MEANING IN MUSIC AND INFORMATION THEORY

LEONARD B. MEYER

I have dealt elsewhere at some length with the central importance of the arousal and subsequent inhibition of expectant tendencies in the shaping of musical experience.[1] In that analysis of musical experience many concepts were developed and suggestions made for which I subsequently found striking parallels—indeed equivalents—in information theory. Among these were the importance of uncertainty in musical communication, the probabilistic nature of musical style, and the operation in musical experience of what I have since learned to be the Markoff process. In particular, it would seem that the psycho-stylistic conditions which give rise to musical meaning, whether affective or intellectual,[2] are the same as those which communicate information. It is this hypothesis which I propose to explore here.

This hypothesis is of particular interest because, if it can be substantiated, then the seemingly disparate and discrete worlds of physical phenomena, bio-social behavior, and humanistic creation can, at least from this point of view, be brought together and subsumed under a single fundamental principle—the law of entropy. And thus Eddington's famous suggestion that "there are the strongest grounds for placing entropy alongside beauty and melody" will have received concrete exemplification.

* * *

Let us begin with a general definition of meaning. As Cohen puts it:

> . . . anything acquires meaning if it is connected with, or indicates, or refers to, something beyond itself, so that its full nature points to and is revealed in that connection.[3]

Meaning in this sense resides in what both Cohen and Mead have called the "triadic relationship" between a stimulus, the thing to which it refers, and the individual for whom the stimulus has meaning.[4] While meaning is thus a mental fact, it is not arbitrarily subjective. The relationship between the stimulus and the thing to which it refers is a real relationship existing in the objective world, whether physical or social. For "*What* anything means is in no wise created by our apprehension, but is presupposed by the latter."[5]

Under this general definition two types of meaning must be distinguished. (1) A stimulus may be meaningful because it indicates or refers to something which

[1] Leonard B. Meyer, *Emotion and Meaning in Music*, (Chicago: University of Chicago Press, 1956). In particular see chapters i and ii.

[2] *Ibid.*, pp. 39f. The differentia between the affective response and the intellectual response to music lies in the dispositions and beliefs which the listener brings to musical experience rather than in the musical processes which evoke the responses.

[3] Morris R. Cohen, *A Preface to Logic* (New York: Henry Holt & Co., 1944), p. 47.

[4] *Ibid.*, p. 29 and George H. Mead, *Mind, Self and Society* (Chicago: University of Press, 1934), p. 75f.

[5] Cohen, *op. cit.*, p. 28.

is different from itself in kind—as when a word refers to or denotes an object or concept which is not itself a word. This type of meaning we shall call "designative meaning." (2) A stimulus or process may acquire meaning because it indicates or refers to something which is like itself in kind—as when the rumble of distant thunder on a sultry day and the piling up of storm clouds (antecedent natural events) indicate the coming of a rain storm (a consequent natural event). This type of meaning we shall call "embodied meaning."

Music gives rise to both types of meaning. Music may be meaningful because it refers to things outside itself, evoking associations and connotations relative to the world of ideas, sentiments, and physical objects. Such designative meanings are often less precise and specific than those arising in linguistic communication. However, this does not make them less forceful or significant.[6] Or music may be meaningful in the sense that within the context of a particular musical style one tone or group of tones indicates—leads the practiced listener to expect—that another tone or group of tones will be forthcoming at some more or less specified point in the musical continuum.

Although these two types of meaning are logically separable, there is in practice an intimate interaction between them. The "character" (designative meaning) of a piece of music will, when well-defined, influence our expectations as to subsequent musical events (embodied meaning), just as our estimate of the character of an individual will influence our expectations as to his behavior in a given set of circumstances. Conversely, the way in which expectations are satisfied, delayed, or blocked plays an important part in the characterization of the designative meaning of a passage, in the same way that we make inferences as to an individual's character on the basis of his behavior in a particular cultural situation.

Since in past analyses of musical meaning considerable confusion has resulted from a failure to specify which aspect of meaning is being considered, let us state at the outset that this study is concerned with those meanings which arise within the context of the work itself—that is, with embodied meaning. And except where the term "designative meaning" is explicitly used, the word "meaning" is to be understood as referring to embodied meaning.

Style constitutes the universe of discourse within which musical meanings arise. There are many musical styles. They vary from culture to culture, from epoch to epoch within the same culture, and even within the same epoch and culture. This plurality of musical styles results because styles exist not as unchanging physical processes in the world of nature, but as psychological processes ingrained as habits in the perceptions, dispositions, and responses of those who have learned through practice and experience to understand a particular style. What remains constant from style to style are not scales, modes, harmonies, or manners of performance, but the psychology of human mental processes—the ways in which the mind, operating within the context of culturally established norms, selects and organizes the stimuli that are presented to it. For instance, the human mind, striving for stability and completeness "expects" structural

[6] See Meyer, *op. cit.*, chapter viii.

gaps[7] to be filled in. But what constitutes a structural gap will vary from style to style. Thus a melodic skip of a third which is a structural gap in the diatonic-chromatic tonal system of the West would not be a gap in a pentatonic tonal system in which such a skip is given as normative.

Once a musical style has become part of the habit responses of composers, performers, and practiced listeners it may be regarded as a complex system of probabilities. That musical styles are internalized probability systems is demonstrated by the rules of musical grammar and syntax found in textbooks on harmony, counterpoint, and theory in general. The rules given in such books are almost invariably stated in terms of probability. For example, we are told that in the tonal harmonic system of Western music the tonic chord is most often followed by the dominant, frequently by the subdominant, sometimes by the submediant, and so forth. Or we are informed in texts on counterpoint that, after a large melodic skip, the melody usually moves in the opposite direction filling in the tones passed over. Ethnologists dealing with primitive or folk music have often implicitly acknowledged the probabilistic nature of tonal systems in their notation of scales as well as in their discussions of tonal progression. Indeed, some have compiled elaborate statistics of the frequency with which a given tone, interval, or progression occurs in the music of the culture under consideration. The problems involved in such statistical analyses of music are discussed toward the close of this article.

Out of such internalized probability systems arise the expectations—the tendencies—upon which musical meaning is built. But probability is not the same as expectation. Or, to put the matter in another way, we must distinguish between active and latent expectation—between the fact of probability and the awareness that an individual has of alternative probabilities.

In a sense our whole mental existence is built around our expectations as to the normal (probable) continuity of events. We "expect" to get up Monday morning, to eat breakfast, to see that the children get to school, to go to the office, and so forth. But we are as a rule unconscious of such expectations. They are *latent* expectations, the norms of behavior which are taken for granted once they have become fixed habit patterns. Such expectations become *active*, either as affective experience or conscious cognition, only when our normal patterns of behavior are disturbed in some way. If, for instance, we over-sleep or breakfast is delayed, then we become aware of our expectant habits. We are aware of the necessity of getting to the office, of making choices and decisions.

In short, the probability relationships embodied in a particular musical style together with the various modes of mental behavior involved in the perception and understanding of the materials of the style constitute the *norms* of the style. Latent expectation is a product of these probability relationships. And expectation becomes active only when these norms are disturbed. In other words, such latent expectations are necessary conditions for the communication of musical information, while the disturbances of these norms are the sufficient condition for musical communication.

[7] A structural gap is a form of incompleteness in which one or more of the tones comprising the normal complement of pitches in a tonal system is left out. In this connection see *Ibid.*, p. 130–35.

Let us now return to an explicit consideration of meaning. Meaning arises when an individual becomes aware, either affectively or intellectually, of the implications of a stimulus in a particular context. As long as behavior is habitual and "unthinking" the stimuli presented to the mind are neither meaningful nor meaningless. They cannot be said to be meaningless, because this implies an active negation of meaning. Rather our experience of such stimuli stands in the same relationship to the meaningful-meaningless axis as the concept of "amoral" stands in relation to the moral-immoral axis. That is, such stimuli are neutral with respect to meaning. For example, as we drive along a highway countless stimuli (on-coming cars, pedestrians, buildings, billboards, etc.) are "seen," but as long as our habit responses "take care" of these stimuli we do not really observe them. They are not meaningful. They do not indicate or require any action on our part. Only when our habits are disturbed do these stimuli become meaningful—e.g., if an on-coming car swerves into the middle of the road and a judgment of speed, space, and distance must be made, or if a detour sign requires a decision as to the future route, or if a particularly striking landscape calls attention to itself.

Similarly in music, a tonal process which moves in the expected and probable way without deviation may be said to be neutral with regard to meaning.[8] Musical meaning, then, arises when our expectant habit responses are delayed or blocked—when the normal course of stylistic-mental events is disturbed by some form of deviation.

Three varieties of deviation may be distinguished. (1) The normal (probable) consequent event may be delayed. Such a delay may be purely temporal or it may also involve reaching the consequent through a less direct tonal route, provided that the deviation is understandable as a means to the end in view. (2) The antecedent situation may be ambiguous. That is, several equally probable consequents may be envisaged. When this takes place, our automatic habit responses are inadequate, for they are attuned only to a clear decision as to probabilities. And (3) there may be neither delay nor ambiguity, but the consequent event may be unexpected—improbable in the particular context.

The first two modes of deviation are very similar in their basic psychological effect. For whenever there is a delay in the antecedent-consequent relationship (as in 1), the mind becomes aware of the possibility of alternative modes of continuation. It weighs, though perhaps unconsciously, the probabilities of the situation in the light of past events, the present context, and the possible influence of the delay on the future course of events. For even though one mode of continuation may seem much more probable than any of the others, it is still only probable, not certain.[9] Thus both varieties of deviation (1 and 2) arouse active expectation because of the necessity of envisaging alternative consequents —of estimating the probabilities of an uncertain situation.

[8] Such stimuli may of course have designative meaning; that is, they may be meaningful because they refer to or designate extra-musical concepts, moods, actions, and so forth. And they may also appear to be meaningful because they constitute elements of a larger architectonic structure which has meaning.

[9] An antecedent-consequent relationship with complete certainty (a probability of unity) will not occur because it would constitute a meaningless tautology.

Sometimes such uncertainty is slight and evanescent, as when a chromatic tone is introduced within a standard cadential progression or when the portamento of a violinist delays the arrival of a substantive (expected) tone ever so little. At other times uncertainty may reach heroic proportions, as it does just before the e minor theme in the development section of the first movement of Beethoven's Third Symphony (measures 248–280). Here the destruction of the rhythmic organization, the weakening of melodic motion, and the arrival at a harmonic impass create a musical situation bordering on chaos. And the tremendous impact of the new theme, when it arrives, is clearly a product of the uncertainty of the antecedent situation.

Our definition of meaning can thus be revised to read as follows: Musical meaning arises when an antecedent situation, requiring an estimate as to the probable modes of pattern continuation, produces uncertainty as to the temporal-tonal nature of the expected consequent.

Here we see our first clear relationship between embodied meaning and information. Information is measured by the randomness of the choices possible in a given situation. If a situation is highly organized and the possible consequents in the pattern process have a high degree of probability, then information (or entropy) is low. If, however, the situation is characterized by a high degree of shuffledness so that the consequents are more or less equi-probable, then information (or entropy) is said to be high.

Both meaning and information are thus related through probability to uncertainty. For the weaker the probability of a particular consequent in any message, the greater the uncertainty (and information) involved in the antecedent-consequent relationship. "Information is . . . a measure of one's freedom of choice in selecting a message. The greater this freedom of choice, and hence the greater the information, the greater is the uncertainty that the message actually is some particular one. Thus greater freedom of choice, greater uncertainty, greater information go hand in hand."[10]

The third variety of deviation discussed above, however, does not involve the active expectation of alternative consequents. No uncertainty is aroused by the antecedent stimulus situation. Deviation occurs because the consequent was not the one expected, the probable one. (However, it conveys a maximum of information.) An understanding of the relationship of this mode of deviation to meaning and information necessitates a further analysis of the experience of meaning.

The meaning of an antecedent event depends upon its relationship to the consequent to which it refers. Since this relationship changes as the music unfolds, so does the meaning attributed to the antecedent event. Meaning, then, is not a static, invariant attribute of a stimulus, but an evolving discovery of attributes.

The development of embodied meaning may be differentiated into three stages. (1) *Hypothetical meanings* are those attributed to the antecedent tone or pattern of tones when the consequents are being expected. Unless deviation is present, hypothetical meanings will not arouse uncertainty or give rise to infor-

[10] Warren Weaver, "Recent Contributions to the Mathematical Theory of Communication," *Etc.: A Review of General Semantics*, x (1953), p. 273.

mation. For, although any consequent is never more than a probability, as the probability of any particular consequent increases, the less probable alternatives are excluded from expectation. Thus, the more structured the situation, and hence the more dominant one mode of continuation over others, the less likely is the listener to envisage alternative consequents unless some deviation is present. This tendency of the dominant probability to exclude the less probable from consciousness is important because it explains why in a probabilistic world we are capable of surprise—that is, it accounts for the fact that the less probable becomes the unexpected.

Though the consequent which is actually forth-coming must be possible within the style, it may or may not be one of those which was most probable. Or it may arrive only after a delay or deceptive diversion through alternative consequents. But whether our expectations are confirmed or not, a new stage of meaning is reached when the consequent becomes actualized as a concrete musical event.

(2) *Evident meanings* are those which are attributed to the antecedent stimulus in retrospect, after the consequent has become a tonal-psychic event and when the actual relationship between the antecedent and consequent is apprehended.

Evident and hypothetical meanings do not, however, arise and function in isolation from one another. Evident meaning is modified by the hypothetical meanings previously attributed to the antecedent. That is, the consequent is not only that which actually follows, but it is that which follows as expected, arrives only after a deviation, resolves an ambiguity, or is unexpected.

Furthermore, the comprehension of the antecedent-consequent relationship in the light of evident meaning involves a revaluation of the hypothetical meaning of the initial stimulus and of the function of the completed progression within the larger context of the phrase, period, or section. Such revaluation then becomes the basis for future probability estimates and future expectations.

This process of revaluation is the mental counterpart to the "feedback" process in automatic control and information theory. For both feedback and revaluation are processes whereby future behavior, whether of automatic systems, motor reflexes, or expectations, is conditioned and controlled by the results of past events. Such mental feedback occurs both where the consequent was the one expected and where the consequent was unexpected.

If an antecedent event arouses no uncertainty and the consequent arrives precisely as expected, then meaning will be neutral, information nil, and feedback is superfluous—performs no function.[11] If the antecedent event has aroused uncertainty, feedback operates upon the arrival of the consequent (whether the one expected or not) causing the listener to modify his opinion of the hypothetical meaning initially attributed to the stimulus. That is, hypothetical meaning (expectation) is understood as having been confirmed, altered by temporary delays or deviations, clarified through the resolution of ambiguities, or mistaken because the improbable occurred. No matter which of the possibilities takes

[11] See Arnold Tustin, "Feedback," *Automatic Control*, The Editors of Scientific American (New York: Simon and Schuster, 1955), p. 13.

place, the information fed back to the initial situation, adding so to speak, a new dimension to both hypothetical and evident meaning, acts to influence and direct the subsequent expectations of the listener—his estimates of future probabilities.

The presence of the feedback mechanism also throws light upon the genesis of meaning and information in those cases where the antecedent arouses no uncertainty, but in which the consequent is not the one (latently) expected. Such situations arise as a result of a discrepancy between the choices understood or felt to be available and those which were actually available. That is, the situation was less structured (more shuffled and higher in entropy) than the listener believed. One might put the matter somewhat differently by observing that while no uncertainty *was* felt, subsequent developments tell us that it *should have been* felt. And it would have been felt, had the "true" nature of the situation been understood.[12] It is important also to realize that such unexpected, improbable occurrences remain in the memory and influence the listener's later estimates of probability for the balance of the piece.

Not only does hypothetical meaning undergo a drastic reinterpretation in such cases, but so does our opinion of the information contained in the experience. For while the seemingly certain series of latently expected events makes it appear that the consequent will add little or no information to that already implicit in the antecedent, the situation was actually much higher in entropy and in information than it was thought to be.

(3) *Determinate meanings* are those which arise out of the totality of relationships existing on several architectonic levels between hypothetical meaning, evident meaning, and the later stages of the musical situation. As the music unfolds in time, later events are continually being related to earlier ones and vice-versa. A recurrent theme or melody, for instance, is not only modified by the fact that it has been heard before, but its recurrence also modifies our opinion of its original meaning. In short, determinate meanings arise only after the experience of the work is a timeless memory—when all the implications of the stimulus on all architectonic levels are realized and their interrelationships comprehended as fully as possible.

The fact that a given stimulus in some sense implies and is involved in later musical events points to still another relationship between musical meaning and information. Namely, the probabilities arising out of a musical progression (viewed on a particular architectonic level) increase as the progression unfolds. For example, the implications of a group of two or three tones are more uncertain—lower in probability—than those of a phrase which is almost complete. Similarly on a higher architectonic level, the implications of a single section are lower in probability than those of a series of sections. In short, the more complete the section, the higher the probability relationship between those terms already established and any future sections.

"A system which produces a sequence of symbols (which may, of course, be letters or musical notes, say, rather than words) according to certain probabilities is called a *stochastic process*, and the special case of a stochastic process in which the probabilities depend upon the previous events, is called a *Markoff*

[12] A musical example of this is analyzed in Meyer, *op. cit.*, p. 48f.

process or a Markoff chain."[13] The fact that music, like information, is an instance of a Markoff process has important practical and theoretical ramifications.

If music is a Markoff process, it would appear that as a musical event (be it a phrase, a theme, or a whole work) unfolds and the probability of a particular conclusion increases, uncertainty, information, and meaning will necessarily decrease. And in a closed physical system where the Markoff process operates this is just what does occur—probability tends to increase.

Uncertainty is, so to speak, "built into" the initial stages of a Markoff process. Such uncertainty is systemic in nature and it tends to decrease as the series progresses. *Systemic uncertainty* of necessity exists at the beginning of a piece (or part of a piece) of music where the relationships between tones, the intraopus norms, are being established. And if music operated only with systemic uncertainty, meaning and information would necessarily decrease through the functioning of the Markoff process.

But music is not a natural system. It is man-made and man-controlled. And it is able to combat the tendency toward the tedium of maximum certainty through the *designed uncertainty* introduced by the composer.

On the basis of this analysis we should expect that designed uncertainty would be gradually introduced to compensate for the tendency of systemically caused information and meaning to decrease. That is, we should expect designed deviations, delays, and ambiguities to be introduced as systemic probability increases—as the pattern approaches completion. This expectation is borne out by the practice of musicians. C. P. E. Bach, for example, writes that "embellishments are best applied to those places where the melody is taking shape, as it were, or where its partial, if not complete, meaning or sense has been revealed."[14] Sachs tells us that in primitive music a new note—one which is necessarily a deviant from the established tonal system—"generally ventures to appear only toward the end of the phrase, when the nucleus has been well established."[15]

Finally, it should be observed that as probability increases so does the *apparent* significance and information of "minor" deviations. The more certain we are that a particular consequent will be forth-coming, the greater the effect of deviation.

Music, like language, contains considerable redundancy. Redundancy is that portion of a message which "is determined not by the free choice of the sender, but rather by the accepted statistical rules governing the use of the symbols in question."[16] Just as letters can be left out of a written statement or words omitted from a message without affecting our ability to understand and reconstruct the word or message, so tones can be omitted from a musical passage without affecting our ability to grasp its meaning. A striking instance of this in music is found in solo sonatas for a string or woodwind instrument where chords are only partially stated and melodic "lines" are mentally constructed on a minimum of material.

[13] Weaver, *op. cit.*, p. 267.

[14] C. P. E. Bach, *Essay on the True Art of Playing Keyboard Instruments*, trans. Wm. Mitchell (New York: W. W. Norton & Co., Inc., 1949), p. 84. For a discussion of the relationship between embellishment and deviation see Meyer, *op. cit.*, chapter vi.

[15] Curt Sachs, *The Rise of Music in the Ancient World* (W. W. Norton & Co., Inc., 1943) p. 37.

[16] Weaver, *op. cit.*, p. 269.

Or, if some of the tones of a melodic line are drowned out by the accompaniment, they can in most contexts be reconstructed in the mind of a listener practiced in the particular style. In short, because of the redundancy present in musical styles we are able to complete incomplete musical events, if what has been omitted is statistically probable.

Redundancy is of particular significance because it is one of the factors which allows for those important places in the experiencing of music where the listener's habit responses are able to "take over"—where the listener can pause, albeit briefly, to evaluate what has taken place in the past and to organize this experience with reference to the future.

Redundancy also serves to combat noise. It seems possible to distinguish between two kinds of noise: acoustical noise and cultural noise. Acoustical noise results from poor building acoustics (echoes, dead spots, etc.), poor transmission systems (which we leave to the hi-fi-natics), or just plain extra-musical sounds (talking, airplanes, and mosquitoes, if one is a devotee of summer concerts). Cultural noise, as I shall use the term, refers to disparities which may exist between the habit responses required by the musical style and those which a given individual actually possesses.[17]

There appears to be positive correlation between cultural distance, whether historical or anthropological, and cultural noise. That is, the more distant a culture is from our present set of habit responses, the greater the amount of cultural noise involved in communication. The obvious exception to this rule is found in the case of contemporary music. Here "noise" is the result of a time-lag between the habit responses which the audience actually possesses and those which the more adventurous composer envisages for it. It is also interesting to speculate as to whether some of the difficulties which audiences have with modern music do not result from the fact that the redundancy rate of this music is at times so low as to be unable to counteract the cultural noise which is always present in a communication situation. One might put this matter somewhat differently by saying that in their zeal to "pack" music full of meaning some contemporary composers have perhaps so over-loaded the channel capacity of the audience that one meaning obscures another in the ensuing overflow.

Since noise, whether cultural or acoustical, generally creates uncertainty, it would seem that noise is beneficial—for, as we have seen, uncertainty is important in the arousal of meaning and information. One must, however, distinguish between desirable and undesirable uncertainty.[18] Desirable uncertainty

[17] Weaver regards such disparities as results of a deficiency in the channel capacity of the audience. While this may be more in keeping with the terminology of information theory, it involves postulating a series of different channels with different capacities for each individual, since one individual will generally respond to some styles with greater sensitivity than to others—and to some styles not at all. In any case treating such disparities (between the habit responses required by the style and those actually present in the listener) as "cultural noise" does no violence to the facts involved and does seem to be a suggestive viewpoint. See Warren Weaver, "The Mathematics of Information," *Automatic Control*, *op. cit.*, p. 108f.

[18] See Weaver, "Recent Contributions to the Mathematical Theory of Communication," *op. cit.*, p. 273f.

is that which arises within and as a result of the structured probabilities of a style system in which a finite number of antecedents and consequents become mutually relevant through the habits, beliefs, and attitudes of a group of listeners. Undesirable uncertainty arises when the probabilities are not known either because the listeners' habit responses are not relevant to the style (cultural noise), or because external interference obscures the structure of the situation being considered (acoustical noise).

These differences can be clearly and concisely illustrated by examples of linguistic communication. In the case of desirable uncertainty, one is uncertain simply as to how a sentence in a familiar language will be completed. In the case of undesirable uncertainty resulting from cultural noise, one is in doubt as to how a sentence in an unknown or partially known language will be completed. Here no consequent can be envisaged and none has any meaning or communicates any information when it arrives, since all seem equally probable (or improbable). Finally, where undesirable uncertainty is a result of acoustical noise, one is uncertain as to how a sentence will be completed because external interference obscures or obliterates the antecedent upon which prediction depends.

The fact that musical styles are probability systems inevitably raises the complex problem of the possibility of a statistical analysis of style and the construction of devices for composing music on the basis of the probabilities inherent in the style of western music. While I do not share the deep-seated antipathy felt by most humanists toward anything that smacks of statistics, I feel that the many difficult problems involved in any statistical approach must be recognized if such studies are to have anything more than a curiosity value.

The mere collection and counting of phenomena do not lead to significant concepts. Behind any statistical investigation must be hypotheses that determine which facts shall be collected and counted.

> An estimate of a probability which is made simply on the basis of unanalyzed samples or trials is not likely to be a safe basis for prediction. If nothing is known concerning the mechanism of a situation under investigation, the relative frequencies obtained from samples may be poor guides to the character of the indefinitely large population from which they are drawn.[19]

Since the nature and structure of the sample being studied is a result of a knowledge of the mechanism of the situation, a statistical investigation, if it is to have any relevance to music, must be based upon a sophisticated and sensitive understanding of the processes involved in the experiencing of musical style. Some of these problems are discussed in what follows.

1. The samples collected must take account of the tendency of systemic uncertainty to diminish and of designed uncertainty to be introduced as the music unfolds. And there may well be a difference between the probabilities of systemic origin and those introduced by design.

2. Tonal probabilities exist not only within phrases and smaller parts of a

[19] Ernest Nagel, "Principles of the Theory of Probability," *International Encyclopedia of Unified Science* (Chicago: University of Chicago Press, 1939), vol. I, no. 6, p. 59. Also see Norbert Wiener, *Cybernetics* (New York: John Wiley and Sons, 1948), p. 35.

musical structure but also between them. These probabilities are not necessarily the same. For instance, it seems more likely that a phrase or melody will begin with a skip than that a progression of phrases will initially involve a large skip. Thus the statistical analysis of stylistic probabilities must be architectonic—different sets of probability must be discovered for different architectonic levels.

3. It is a mistake to suppose that probability remains relatively constant throughout musical works. Quite the contrary. Some parts of a work tend to adhere much more closely to the normative and probable than do other parts. For instance, the development section of a sonata-form movement involves much more deviation—much more use of the less probable—than do the exposition and recapitulation. And this difference of probability between parts holds even in the case of short melodies. Thus serious statistical and methodological errors arise if probabilities are computed on the basis of a total "average" frequency over the entire piece. Subsystems must be analyzed within the larger probability system. And since the differences between subsystems will vary from style to style, so must the estimates of probability.

4. In defining the limits of a sample and discussing the probabilities involved, it is important to be cognizant of the historical development of musical styles. The fact that a given progression occurs in a large majority of cases is not a sure sign that it is psychologically probable. And conversely, the mere fact that the frequency of a particular progression is low is no certification of its improbable character. For instance, though the perfect cadence occurs infrequently in the later music of Richard Wagner, it is nevertheless presupposed as a norm; and when Wagner avoids the cadence, as he does time and time again, his resolutions are felt to be less probable deviants. Later in the 19th century the situation with regard to the perfect cadence becomes even more complex. For now the frequency of irregular cadential progression has influenced probability to such an extent that the probabilities are in doubt and the cadence becomes ambiguous.

5. Not all the probabilities embodied in a musical composition are determined by frequency. Some are based upon the nature of human mental processes—ways of thinking. For example, even though the frequency with which a large structural gap is immediately filled in is low in a given sample, the felt probabilities are high that it will be filled immediately. For this reason one of the preliminaries to a statistical analysis of musical styles must be a description and analysis of the constants involved in the psychology of thought.

These observations raise a further question: Is it possible to develop an accurate mathematical picture of musical style which could serve as a basis for the quantification and measurement of musical information? Indeed Wiener's statement that "the human sciences are very poor testing grounds for a new mathematical technique"[20] seems persuasive both in theory and in the light of the statistical investigations of music carried on thus far.

But the case is not, I think, completely hopeless. Two things are required. First we must arrive at a more precise and empirically validated account of mental behavior which will make it possible to introduce the more or less in-

[20] *Ibid.*, p. 34.

variant probabilities of human mental processes into the calculation of the probabilities involved in the style. This account need not necessarily be statistical itself.

> . . . probability statements do not always occur singly and are often part of a more or less inclusive *system* of statements or a *theory*. In such cases the estimation of the numerical values of the probabilities and the subsequent testing of such values may be made on the basis of *indirect* evidence which in some cases may even be nonstatistical.[21]

Second, and this is ultimately dependent upon the first, it is necessary to develop a more precise and sensitive understanding of the nature of musical experience.

The impossibility of measuring musical information precisely at present does not weaken or invalidate the theoretical position adopted in this paper. Rather it should act as a cue for further study and experimentation. Much might be learned, for instance, by making a more discriminating study of stylistic probabilities, introducing hypothetical mental constants with arbitrarily assigned numerical probabilities, taking into account the various difficulties discussed above—then studying the resulting melodies. What sort of melodies, for instance, would arise if we assumed a numerical value for the mental tendency of a melodic process to continue itself, or took account of the differences in probabilities between different architectonic levels or introduced random deviations in some parts but not others? Or having arrived at a tentative probability scheme what effect would changes in one variable—say the presence of chromaticism—have on the resulting melodies? Such experiments carried on by students who understand the mechanism of musical communication might reveal much not only about music but also about some of the constants in human perception.

The preceding discussion has shown that embodied meaning and information arise out of the same processes. This does not, however, assert that they are identical. The differentia between them lies not in the nature of the processes involved, but in the psychological attitude taken toward these processes. For though both information and meaning are manifestations of the probabilities present in antecedent-consequent relationships, each has a different focus of attention. In the case of meaning, attention is for the most part directed toward the antecedent, though of course the consequent is, as we have seen, of vital importance. In the case of information the greater part of attention is concentrated upon the consequent. To put the matter briefly: in meaning, the musical process is considered and evaluated from the viewpoint of antecedents, in information the same processes are examined and assessed from the viewpoint of consequents.

This study has intentionally avoided the perplexing problems of value and value theory. However, without entering into the many heated discussions raging in these areas, it seems permissible in closing to suggest that the viewpoint adopted here might prove fruitful in the analysis of value. For, aside from the obvious fact that something without meaning or information is, almost by definition, valueless (indeed what we mean by "trite" or "banal" is the most probable means of achieving the most probable end), it would seem that valu-

[21] Nagel, *op. cit.*, pp. 23–24.

ations, evaluations, and perhaps values as well arise only as the result of the uncertainties involved in making means-end choices—i.e., in predicting alternative antecedent-consequent probabilities.

Furthermore, it would seem plausible to regard "value" as an experience which, like meaning, evolves and changes, rather than as a fixed rigid attribute of particular stimuli. From this point of view, *valuation*, the estimate of probable consequents within a means-end continuum, would be a correlate of hypothetical meaning; *evaluation*, the apprehension of what has actually taken place, would be a correlate of evident meaning; and *value*, the ultimate comprehension of an experience when it is timeless in memory, would be a correlate of determinate meaning.

Thus value, information, and meaning might profitably be considered as being different, though related, experiential realizations of a basic stochastic process governed by the law of entropy.