correct movements that carry them away from this oriented attitude. Similarly with Hunter's Delayed Reaction apparatus, even when the animals were restrained from going to the correct door for some little time after the signal light had been turned off, they succeeded in doing so by keeping their noses pointed during the delay interval towards the place where the light had been. The original stimulus for this oriented attitude is of course external, the light, or the smell of food in the maze; but the orientation seems to be capable of persisting for some time after the stimulus is gone, and to be revived by associated stimuli, as when a dog entering a room looks under the chair where he left a ball. Following our general custom of deriving our terms for abstract relations from terms meaning spatial relations (as when we speak of "straightening out" a mental puzzle), we use the expression "thought *directed toward a goal.*" May not the steadily tense bodily attitude accompanying directed thought be in some sense a relic of the orientation in lower animals of the entire body towards the stimulus that will bring relief from a drive? In the beginning, while the reflex and tropism were adequate modes of behavior, the drive discharged in a definite direction. As the environment became more complex, the drive discharged into random movements of which those associated with the drive in its last and most intense stages tended to survive and become organized into systems. In this process the drive secured the persistence needed for purposive action, but the definite direction of the tropism was lost. Often, however, in animals, part of the energy of the drive goes into the tendency to maintain and restore a bodily orientation towards the goal; while in man, for whose varied activities general bodily orientation is too confining, directed thinking is sustained by a vestige of this general bodily orientation, the tense quietness of the trunk muscles that may persist even when we turn from one position to another.

In explaining, then, the persistent character of purposive action, the mechanist may substitute for the vitalist's mysterious, emergent entelechy, involving something over and above the ordinary physico-chemical laws, the *drive* as a state of unstable physico-chemical equilibrium, underlying all purposive action, and an attitude of steady contraction of the trunk muscles, into which the energy of the drive may discharge and which accompanies the higher forms of purposive action. These suggestions towards a mechanistic explanation of purposiveness have had to be put concisely and dogmatically because of the limits of my time. If they are highly speculative, they are at least, it seems to me, by virtue of being mechanistic, closer to the spirit of science than the semi-personal and animistic emergents of the vitalist.

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THE COLLECTING OF FOLK SONGS BY PHONOPHOTOGRAPHY[1]

Ear analysis of folk music. The traditional method of the anthropologist in collecting folk or primitive music has been an analysis of the songs by ear, whether taken directly from the lips of a singer or from a phonograph record. This subjective method has many serious limitations.

That the ear is inadequate to describe many of the important elements of music is best indicated by the American Negro vocal embellishments, whose description has baffled the keenest ear. The fast changes of the voice lose their original identity when heard, becoming fused in perception. Another difficulty with a subjective analysis is the bias due to past musical experience which deafens the notator to elements foreign to his own music. For example, the European musician holds that American Negro music belongs to his musical system, while the African analyzes out of the great sound complex reaching his ear so much in common with his own music and so little that is not that he draws a natural but opposite conclusion.

Conventional notation. The conventional symbols which have been used by collectors of folk music were devised as a representation of European music. Consequently to use such symbols neglects those factors which might make a folk music distinctive. In Negro music, that part which is characteristically Negro is not found in the stilted notes on the conventional five-line staff, but rather in the twists and slides between the lines.

Measurable records of music. In the fall of 1925 we undertook a field study of Negro music, but instead of using the cylinder phonograph we substituted a portable phonophotographic camera. The voices of Negroes were photographed on motion picture film, by using an optical lever somewhat on the order of Miller's phonodeik.[2] This photographic method shifted the analysis of folk songs from auditory experience to an objective measurable record of the sound wave.

[1] Presented before the National Academy of Sciences, at Urbana, Illinois, October 18, 1927.

[2] Miller, D. C. "The Science of Musical Sounds." Macmillan, New York, 1916.

Phonophotographic theory. The most strategic approach in a description of folk music is an analysis of the sound wave, because it is the connecting link between the singer and listener. Preceding the sound wave there is a series of events within the organism of the speaker, and following it there is another series within the listener. All these events may be related in a causal series.

What we are calling the speech and music causal series consists of two main segments. The first, or expression, segment consists of a description of the speaking or singing experience, of the neural action occurring at the same time, of the muscular action following, and of the sound-wave resulting. The second, or impression, segment involves a description of the sound-wave, the action of an adequate receptor, together with neural action and auditory experience.

The sound wave overlaps each segment or, taking the causal series as a whole, it occupies a central position. For musical purposes it may best be described in terms of four properties, *viz.*, wave-frequency, wave-amplitude, wave-form and wave-recurrence. Each of these properties of the sound-wave may be converted into related aspects of links either way in the causal series. When paired with attributes of the sound heard, wave-frequency may be converted into pitch, wave-amplitude into intensity, wave-form into timbre, and wave-recurrence into subjective groupings.

The sound wave properties may likewise be converted into aspects of muscular action, which in turn may be translated into aspects of neural action. Frequency, for example, is linked with the length, thickness and tension of the cricothyroid muscle. Much of the pairing remains to be accomplished, but at least the possibility of relating aspects of each link in the causal series is established. The research of the next decade in speech and music will probably be centered on the formulation of laws of relationship of the causal series links.

Once such laws of relationship are established, it will be possible from only a knowledge of the nature of the sound waves of primitive music, not only to understand the action of the ear and the nature of the auditory experience in folk music, but also to go the other way in the causal series and state the muscles and nerves involved and their mode of action. The collector of primitive music then gets a possible description of some of the neurology, anatomy, physiology and psychology in the production and reception of primitive music, when he only photographs the sound-wave.

Pattern notation. It is possible to decipher the code of the sound-wave into the notes, rests and signatures on the conventional five-line staff. The best argument against such a procedure when used alone may be inferred from the notation we have adopted as a representation of speech and music shown in Figure 1.

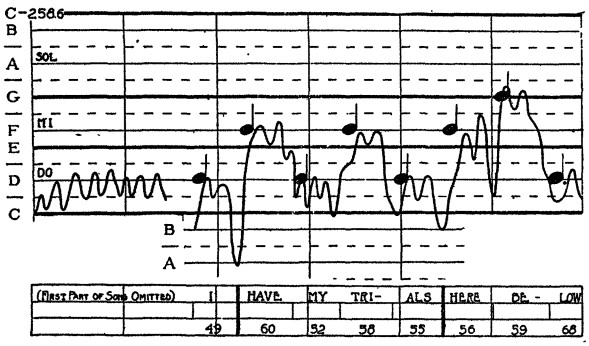

FIG. 1. First part of a Negro spiritual. In the present collection, now in press, there are over thirty folk songs on pattern notation. Leger lines are extended from the staff wherever necessary, in this case the three half steps from B to A inclusive, below the staff proper. The numbers at the bottom of the legend beneath the staff are in terms of .01 sec., representing the duration of a tone.

In this illustration, the graph-curve forms itself into certain definite patterns, which are descriptive of the vocal phenomena of the sound-wave. We are calling this the "pattern notation." The horizontal lines represent a half-step, and the six equal divisions from left to right each have a value of one second. This graph displays only the frequency and recurrence patterns, but wave-energy and wave-form analysis may also be represented.

The distorted and insufficient view of the nature of music revealed by a note-symbol may be seen on the tone "I," Fig. 1. The voice brushes up against the note for a brief time, but the tone begins three half-steps below, and drops rapidly for five half-steps on the release. This type of release is quite common in Negro singing. It seems as if the extended drop releasing "I" were intended to give a running start on the tone following. Then there are the wavy lines at the left of Fig. 1 representing the vibrato, which persist whenever the tone is held for any length of time.

Figure 2 is a sample of a Negro workaday religious song. Here the note-symbol crumbles completely, for many of the tones are entirely intonations. Tones such as *since,* Fig. 2, a glide upward throughout its duration of a quarter-note, suggest that the Negro frequently adds a touch of the dramatic by including speech intonations here and there. The sweeping attacks and releases of tones illustrate how the free-

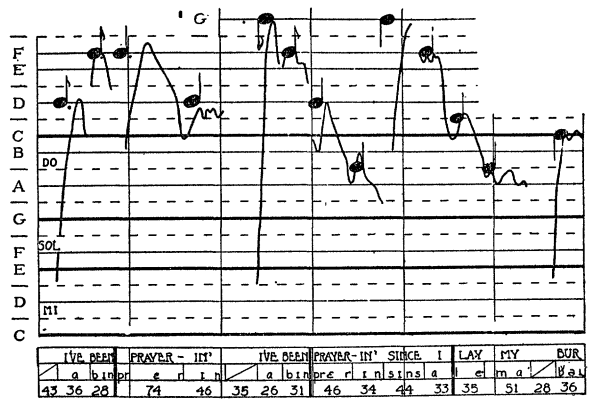

FIG. 2. Section of a Negro workaday religious song. The second line on the legend below the staff is the phonetic transcription.

dom which the Negro enjoys in singing is left intact on the pattern notation.

It is apparent from these examples that no longer need the word "unnotatable" be applied to anything in speech or music.

Negro vocal ornaments. The personal decorations of primitive man are no more tangible than the ornaments of voice, when the latter are brought out by phonophotography. The vocal ornaments may be isolated from a song, classified and placed on exhibit as a particular pattern. With a phonograph record or film to reproduce the music, any one may hear the vocal ornaments which are pictured.

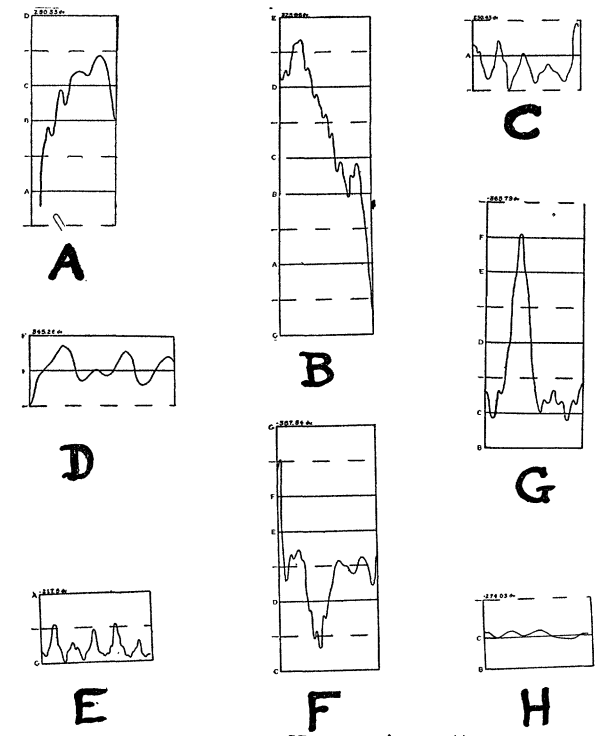

FIG. 3. Various Negro voice patterns.

Such a museum exhibit is presented in Fig. 3. These are close-ups of the pattern notation. *A* represents a Negro attack of a tone, and *B* and *C* releases. The falling intonation at the end of *B* is heard often at the close of a breath-group. The upward flip shown on *C* is not such a frequent pattern, but it is used for variety effect. *D* is a slow quaver, the voice slowly alternating, while *E* is a Negro vibrato. Note the irregularity, for it is characteristic of this pattern among Negroes. The artistic singer much more nearly approaches a smooth curve. *F* shows one variety out of many of the interpolated-tone. The tone is begun and ended on the same pitch and with the same vowel, but a short tone is interpolated somewhere within the limits, sometimes above and sometimes below. *G* is a falsetto-twist, where the voice twists in and out of the falsetto for an instant, giving a peculiar tone coloring. *H* shows an erratic-waver, which is due to the unsteadiness of the vocal cords in holding a tone. There is no definiteness about the wavering as in the case of the vibrato.

Vocal customs. The vocal customs which make one folk music distinctive from another may now be added as a new chapter for the folk-lorist. Some of these customs have been observed by ear, yet even such a factual problem as quarter-tones in various folk music scales is still being debated. By measuring the sound-wave, it is possible to determine all the intervals in given music to a fraction of a vibration, if desired. It follows that the scale of any music existent at the present time may be determined with precision. The interval graph of Fig. 4 is intended

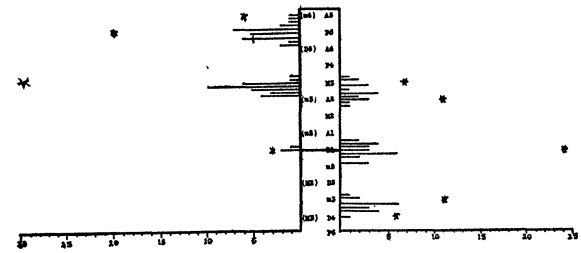

FIG. 4. An interval graph.

to be accessory to the pattern notation, isolating intervals and placing them in compact form for a study of scales.

Another accessory graph, Fig. 5, is the tempo graph. The sudden and expressive speeding up or slowing down of tempo in Negro songs is here illustrated.

Preservation. The many records of folk music lying idle in the museums of America and the *Phonogram Archiven* of Europe in effect are preserv-

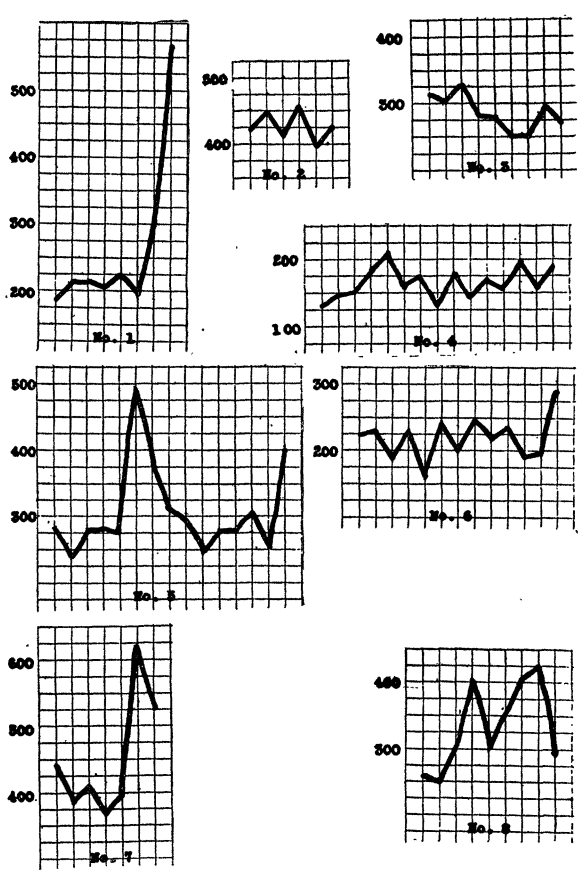

FIG. 5. Some of the tempo graphs of the collection. Vertical values are in seconds, with one square from left to right for each measure in the song.

ing the sound-wave, but not in directly measurable form. The phonophotographic record will not only preserve the sound-wave for measurements, but may use the same waves for auditory reproduction by use of the photoelectric cell.

The cylinder records already collected might be photographed second hand to a profit, now that the announcement of a machine which simplifies the measurements of frequency and recurrence is imminent. There is of course a large error involved in the making of such cylinder records, and the favored method would be to make the record photographic in the original.

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SCIENTIFIC EVENTS

NEW LABORATORIES FOR THE FACULTY OF MEDICINE AT PARIS

THE Faculty of Medicine of Paris came into possession, in 1920, of a large tract of improved property formerly owned and controlled by the College of Jesuits, rue de Vaugirard, comprising a hectare and a half of land (nearly four acres), which became alienated through the operation of the law pertaining to teaching religious organizations. The property was acquired by the government for 5,500,000 francs and two annuities of 5,000,000 francs each. The Paris correspondent of the *Journal* of the American Medical Association writes that the Faculty of Medicine has decided to establish a hygienic institute and the services of an experimental surgical clinic, under the direction of Professor Pierre Duval. For the latter a gift of the government of Brazil was utilized, which had organized there a model hospital during the war and which turned over to the Faculty of Medicine all its installations and a large amount of material without asking any recompense. But the government has been prevented by the financial crisis from supplying either institution with the 5,000,000 francs promised. Only 1,200,000 francs has been allotted to the surgical clinic. As for the hygienic institute, it still remained, after seven years, in the same condition it was in before. Its director, Professor Léon Bernard, has collected, through various gifts, only 800,000 francs, which has been used for the repairs on these buildings, which had deteriorated owing to their having been neglected over a period of fifteen years. Neither the minister of health nor the city of Paris, nor the general council of the Seine, has sufficient funds, at present, to supply the amount needed, by reason of the creation of overburdensome taxes, which paralyze general activities and yet do not furnish an adequate return, while the high cost of living and the increase of salaries and pensions absorb a large part of the available liquid assets. An anonymous donor has contributed 500,000 francs; the fund into which are paid the levies on gambling, clubs and horse racing has furnished an additional 150,000 francs. With this sum, the buildings that were falling into ruin have been restored and six large laboratories have been built and equipped with the necessary supplies, including suitable quarters for experimental animals. The final results are excellent, but it is claimed that they would not have been possible except for the fact that the Faculty of Medicine was free to dispose of the funds as it chose, whereas if the government had taken charge of the improvements the expenditures might have been twice as great. The architects and contractors granted discounts of from 25 to 40 per cent. on the prices that they demand of the government, which pays their bills only after long delays and innumerable formalities. The new laboratories are intended for the department of physiology, which was very poorly equipped heretofore, and are placed under the direction of Dr. Santenoise. The official dedication took place on Novem-