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COMPUTER CRITICISM

COMPUTER APPLICATIONS FOR LANguage and literature studies have generally fallen into two major groups: those in which the computer was used to produce through textual manipulation conventional aids for future research (dictionaries, concordances, etc.) and those in which the computer was used in the actual analysis of specific works of literature (thematic analyses, stylistic studies, etc.). The former group has, in general, been viewed as beneficial or, at least, inevitable; the products that have resulted have been familiar and their value apparent. The latter group of applications has presented certain problems. These studies have often been based on initial assumptions that are unfamiliar and developed through techniques that seem more mathematical than literary.[1] In such cases the critic has had to supply an intellectual context for his study, relating it to conventional critical approaches, or risk losing his reader. Preferable to statements of context on an *ad hoc* basis would be a general awareness of the assumptions and methods inherent in computer assisted studies of literature and the relations such studies have to major areas of conventional critical thought. Of greater consequence, however, would be the increased awareness of critics that this new critical methodology is available for use on a wide variety of problems. As late as 1973 Paul de Man wrote:

> It can legitimately be said . . . that, from a technical point of view, very little has happened in American criticism since the innovative work of New Criticism. There certainly have been numerous excellent books of criticism since, but in none of them have the techniques of description and interpretation evolved beyond the techniques of close reading established in the thirties and forties.[2]

The computer, properly and sensitively applied, offers the literary critic a rich collection of new techniques that may help to meet de Man's challenge.

In the remarks that follow, I shall consider three aspects of computer studies of literature. I shall look at exactly what one does in using the computer to study language. I shall try to identify a mode of criticism that arises from using the computer, which I term *Computer Criticism.* Finally, I shall try to show that this mode of criticism is closely related to the major critical developments of this century.

Let me confess at the outset that I am uncomfortable with the term, *Computer Criticism*, for it suggests that, somehow, it is the computer that does the criticism. Nothing could be further from the truth. The role of the computer is to gather the information the critic asks for, to display or present the information, or to apply some analytic model to the information. As with any mode of criticism, assimilation and interpretation takes place in the mind of the critic. One might argue that the computer is simply amplifying the critic's powers of perception and recall in concert with conventional perspectives. This is true, and some applications of the concept can be viewed as a lateral extension of Formalism, New Criticism, Structuralism, etc. On the other hand, when the computer is used extensively in an analysis it can influence the questions one asks of a text and the way one sees the text and its meanings. It is at this junction that the computer can lead to a linear, rather than lateral, extension of Formalist/Structuralist thought.

A survey of recent criticism is not necessary; however, since my thesis is based on the assumption of a particular pattern of development within twentieth-century criticism, I shall pause briefly to outline that perspective. In my view, the mainstream of recent critical thought has moved steadily, inexorably, toward greater formality and toward the notion of a "science" or "sciences" of criticism (these assertions are probably two sides of the same coin). In this country, the movement begins, at least in earnest, with the New Critics and their attempts to break criticism out of the philological mold, to remove the encumbrance of authorial intention (an epistemic impossibility), and to center the critical response on the language of the work itself. Similar intentions lie behind the earlier Russian Formalists. Concentrating more on linguistics, rather than on diction or rhetoric, they sought to distinguish the language of literature, viewed as a coherent system of linguistic traits, from other language/mental activities. They were most successful in their thematic studies (such as those of Propp) where their analyses really began after language *per se* was left behind and they were able to deal with the structure of symbols/categories derived from language. A necessary step toward formality is the awareness of the relativity of models or critical perspectives; this important step in the progression toward greater formality was provided by, among others, the Chicago Aristotelian critics. Stressing the necessity for critical pluralism, they liberated the work of literature from the particular critical statement just as the New Critics had liberated it from the author. More recently, Formalism has moved one step further in the Structuralists' view of a literary work, itself, as a semiotic structure. The full implications of regarding the literary work as a sequence of signs, as a material object, that is "waiting" to be characterized by external models or systems, have yet to be realized. Inherent is the possibility for defining content by formal rules of association, contiguity, and syntax; inherent is the possibility of defining esthetic response by similar formal rules.

The potential of structuralist thought has not been realized for two reasons. First, in spite of statements that Structuralism is really only a method, it is not methodical enough; Structuralists have never codified a set of methods or tech-

niques that is adequate and general enough to accommodate close, sophisticated analyses of a variety of specific literary works. Second, their concept of structure has been overwhelmed by the notion of *linguistic* structure. There is no reason to believe, and in fact numerous reasons to believe otherwise, that segments larger than the sentence are structured in a form similar to the structures within a sentence. The next logical step in this progression toward greater formality would be a mode of criticism based on a coherent set of techniques that includes linguistic models but that goes beyond to include *any* concept of structure that is potentially useful for characterizing linear sequences of signs.

The progression toward the concept of a science of criticism is probably another manifestation of the movement toward greater formalism. The New Critics, while often using "the scientist" as a whipping boy in their efforts to distinguish the rich, connotative language of poetry from merely descriptive language, nevertheless, endorse a mode of criticism that would be more precise, systematic, structural, i. e., "scientific." The Russian Formalists were more direct: as William Harkins has observed, they quite consciously saw themselves as "trying to create a literary science."[3] While not calling criticism a "science," *per se*, Northrop Frye has forcefully described the *scientific* aspects of contemporary inquiry:

> It seems absurd to say there may be a scientific element in criticism when there are dozens of learned journals based on the assumption that there is, and hundreds of scholars engaged in a scientific procedure related to literary criticism. Evidence is examined scientifically, texts are edited scientifically. Prosody is scientific in structure; so is philology. Either literary criticism is scientific, or all these highly trained and intelligent scholars are wasting their time on some pseudoscience like phrenology.[4]

Similarly, Robert Scholes has identified the "scientific" aspect of criticism with the "cumulative" aspect of scholarship,[5] a practice prescribed by McKerrow in 1952 and now expected by virtually every serious journal. A final, and perhaps extreme, view of criticism as a science is that of Roland Barthes stated in "Science versus Literature."[6] Barthes not only identifies a scientific mode of criticism present in French Structuralist/Semiological Criticism, but asserts that the emerging field of semiology will constitute a "meta-language" (by which he means a meta-science involving both perspective and method) that will eventually include and absorb the sciences, proper.

This brief overview of the Structuralist/Formalist tradition and the related movement toward a science of criticism has omitted reference to social, psychological, and phenomenological criticisms. There have, of course, been partial attempts to bring Marxist and Freudian criticisms into the domain of Structuralism. It is my belief that this trend is likely to increase and that social and psychological approaches will make substantial, permanent impact only to the extent that they can

be incorporated into a formal consideration of the text itself. As for phenomenological approaches, I see them as the "loyal opposition," an inevitable and opposite reaction to this very strong main current of thought. When neurophysiology and psychology finally merge and we have an operatively defined gestalt psychology, perhaps phenomenological criticism, too, can move toward a Formalist base.

Before attempting to infer the intellectual perspectives that constitute Computer Criticism, I shall describe briefly for the reader unfamiliar with the internal operation of the computer how the computer can be instructed to deal with texts.

Textual Processing

In principle, a computer is a very simple machine. It is a symbol manipulator that can recognizes 256 codes or characters.[7] These codes, which may be thought of as being ordered from zero to 255, can stand for numbers, letters of the alphabet, or practically anything that one wishes to associate with them. They may be considered separately, as is usually the case for language processing, but they can be considered in groups in order that numbers larger than 255 can be represented or texts with more than 256 characters (texts with a variety of fonts) can be represented.

Computers operate sequentially: they can look at two characters, compare them to see if they are equal, see if one is higher or lower than the other in alphabetic sequence, or move them from one place to another. For numbers, the computer does the same things but it may also add them, subtract them, multiply them, divide them, etc. Using these basic operations one can describe procedures that can be applied to a text to do something useful and, eventually, to do something interesting.

Before such a procedure can be applied to a text, however, the text must be presented to the computer in a form that it can recognize; unfortunately this is normally not in the form of a physical book. Usually the text must be typed onto cards, or preferably, typed directly into the computer memory using a keyboard terminal. Texts are normally typed virtually as they appear in the printed book—one textual line per card or one textual line per terminal line—except that special characters are inserted to denote unusual features of the text: for example, one may mark Italics by typing, say, a pound or hash sign (#) immediately before or after the word to inform the computer that this word is of different font and to notify it to mark it accordingly. With most textual material and with many sets of conventions, the encoded text can be read both by the computer and by the human being without great difficulty.

After the text has been encoded it must be "read" by the computer. For cards, this is done by a card reader, a device that examines each column of each card, in order, to determine which of the 256 characters is represented. For texts

typed directly into the computer through a terminal, this is done through a statement that is typed on the terminal but which the computer recognizes as a command rather than as more text. To read the text and to process it, the computer requires a detailed sequence of instructions or program; this can be written by the analyst, but there is an increasing number of such programs available. These may be stored in the computer's program library and simply called by the analyst when required.

As far as the computer is concerned, the text will appear as one long sequence of characters, starting with the first, continuing from card to card or line to line, to the last. It is usually preferable to segment the text into recognizable units: words, sentences, paragraphs, etc. Each segment, however, must be described to the computer in terms that it can "understand"; for example, a word might be described to the computer as a sequence of nonblank characters bounded on the left and right by blanks. The situation can get a bit more complicated for abbreviations, words before commas, the last word in the sentence, etc.; but by careful planning and through a set of encoding conventions that anticipates such difficulties, the computer can be trained to recognize a word within the stream of characters. Similarly, it may be given a set of instructions or rules to recognize sentences, paragraphs, chapters, etc. Once the text has been prepared and the computer instructed to recognize its particular features, the computer may then be used to produce a variety of conventional aids, such as a lexicon, a collated text, or a concordance.

To produce a lexicon, the computer might be told to extract each word from the running text and to place that word in a list, one word per line. The computer would then be instructed to sort the vocabulary into alphabetical sequence. This can be done by instructing it to start at the top of the list, compare adjacent pairs of words, exchange them if they are in reverse alphabetic sequence, or, if not, proceed to the next pair. By going through the list over and over again until no pair is out of sequence, the computer can eventually determine that the list is in alphabetical order. From the sorted vocabulary, it may then be instructed to run through the list and print a lexicon or dictionary of the text along with each word's frequency of occurence for the critic's examination.

If two editions of a text were processed, one placed in one list and the other in a second list, the computer could be used to collate the two. That is, it could be instructed to compare the first word in each list. If they are identical, it would go to the next word in each list and repeat the process. If they are not identical it could then move down one list until the words match or if that doesn't work move down the second list. In some cases the comparison can be a bit tricky, requiring a jump ahead and comparisons both backwards and forwards within both lists; but the computer is far more accurate than the human eye, particularly for texts representing different type settings.

To produce a concordance, the computer must recognize not just words but also sentences. The words may be placed in one list and the entire sentence for

each word placed in a second wider, but corresponding, list. The list of words is then sorted, but whenever a pair of words is exchanged in the list, alphabetically, the corresponding sentences are also rearranged. When the word list is in alphabetical order a concordance could be printed by having the computer move down the list, printing each word and its corresponding sentence. The resulting concordance could be complete, or it could be selective, providing contexts for only a specific set of words supplied by the critic. The computer could even be instructed to print a concordance for only those sentences in which particular combinations of words appear.

In the remarks that follow, where I shall be dealing with computer materials that may be less familiar, I shall not burden the reader with discussion of *how* the particular aid was produced; I shall concentrate more on describing the product itself, the assumptions that have led to it, and its implications for literary research and critical perspective.

Computer Criticism: Materialist View of a Text

As we would anticipate, the computer's "awareness" of a text is quite different from that of a human reader. For the human being, the text "exists" on at least three different levels: the medium (ink marks of particular shapes on paper), the signifier (the character or letter *A*), and the signified (the meaning "A"). While we normally are not conscious of these levels—indeed, we normally deal with aggregates of such characters in the form of words, phrases, concepts—we can, if we need to, distinguish among medium or form, the signifier, and the signified.

These distinctions do not exist for the computer. As we saw in the previous section, the computer's total "awareness" resides in its ability to distinguish among a small (256) set of codes or states; the only physical dimension of these is the configuration of electrical impulses that constitutes them. All "awareness" is relational: one state "higher" or "lower" than another (*A* higher than *B* in alphabetic sequence).

Because the computer is a sequential processor of symbols, there is a notion of linearity and segmentation inherent in its design. The concept of linearity is fundamental to the "stream" of characters that it receives from outside—through the card reader or terminal. When the computer "reads" the text, it normally removes extra blanks in the typed lines and stores the text as a long, continuous string of characters, beginning with the first word and ending with the last. The fundamental segment is, of course, the character. Since each character is represented by one of 256 states, there is no variable spacing: all characters occupy equal space in the sequence and all are segmented from one another. Segmentation in the linguistic sense must be defined for the computer formally and functionally: the sequence of nonblank characters between blanks, or some equivalent definition.

If these segments, words in this case, are moved to a list where each slot is of equal width, this transformed list version of the text becomes a text of equally spaced segments analogous to the character-level defined text. Thus, the items in the list, words, become the fundamental units or states and are usually dealt with by the computer as "wholes"; and the text considered as a sequence of words emerges with the same material characteristics as the text viewed as a sequence of characters.

The notion of signified is, therefore, missing from the text considered as a a sequence of words just as it is missing from the text considered as a sequence of characters. When the computer "reads" a text, the three levels—the physical, the signifier, and the signified—collapse into the single stratum of the signifier: the sequence of characters or internal states of the computer. The process is necessarily and formally reductive but not as limiting as it may first appear. While the computer can deal only with *encoded* material, there is no reason that physical as well as semantic characteristics cannot be encoded into symbol sequences parallel to the textual sequence. One way of doing this is to envision the text as a list of equally spaced characters or, more likely, words, as described in the last section, but to divide that list into two columns: one for the word and a second for the designation of specific characteristics of the word. Thus, characteristics such as physical segmentation (page, line, position within the line), font, etc. can be encoded as separate sequences of symbols parallel to the actual textual items. Similarly, semantic relations such as synonymity, oppositeness, etc., can be encoded in still another symbol sequence (or if necessary, several such sequences), and the text "viewed" by the computer as three or more parallel symbol sequences; unlike the human being, however, the computer cannot infer any relation or order among these separate sequences unless that relation is supplied by the researcher. So considered, the text becomes for the computer a material, linear sequence of symbols with, perhaps, additional parallel sequences. Of course, it makes no difference whether we "view" the text as a list running from top to bottom (as described) or whether we, mentally, turn it on its side and "view" it as running from left to right. The latter would result in the category columns becoming strata that are parallel to and "above" the textual sequence. I shall refer to the latter "view" below, particularly when discussing *hierarchical strata*.

Since the computer can deal only with formal relations among characters, words, or other segments, the researcher must provide all concepts of "meaning"; this is usually done through a system or systems of categories. Since the computer *can* produce a dictionary or lexicon, we may assume that the researcher has at his disposal an alphabetized list of the words that occur in the text under consideration. One type of categorization is obtained by dividing or partitioning the dictionary. That is, the researcher might read down the dictionary and divide the vocabulary into words that suggest sensory impressions (images) or words that carry content (as opposed to some list of functors); similarly, the researcher may wish to designate a number of such categories, as appropriate for a thematic analysis, in

which the vocabulary of the text is divided into a number of separate categories. The computer, in its capacity as symbol manipulator, could then be instructed to establish a parallel symbol sequence and mark each word according to which group or category it fell into. For example, he may select for the theme, *fire*, the words *burn, burned, burning, fire, heat, hot* and for *water: damp, water, watery, wet*, etc. A broader study might deal with all content words but ignore, in its semantic emphasis, syntactic variability indicated by suffix. An appropriate category system for such an analysis, instead of having twenty or thirty categories, could employ several thousand with each category standing only for a single root-group (*hope, hoped, hoping*, etc.) and containing only a half-dozen or so members. From the standpoint of the computer, it makes no difference whether the vocabulary is divided into two categories, thirty categories, or several thousand, nor does it matter what the rationale is behind the particular categorization scheme: all such relations can be handled analogously.

This notion of category, dependent on the concept of a dictionary, alone, is not sufficient for many studies. For example, the configuration of characters, *r o s e*, may signify a flower, as appropriate for an imagery study; but it may also describe an action—he *rose* from his chair. Here context must be taken into consideration. Since the computer *can* produce a concordance, we may assume the researcher has at his disposal a concordance as well as a dictionary. Consequently, the concept of category can be refined to include linear, diachronic relations as well as dictionary-based, synchronic relations defined for *every* occurence of a given configuration of characters.

Since words in the same category would be marked by the same symbol(s) in the parallel signified column of the text list, the computer by being instructed to consider that column can regard a number of different word forms as equivalent. Consequently, it could look for paradigm-like sequences or patterns of categories in which, on the textual level, the elements of the paradigm could be any word contained in the appropriate category. If the categories indicate synonymous groups, the logical configurations of categories might be regarded as themes or content—the General Inquirer, an early and still the best known content analysis program, defined content precisely in this way: the logical configuration of conceptual categories of words.[8] If the categories indicate parts of speech, the paradigm could indicate syntactic structures; thus, the computer might locate most prepositional phrases by locating all category sequences of preposition followed by a noun, within so many words.

Once a category paradigm has been defined and the particular instances of its occurrence located, a third sequential level can be established, above that of the text and its parallel category level(s), in which the elements are those particular configurations: a specific thematic combination of words or a specific syntactic structure. Of course, this stratum could be viewed as just a second order stratum of categories; so viewed, we can imagine defining paradigms among *those* elements to derive still higher levels of abstraction. The process could be continued indefinitely.

In retrospect, we have seen that the text can be formally segmented in a step by step manner such that each higher segment is defined in terms of units at the next lower level, ranging from the character to the entire work considered as a whole and by extension to the corpus. For each level of segmentation, parallel strata of symbols representing both physical as well as conceptual aspects of the text may be extablished. These may refer directly back to the textual sequence, itself, and are hence logically lateral to one another, but they may also be established hierarchically by referring directly to an intermediate stratum (category of categories, categories of syntactic forms, etc.). Concepts of form, structure, and meaning relate to patterns along, across, and among these various strata.

Conventional Criticism: Materialist View of a Text

The concepts of autonomy of art, materiality of the text, and primacy of category to define and characterize form are also central for Russian Formalism as well as its second generation in Prague. As Victor Erlich has observed, the autonomy of art for the Formalists ranges "from the autonomy of the individual poetic word *vis-a-vis* its object to the autonomy of the literary work of art with regard to reality."[9] At the level of word or figure, the Russians placed considerable emphasis on liberating the word from its fixed conventional connotations so that its full richness could be seen.[10] On a more general level, Skaftymov demonstrated that characters in the narrative, actions in the plot, and, indeed, the philosophic dimensions of the fictive universe must be considered first as components organized within a formal autonomous esthetic structure before substantive extrapolation can be attempted.[11] The concept of category, also, is both pervasive and varied in its manifestations. To reveal the universal narrative structure of a collection of fairy tales, Vladimir Propp reduced the texts of a collection of some 479 tales to sequences of basic actions or *functions*. Since Propp's *function* represents an action described in the narrative, each function could be related to a set of configurations of words or phrases. Thus Propp's functions could be viewed as a second or, possibly, third level category stratum within the general framework of Computer Criticism, and his familiar symbolic representation of thematic structure would be the sequence of categories or symbols within that stratum.[12] The "bootstrap" hierarchical structure encouraged by Computer Criticism in which categories of higher strata are defined in terms of patterns of elements in a lower stratum is more directly analogous to the three level thematics of A. A. Reformatsky. He distinguishes among *themes*, "the simplest static unit of plot construction," *motif*, a set (usually two) of themes joined by a verb, and *plot theme*, units composed of combinations of themes and motifs.[13] *Theme* could be viewed as a first level set of categories; *motif*, as a logical configuration of themes, would be a second level set of categories; and *plot themes*, as combinations of themes and motifs, would be a third level set of categories. Because Reformatsky is primarily interested in

narrative sequence, he often in practice collapses these logically distinct categorical strata into a single symbol sequence to represent narrative structure. More important, particularly in later Structuralist thought, is the concept of metonymy. In distinguishing between figures of speech natural for poetry and those natural for prose, Roman Jakobson distinguishes between the relation of comparison inherent in metaphor and logically contiguous substitution inherent in metonymy. The latter, when considered methodologically, is an example of semantic category: the collection of textual items used individually to stand for the set.[14]

New Criticism shares several basic perspectives with Computer Criticism, but does not come as close as Russian and Prague Formalism. The concept of a materialistic text is apparent in Ransom's ontological concern for the *poem as object*, a predominantly holistic perspective in which sound and meaning must be joined phenomenologically by the critic.[15] Ransom's perspective is made much more concrete and applicable in Wellek and Warren's delineation of perceptual strata. They divide the text into: (1) the sound stratum, euphony, rhythm, and meter; (2) the units of meaning which determine linguistic and stylistic structure; (3) image and metaphor; (4) mythic level of poetic symbols; (5) the fictive world; (6) the system of genres inherent in literature; (7) the evaluative domain; and (8) the historical context of the work.[16] While their delineation of strata has been useful for students of literature, their emphasis is historical and comparative rather than methodological; consequently, while the basic perspective is similar to the overall hierarchical strata of Computer Criticism, the analogy cannot easily be extended further. Perhaps the closest approximation to a New Critical methodology is Caroline Spurgeon's earlier categorization and tabulation of Shakespeare's images,[17] although her biological extrapolations were, of course, contrary to New Critical principles. To the extent that her images can be described formally, her identifications and tabulations can be accommodated by Computer Criticism.

More directly related to Computer Criticism's assumptions of a material text and the notion of categorical strata is French Structuralist criticism, perhaps best summarized in Roland Barthes' "The Structuralist Activity." Most Structuralists claim at least all of the arts as their domain while their near kin, the Semiologists, claim all knowledge; consequently, when Barthes addresses first the ontological nature of the object of scrutiny and, next, its dissociation into parts from which collections (paradigms) are formed, he does so for areas other than literature:

> The goal of all structuralist activity, whether reflexive or poetic, is to reconstruct an "object" in such a way as to manifest thereby the rules of functioning (the "functions") of this object. . . .
>
> The structuralist activity involves two typical operations: dissection and articulation. To dissect the first object, the one which is given to the simulacrum-activity, is to find in it certain mobile fragments whose differential situation engenders a certain meaning; the fragment has no meaning in itself, but it is nonetheless such that the slightest variation wrought in its configuration produces a change in the whole; a *square* by Mondrian, a *series* of Pousseur, a versicle of Butor's *Mobile*, the "mytheme" in Lévi-

> Strauss, the phoneme in the work of the phonologist, the "theme" in certain literary criticism—all these units . . . have no significant existence except by their frontiers: those that separate them from other actual units of the discourse . . . and also those which distinguish them from other virtual units, with which they form a certain class (which linguistics calls a *paradigm*.) This notion of paradigm is essential, apparently, if we are to understand the structuralist vision: the paradigm is a group or reservoir—as limited as possible—of objects . . .; what characterizes the paradigmatic object is that it is, *vis-a-vis* other objects of its class, in a certain relation of affinity and dissimilarity. . . . The dissection operation thus produces an initial dispersed state of the simulacrum, but the units of the structure are not at all anarchic: before being distributed and fixed in the continuity of the composition, each one forms with its own virtual group or reservoir an intelligent organism, subject to a sovereign motor principle: that of the least difference.[18]

Illustrative of Barthes' view of the text as "mobile fragments" and his insistence on the primacy of category (paradigm) for critical analysis in Tzvetan Todorov's *Grammaire du Decameron* in which he proposes a specific instance (Grammar of Narrative) of a universal grammar appropriate for all conceptualization. Similar to Propp's study of Russian folk tales, Todorov's study is a highly abstract study of narrative sequence after the text has been transformed into several strata of categories. He first distinguishes among textual segments: stories, sequences (complete "little tales"), propositions (basic narrative sentence), and parts of speech. He next reduces all actions to these verb categories and all attributes to the other categories. He then proposes a transformational grammar of narrative to accommodate the individual tales. Both the statement of principle as well as the illustrative example emphasize a critical perspective based on a segmented text of functional units that may be grouped in various ways in order to define relational patterns. Computer Criticism shares this perspective but is a bit more inclusive; that is, it demands neither Barthes' concept of the smallest possible set or Todorov's specific categories. The two differ most in the matter of structure, itself, to be discussed in the two succeeding sections.

The formalist group closest to Computer Criticism is the London School, centered in J. R. Firth but most thoroughly and articulately developed by M. A. K. Halliday. Firth and Halliday use the concept of *exponent* to define the substantive within a categorical stratum and to connect the various strata. Halliday, who borrows the concept from Firth, states the relation as follows:

> Exponence is the scale which relates the categories of the theory, which are categories of the highest degree of abstraction, to the data. . . . Each category can be linked *directly* by exponence to the formal item. This has then to be related, in turn, to the substance. . . . When grammar reaches the formal item, either it has said all there is formally to be said about it or it hands it over to lexis.[19]

Lexis, for Halliday, is the *set* of substantives that occupy the places in the sequence of categorical units within a stratum; at the lowest, or most delicate, level this consists of the orthographic or phonemic symbols. Larger units—words, phrases, syntactic patterns, etc.—are produced by formal patterns of textual co-occurrences, called *collocations*, which may be ennumerated to form *sets*. There is, thus, a direct correspondence between the Firth/Halliday notion of sets and the Computer Criticism concept of *states* that constitute textual items; both share the view that subsequent categorical strata can be defined by formal delineation of patterns within a lower level; both establish correspondences between strata, one by the concept of exponency, the other through the concept of location and co-occurence. These and other similarities will be explored further in the discussions of structure below.

Thus several recent structuralist schools share the assumptions of an autonomous, material text; they encourage examination of the text with the aid of stratified levels of conceptual categories; they differ widely, however, in the formality with which such strata are defined and linked to one another. The computer demands an extraordinarily explicit degree of definition simply to function; consequently, it encourages a much more formal description of conceptual categories and relations. But since categories and strata must be defined functionally, Computer Criticism can accommodate the basic critical perspectives of all these groups. These structuralist schools have all been limited by the lack of a developed methodology and the impracticality of applying their perspectives to large, full length texts. The computer, with its ability to accommodate a variety of conceptual points of view through functional generality and its ability to handle large texts with comparative ease, offers the possibility of removing these encumbrances and permitting the application of structural hypotheses to actual works of a substantial nature. At this stage of consideration, the Computer Criticism perspective can be merged with conventional Formalist/Structuralist perspectives by regarding it as a compatible methodological adjunct.

Computer Criticism: Concepts of Structure

Computer Criticism, while compatible with conventional Formalist/Structuralist criticisms, may eventually be seen as a separate school because of its expanded concept of abstract structure and the resulting shift in the critic's conceptualization of the text and its meanings. Structuralism has been dominated by the concept of linguistic form, particularly the mathematical notion of the transformation; Computer Criticism, by viewing the text as a functional, material sequence of symbols, may employ linguistic models when appropriate, but it has developed or adopted a number of nonlinguistic models that fit its functional view of the text. These models have usually been of two kinds: those that describe or predict patterns of occurrence along the "horizontal" textual axis (the text viewed as one

long sequence of words, ticker-tape fashion) and those that develop patterns of co-occurrence among vertical strata to produce still higher, more abstract generalizations or category sequences. To give the discussion of structure illustrative content, I shall develop it in the context of thematics with specific examples taken from a study of James Joyce's *A Portrait of the Artist as a Young Man*. Of course, theme is just one type of secondary stratum that can be defined. By using different principles of categorization, identical structural patterns would have radically different meanings. Additionally, the segment of text over which the pattern is defined can greatly alter the interpretation of patterns. Where the primary focus is on the sentence, the patterns that result are likely to be viewed in the context of linguistics; for segments of paragraph length, the patterns are more likely to be seen in the context of discourse analysis. Thematics usually adopts the primary segment of the entire text and uses *themes* as categories consisting of metonymic collections of words. (The collections of words relating to *fire* and *water* mentioned above can serve as examples, but the general notion of category can accomodate other definitions as well.) Were a structural description of an author's entire canon developed, we might approach Northrop Frye's concept of contextual criticism.

Designation of the theme or category, as was seen in Spurgeon's study of Shakespeare, draws the critic's attention to the functional equivalence of the words or units of the category; Computer Criticism provides the further possibility of describing the form or "behavior" of the theme over the entire text. That is, we may count the number of times the category appears and by comparing this value with similar totals for other thematic groups gain some partial insight into its relative prevalence and, perhaps, importance. If the text is segmented on the physical level into segments of equal length (say, 500 words) and subtotals for each segment computed, the resulting values may be used to produce a distribution of the theme over the text (see Figure 1: a distribution of the theme, *fire*, for Joyce's *A Portrait of the Artist as a Young Man*). In such a drawing we may not only confirm critical impressions of thematic density, we may see exactly the proportional concentration in one section of the text compared with another.

While a distribution of a theme can be regarded as a structural description of that theme, Computer Criticism can go one step further and employ models that *characterize* that distribution. That is, the critic may not only display the actual distribution, but uncover the underlying form or dynamics of that distribution and compare it with similar analyzed distributions. By regarding the diachronic sequence of words as analogous to the unitary progression of time, the critic may employ a variety of analytic models, known collectively as Time Series Analysis, to characterize the distribution. One such model is Fourier Analysis.

To apply Fourier Analysis to the distribution of a category or theme, the critic must view the distribution as analogous to a wave over time, such as a graph of a sound wave over some period of time. If the sound wave has definite maximum and minimum frequencies, as would a sound wave carried over a telephone, it is

a remarkable mathematical fact that no matter how irregular the wave appears, it can be reproduced by combining a definite number of flowing, perfectly regular (sine and cosine) waves of different frequencies and amplitudes/heights. By picking only the most important waves (those with the greatest amplitudes), adding them together, and ignoring the rest, one can produce a "smoothed" transformation of the original distribution in which the form and major dynamics of the theme are readily apparent. Further, a distribution of the amplitudes (actually, a function of the amplitudes) of the smooth waves can be regarded as a formal description of the complexity of the theme; a thematic distribution with only eight important terms or rhythms might be considered less "complex" than a distribution with sixteen. Thus, the critic may use the computer to draw attention to the variety of words connoting a theme, to compute its frequency of occurrence, to display its form or behavior over an entire text, and to characterize that form. The techniques described could also be employed to consider a variety of themes and the resulting materials used for comparative purposes.

The concept of distribution is a diachronic, "horizontal" concept of structure that characterizes patterns along one of the vertical strata described earlier; a different concept of form or structure is the collection of synchronic relations among a number of such distributions. Synchronic patterns of interrelation are, essentially, patterns of co-occurrence; these patterns may produce direct interpretive results or they may serve as elements to derive more general "hyperthemes" of greater abstraction and complexity. For example, in Joyce's *Portrait,* a great deal is re-

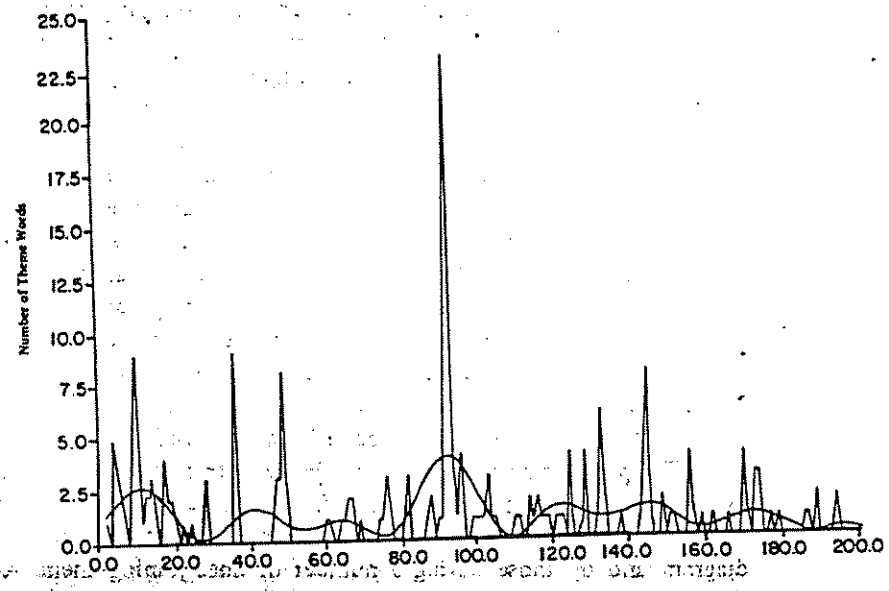
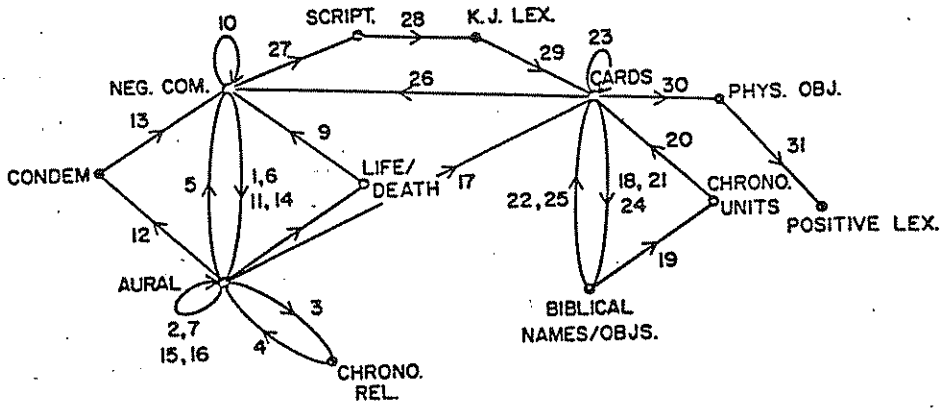


Figure 1: Linear Words x 500 FIRE/HEAT

vealed about Stephen by the *combination* of themes and images that flow through his mind. In Chapter 1, he seldom recalls the pleasant and secure hearth fire of home without recalling the dreadful fall into the cold waters of the ditch; other combinations abound. A number of models are available for determining such patterns of co-occurrence: one I have found particularly useful is factor analysis or, more specifically, Principal Component Analysis. To use it, in the context cited above, the critic would determine a section of text—possibly the entire text—in which he feels that thematic interaction is relatively consistent. By next dividing that portion of the text into small, uniform physical segments (perhaps 100 words) and by computing distributions on the basis of those segments for all themes or categories to be considered, he may use Principal Component Analysis to determine specific clusters or groups of themes that consistently occur close to one another. With this information he may return to his concordance or to the text to explore the specific thematic significance suggested by these patterns of interrelation.

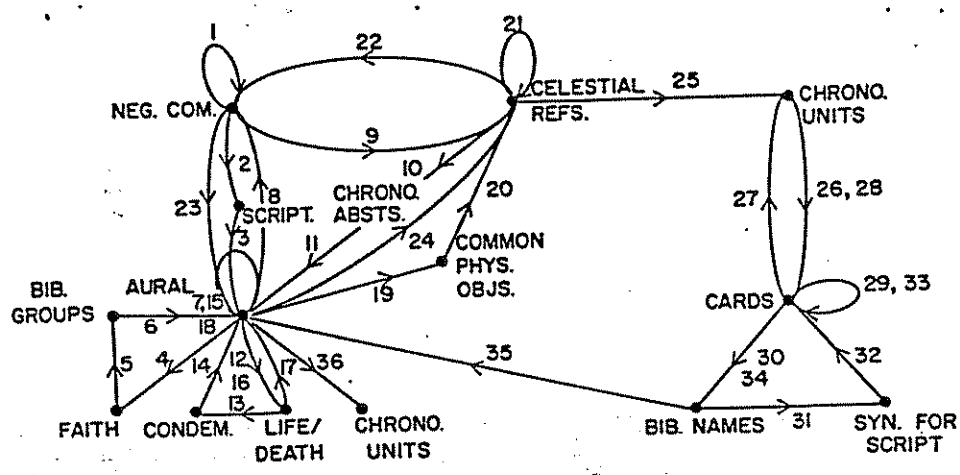
The result may be a direct interpretive statement; it may also be a higher, more abstract level of thematic combinations (themes whose elements are thematic clusters). Once this stratum is defined, it becomes subject to examination and characterization using all of the concepts of structure described. One possible approach is the consideration of thematic progression. To pick up the example from Joyce, while much is revealed about the development of Stephen's mind by considering the combinations of themes that occur in his consciousness, more is revealed in the *changes* in such associative relations that develop over the course of the novel. To trace structures such as the developing network of associations among themes, I shall describe two approaches. The first, employing a technique known as the state diagram, is rather simple to apply; the second, known by the acronym, CGAMS, at present requires rather specialized computing equipment but is more powerful. State diagrams are used in Automata Theory to designate the particular configurations or states of a theoretical computing machine, the history of the "machine," or the permissible transitions from state to state. This is done by representing the states as a set of points and the transitions by lines or arrows between the points. The technique can be used to reveal the developing structure or network of thematic associations by representing each theme by a point and indicating the associative relations between themes as lines joining the appropriate points/themes. More specifically, one could have the computer mark each theme or, perhaps, cluster of a theme (a cluster could be a section of text in which, say, three words in the same theme occur within 100 words of one another).

The progression from theme to theme or from cluster to cluster can be traced by drawing and numbering the lines from appropriate point to appropriate point. Close thematic interaction will be revealed in points close to one another in the diagram and by those having a number of lines joining them. An example of a thematic network of this sort is shown in figures 2 and 3, representing two versions of the same basic text, in this case, a folk sermon.[21] While the diagram itself repre-



DOC I

Figure 2: Thematic Structure of DOC I



DOC II

Figure 3: Thematic Structure of DOC II

sents a synchronic structure for the entire text, the diachronic progression from theme to theme can be traced: locate START; find the path marked 1; move to the next point or theme; find the path marked 2; move to the next theme; etc. Used singly, diagrams of individual texts reveal the specific thematic progressions in that text; diagrams for several texts can be used in combination for comparative purposes to approach questions such as thematic complexity and the relation of thematic structure to other aspects of the work.[22]

When the critic wishes to explore the dynamics of thematic interaction over a long text, the computational system, CGAMS, may be more appropriate.[23] CGAMS, while most useful for deriving a macroscopic representation of thematic relations, may also be used for close inspection of specific thematic relations within a smaller textual segment. The system produces a pictorial representation of the relations between a selected set of themes on a t. v.-like screen (see figure 4, a representation of some half dozen themes in Chapter I of Joyce's *Portrait*). The basic picture resembles an aerial view of a mountain range in which there is a peak for each theme. The height of a peak represents the relative prevalence of that theme for the section of text under consideration. The horizontal distance between peaks represents the proportional diachronic distances in the text between those two themes relative to similar distances for all other theme pairs. The slope of the facet between two themes/peaks indicates whether the two themes tend to be a stable distance from one another (for example, nearly always ten or twelve words apart resulting in a sharp, abrupt facet, or whether the distances vary con-

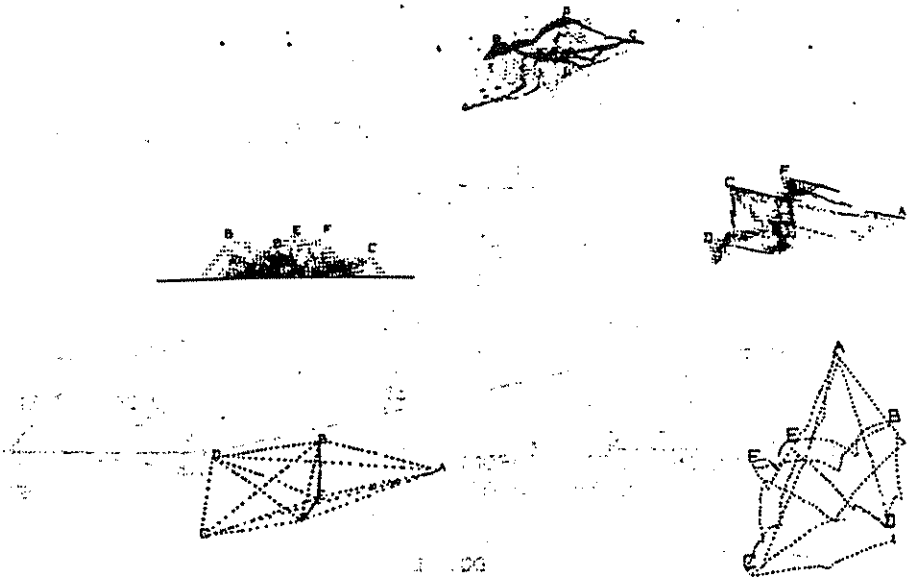


Figure 4: CGAMS Images

siderably (sometimes two or three words apart, sometimes twenty or thirty words apart) resulting in a sloping facet. The perspective on the "mountain range" may be changed by turning dials so that the critic can zoom up and look down on it from above, move down and look at it from ground level, or assume any other position he wishes. By producing an entire picture for, say, the first 1000 words of the text, another, cumulative, picture for the first 2000 words, another for the first 3000, etc. through the entire text, one can note in the progression of pictures the way in which themes grow and shift in relation to one another over the diachronic course of the work.

The basic view of the peaks resembles a fishnet laid over mounds of sand; to gain a closer, more detailed perspective of the exact pattern of thematic interaction for a section of text, the researcher may remove the "fishnet" and examine the specific information on which the picture is based. Thus, CGAMS can portray the structural dynamics for selected themes from a micro-perspective as well as a macro-perspective.

I have argued elsewhere that in Joyce's *Portrait* the personality of Stephen remains constant between moments of epiphanal transition (the pandybat episode, the encounter with the prostitute, the confession, the encounter on the beach, etc).[24] At these moments of epiphany, however, what *exactly* changes is the pattern of associations among images manifest in changes in the pattern of proximity of images in the text. The careful reader will, of course, notice certain shifts in proximity and association, but CGAMS marks the exact place where shifts occur, reveals the precise nature of the shift relative to other thematic relations, and indicates the relative importance of the shift. It does so in the form of an actual visual representation that can be used for demonstrations or for comparisons with similar representations of thematic activity in other textual sections.

Diachronic distributions, Fourier Analysis, Principal Component Analysis, state diagrams, and CGAMS are all models that may be used to explore thematic structures and relations. These same models could be used to examine different strata; for example, applied to a stratum of syntactic categories, they could be used to document shifts in syntactic patterns in a text (see the discussion of Halliday's study of *The Inheritors* in the section that follows). However, these are only a few of the concepts of structure that the computer makes practical to apply to extended texts. Once the critic makes the conceptual move to consider the text from a functional point of view and to consider "meaning" as originating from the reader's interaction with features and patterns within that text, the computer offers a wide variety of relational possibilities. In addition to the models or concepts of structure described here, there are numerous other possibilities. For example, additional parametric and formulaic possibilities exist that permit comparison of the distribution of a textual feature against some pre-established distribution or against an expected distribution of that feature based on earlier patterns of occurrence within the text; authorship studies typically have employed relational models of this kind. In short, the array of models or concepts of structure

that the computer offers the critic as available analytic tools is truly stunning; the possibilites are limited only by our willingness to explore the unfamiliar.

Conventional Criticism: Concepts of Structure

Most of the formalist schools of criticism discussed have used a stratified view of the text as the basis of their concept of form or structure. Summarizing the theoretical assumptions of the Russian Formalists, Tzvetan Todorov observes: "The concept of form produces and is then fused with the concept of function. Analysis of form . . . leads to the identification of its function, i. e., the relation between its various components. Its components . . . are connected by algebraic signs of co-relation and integration . . .: horizontal relations of distribution and vertical relations of integration."[25] The concept of vertical strata is most strongly associated with Shklovsky's metaphor of "staircase" construction. Erlich comments on Shklovsky's concept: "The principle of juxtaposition, Shklovsky asserted, is especially pertinent to the short story, the most 'artful' fictional genre. In short stories and novelettes the esthetic effect rests more often than not upon deliberate exploitation of various types of contrasts and incongruity. These range from a 'realization' of a pun in terms of narrative structure through a motif of misunderstanding to that of a collision between two codes of morals."[26] While Shklovsky's staircase structure necessarily embodies a horizontal narrative medium, it emphasizes the effect of modulated vertical tensions and attractions among the various denotative and connotative strata parallel to the text.

A concept of structure shared by Shklovsky and his *Opojaz* associates that emphasizes the horizontal dimension of a text is that of retardation. Closely related to the factors producing staircase structure, retardation is the effect of delay in the narrative of episodic development relative to what might be expected if one simply stated the sequence of narrative events without digression, supplementation, or embellishment. By noting the relation between suspense and retardation, the Formalists suggest the possibility of developing a formal explanation of esthetic response or behavior; unfortunately, they did not pursue this lead to the point of developing a practical, general methodology. Similarly, integration of vertical and horizontal concepts of structure was foreseen by the Russian Formalists, but the development of specific methods or models for achieving this was only partially realized. A. A. Reformatsky, we saw, established several distinct strata of categories, denoting theme, motif, etc., parallel to the textual sequence. Propp went two steps further to formulate comparable symbol sequences for a number of narratives and to deduce the inclusive underlying structure shared by all such sequences under omission or simple transformation. The concept of structure in both, however, is

the unidimensional projection of strata into a single sequence of symbols. Pattern or form must still be inferred through observation of repeated sequences of symbols or symbol groups.

The Russian Formalist's concept of structure was extended by the Prague Structuralists in two major respects. With their emphasis on esthetic theory and esthetic response, they made important contributions toward establishing normative patterns; second, they were able to define more clearly the functional strata operating in a literary work and to demonstrate the value of this perspective by actually tracing structural patterns within and across the various strata.

The relations between normative expectation and variation is most thoroughly developed by Jan Mukarovsky in considering the relation between standard language and poetic language:

> The function of poetic language consists in the maximum of foregrounding of the utterance. Foregrounding is the opposite of automatization. . . . The standard language in its purest form, as the language of science . . ., avoids foregrounding. . . . In poetic language foregrounding achieves maximum intensity to the extent of pushing communication into the background as the objective of expression and of being used for its own sake; it is not used in the service of communication but in order to place in the foreground the act of expression, the act of speech itself.[27]

Mukarovsky goes on to suggest that since non-normative language can be perceived only against a background of standard language, the esthetic effect of poetic language is determined in large part by patterns of transition between the two:

> Foregrounding arises from the fact that a given component in some way . . . deviates from correct usage. . . . The simultaneous foregrounding of all components is therefore unthinkable.[28]

Having observed that the transition from esthetically indifferent speech to esthetically colored speech can occur quite rapidly, often in the same sentence, Mukarovsky concludes that the structure of such transitions and juxtapositions constitutes the esthetic structure of the work:

> The work of poetry forms a complex, yet unified, esthetic structure into which enter as constituents all of its components, foregrounded or not, as well as their interrelationships. . . . The predominancy of the esthetic function in poetic language, by contrast with communication speech, thus consists in the esthetic relevance of the utterances as a whole.[29]

To become a practical method of analysis, this view must be supported by a description of normative language. A functional model for normative stylistic traits has recently been proposed by Lubomir Doležel, a member of the Prague School now at the University of Toronto.[30] Doležel suggests that the investigator begin with a large collection of statistical measures for a text. Among these, he can determine empirically those that represent objective factors of language in general and, hence, remain constant throughout all texts (distributions of graphemes and phonemes), those that vary widely in all texts and, thus, represent subjective factors (distributions of specific content words), and, finally, those that range within certain limits over a number of texts and, hence, represent context sensitive or "subjective-objective" characteristics (sentence and word length distributions). Under this taxonomy, Doležel proposes that we may determine empirically not only normative values for a variety of statistical measures but an adequate set of distinctive features for characterizing a spectrum of styles over a variety of authors and subjects. While Doležel does not specifically say so, it is clear that the computer affords the only practical way to apply his model to a text of any substantial length. To the best of my knowledge, this had not been attempted.

The second major contribution by the Prague Structuralists in the continuing development of a stratified concept of structure is contained in the rather recent and controversial paper by Jakobson and Lévi-Strauss. While numerous Structuralists have suggested the possibility of analyzing literary works formally in terms of complex relations within and among a number of linguistic strata, Jakobson and Lévi-Strauss have demonstrated the validity of this view by exhaustively examining a sonnet by Baudelaire. Beginning with the rhyme scheme, they factor out the phonic, syntactic, and semantic levels, and the patterns and relation within each. However, it is in the complex relations across these strata that the poem presents the most difficulty; it is within the interpretive domain, several levels removed from the text, that the various levels are drawn into a coherent whole as they contribute to a highly generalized theme of dialectic tension and resolution.[31]

The notion of structure most prevalent in New Criticism is that of "organic unity," relating part to whole, defined primarily in terms of metrical relations and image patterns. Caroline Spurgeon's classification and cataloging of Shakespeare's imagery has already been mentioned; the concept of structure, however, contained in that work is that of category and frequency. By classifying images and then counting the members of the various classes present in each play, she draws our attention to the tone-setting, often substantive, backdrop of verbal figures. Questions concerning combinations and patterns among categories, not her concern, were raised by later New Critics. For example, Cleanth Brooks, in his discussion of imagery in *Macbeth*, concentrates on two predominant patterns: images of clothes and concealment and images denoting babes. He goes beyond Spurgeon's method, however, by showing that it is the *interaction* of these two groups that underscores and comments upon the major action and theme of the play. Macbeth's ill-fitting garments, like adult clothes on a child, make him ridiculous in

his present circumstances: the naked babe, paradoxically, suggests the strength of historical continuity that eventually crushes Macbeth's vain hopes. While it is the interweaving of these two image groups that results in the complex, multi-faceted semantic structure that attracts the critic's attention, the concept of structure involved is still that loose construct, "organic form," suggested by combination and juxtaposition.

Wellek and Warren, describing the levels of existence of a text, present an interpretive stratification somewhat similar to that described above. As we noted above, they describe some eight interpretive dimensions. Within each stratum, they discuss the historical background of critical concern and often suggest approaches that could lead to methodological formality. For example, in discussing the level of euphony, rhythm, and meter they note Tomashevsky's statistical methods as well as other acoustic approaches; in their discussion of stylistics they, similarly, note the possibility of a stylistics based on normative values and a set of distinctive features. However, in their attempt to be suggestive rather than critically dogmatic, they stop short of advocating any specific methodology beyond recognition of these factored strata.

Within French Structuralist criticism the notion of structure has centered primarily on concepts of *linguistic* structure, with several notable exceptions. For Barthes, structure means primarily patterns of recurrence and association:

> Once the units are posited, structural man must discover in them or establish for them certain rules of association. . . . What we discover in every work of structural enterprise is the submission to regular constraints whose formalism . . . is much less important than their stability; for what is happening . . . is a kind of battle against chance; this is why the constraint of recurrence of the units has an almost demiurgic value: it is of the regular return of the unit and of the association of units that the work appears constructed. . . . Form, it has been said, is what keeps the contiguity of units from appearing as a pure effect of chance.[32]

The best known application of Barthes' concept of structure is his study, *S/Z*. Barthes divides a short story by Balzac, entitled "Sarrisine," into some 561 textual segments or "lexies" each of which represents Barthes' judgment of the smallest portion of the narrative that carries "meaning." He then factors this "meaning" into five vertical planes or "codes" parallel to the horizontal sequence of lexies. Each code represents a different relation among the narrator, the subject matter of the text, and the culture. Barthes' method of application is to work his way through the story, lexis by lexis, commenting on the portion of his experience as highly informed reader drawn into focus by the various codes. The result is a brilliant but highly idiosyncratic reading. Associations and patterns of repetition are observed and discussed but are limited to the patterns Barthes happens to notice through his polarizing critical apparatus. There is no attempt at formality or reproducibility.

Todorov's analysis of structure in the *Decameron* is based on the concept of the transformation: individual tales are shown to be derivable from a general, paradigmatic form.[33] By demonstrating that all tales can be derived from a small number of paradigms through a set of basic transformations, Todorov shows that there exists a narrative generative grammar analogous to a Chomskian-style generative grammar for some specific set of sentences. While Todorov does extrapolate on the mental factors involved in composing large tale sequences, he does not attempt any systematic analysis of his paradigm sequence or its macroscopic structure.

More recently, Paul de Man has suggested the possibility of adopting the concept of a lattice structure for literary analysis. After noting the scarcity of new techniques for literary study ("There certainly have been numerous excellent books of criticism since, but in none of these have the techniques of description and interpretation evolved beyond the techniques of close reading established in the thirties and forties"[34]), he considers a passage from Proust from a rhetorical perspective. Concentrating on metonymic patterns of association as opposed to the more conventional assertions carried by metaphor, de Man foresees the possibility of a truly comprehensive Structuralist methodology:

> The further text of Proust's novel . . . responds perfectly to an extended application of this deconstructive pattern: not only can similar gestures be repeated throughout the novel, at all the crucial articulations or all passages where large aesthetic and metaphysical claims are being made . . ., but a vast thematic and semiotic network is revealed that structures the entire narrative and that remained invisible to a reader caught in naive metaphorical mystification. The whole of literature would respond in similar fashion, although the techniques and the patterns would have to vary considerably, of course, from author to author.[35]

Such networks of associations have been partially realized through considerations of selected passages in the work of Genette (particularly in *Figures III*), Greimas, and other Semiological critics; however, it has been impractical to explore such associative patterns for full length works.

The Formalist school whose concept of structure most closely resembles the stratified concept implicit in Computer Criticism is that associated with Firth. The comparison is closest not in the relation between the term, structure, as I have used it in this essay and the term, structure, as it is formally used by Firth and Halliday; rather, the comparison must be drawn between what I have called structure and the concept of the total language construct or model found in the London School. As mentioned above, Firth begins with a material text: either a sequence of characters or a sequence of sounds. He then suggests a succession of levels, each abstract but each growing out of a materialist consideration of the symbol sequence comprising a lower level, that culminates in a *context of situation.*

Inherent in the levels of this outer domain is the possibility of a behaviorialist theory of language which Firth anticipates in one of his final essays in his appeal for the aid of psychology and psychiatry in linguistic description.[36] Because of his untimely death, Firth was unable to complete the model that he had sketched; much of this job, fortunately, has been done by M. A. K. Halliday, particularly in the area of syntax. Halliday's elaborations have dealt primarily with levels ranging from text to sentence structure. *Structure*, as formally defined by Halliday, is an "arrangement of elements ordered in 'places.' " Thus, *structure* is a "horizontal" concept; actual description of that horizontal order, however, is not addressed by Halliday. Relations across levels, referred to as exponency, are the relations between category designators and the lower level members that constitute them; while rules govern the general form of one level relative to those lower than it, specific procedures for deriving higher levels are not developed.

Nevertheless, Halliday has shown the strength of this stratified view of language as a tool for literary and stylistic analysis in his study of William Golding's *The Inheritors*.[37] Choosing several sizable samples distributed over the text, he establishes a level of syntactic pattern and parses each sentence in the samples. Through frequency counts he establishes what are really syntactic collocations to show that these patterns inform/constitute the growing conceptual awareness of the central character. The implication that the theme of growing mental complexity is, itself, an outer sequential level of the novel that could potentially be formally linked through exponency down through numerous intermediate levels to the material text is an exciting, perhaps frightening, possibility. Halliday does not take this last step, however, probably because of the impracticality of doing so through conventional methods.

A central aspect of the concept of structure for each of these critical schools is the notion of a horizontal material text over which various abstract strata are projected. The Russian Formalists identified such strata with the expectation and alternative narrative possibilities. The play on the reader's sense of anticipation was addressed more formally by the Prague Structuralists as they envisioned the development of actual probabilities of occurrence for textual items that would constitute normative patterns against which poetic variation could be perceived. For both New Criticism and the French Structuralist, secondary levels serve to focus the reader's attention on specific intrinsic and extrinsic dimensions of the text. While Barthes is more rigorous in the application of his framework than the New Critical practitioners, he makes no attempt to establish a true Formalist methodology. The group that comes closest to doing so is the London School, especially in the elaborations by Halliday. There, formal rules govern the form of individual strata relative to their relation to the lower level elements that constitute them; however, procedures to develop specific higher strata are left to the adoption of available linguistic models.

To describe relations along and across strata, these Formalist/Structuralist critics have relied primarily on the concepts of the transformation, the paradigm

(including patterns derived through omission and repetition of elements), and, to a far lesser degree, the lattice. These are all powerful models, but the time required to apply them by hand has limited their value for examining actual extended texts. Computer Criticism, because of its functional generality, can accommodate both the stratified perspectives of these groups as well as the basic relational models they have employed. As we have seen, however, it can go further. It can add to the store of models a far wider collection than has been used in conventional criticism, and it can apply these models to extended, full length texts quickly and easily. Consequently, Computer Criticism is not just compatible with traditional Formalist/Structuralist schools; their perspectives may be viewed in their functional dimensions as special cases of the more general perspective of Computer Criticism.

Conclusion

In the introduction to this paper, I stated that I would address three major issues: the cognitive perspective of the text and its meanings inherent in computational analyses, the relation between this perspective and major schools of Formalist and Structuralist criticisms, and, finally, the identification of this perspective as an emerging school in its own right. While I have suggested throughout how Computer Criticism goes beyond conventional schools, I have focused most directly on the first two issues. Let me now address this last assertion more directly, but in doing so, let me acknowledge that I shall ultimately have to beg the question. That is, I shall look at some three major implications that suggest a shift in perspective, but a shift will in fact be seen only after it has taken place in the mind of the critic. The situation is analogous to Thomas Kuhn's "scientific revolution": a shift in intellectual perspective that can be recognized only after it has taken place within the individual.[38]

A major thrust of interpretive criticism has traditionally been an enriched, expanded aesthetic and emotional response to literature. By knowing more about the work, its historical and biographical contexts, as well as the responses and insights of sensitive, informed readers, we can, in turn, understand and respond to the work more fully ourselves. Computer Criticism offers the additional opportunity to refine our awareness of our responses to the text. Instead of using secondary strata to represent only intrinsic patterns within the text, such strata may be used to record extrinsic factors. For example, in considering the text of a performance of a play, we could observe the various responses of the audience (it watched quietly, it laughed quietly, it roared with laughter, it gasped, etc.) among a variety of behavioral/temporal factors. By considering textual features in conjunction with observed responses we can gain a clearer sense of the affective dynamics of the theater. Similarly, it may be possible for a reader to record his own encounter with a text, the thoughts and images evoked, and the nature of his emotional responses. Similar configurational analysis could lead to a clearer awareness of the phenome-

nology of one's reading experience. While the techniques to actually achieve precise, sensitive results are only appearing on the distant horizon, we can see, nevertheless, their possibility. When more fully developed, we may be able to bring phenomenological criticism into the domain of Formalism and Structuralism.

The second major implication of Computer Criticism is an altered concept of proof and what constitutes demonstration of a literary hypothesis. Because the computer requires coherent, formal rules/procedures to move from level to level within its stratified structure, abstract assertions remain closely linked to, if not coincident with, patterns within higher strata. Since a study progresses by developing successively higher strata in terms of patterns within lower strata, generalizations, no matter how abstract, can be traced back through the various levels to actual textual features and/or to closely observed primary responses. As we would anticipate, the computer can locate each occurrence of a particular configuration. Consequently, the traditional modes of demonstration that have relied on authority (both previous critical statements as well as references to one's own responses) and citation of examples are expanded to include the additional concepts of pervasiveness and adequacy. That is, in addition to offering confirming examples, the critic may indicate the pervasiveness of that feature or pattern; by offering a comprehensive description of the features considered for the particular focus of the study (for example, a comprehensive list of themes for a thematic analysis), the critic may address the question of adequacy of a particular assertion with regard to any specific combination of features. Thus, the computer offers the critic additional verificational concepts through its ability to address the entire text synchronically.

Finally, there is the distinct prospect of a discovery procedure for interpretive generalizations. At present and for the foreseeable future the computer will be used as an investigative tool under the close control of the critic. But as the critic becomes familiar with the products it generates, he may begin to apply analytic models used in one context to different contexts. For example, he may employ by analogy transformational models originally developed for syntactic analyses to thematic configurations by adapting the categories and the specific form of particular rules; indeed, this has already been done, as was described in Todorov's study of the *Decameron.* The functional nature of the stratificational system of Computer Criticism, however, makes this and other extensions by analogy virtually routine. As an experienced rider controls his horse with ever more subtle commands, so the critic may control the exact routines of the computer with more latitude. That is, he may develop "metaprograms" that can extend a structural model defined in terms of the categories of one stratum to the categories of another in an effort to discover combinations and configurations that could not be foreseen; automatic indexing merged with automatic theorem-proving would offer a primitive analogy. These speculations are, of course, highly tentative; but we can see enough substance in the current state of computer development to mark their outline.

At this stage, however, it is not important whether one views Computer Criticism as a separate school of criticism or whether one views it as a collection

of techniques that can be used in conjunction with conventional perspectives. If one adopts the latter position, the computer can be viewed as a powerful ally to consider interpretive questions with a detail and clarity that has been impractical until now. If one accepts the former position, a number of new questions emerge that offer the excitement and risk of the unknown and the untested. Regardless, the computer is a resource for critical inquiry that is limited only by our imaginations.

Addendum

Most of the preceding discussion has dealt with theoretical aspects of Formalism, Structuralism, and Computer Criticism, or with abstract concepts of structure and form. It may be useful for the reader unfamiliar with the computer to see how a critical assertion might be handled by the computer. It is important to realize, however, that it is the critic, not the computer, who provides the intellectual context for the study, interprets the information produced by the computer, and forms the critical insight.

As with any critical mode, a study using the computer must begin with a strong initial hypothesis or question. In its initial formulation the problem should be cast in a familiar context, using conventional terminology. Similarly, the study must justify itself within conventional critical values; it must be worth doing in its own right and not simply something that *is* done because the computer *can* do it.

Once the hypothesis has been formulated in this manner, the critic must translate the hypothesis from substantive terms (as described above) to operative or functional terms. As with any translation process, there is great opportunity for distortion and error. The critic must be extremely judicious to insure that the operative definition of the hypothesis closely fits the substantive definition.

There is no set way in which this translation can always be made; however, an approach that may be useful is for the critic simply to probe his own critical assertions and assumptions, repeatedly asking himself, "What, *exactly*, do I mean by ————————?" For example, take the rather obvious assertion that the first chapter of Joyce's *Portrait* is structured by the tension between the themes of *fire* and *water*. To demonstrate this with the aid of the computer would involve several translation steps. The critic might engage himself in an imaginary dialogue similar to the following:

1. Q. What, *exactly*, do you mean by the themes, *fire* and *water*?
   A. Well, by *theme*, I mean a group of words or phrases, mostly images, that denote or suggest a basic concept or experience. Obviously, the theme of *fire* will be those words or phrases that suggest fire or heat and the theme *water* will be those words or

phrases that suggest water, wetness, and, in this context, coldness.

2. Q. Fine, but *what* words or phrases suggest fire or water? To the computer, they all look alike.

   A. I mean specific words like *burn, burned, burning, fire, hearth, heat,* etc. For water, I mean *cold, ditch, spit, water, watery,* etc.

3. Q. Now that you have translated the term, *theme,* from a substantive term (a group of words or phrases that suggest the same basic concept or experience) to a functional term (a *list* of specific words or collocations of words) recognizable by the computer, can you take the next step and clarify what you mean by the relation, *tension,* when you say that *fire* and *water* are in a state of *tension*?

   A. *Fire* is usually related or associated in Stephen's mind with thoughts of home or other pleasant memories; conversely, *water* is associated with his terrible fall into the ditch. While these two themes carry dialectically opposite connotations, he seldom recalls one without his mind jumping to the other. It is this constant, ironic juxtaposition or association between basically opposite themes that constitutes *tension.*

4. Q. Fine, but what do you mean by the statement that the chapter is *structured* by this relation of tension between the themes of *fire* and *water*?

   A. That's a little harder because to say that the chapter is *structured* by this relation means several things. It means that this dialectic juxtaposition occurs frequently; it occurs at fairly regular intervals; and it is "fundamental" in some respect to other thematic relations. That is, it occurs in a variety of thematic contexts; and other major themes, while relating to this pair, do not occur with the same regularity or with the same diversity of context.

   Q. Let's take them one at a time. How can you show that these two themes occur close to one another frequently?

   A. I could divide the text into, say, 100 word intervals, have the computer tally up all of the *fire* words for each such interval, and then have it draw a picture or graph of this distribution over the chapter. By comparing this with a similar distribution of *water* words I can tell both the prevalence and the consistency of association of these two themes.

   Q. Fine, you killed two birds with one program, but how are you going to show that this relation is more "fundamental" than other thematic relations?

   A. First, I'll have to define *all* of the themes that I feel are "major," just as I did in step 2; but then I'll have to show that these are

less "prevalent" and less "pervasive" than fire and water and that they are oriented in some way to the fire/water dialectic. If I graph *all* of these themes, I can compare their distributions with those of *fire* and *water* for "pervasiveness." If this relation turns out to be true, then I can look at the section of text where these other themes seem to be important and see if they are in some way related to *fire* and *water*.

5. Q. How are you going to get the computer to tell you how these themes are related to *fire* and *water*?

A. I *can't*, but the computer *can* tell me where to look. Thus, it points me to the *right* places and it can tell me whether I have looked at *all* the places.

Having translated the substantive hypothesis into functional terms and having used the computer to gather and display information and to explore various structural relations, it is then incumbent upon the critic to assimilate this information, to place it in context, and to synthesize his "interpretation." Obviously, the computer can only strengthen, not replace, his critical judgment. The final results of the inquiry should be expressed, once again, in the vernacular of the profession. To do this, the critic must translate in reverse the relations, patterns, and structures he has discovered on the functional level back into meaningful critical assertions. The computer should recede into the background leaving behind the unencumbered thesis, but a thesis that rests firmly on a body of specifiable assumptions and demonstratable textual relations. It is this joining of the deductive, critical response of the researcher with the empirical methodology of the computer that makes it possible to envision a science of literary criticism that is powerful but not reductive, sensitive but not simplistic.

NOTES

[1]See Sally Yeates Sedelow, "The Computer in the Humanities and Fine Arts," *Computing Surveys*, 2 (June 1970), 89-110; R. L. Widmann, "Computers and Literary Scholarship," *Computers and the Humanities*, 6 (Sept. 1971), 3-14.

[2]Paul De Man, "Semiology and Rhetoric," *Diacritics*, 3 (Fall 1973), 27.

[3]William E. Harkins, "Slavic Formalist Theories in Literary Scholarship," *Word*, 7 (August 1951), 184.

[4]Northrop Frye, *The Anatomy of Criticism* (Princeton: Princeton Univ, Press, 1957), p. 8.

[5]Robert Scholes, *Structuralism in Literature* (New Haven: Yale Univ. Press, 1974), p. 77.

[6]Roland Barthes, "Science Versus Literature," *Times Literary Supplement* (Sept. 1967), reprinted in *Structuralism: A Reader*, ed. Michael Lane (London: Jonathan Cape, 1970), pp. 410-17.

[7]I shall discuss the computer and its functions for language analysis within the context of large IBM machines. These remarks can be interpolated for other computers.

[8]Philip J. Stone, *The General Inquirer: A Computer Approach to Content Analysis* (Cambridge: M. I. T. Press, 1966).

[9]Victor Erlich, *Russian Formalism: History-Doctrine* (The Hague: Mouton & Co., 1955), p. 177.

[10]Erlich, especially his discussion of Shklovsky in Chapter X.

[11]Erlich, pp. 176-77.

[12]V. Propp, *Morphology of the Folktale*, 2nd ed., (Austin: University of Texas Press, 1968), especially Chapter II.

[13]A. A. Reformatsky, "An Essay on the Analysis of the Composition of the Novella," trans. Christine School, in *Russian Formalism*, ed. Stephen Bann and John E. Bowlt (New York: Barnes and Noble, 1973), pp. 88-89.

[14]Roman Jakobson, "Randben Rkugen Zur Prora des Dicktus Pasternak," *Slavische Rundschan*, 7 (1936), 357-74; these concepts are discussed by Erlich, pp. 177-78, and 200.

[15]John Crowe Ransom, "Wanted: An Ontological Critic," in *The New Criticism* (Norfolk: New Direction, 1940), pp. 297-301.

[16]Rene Wellek and Austin Warren, *Theory of Literature*, 3rd ed. (New York: Harcourt, Brace, and World, 1956), p. 157.

[17]Caroline F. E. Spurgeon, *Shakespeare's Imagery* (Boston: Beacon Press, 1958).

[18]Roland Barthes, "The Structuralist Activity," in *Critical Essays*, trans. Richard Howard (Evanston: Northwestern University Press, 1972), pp. 214, 216-17.

[19]M. A. K. Halliday, "Categories of the Theory of Grammar," *Word*, 17 (1961), 270-71.

[20]For a more thorough discussion of models useful for illustrating and characterizing thematic structures see, "Thematic Structure and Complexity," *Style*, 9 (Winter 1975), 32-54.

[21]For a detailed description of this study see Bruce A. Rosenberg and John B. Smith, "Thematic Structure in Four Fundamentalist Sermons," *Journal of Western Folklore*, 34 (1975), 201-14.

[22]For a full discussion of a formal notion of thematic complexity appropriate for thematic structure similar to that represented by state diagrams, see "Thematic Structure and Complexity," cited above.

[23]John B. Smith, "Computer Generated Analogues of Mental Structure from Language Data," *Proceeding of IFIP '74* (The Hague: North Holland Publishing Co., 1974), pp. 842-5.

[24]John B. Smith, "Image and Imagery in Joyce's *Portrait*," in *Directions in Literary Criticism*, ed. Stanley Weintraub and Philip Young (University Park: The Pennsylvania State Univ. Press, 1972), pp. 220-27.

[25]Tzvetan Todorov, "Some Approaches to Russian Formalism," in *Russian Formalism*, trans. Bruce Merry, ed. Stephen Bann and John E. Bowlt (New York: Barnes and Noble, 1973), p. 11.

[26]Erlich, 212.

[27]Jan Mukarovsky, "Standard Language and Poetic Language," in *A Prague School Reader*, ed. Paul L. Garvin (Washington: Georgetown Univ. Press, 1964), p. 19.

[28]*Ibid*, p. 65.

[29]*Ibid.*

[30]Lubomir Doležel, "A Framework for the Statistical Analysis of Style," *Statistics and Style*, ed. Richard W. Bailey and Lubomir Doležel (New York: American Elsevier, 1969).

[31]Roman Jakobson and Claude Levi-Strauss, "Charles Baudelaire's 'Les Chats', in *Issues in Contemporary Literary Criticism*, ed. Gregory T. Polletta (Boston: Little, Brown and Co., 1973), pp. 372-89.

[32]Barthes, "The Structuralist Activist," p. 217.

[33]Tzvetan Todorov, *Grammaire du Decameron* (The Hague: Mouton and Co., 1969).

[34]Paul De Man, "Semiology and Rhetoric," *Diacritics*, 3 (Fall 1973), 27.

[35]*Ibid*, 32.

[36]J. R. Firth, "The Treatment of Language in General Linguistics," in *Selected Papers*, (Bloomington: Indiana Univ. Press, 1968), p. 209.

[37]M. A. K. Halliday, "Linguistic Function and Literary Style," *Literary Style: A Symposium*, ed. Seymour Chatman (London: Oxford Univ. Press, 1971), pp. 330-68.

[38]Thomas Kuhn, *The Structure of Scientific Revolutions* (Chicago: The University of Chicago Press, 1962).

[39]For an example of such a study, see John B. Smith and Bruce A. Rosenberg, "Rhythms in Speech: Formulaic Structure in Four Fundamentalist Sermons," *Computer Studies in the Humanistic and Verbal Behavior*, 4 (Fall/Winter 1973), 166-73.

A longer version of this essay will appear in *Formalization in Literary and Discourse Analysis*, eds. Sally and Walter Sedelow (The Hague: Mouton and Co., 1979).