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Source: *The Journal of Aesthetics and Art Criticism*, Vol. 17, No. 4 (Jun., 1959), pp. 510-522
Published by: Wiley on behalf of The American Society for Aesthetics
Stable URL: http://www.jstor.org/stable/428224

in the right places for regularity is precisely what constitutes "creativity" in the scientist. Thus the computer capable of analyzing Mozart's symphonies would probably require, as a source of hypotheses, a catalogue very much like that suggested above, though perhaps less detailed.

In some respects more appealing than either the imitative or the autonomous computer would be one which allowed the rules of composition to be varied easily and precisely by a human artist. Suppose that each variety of lawfulness in the catalogue (pertaining to temporal arrangements of sounds in the case of music; to spatial arrangements of lines and colors in the case of visual art) were represented by a knob on a large control panel. Adjustment of these controls would give any desired combination and weighting of the possible rules. Such a device would offer extraordinary opportunities for artistic exploration and experimentation. It would function essentially as a tool or extension of the user's imagination, and throw a correspondingly greater burden upon his evaluative or critical capacities.

INFORMATION AS A MEASURE OF THE EXPERIENCE OF MUSIC

DAVID KRAEHENBUEHL AND EDGAR COONS

In order to show the application of information theory to the experience of music, it is necessary to understand the general purpose of a musical composition. A musical composition is an arrangement of acoustical events intended to communicate the essence of an experience. The effectiveness of such a communication relies upon the structural relevance of the acoustical arrangement to the experience to be communicated. In the foregoing, arrangement implies both the choice and order of events resulting in an event-order; in music, in a pattern of sound in time. An acoustical event may be any arbitrarily designated sound or group of sounds from as little as a single pitch or chord to as much as an entire symphonic movement. For the purpose of the following discussion, acoustical events will be designated by arbitrarily assigned letters each of which will signify an event at a particular agreed-upon level of magnitude.

Information theory has been applied most successfully to small finite sets of events where all possible events in any particular set could be designated and a reliable probability established for the frequency with which each event would occur in samples of sufficient length. In music both the twelve-tone chromatic and seven-tone diatonic scales are such sets of events. Traditional information analyses of musical styles based on these scales have been made by Pinkerton[3] and Youngblood[4]. The success of such analyses rests upon the selection of a limited group of compositions for which stylistic homogeneity is assumed. But the act of experiencing music is not of such a general nature. The listener reacts

[3] Richard C. Pinkerton, "Information Theory and Melody," *Scientific American,* 194, 2, 77–87.

[4] Joseph E. Youngblood, "Style as Information," *Journal of Music Theory,* II, 24–35.

to a succession of acoustical events, at whatever level we choose to define them, one at a time. The composer is interested in the particular effect on the listener of each event as it occurs. Traditional information theory does not provide us with any useful analytical tool for the study of this immediate problem of musical creation.

Information theory relies upon the establishment of a probability system that is relatively constant. This means that the event-orders under consideration must have certain specific qualities: (1) that no event not already known to be in the set can occur, (2) that any given event will occur with the same frequency in any large sample of the same size, and (3) that the occurrence of any given event will always be constrained in the same manner by any selected event-order which may precede it. If a probability system is to have any predictive value, it must further be assumed that the properties of the set enumerated above, i.e., that it be (1) stochastic, (2) ergodic, and (3) consistent with regard to Markov properties, will not be disturbed by the ensuing events in the event-order. It is evident that such an assumption is only reasonable if we possess a long past experience with the set of events under consideration and can establish at least that it has always demonstrated heretofore the prerequisite qualities for a useful probability analysis. A new musical composition does not provide us sufficient data, even in its entire length, to justify such an assumption. Hence, any traditional information analysis of its structure is impossible since the underlying probability system cannot be validly established. We require an analytical tool which is both more sensitive in that it will advise us of the effect on the probability system of each event as it occurs, and more general in that it will begin to advise us of the nature of the probability system after the smallest conceivable past.

These conditions require the development of some dynamic operational procedure which will produce a new probability system for the entire event-order as each new event occurs. This new probability system would constitute a predictive system with regard to the next event. The next event, when it occurs, will create one of only two possible conditions: it will either confirm the probability system just established or it will fail to confirm it. We will use the expression "to nonconfirm" for this second condition. Out of this two-valued situation it is possible to construct a procedure of measurement that will describe the information flux in a unique experience as it develops, indicating the informedness of each event as it occurs.

It is necessary to make a slightly more general definition of the term "information." Traditional information theory defines information as essentially the reciprocal of probability. The most probable event, should it occur, would generate the least information; the least probable event, should it occur, would generate the most information. For our purposes, information is better defined as the nonconfirmation of a prediction. If the prediction happens to be a valid probability system built around the known and constant properties of a closed set of events, then the traditional definition of information in no wise differs from ours. However, since we wish to measure information before we can be certain that our probability system is valid under the traditional conditions, we must accept the probability system actually established by the event-order under consideration as having provisional predictive value. To the extent that the next event in the event-order nonconfirms this provisional prediction, it generates information. The occurrence of another event in the event-order also compels us to create a new probability system which takes the new event into account. This new probability system will be tested further by the next event to occur.

If we accept the notion that information is generated by the nonconfirmation of a prediction, it becomes possible to measure the informedness of each new event in an event-order as it occurs. It is only necessary to determine the exact predictive system implied in the event-order to the moment and the exact amount of this predictive system which is nonconfirmed by the new event. If the entire predictive system is confirmed by the new event, then no information whatsoever is generated. This is never the case in the measurement of actual experience since our sensory perception of a new event relies entirely upon some minimal state of informedness, some nominal nonconfirmation of the predictive system to date. On the other hand, if the new event totally nonconfirms the entire predictive system established by the past, infinite information would be generated. This also is never the case in the measurement of actual experience where the predictive system may be maximally nonconfirmed but never totally.

We may begin the construction of a two-valued measure of information as the nonconfirmation of a predictive system by assuming the simplest possible prediction, that of a single event, designated as "A." If this is the sole experience to date, it is the only possible prediction.[5] Beginning with "A" there are only two possible 2-event patterns. These are "AA" and "AB." In the first case, the second "A" confirms the predictive system to date, generating a state of minimum informedness. In the second case, the occurrence of "B" after "A" (and here "B" really means any "not-A") constitutes a nonconfirmation of the predictive system to date, generating a state of maximum informedness. Maximum informedness is a property of the relationship of dissimilarity, the result of a nonconfirmation of a prediction. Minimum informedness is a property of the relationship of similarity, the result of a confirmation of a prediction. We may take the symbol d to represent both a relationship of dissimilarity and a condition of maximum informedness. We may take the symbol s to represent both a relationship of similarity and a condition of minimum informedness. The symbols d and s will have then a double significance wherever they appear. As substantive indicators they will denote specifically the relationships of dissimilarity and similarity respectively; as evaluative indicators they will represent maximal and minimal states of informedness respectively. The relationships they denote will be the building blocks of our system; the values they represent will be the basic units of our measurement of informedness. The equation $A/A = s$ will be the abbreviation for the expression "if event 'A' follows event 'A,' a

[5] It must be remembered that we are operating under "laboratory conditions." The patterns under discussion will be isolated from their environment and discussed as if they were each unique and in no wise affected by preceding or accompanying patterns. This will provide us with an analysis of the pattern in the abstract which can then be evaluated in terms of various types of context.

TABLE 1

First event (I)		A	
Second event (II)		B	
Proposed third events (III)	A or	B or	C
Prediction I = A (I/III)	*s*	*d*	*d*
Prediction II = B (II/III)	*d*	*s*	*d*
Prediction I/II = *d* (I/II:I/III)	*d*	*s*	*s*
(I/II:II/III)	*s*	*d*	*s*

relationship of similarity will exist at the second 'A' and hence the second 'A' will be minimally informed." The equation $A/B = d$ will be an abbreviation for "if event 'B' follows event 'A,' a relationship of dissimilarity will exist at 'B' and hence 'B' will be maximally informed." Since the relationships *d* and *s* are substantive, they may themselves serve as events in an event-order. This gives rise to four basic equations, similar in structure to those above, that will provide the operational foundation for the measurement of information: $d/d = s$, $s/s = s$, $d/s = d$, and $s/d = d$.

In order to demonstrate the application of these operations to problems in pattern, we will examine some selected 3-event patterns. Having presented two events in the pattern "AB," we wish to determine the difference in effect if we select "A," "B," or "C" as the next event in the event-order. To do so, we must first identify all the predictions inherent in the event-order "AB." There are four, only three of which are relevant to the problem of the moment. They are "A," "B," a relationship of *d* which has resulted from "B" following "A," and "AB" as a structural unit. The last-named prediction would not be relevant until a second 2-event unit, distinct from the first, had developed. This cannot be the case until there are four events in the pattern. Table 1 presents a test of the predictive situation with regard to each possible third event in the pattern. There are altogether three predictions involved in each case. The first two predictions can be dealt with summarily. The third event either confirms or nonconfirms them entirely. The third prediction sets up a more intricate situation. There are two relationships that develop at the third event, each of which constitutes a partial test of the prediction *d* established by the pattern "AB." When "A" is the third event, for example, one of these new relationships confirms the prediction, the other nonconfirms it. The same is true when "B" is the third event. Either "A" or "B" as a third event nonconfirms our third prediction only one-half.

Table 2 is a reduction to numerical form of Table 1. In Table 2, "0" represents minimal information, "1" represents maximal information, and figures lying between "0" and "1" represent states of information lying between these extremes when any single prediction is being considered.[6] The pattern "AB" provides three relevant predictions. Of these, "A" as a third event nonconfirms 1.5, "B" nonconfirms 1.5, and "C" nonconfirms 2. Therefore, after "AB" the most

[6] The numerical values given here have only relative significance and must not be confused with the "bit," the basic unit of measure in traditional information analyses.

TABLE 2

Proposed third events	A or	B or	C
Prediction I	0	1	1
Prediction II	1	0	1
Prediction I/II	0.5	0.5	0
Total nonconfirmations	1.5	1.5	2
Percent nonconfirming	50	50	67

informed event that could occur would be anything other than "A" or "B." The repetition of either "A" or "B" as the third event generates equal information. The experience of any competent composer would make these observations no surprise to him.

Computations of the sort demonstrated above become more useful, both to the analyst and to the creative artist, if the results are presented in another form. In the above case, it is shown that events "A" and "B" nonconfirm 50 percent of the predictions, are therefore 50 percent informed while event "C" nonconfirms 67 percent of the predictions, is therefore 67 percent informed. The occurrence of "B" as the second event in the pattern generated a state of 100 percent informedness. Therefore, no matter what occurs at the third event, a reduction of information will take place at the third event if the two preceding events are dissimilar.

It is this change in informedness from event to event that constitutes the reality of experience, and it is this change that is the measurable aspect of any experience. If methods for interpreting this measure can be both rationally and empirically developed, they will provide a useful tool for any scientist seeking to construct a general theory regarding any type of temporal experience. The authors will propose a few suggested interpretations, none of which have as yet been sufficiently tested empirically. They are offered as reasonable hypotheses from which the development of a general method for the interpretation of information flux can begin. We will omit here any further account of the computation procedure which becomes quite elaborate when longer event-orders are considered. The results given in Table 3 in the form of percentiles based on "1" as maximum informedness have been calculated in accordance with a procedure which is described in detail in another article.[7]

We may assume that the listener wishes to be rewarded by a musical experience. He will not be rewarded if the experience makes no sense. "Making no sense" is an everyday expression for randomness. Information is a measure of randomness. As randomness increases, the overall information in a system increases. As a musical experience approaches randomness, its reward value decreases. From this standpoint a composition would be most effective if its overall randomness, i.e., its informedness, were low. If we examine the information values given in Table 3, we discover that the patterns "AAAA" and "AAAB"

[7] Edgar Coons and David Kraehenbuehl, "Information as a Measure of Structure in Music," *Journal of Music Theory*, II, 127ff.

TABLE 3

Form	Information at each event				Avg. info. at event 3	Avg. info. at event 4	Average info. reducs.	Average info. change
I	A	A	A	A				
		.00	.00	.00	.00	.00	.00	.00
II	A	A	A	B				
		.00	.00	1.00	.00	.33	.00	.33
III	A	A	B	A				
		.00	1.00	.50	.50	.50	.50	.50
IV	A	A	B	B				
		.00	1.00	.60	.50	.53	.40	.47
V	A	A	B	C				
		.00	1.00	.71	.50	.57	.29	.43
VI	A	B	A	A				
		1.00	.50	.50	.75	.67	.50	.50
VII	A	B	A	B				
		1.00	.50	.50	.75	.67	.50	.50
VIII	A	B	A	C				
		1.00	.50	.69	.75	.73	.50	.56
IX	A	B	B	A				
		1.00	.50	.53	.75	.68	.50	.51
X	A	B	B	B				
		1.00	.50	.50	.75	.67	.50	.50
XI	A	B	B	C				
		1.00	.50	.69	.75	.73	.50	.56
XII	A	B	C	A				
		1.00	.67	.50	.83	.72	.25	.50
XIII	A	B	C	B				
		1.00	.67	.50	.83	.72	.25	.50
XIV	A	B	C	C				
		1.00	.67	.50	.83	.72	.25	.50
XV	A	B	C	D				
		1.00	.67	.50	.83	.72	.25	.50

exhibit the lowest average informedness. They are unquestionably the least random patterns and, from this standpoint alone, would seem to be the most effective. We will discover shortly that they have other formal deficiencies that would limit their usefulness.

If we accept the theory that learning is reinforced by reward, it would seem possible that the event in a pattern which most effectively disposed of randomness would be the best-learned by reason of its being the most rewarding. In terms of information, this would say that the event in a pattern that creates the maximum information reduction is the most effectively impressed upon the listener. In this case, the concept of information reduction is comparable to the concept of drive-reduction in learning theory.[8] In musical terms, the event in a pattern creating a maximum information reduction would become the "point" or "principal material" of a composition. Our analysis of 3-event patterns "ABA," "ABB," and "ABC" shows that the last idea in each case becomes the

[8] For an account of this theory see John Dollard and Neal E. Miller, *Personality and Psychotherapy*, pp. 40–42.

point of a composition so arranged since it creates the only information reduction in the pattern.

When we examine the 4-event patterns in Table 3, we discover that the patterns "AAAA" and "AAAB," which seemed so effective in terms of overall orderliness, lack the property of an information reduction. We must emphasize here that it is not the degree of informedness achieved by an event but rather the degree of information reduction that it achieves that calls it to our attention. It is not possible, of course, to achieve an effective information reduction without first generating a relatively high state of informedness. This is why a composer must introduce a considerable degree of randomness into his composition before he can make an effective information reduction and thereby establish the "point" of his composition. In traditional terms, "variety" becomes essential to the establishment of "unity" in a composition. The pattern "AAAA" fails to generate any reducible information while the pattern "AAAB" generates a maximum state of informedness but does not continue to reduce it. These two patterns as formal units fail to establish any clear hierarchy among their constituent events.

Information reduction may also operate to provide us with clues to the way in which an event-order gives the impression of being sectionalized or articulated. A reduction in information seems to be associated with our sense of beginning while a gain in information contributes to our sense of continuing. This is easily demonstrated in the short patterns under consideration here. In longer patterns, this is by no means always the case. It seems that a sharp gain in information will as effectively create an articulation, a new beginning, as a considerable reduction. Such a sharp gain is generally achieved by introducing a previously unknown event into the pattern. This observation would suggest that *any major change* in the informed state (and the exact degree of such a "major change" could be determined only by a series of carefully designed empirical studies) establishes a "natural" articulation in an event-order.

In dealing with the 4-event patterns shown in Table 3, we need not be concerned with this last possibility since it does not arise. We will consider three aspects of effective structural organization that are associated primarily with information reduction:

1) The most generally effective form will be that which has the lowest average information, is therefore the least random.

2) The most significant event in an event-order is that event which achieves the greatest information reduction.

3) An articulation, at least in a short event-order, results from an information reduction.

On the above bases, we may assume that the most effective form will be that one that demonstrates (1) minimum randomness, (2) a clearly established "point," and (3) maximum clarity in its articulate structure. Table 4 presents a rank-order of effectiveness for all the possible 4-event patterns as formal units. We have used the average information generated in each pattern as a measure of randomness; the average information reductions in each pattern as a measure of clear hierarchy; and the average information change in each pattern as a measure of articulative clarity.

TABLE 4

Form	Rank-orders			
	Average Information	Average Reduction	Average Change	Total
I	1.0	14.5	15.0	30.5
II	2.0	14.5	14.0	30.5
III	3.0	4.0	7.5	14.5
IV	4.0	8.0	12.0	24.0
V	5.0	9.0	13.0	27.0
VI	7.0	4.0	7.5	18.5
VII	7.0	4.0	7.5	18.5
VIII	14.5	4.0	1.5	20.0
IX	9.0	4.0	3.0	16.0
X	7.0	4.0	7.5	18.5
XI	14.5	4.0	1.5	20.0
XII	11.5	11.5	7.5	30.5
XIII	11.5	11.5	7.5	30.5
XIV	11.5	11.5	7.5	30.5
XV	11.5	11.5	7.5	30.5

Summary of the above rank-orders

AABA	14.5
ABBA	16.0
ABAA, ABAB, ABBB	18.5
ABAC, ABBC	20.0
AABB	24.0
AABC	27.0
AAAA, AAAB, ABCA, ABCB, ABCC, ABCD	30.5

Although Table 4 gives a clear account of the relative merits of all the possible 4-event patterns, a composer would be more interested in the specific properties of any given form which he wishes to use. A study of the forms as they are presented in Table 3 indicates that certain of them have special properties that would make them useful under special conditions. They may be grouped as follows:

I, II: Minimum randomness but no clear hierarchy or structure.

III, IV, V: Medium randomness but clear hierarchy and structure.

VIII, XI: Considerable randomness but clear hierarchy and structure.

As was already shown in Table 4, "AABA" is the most generally effective form. It is perhaps for this reason that through the centuries it has been the most commonly employed form for the popular song, that musical composition that must make its point in a single hearing. It is also a form in which the psychological laws of primacy and recency operate to impress the idea "A" upon the listener. On the other hand, this same form would make an unsatisfactory opening section for a long composition because an information reduction on the final event of a formal unit tends to close it. Forms VIII and XI, which are open-ended in this respect, would serve more effectively to begin a long movement. The information generated by the final events of these patterns provides the composer with a basis for effective continuation since there is a considerable amount of information which may be effectively reduced.

Forms I and II, precisely because they are inarticulate but maximally integrated, are effective as the incisive small patterns, occupying a short time-span, that carry the basic energy of a larger composition. There is not space here to elaborate on the reasons why such basically uninformed patterns become very intense if they are compressed into a short time-span. Briefly, however, since any event has an information increment that is inherent in its existence and is not derived from its location in an event-order, the listener requires time for his nervous system to process any event no matter how clearly its occurrence is predicted. If the events are sufficiently compressed in time, the information generated by one event is not fully assimilated when a new event occurs. The result is a piling up of information at the occurrence of each new event. A series of identical pitches played slowly, allowing the listener time to assimilate the inherent information in each new attack, is as uninformed as our analysis of Form I indicates. If, however, the same pattern is played very fast, the result is a gradual increase in information, a maintenance of intensity although the tones of the pattern are fully predicted. An example of Form II is found in the famous "victory" motive of the Beethoven *Fifth Symphony*. It appears in virtually every bar of the piece creating an upsurge of information at the end of each of its repetitions. Beethoven's insight as a composer told him immediately that the choice of such a pattern as the basic figure of a fast composition would provide a relentless forward drive.

A glance at Table 3 brings out one more interesting point. With very few exceptions (Forms II, IV, and V) the extension of a 3-event pattern to a 4-event pattern involves no gain, in fact, in most cases, an actual reduction in the randomness of the pattern. The overall information at the fourth event is equal to or less than it was at the third. This may account for the general preference among composers for structural patterns of four rather than three events. Having presented three ideas, composers must have sensed that they could do nothing but improve the overall situation by presenting a fourth; therefore, they most commonly did.

So far we have been concerned only with the interpretation of information values in time sequence. It is evident in such cases that information reduction ordinarily underlies significance. The same does not hold for simultaneous events. In such cases, it seems likely that the listener's attention is drawn to that which is most informed. Studies in the visual arts tend to indicate this.[9] A simple example in the field of music will demonstrate the application of this principle.

Various reasons have been advanced from time to time for the marked difference in the quality of major and minor triads. Yet another basis for this difference may be adduced from an information analysis of each triad. We may assume that the first partial of a pitch constitutes a prediction of the other partials of the same pitch. We may also assume, as is generally the case in music theory, that partials beyond the sixth are of no especial relevance to problems of

[9] See Fred Attneave, "Some Information Aspects of Visual Perception," *Psychological Review*, 61, 183–93.

TABLE 5

Fundamentals	Partials					
	1	2	3	4	5	6
C	C	C	G	C	E	G
E^b	E^b	E^b	B^b	E^b	G	B^b
E	E	E	B	E	G♯	B
G	G	G	D	G	B	D

tonal relation. The pitches predicted by the fundamental pitches C, E^b, E, and G are those indicated in Table 5.

If we do not consider the octave of occurrence, we may then state what tones of the major and minor triads on the root C are predicted by the partial series of each tone of the triad. Those tones which are predicted by the partial series of another tone will be minimally informed. For example, the G which appears in both triads is uninformed in the light of the partial series on C since it is predicted by the latter. On the other hand, the C in both triads would be informed in the light of the partial series on G since C does not occur in it. The partial series on G constitutes a prediction of not-C. Since information is the nonconfirmation of predictions, we can summarize the informedness of the major and minor triads on C as shown in Table 6.

Experiment has shown that the prominent event in a group of simultaneous events is that event which is most informed. In the case of the C-major triad, this would be C, the tone which is commonly called the root of the triad. On the same premises, however, the C-minor triad has two equally likely roots. Since ambi-

TABLE 6

Predictions	Triad tones		
	C	E	G
Major Triad			
C-partials	0	0	0
E-partials	1	0	1
G-partials	1	1	0
Nonconfirmations for each tone	2	1	1
Minor Triad			
	C	E^b	G
C-partials	0	1	0
E^b-partials	1	0	0
G-partials	1	1	0
Nonconfirmations for each tone	2	2	0

TABLE 7

Fundamentals	Relevant partials 1	3	5
C	C	G	E
E^b	E^b	B^b	G
E	E	B	G#
G^b	G^b	D^b	B^b
G	G	D	B
G#	G#	D#	B#
B^{bb}	B^{bb}	F^b	D^b
B^b	B^b	F	D
B	B	F#	D#

Predictions	Tones of the Chords C	E^b	G^b	B^{bb}
C-partials	0	1	1	1
E^b-partials	1	0	1	1
G^b-partials	1	1	0	1
B^{bb}-partials	1	1	1	0
Total nonconfirmations	3	3	3	3 = 12
	C	E^b	G^b	B^b
C-partials	0	1	1	1
E^b-partials	1	0	1	0
G^b-partials	1	1	0	0
B^b-partials	1	1	1	0
Total nonconfirmations	3	3	3	1 = 10
	C	E^b	G	B^b
C-partials	0	1	0	1
E^b-partials	1	0	0	0
G-partials	1	1	0	1
B^b-partials	1	1	1	0
Total nonconfirmations	3	3	1	1 = 8
	C	E	G	B^b
C-partials	0	0	0	1
E-partials	1	0	1	1
G-partials	1	1	0	1
B^b-partials	1	1	1	0
Total nonconfirmations	3	2	2	3 = 10

TABLE 7—*Continued.*

	C	E	G	B
C-partials	0	0	0	1
E-partials	1	0	1	0
G-partials	1	1	0	0
B-partials	1	1	1	0
Total nonconfirmations	3	2	2	1 = 8
	C	E	G♯	B
C-partials	0	0	1	1
E-partials	1	0	0	0
G♯-partials	1	1	0	1
B-partials	1	1	1	0
Total nonconfirmations	3	2	2	2 = 9

guity is one of the sources of emotional uneasiness, perhaps our various sinister associations with the minor triad are reasonably founded upon its information properties. It is possible that the "brightness" of major and the "darkness" of minor are due to the clear information structure of the major triad as compared with the ambiguous information structure of the minor triad.

An analysis such as that given in Table 6 may also be used for another purpose. It is possible that relative consonance and dissonance may be demonstrated to be the result of degrees of total informedness in a tonal combination. If this is true, then the difference in quality in major and minor triads is not demonstrated in Table 6 to be founded upon relative consonance. Both the major and

TABLE 8

Chords	Rank-orders		
	Root clarity	Informedness	Total
C-E♭-G♭-B♭♭	6.0	6.0	12.0
C-E♭-G♭-B♭	5.0	4.5	9.5
C-E♭-G-B♭	3.5	1.5	5.0
C-E-G-B♭	3.5	4.5	8.0
C-E-G-B	1.5	1.5	3.0
C-E-G♯-B	1.5	3.0	4.5

Cords in order of complexity

C-E-G-B	3.0
C-E-G♯-B	4.5
C-E♭-G-B♭	5.0
C-E-G-B♭	8.0
C-E♭-G♭-B♭	9.5
C-E♭-G♭-B♭♭	12.0

minor triads develop four units of information altogether. However, an analysis of seventh chords in the same fashion (see Table 7) produces some interesting results.

Table 8 summarizes the observations in Table 7, ranking the seventh chords on the pitch C from the clearest to the most ambiguous in terms of root and from the least to the most informed. When these rank-orders are combined, the six seventh chords can be arranged in order from the simplest to the most complex. It is interesting that perhaps the most commonly used of these, the dominant seventh chord, is in the middle of such a ranking. This demonstrates again our oft-noted aesthetic tendency to prefer materials that represent a balance between the simple and the complex.

A very few applications of information analysis to the theoretical problems of music have been demonstrated here. It is probable that the development of increasingly validated interpretations of the measurements provided by information analysis will lead to many applications of an analytical tool which permits us, for the first time, to consider at once both the rhythmic and tonal aspects of music and to develop a descriptive technique for all the affective characteristics of a musical composition which will be based on a property common to all, information.