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NEW VANTAGE GROUNDS IN THE PSYCHOLOGY OF MUSIC[1]

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THE Baconian series of lectures was established for the purpose of furnishing from time to time a highlight review of the state of progress in given fields of knowledge. Ten years ago, I had the pleasure of giving the first lecture under this new organization. At that time I reviewed the status of the psychology of music. Since that time much water has run under the bridge, and this evening I have the pleasure of returning to the same subject with the satisfaction of reporting gratifying progress.

I. MEASURING INSTRUMENTS

The progress that has taken place in the last decade by leaps and bounds is due to the extraordinary development of recording, measuring, transmitting and generating instruments by electrical engineers. We see this progress exemplified in the radical changes which have taken place in the recording of music by phonograph and film and in broadcasting over the radio. In acoustical engineering, as in every other science, there is a normal order of evolution. Each introduction of a new fundamental principle in physics or chemistry furnishes a vantage ground for further achievement. The recent development of the microphone and the thermionic tube has been revolutionary.

By the use of such tubes, a sound may now be amplified a million times. A sound made by a parasite squirming and crunching in a grain of wheat may be amplified so as to disturb the conversation in an adjoining room. Such amplification we hear every day in listening to our radios. We may now pick up the minutest characteristic of a single vibration in a tone

[1] An address in the Baconian series of lectures at the University of Iowa, November 13, 1936.

and isolate it, magnify it, modify it under experimental control, and measure it to the limit of all practical and theoretical needs.

Perhaps the most significant application of extraordinary amplification lies in the possibility of picking up nerve impulses in any part of the nervous system, tracing their course in rich ramifications, detecting their occurrence and measuring duration and intensity of sensory impressions as well as the response to nerve impulses in the muscular mechanism of the body. This is known as the action-current technique. The flow of a nerve impulse generates an electrical current which corresponds in many respects to the nerve impulse itself. This current is amplified and can be studied in great detail. When I bend my forefinger, this is the result of the discharge of nerve impulses from the central nervous system into the muscles of the finger at a rate sufficiently rapid to keep the finger from trembling. The action currents from these nerve impulses are picked up and may be converted into sound waves, giving a tone which may be heard as loud as a man can roar. Of course, these waves may be sent around the globe and may come back to me and be heard while the finger is still bent. By the same technique we can measure hearing ability in man or in any of the lower animals by measuring the action-currents which flow through their auditory nerves as a result of sound stimulation. For many purposes measurements on the nerve impulse are more accurate and there are far more possibilities than the traditional psychophysics methods through hearing.

By such action currents we can even measure various aspects of activity in the brain. For example, it is possible to detect the exact moment that a person sees light or has a dream. If I should be far off in London, sleeping in a hotel, and my wife should want to know if I was sleeping well or dreaming, she could ask to have my brain waves cabled to our psychological laboratory and a laboratory assistant could tell from the characteristics of these whether or not I was sleeping soundly. By ordinary sound transmission she could, of course, hear whether or not I was snoring.

Likewise, in the field of producing synthetic tones, marvelous progress has been made so that it is now possible to produce practically any conceivable kind of tone for musical purposes. We are at the beginning of an era of radical revolution in the improvement of musical instruments on the basis of scientific measurements and in the substitution of comparatively simple electrical devices with infinite possibilities for modification of tone for organ pipes, strings, horns and drums. The Hammond organ is a step in this direction. In cooperation with electrical engineers, we have in the university built one tone as an experimental model for what might become an organ. With this generator, a tone may be made up of as many as sixteen partials in which it is possible to vary the number, the distribution, the relative strength, the phase relationship and the fundamental frequency in the sixteen partials. Any mathematician can tell us that this makes possible the production of more than a million changes in the character of that tone. By playing on this one instrument, it is possible to imitate the violin, the organ pipe, the tuning fork, the bass horn and even the bass drum; and every type of tone produced can be described and recorded in exact physical and mathematical terms.

But no musical ear can distinguish that many differences in tone. For that reason, a sort of keyboard has been built into the instrument on which one can set up the most desired tone qualities that can be heard and desired. These keys are operated like the stops on an organ. For a particular flute tone, a cornet tone, a clarinet tone or a specific organ quality, one can draw a particular stop and that quality of tone can be guaranteed, described and repeated. It is even possible to speak particular vowels, such as a, e, i, o, u, with considerable fidelity. We can look into the internal structure of a tone, trace the reverberation of its individual partials in the auditorium and follow their course through the ear, the nerve and the brain, and record their response in specific muscles.

These are but samples of acoustical experiments that have taken place in the last decade. With such instruments placed at the command of the experimental psychologist in the studio for the psychology of music, it can readily be seen that a new world of science is opened up. Musical tones have been harnessed, can be recorded, transmitted, built up in any conceivable variety of quality. Thus acoustics, the youngest of the sciences, has made its debut. All this culmination of achievement has taken place largely within the last decade.

II. The Adoption of Scientific Method

This acquisition for mastery of the musical tone has facilitated the adoption of strictly scientific procedure in the study of musical phenomena, so that those who are now pursuing the subject seriously can set up as criteria of scientific validity such sanctions as these: (1) The factor under consideration must be isolated in order that we may know exactly what it is that we are measuring; (2) this factor must be varied under control while other factors are kept constant; (3) the observed facts must be recordable; (4) the situation must be repeatable for verification; (5) the conclusions must be validated in relation to the total personality in the total musical situation; and (6) the conclusion must be limited to the factors under control.

Adherence to such basic principles is now an attain-

able goal and one for which we must hold ourselves responsible in the science of music. With these principles as a criterion, we must, of course, admit that much of the amateurish work that has been done in the name of the psychology of music is condemned and must be done over again. On the other hand, the scientific approach to music is vastly enriched by the adoption of these principles because basic approaches to the science will be contributed through the cumulative development in underlying sciences; such as, physics, anatomy, physiology, mathematics and anthropology, all of which now are entering upon a new era in the form of contribution to phonetics and acoustics. The instrument maker, the musical performer and the composer now have new concepts and new effective tools placed at their command. It is the function of the psychology of music to organize, integrate and interpret contributions from all such sources in order that we may gradually build an applied science on musical experience and musical behavior.

III. Terminology and a Musical Pattern Score

The growth of knowledge of music in the manner just described is beginning to result in the clarifying of concepts, the definition of terms and the radical revision of musical language. Take such a concept as that of tone quality. Musicians have literally hundreds of names improvised under the influence of impulse and the necessity to designate this characteristic of tone. None of these terms have been defined or standardized in musical literature, but since we have taken the tone into the laboratory, it has been possible to analyze, define and describe characteristics of tone quality, so that any scientifically minded person can know exactly what the term means and what he means by it. For example, when, as a result of thorough-going experiment, we have defined tone quality, that definition can be formulated, verified and standardized, and the hierarchy of characteristics of tone quality defined consistently in terms of that definition, with the result that undefined, ill-adapted and confusing terminology now prevalent will gradually be scrapped.

Nobody is to be blamed for the existing jargon in this field. With the best of intentions, musicians have had to await the coming of scientific experiment. It is the business of scientists to develop the science of music; musicians must ply the art. But the musician must keep in cooperative touch with scientific development and absorb the new knowledge progressively.

An analogous development to that of musical terminology is that of musical symbols by which scientifically determined facts about the tone may be represented in a compact semi-diagrammatic form of notation which is capable of reporting scientific data in a new type of score which shall be musically significant. This has been accomplished in the introduction of what we call the musical pattern score in which the actual performance of a note is shown in minutest detail in the form of a simplified graph which takes the place of the conventional musical note. This musical pattern score has been simplified and condensed so that it is now possible to show in terms of this score exactly how a song or instrumental performance was rendered; and this can be done almost in the space occupied by the original musical score.

IV. Analysis of a Problem

In the pre-scientific stage, musical phenomena impressed one as of such infinite range of characteristics of an intangible nature that a scientific approach seemed futile and rash; but the actual scientific approach, when persistently pursued, dispels this confusion and attempts to make every aspect of the phenomena tangible. Let me give a few illustrations of actual vantage grounds that have been gained in recent years.

The psychology of music deals with the experience and behavior of the singer and of the listener. These are both approached through the study of the music as such, which is the message of the composer and the interpretation of the performer, and in turn becomes the stimulus for musical experience and behavior. The scientific approach, therefore, makes it desirable to begin with the music as such, a work of art, as distinguished from the creator or the person appreciating the creation. But this art object is often intimately tied up with words, dramatic action and countless influences of personality, audience, service to be rendered by the music. Each of these is significant for the music, but for the scientific purpose we may eliminate them entirely and say that in this work of art all that is transmitted from the performer to the listener is carried through the medium of sound waves. We, therefore, postpone a study of all the accessories and isolate the sound wave for study.

Sound waves, when adequately recorded, have four characteristics, and only four; namely, frequency, amplitude, wave form and wave duration. All these can be accurately measured, and in terms of these, all points of physical tone may be described. The adoption of this point of view simplifies our problem of approach and gives us positive assurance as to the possibility of measuring and controlling each and every kind of tone as a physical phenomena.

But we must now take the long leap to give this musical and psychological significance. We do not hear sound waves; we hear tones. The first step was to recognize that for each of these measurable aspects

of sound waves, there is a mental process. Frequency gives us pitch; the amplitude gives us loudness; the wave form gives us timbre; and the duration of sound waves gives us time. These are the four attributes of sensation in terms of which we hear, appreciate, remember, think and produce tones; so that we may say that, in terms of pitch, loudness, timbre and time, we may describe every musical experience of tone. This was a great step in the effort to make music tangible for scientific analysis. In the absence of that concept we should have continued thoroughly baffled by the apparent chaos and confusion of musical experiences.

But, with the progress of science, it was found necessary to modify the concept of the 1:1 relationship between the physical and the mental. Pitch is a psychological and musical term denoting experience and, while in general it is determined by the frequency of the sound wave, there are many exceptions depending upon a variety of objective and subjective conditions, such as the amplitude, the form and the duration of the sound wave. A tone of 220 vibrations does not seem to be of the same pitch in a loud tone as in a soft tone, in one characteristic timbre as in another, or in one limited duration as in another; and the same was true about the other three characteristics.

There is not always a ratio of 1:1 between the physical and the mental; but from this embarrassment we again found relief in the conception that the differences between the physical and the mental may be regarded as normal illusions and such normal illusions can be measured. The demonstration of this was an extraordinary achievement; thus, a vast field of the psychology of music consists of the description and explanation of normal illusion as a medium of musical art. Since there is much truth in the aphorism "All art is illusion. Thank God for illusions!", a great conquest was made in the establishing of the possibility of measuring these illusions.

But still another fundamental step had to be taken in the effort to measure and evaluate artistic performance and experience. This took the form of recognizing the possibility that beauty of music consists primarily in artistic deviation from the rigid—true pitch, even intensity, metronomic time, pure tone. It is difficult to comprehend the far-reaching significance of this conquest in the interest of scientific measurement. In the study of pitch intonation we rarely encounter a fixed pitch in musical performance. Indeed, the entire range for the expression of individuality, mode of interpretation, art, etc., in terms of pitch consists in artistic deviation from true pitch. This in all its forms can easily be measured, classified and described. The same is true of the other attributes of tone: loudness, time and timbre.

For each of these four variables, it was necessary to establish a sort of zero point for a measuring scale. Thus for pitch, the zero point is the frequency of the standard tone; for loudness, it is the absence of sound; for duration, it is the lapse of time in terms of a fraction of a second; and for timbre, pure tone. The taking of this step constituted the laying of a corner stone in musical esthetics, in that it furnished the means of interpretation for every aspect in the exhibition of musical art or in faults of the art, in an exact and verifiable way. Thus, since art is an appeal to feeling and an expression of feeling, we have here a scientific approach to the analysis, description and explanation of the expression of musical emotion, or feeling, in so far as that can be expressed in music.

The reaching of this vantage ground constituted a contribution to scientific psychology in itself in that it opened up a new field for reliable measurement of emotional expression. But our process of simplifying the approach had to be carried one step further. That was to recognize that the higher and more complex processes in music are all relatable to these four basic concepts. Mental images, whether in imagination or in memory, are in terms of the same attributes as we found in sensation. We can imagine or recall tones in terms of these characteristics of the image or names for them. Likewise, thought about tone must be couched in terms of these same concepts. And what is it that arouses musical emotion? In what terms is emotion expressed? We must answer, in these same terms. And when we come to the musical performance, what does the musician have to do? He has to control pitch, loudness, time and timbre. This conception does not oversimplify; because it leaves room for all kinds and degrees of complexity. Rhythm is primarily a periodic pulsation in time and loudness, but it carries meaning and this meaning lies in a rich infiltration with higher cognitive emotional and motor factors, but all these are integrated in a hierarchy of manifestations of the basic concepts. The same is true in principle of volume, harmony and tone quality. Musical emotion, in so far as it arises from the musical stimulus or the response, as in musical phrasing, is subject to interpretation on the same principle.

These processes of simplifying the psychological approach to music are all essential to the scientific effort in analyzing, measuring and evaluating musical talent. We are no longer confronted with the question whether the child is musical or unmusical, but rather with such specific, answerable questions as: To what degree does this child have a sense of pitch, a sense of loudness, sense of time, sense of rhythm, sense of timbre, sense of volume, sense of harmony, sense of tone quality? Each of these it is possible to isolate, to measure and to evaluate in relation to the total profile obtainable through these and numerous other measure-

ments. Thus, vocational guidance was given a sound basis.

V. Norms of Artistic Performance, Actual or Ideal

With the progress thus made, it has been possible to establish norms of musical capacity and norms of musical performance. Under various conditions it has been possible to show the normal mode of attack in the intonation as exhibited by the best singers of to-day, and state quantitatively in the pattern score the degree and character of its variations. The same has been done for the sustaining of tone, the release and portamento, so that in picking up a new specimen of vocal intonation, we can immediately compare it with established norms. This procedure of establishing norms can be continued indefinitely, thus setting up standards of performance in any aspect of music. The musical critic may be able to speak in concrete terms of the characteristics of the performance of a singer or violinist in relation to established norms.

But in so far as psychology of music is an applied normative science, it is not satisfied with what is, but continually raises the question, What ought to be? This question is, of course, of profound significance for the art. Take the case of that pulsating, tender quality of music which we call the vibrato. Adequate norms for reporting the scores of the best singers of to-day show that the average extent of the pulsation is a little over a semi-tone. This seems unbelievable; but it is possible and tolerable because we do not hear the pulsation as it actually is; we hear it as only a small fraction of that extent. It is modified by certain laws of illusion; but even then psychologists have come to the conclusion that what we have now is not the best possible. So by elaborate experiments it has been determined that the vibrato of the singer should be greatly reduced and that the ideal norm for musical ears would come nearer to a quarter-tone than a half-tone of pulsation. That is establishing an ideal norm with numerous concrete specifications for its variability.

In the same connection, elaborate experiments have been made to determine by what method of instruction and training this refinement can be made, and it has been found that it can be made quite rapidly and with a high degree of precision by an expert. How much would such a change in the singing profession be worth in terms of cost of musical education? How much would be the substitution of the ideal for the actual norm worth in the development of higher art principles?

Another phase of the psychology of learning which has come out of the laboratory situation is the art of developing particular musical skills. This art may be expressed in two propositions: in acquiring musical skill, isolate and master one factor at a time until it becomes habitual and automatic; and, in the actual musical performance, act in the musical mood without consciousness or deliberation about each of the scores of musical skills which have been made automatic. For this purpose instruments have been devised to facilitate musical training so that when a student is learning to sing or play intervals in accurate intonation, he sings or plays in front of an instrument which shows to the eye instantly whether or not he is right or, if he is wrong, to what extent he is wrong. Thus, training the ear by the eye vastly shortens the training period and makes possible a much higher degree of precision.

Thus, we have traversed steps in the evolution of an applied science, showing the possibility of establishing law and order in music as a work of art, of gathering and organizing facts from underlying sciences so as to be of trustworthy value in the evaluation of a particular bit of music as a work of art, of guiding and evaluating talent, of establishing principles of musical training and of setting up new goals for attainment within the art.

Much of the achievements in these respects constitutes a contribution to pure psychology, and in turn it will be safely said that achievement in this field is contingent not so much upon specific orientation in the psychology of music as such, but rather upon a general power and mastery of pure psychology based upon experiment. Without experiment, there can be no science, and without pure science, applied science could not get far.

VI. The Science of Fine Arts

The development in the science of music has been fertile in its contribution toward a scientific approach to the other fine arts. Dramatic speech and poetry are notable examples. The same instruments which are used in measuring music can be used in measuring speech, as in the reading of poetry or in acting. Many of the same criteria of scientific procedure apply. Many of the vantage grounds obtained in one art relate to another. Poetics, for example, which is a highly developed discipline in literature, has been approached with distinguished success by the same techniques, instruments and point of view as have been developed in music. The psychology of the graphic and plastic arts transfers in large part from the psychology of music. The result of this tendency is that there is a rapidly forming general science of the fine arts.

VII. Esthetics

I must mention one other vantage ground; namely, the gaining of a sound footing in the laying of foundations for a scientific musical esthetics. The scientific

approach having been made available, current theories of esthetics must be submitted to a rigid re-examination to determine the degree of their validity. Many of the theories of esthetics now current in the books will be swept away under the acid test, and in place of these there will gradually begin to accumulate new concepts, new organizations, new foundations for a scientific philosophy of the beautiful in music.

The above has been an interpretation in high relief, ignoring manifest limitations, qualifications, difficulties and discouragements, of which there are many. Instead of representing the view from peaks of success, I might well have prowled through the shadows and slues of despondency, calling attention to the limitless scope of the undertaking, the dangers involved, the heroic courage required in overcoming difficulties. All these phenomena in low relief are very real and abundant, but it has been my object and pleasure to limit myself to the pointing out of the vision gained from successive new vantage grounds in the infant science of acoustics and its subsidiary, the applied psychology of music.

THE EFFECTS OF AMERICAN ENVIRONMENT ON IMMIGRANTS AND THEIR DESCENDANTS

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THE problem of the assimilation of alien populations transplanted into a new cultural medium in which they form a minority has given rise to much public discussion. Few attempts have been made to obtain verifiable data. The problem involves the answer to two questions. Knowing the importance of heredity in determining bodily form and function we have to understand the composition of the immigrant and native populations and their biological differences. Furthermore, we must try to differentiate sharply between what is hereditarily and what environmentally determined. In other words, we have to inquire whether and to what extent bodily form and function are constant or changing in different kinds of environment.

A study of this kind must necessarily cover a sufficiently long period during which assimilation may have been going on and requires, therefore, a long period of observations. I will try to sum up briefly the results of studies extending over a period of twenty-seven years.

The comparative study of alien and native populations had to be based on the degree of variability of each population; in other words, on the multiplicity of forms of the component individuals. We have known for many years that this variability is much greater in man than in pure-bred domesticated animals. This is due to the very slight amount of selective mating of man. We have also been able to show that in some zones in which different types came into contact the variability in regard to certain bodily features increases. Thus the variability of types in Italy is greatest in Central Italy, where the North Italians and South Italians who are very different in physical build mingle. This, however, is not true of all bodily features, some of which are quite uniform in mixed populations. On the basis of such observations it has been found by many observers that every large population is of very mixed origin, so much so that in Europe it is hardly possible to assign any individual with certainty to a particular part of the continent, because the variations in every type overlap. I have tried the experiment of identification in colleges. The new students who did not know one another were asked to designate the descent of their new fellow students. The most contradictory answers were received. Not only was it found impossible to distinguish between North European individuals, but Italians, North Europeans and Jews were misplaced in as many as 40 per cent. of the cases.

The variation of forms of individuals does not give a sufficiently clear picture of the genetic constituents of a population because we do not know how much may be due to outer conditions, how much to the presence of distinct genetic lines. The existence of diverse genetic lines is clearly proved by family resemblances between parents and children and between brothers and sisters. It is necessary to determine the degree of genetic complexity in a population. Obviously, if all families were genetically alike and uninfluenced by outer circumstances, there would be no family resemblances, because for any one member of a family, one of another family might be substituted. In a closely inbred population something of that kind might be expected, but no case is known in which an identity of family lines, such as is nearly attained in pure breeds of domesticated animals, is found. On small islands with inbred populations, among the isolated mountaineers of Kentucky and in other inbred communities a considerable diversity of family lines remains, and in the large areas of so-called uniform racial types great differences in bodily form of distinct