XVI. META ≁ HODOS

The three papers that explore Tenney's ideas of hierarchical gestalt perception (although two are more or less book length), form a body of theory that is essential and unique in the twentieth century, and one of the most profound expositions of Tenney's thought. The first, Meta ≁ Hodos was written in 1961, while Tenney was still a student of Ken Gaburo's at the University of Illinois. The second, META Meta ≁ Hodos evolved about fifteen years later as an "outline" for a course in Formal Perception and Analysis at Cal. Arts, and the third, Hierarchical Gestalt Perception in Music, over a period of about three years beginning while Tenney was at UC Santa Cruz (around 1976), and ending in 1978 at York University in Toronto, where he is currently on the faculty. The third (HGPM) is an extension of the first two, and the second (MMH) more or less a condensation of the first (MH).

META ≁ HODOS, though it has never been published in any accessible fashion, has an extremely wide following among composers and theorists, especially those of the younger generation, and has had a tremendous impact on the musical thinking of composers far in excess of its popular acclaim. It is always astonishing to me how many people I run into who say they've read it, and that it was an important influence on their musical thinking, when the fact is that it is only circulated hand-to-hand, and that at present new copies are only available by reproducing older ones or by writing to Tenney (which does not necessarily get you one). Yet it has a wide circulation in certain circles, and I think this is because of the relative paucity of real music-theoretical, non-textbook work that exists. MH is a difficult work, but is one of the clearest attempts by a contemporary musician/theorist to lay a formal basis for much of contemporary music. In this it takes its place alongside Partch's Genesis of a Music, Cage's Silence, and other seminal works of modern theory.

The following is an attempt to comment on and very briefly describe these theoretical formulations, and relies chiefly on quotations from the three papers themselves. (Page numbers should not be considered to be authoritative, as there are more than one pagination of the papers in circulation). The reader should consult the works themselves for a full statement of the theories.

META Meta ≁ Hodos basically presents the same material as MH, but in highly concise and abstracted form. While MH is full of musical examples and long, detailed descriptions of certain processes, these same ideas are presented more as theorems and postulates in MMH. The two papers can be read and studied as one, with the second being a kind of "abstract" to the first.

The fundamental motivation for the "theory of hierarchical perceptual gestalt formation" as outlined in these two papers is the failure of modern theory to account for what Tenney calls the "new musical materials". To deal with the music of Webern, Varèse, Schoeberg, Ives, Ruggles, etc. in a manner which represents an extension of older formal ideas is of course partially justified, for their music is steeped in tradition, and though revolutionary, it also bespeaks a complete mastery of the music of past generations. Yet Tenney argues that with this new revolution in music - the breakdown of functional harmony, the focus of attention on musical parameters (timbre, density, intensity) which were, in the past, secondary - new means for formal distinction need be developed. Theory must not only analyze what has happened, it must also provide a perceptual basis for the listener to start from. With this in mind, Tenney's theory is an attempt to formalize musical theory from a new standpoint which draws considerably more from gestalt psychology and an abstract notion of formal perception than it does from classical music theory.

Basic to the theory is the consideration and codification of the multidimensional space in which musical "points" exist. Each musical event, whether it be a single note or a larger grouping of notes, phrases, or even the entire piece, can be quantified in various ways that reflect its perceptual impact. These values are called the state of a temporal gestalt unit, and are expressed simply as the means and ranges (and possibly other similar statistical measures) of various parameters over a given temporal span. For instance, the pitch state of a single note might be just its frequency (or more likely a logarithmic expression of same), whereas the pitch state of a phrase (which we'll call clang after Tenney's terminology; see glossary) might be expressed as the mean of all the single pitches occurring in that clang (or next higher level TG). These kinds of measures are applicable to all parameters, and all levels of TG formation, but are not necessarily defined in mathematical detail in these two papers (that formulation is explored in the third of the set). Once these values are taken into account, however, it is easier to explain how the gestalt notions of segregation and cohesion become factors in our musical perception, for these depend to some degree on the notion of a difference function in the temporal input stream, and by computation of these states, even if it is done by the ear and brain, such a difference function becomes reasonable. Another, equally important factor of perceptual grouping in TG formation is that of the temporal (or statistical) proximity of two TGs - those most proximate will tend to form higher level TGs. (It is interesting to note that these measures become integrated into one metric in the later mathematicization of the model).

Perhaps less formally developed, but just as important an area for investigation, is the notion of shape, or the set of parametric values in which the sequence of events is important. In statistical measures of the mean and range variety, a given set of values is unordered for quantitative purposes, but this obviously does not take into account the important function of various types of motivic recognition processes in our perception. The definitions from MMH show this difference in Tenney's own words:

> "DEFINITION 16: State refers to the statistical and other "global" properties of a TG, including the mean values and ranges in each parameter, and its duration.
>
> DEFINITION 17: Shape refers to the "profile" of a TG in some parameter, determined by changes in that parameter with respect to either of the distributive parameters, epoch and pitch-height (or their acoustical correlates, "real" time and log-frequency)."
> (p.4, MMH)

Each "aspect of form", state and shape (though Tenney also discusses a third, structure) is involved in the formation of the hierarchical gestalt "map" of a piece. The notion of hierarchical gestalts is a rather simple one - successively higher level TGs are composed of lower level TGs, ranging perhaps from the "sub-element" level (the spectra and envelopes of single tones) to the highest level, a piece itself, a composer's entire work, or even a musical-historical epoch.

Tenney's description of the various dimensions of the musical space is one of the more interesting realms of the theory, as it draws heavily from his research into acoustics and the psychophysics of sound. It tends to support those descriptions of music which would be least susceptible to the type of subjective discussion in which theory and criticism is often confused. As an example, it is perhaps worth an extensive quotation from MMH on these parameters:

> "B. On Musical Parameters.
>
> DEFINITION 9: A parameter will be defined here as any distinctive attribute of sound in terms of which one sound may be percieved as different from another, or a sound may be percieved to change in time.
>
> COMMENT 9.1: This definition refers to "subjective" or musical parameters (e.g., pitch, loudness, etc.), as distinct from "objective" or acoustical parameters (frequency, amplitude, etc.).
>
> COMMENT 9.2: There is not, in general, a one-to-one correspondence between musical and acoustical parameters. Where there is such a correspondance, the

relation is more nearly logarithmic than linear.

PROPOSITION III: Pitch, timbre, and (musical) time are not simply one-dimensional parameters, because each includes at least two relatively independent "sub-parameters".

COMMENT III.1: Similarities and differences between any two pitch intervals are percieved in two different ways, depending on their relative magnitudes and their interval qualities. These, in turn, result from differences in what will be called (1) pitch-height, and (2) pitch-chroma.

DEFINITION 10: Pitch-height refers to that aspect of pitch-perception which depends on the existence of a continuous range of pitches, from low to high.

DEFINITION 11: Pitch-chroma refers to that aspect of pitch-perception which depends on the phenomenon of "octave equivalence", and the fact that the continuous range of pitches is also cyclic, virtually returning to its starting-point in each transition from one octave to the next.

COMMENT 11.1: These two sub-parameters may be related to the fact that there are two distinct mechanisms of pitch-perception involved in hearing - a "place" mechanism (determining pitch-height) and a "time" mechanism (determining pitch-chroma). The place mechanism is most effective for high frequencies, the time mechanism for lower ones, but the two overlap over a fairly broad range in the middle register, and it is here that our pitch-perception is the most acute (and the most bi-dimensional).

COMMENT 11.2: The multi-dimensionality of timbre is due to the fact that it is determined in a complex way by our perception of a large number of acoustical features, which may be subsumed under three categories:

(1) the steady-state spectrum,

(2) various kinds of steady-state modulations, and

(3) transient modulations or envelopes.

COMMENT 11.3: The sub-parameters of (musical) time will be called (1) epoch, (2) duration, and (3) temporal density.

DEFINITION 12: Epoch refers to the moment of occurrence - in the ongoing flow of experienced time - of any musical "event", compared to some reference moment such as the beginning of the piece.

DEFINITION 13: The temporal density of a TG is the number of its component, next-lower-level TG'S per unit time; ("duration" will be used in its usual sense).

COMMENT 13.1: The average temporal density of a TG at a given hierarchical level will thus be equal to the reciprocal of the average duration of its component TG's at the next lower level.

COMMEMT 13.2: "Tempo" is a special case of temporal density, referring to an expressed or implied pulse or "beat", rather than to actual durations, and it is only relevant to lower-level TG's.

DEFINITION 14: Pitch-height and epoch (which correspond most closely to the acoustical parameters, log-frequency and "real" time) will be called distributive parameters, because a difference in at least one of these is necessary for two sounds to be percieved as separate.

DEFINITION 15: All other parameters (including loudness, pitch-chroma, duration, temporal density, and the several sub-parameters of timbre) will be called attributive parameters. Note that a difference in any of these is insufficient, by itself, for two sounds to be percieved as separate - there must also be a difference in one of the distributive parameters."

(pp. 2-3, MMH)

Note that Tenney is careful to make a clear distinction between acoustical and perceptual parameters (e.g., frequency and pitch), and that the subclassifications (for example, pitch-height and pitch-chroma) are somewhat unorthodox in terms of conventional "musical" thought. The temporal parameters are, I think, especially interesting and illuminating, and this became of tremendous importance in the computer model of the TG formation process.

Tenney is interested in an objective theory, one which has little room in it for judging one piece against another. There are some things which the theory does not include, like a description of the mechanics of "vertical perception" (harmony, rhythmic counterpoint, aggregate formation...), and an investigation into the perception of musical shape, but these are left as areas for further thought which will later fill in the gaps in the broader superstructure. Tenney has already begun a rather extensive examination of harmony (as we will see in the next chapter), and has made tremendous advances in the modeling of hierarchical gestalt formation (see below). An equally in-depth discussion of "shape" from him is something that many look foward to.

The conclusion of MMH represents an extension of MH, in that it attempts to include some of Tenney's thoughts on information (or entropy) theory in relation to TG formation and perception. Once again, I refer the reader to the paper itself for the clearest exposition of this. In this final section lies a theoretical statement for the perceptual ideas underlying many of Tenney's pieces (with the computer works being the most obvious examples), as well as, I believe, a fertile area for compositions yet to come. Each of the definitions and propositions in this section seems to me to be a "proposition" for a piece, some realized already, some not yet composed.

The final installment (or maybe just the most recent) is entitled somewhat ominously: Hierarchical Gestalt Perception in Music, A Metric Space Model, and the first version was completed in Toronto in 1978. (The published version, "Temporal Gestalt Perception in Music", in the Journal of Music Theory, is a shortened version of the first manuscript. My references are to the original). Here, Tenney models the statistical TG formation process by means of a relatively simple (just a few hundred lines of straightfoward FORTRAN code) computer program in a powerful way. The algorithm is very direct: given a set of parametric values (and later, multiparametric "distances"), the resultant difference function is analysable in such a way as to be able to determine at what point TG's will be formed. Tenney himself papaphrases the theory and algorithm outlined in MH as follows:

> "...in a collection of sound-elements, those which are simultaneous or contiguous will tend to form clangs, while relatively greater seperations in time will produce segregation - other factors begin equal... those which are similar (with respect to values in some parameter) will tend to form clangs, while relative dissimilarity will produce segregation - other factors being equal."
> (from MMH, quoted on p.6 of HTPGM)

> "First, the principles, as stated, were not "operational", but merely descriptive. That is, although they were able to tell us something about TGs whose boundaries were already determined, they could say nothing about the process by which that determination was made. They described the results of that process, but not its mechanism. Second, "similarity" was not defined in any precise way, except by reference to "values in some parameter". The assumption here, of course, was that the similarity of two elements is an inverse function of the magnitude of the interval by which they differ in some parameter.

This remains a plausible assumption, though it was never made explicit - but even such a correlation of similarity/dissimilarity with interval-magnitude does not, by itself, allow the simultaneous consideration of more than one parameter at a time. This rather profound difficulty was implicit in the "other factors being equal" clause appended to the two statements. At the time, this qualification seemed necessary, in order to rule out cases where two or more parameters vary in conflicting ways, or where two or more "factors" function independently. Although this was a useful device for isolating and studying some important aspects of temporal gestalt perception, it imposed a very severe limitation on the range of musical examples whose gestalt structure might be predicted. In most real musical situations, other factors are manifestly not "equal", and our perceptual organization of the music is a complex result of the combination and interaction of the several more-or-less independent variables.

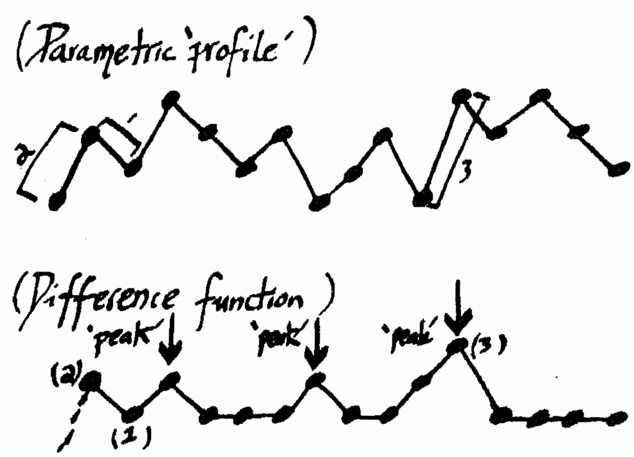
Third (and finally), these early formulations referred to one hierarchical level only - the grouping of elements into clangs - although it was obvious to me even then that the similarity-factor, at least, was of great importance in the perceptual organization of TGs at all higher levels."

(p.6-7 HTGPM)

The "mechanism" can be illustrated visually as follows: The top function is simply a "parametric profile" or plot of the functional values in some arbitrary parameter. This could, for example be a set of pitches, intensities, or even timbres. The bottom function is a first order difference plot, in absolute values, of the parametric profile. Note that it always has one less value than the top. We can easily see where the TGs are formed - where there are peaks in the difference function, and this rather simple algorithm is the basis for the computer model.

It was clear that the perception of TGs is not based on

Example XVI.1



single parameters by themselves, but rather on a perceptual integration of all relevant parameters, and to this end the resulting metric space model was developed. A metric is a single-valued distance function which has certain minimum criteria (always positive, zero implies identity, reflexivity, and the "triangle inequality" - all mathematical notions that are not germane here). A metric space is a set of points in which we can determine the distance between any two points by some assigned "distance function", or metric. In a topological sense, the nature of the function and the charateristic property of the points defines the "nature" of the space. For example, in ordinary Euclidean 2-space (the set of real valued pairs) the simple Euclidean metric:

$$d(A,B) = \sqrt{(x1 - x2)^2 + (y1 - y2)^2}$$

- where A = (x1,y1); B = (x2,y2);
(A and B are points - ordered pairs - in Euclidean 2-space).

reflects to a large extent our normal perception of the physical (non-relativistic) realm, or would if this were carried out into three dimensions. There are of course infinitely many metrics in infinitely many spaces, and experimental psychology (as in the pioneering work of Roger Shepard) has long been interested in what ways metric spaces model perceptual spaces. Tenney's model is simple, yet elegant. The multidimensional parametric values are mapped onto Euclidean n-space (the set of real valued n-tuples), and the metric used, after some experimentation, is a simplified version of the Euclidean - one called the city block or taxicab metric (because the distances it produces are similar to the way one must travel around, say, the streets of (midtown) Manhattan). It is beyond the scope of this paper to go into the mathematical motivations for this essentially topological decision other than to say that there were empirical and perceptual motivations as well, based on evidence from the literature and on the results of preliminary program runs.

By using such a metric, we can obtain a single-valued difference function (exactly like Example XVI.1) from a multi-valued parametric profile. The metric gives us the means for integrating various musical parameters in a way that is likely to be similar to our own perceptual processes. Various details come into play, e.g., how should different parameters be weighted and scaled in the metric function? For a more thorough discussion of this the reader should refer to the paper. The precise algorithm for multiparametric TG formation is given in the paper as follows:

> "A new clang will be initiated in perception by any element whose distance from the previous element is greater than the inter-element distances immediately

preceding and following it."
(p. 16 HTGPM)

Using this metric and decision making procedure for "peak formation", we can for example partition the set of elements (multidimensional note values) into a set of clangs. By computing the means of these clangs (parametrically), the same process can be applied to that level to parse clangs into sequences, and so on up the hierarchical ladder. It is interesting to note that the actual computer program reflects this: the code is the same for all levels, and simply loops back at the end of each. There is no distinction made in the algorithm between TG formations at different levels, and this seems to me to be quite elegant, and an interesting sidelight on our perception.

The program accepts as input the notes for a given piece (however, only monophonically), and outputs an analysis of that piece into its constituent TGs at all levels, with some relevant information as to the "strength" of TG initiations, and statistical means and ranges of higher level TGs. Much of the paper deals with detailed examples from standard literature (Varèse's Density 21.5, the melodic line from Webern's Concerto, and Debussy's Syrinx), so that the results might be tested against our own perceptual analyses of this same music. Some inspection of these results will, I think, surprise the reader in its ability to accurately model the percieved form and structure of the piece on this simple statistical data alone, where harmonic and motivic considerations are not even used.

The model is still a primitive one, even if its results are quite "slick". As yet, there is no means for formally determining weightings, nor is there any allowance for these weightings to shift during the course of the music (as our attention shifts from say the melody to the rhythm). Harmony and motivic recognition, when integrated, would make this model an even more striking example of musical artificial intelligence, as would the ability to consider polyphonic input streams. However, the algorithm and model even now seem to be of revolutionary importance in the understanding of musical form and perception, and one hopes that others will see fit to continue Tenney's work.