THE NEURAL LYRE: POETIC METER, THE BRAIN, AND TIME

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This essay brings together an old subject, a new body of knowledge, and a new scientific paradigm which have not previously been associated with one another. The subject is poetic meter, a universal human activity, which despite its universality and obvious importance in most human cultures, has received very little attention from humanists, except for the studies of a few literary prosodists, and virtually none at all from science. The new body of knowledge consists in the findings of that intense study of the human brain which has taken place in the last few decades; the new scientific paradigm has been developed by the International Society for the Study of Time. Its major postulates are: that an understanding of time is fundamental to an understanding of the real world; that time is not simple, but composite; that time is a hierarchy of more and more complex temporalities; that the more complex temporalities evolved as part of the general evolution of the universe, and in a sense the evolution of time constitutes the evolution of the universe; and that the hierarchical character of time as we know it reflects and embodies the various stages of its evolution.[1]

The radically interdisciplinary nature of this essay is not simply a consequence of the need to seek explanations across the boundaries of different fields. It represents also a commitment and a belief on the part of its authors. We are convinced not only that this type of study will cast light on its specific subject (poetic meter), but also that the scientific material will be reciprocally enhanced in value, taking its place within a framework which gives it greater predictive power; and we further believe that "understanding" itself consists in just such a union of detailed knowledge with global significance.

At this point it might be helpful to review the major characteristics of human cortical information-processing, as it has been provisionally determined by studies in perceptual psychology, brain-chemistry, psychology, brain evolution, brain development, ethology, and cultural anthropology[2]. Individually, the characteristics of human brain-activity which are listed below are commonplace and uncontroversial for the most part; collectively, they constitute a new picture of the human mind. This new picture replaces

older, simpler models of it, such as the unextended rational substance of Descartes, the association-matrix of Locke, the tabula rasa of Hume, the passive, reinforcement-driven animal of Skinner, and the genetically hard-wired robot of the sociobiologists, though it does include the elements which led those writers to construct their models.

Human information-processing is, on the crude level of individual neurons, procrustean. That is, it reduces the information it gets from the outside world to its own categories, and accepts reality's answers only if they directly address its own set of questions. In the macrocosm, our perception of electromagnetic radiation cuts out all but heat and the visible spectrum; in the microcosm, a given neuron in the visual cortex will fire only if certain characteristics-say, a moving vertical light contrast-are met by the retinal image, and will ignore all others. We possess, as it were, a certain domineering and arrogant quality in our dealings with sensory information, and our brain will "listen" only to replies to its own inquiries. In quantum physics the familiar procrustean questions-Waves or particles? Which slit did the photon pass through? Is this ray of light polarized north-south or east-west?-force reality into a certainty and definiteness which it did not naturally possess: and this insistence on unambiguity is rooted in our neurons themselves.

Thus we may say that human information processing is, secondly, determinative: that is, it insists on certainty and unambiguity, and is thus at war with the probabilistic and indeterminate nature of the most primitive and archaic components of the universe. This insistence on definiteness, however, is in a grand tradition: matter itself is a condition of energy which severely limits the probabilistic waywardness of its elementary particles; large clumps of organized matter, like crystals, have overcome much of the vagueness and unpredictability of their primary constituents (though they pay for their certainty by becoming liable to entropic decay). Indeed, the replication of living matter could be said to be another stage in the suppression of physical ambiguity, for it implies an exact continuity and stability of structure which survives even the matter of which it is composed. Thus the human neural insistence on determinateness is in line with a general tendency of nature, and is related to the syllogistic proposition that homeostatic systems tend to endure and survive.

Third, and in contrast to the "conservative" tendency we have just described, the human nervous system seems designed to register differences. It is habituative. That is, it tends to ignore repeated and expected stimuli, and respond only to the new and unexpected. Though it asks the questions, it is more interested in odd answers than ordinary ones. Temporally it hears changes and sees movements; spatially it sees contrasts and borderlines. Deprived of its saccades, the eye sees nothing, for it sees no differences.

Fourth, human nervous activity is fundamentally synthetic in its aim. It seeks gestalts even when they are not there: and there is a serious ontological question as to whether they do in fact come to exist when we find them there.

It is (5) active rather than passive: it constructs scenarios to be tested by reality, vigorously seeks confirmation of them, and painfully reconstructs them if they are deconfirmed. The brain is at least as much an organ of action as it is an organ of knowledge.

It is (6) predictive: the patterns it extrapolates or invents are patterns which involve specific expectations of what will happen next, and in the more distant future, expectation which await satisfaction and are tested by the senses. Dreaming-it would seem from the testimony of Shakespeare, Descartes, Kékulé, and Freud-is the formative stage of pattern-creation: out of dreams come A Midsummer Night's Dream, skeptical philosophy, the benzene ring, and a viable ego. So dominant is the human adaptation for predictive calculation that it might be said the human senses exist as a check on our predictions rather than, as in most other animals, triggers for appropriate behavior.

The whole matter of prediction is very complex. One of us (Pöppel) has pointed out the relationship between prediction and memory; indeed, he says, the adaptive function of memory is prediction[3]. Memory, however, would be useless in an entirely random and indeterminate universe: therefore the very fact that the metabolically expensive neural machinery of memory evolved and proved adaptive is a kind of odd proof that the universe is at least locally predictable, to justify such an investment.

But, on the other hand, an entirely deterministic and predictable universe would have no use for memory, either. The Umwelt of the lower animals, as determined by their affectors and receptors, is so limited that, to the extent that organisms survive, such an Umwelt constitutes a predictable universe; therefore, they possess no memories but only fixed action patterns triggered by appropriate stimuli. Memory only makes sense in a world of many possible futures, a world not fully determined: otherwise we could be programmed to perform an automatic and invariable set of behaviors, which would exactly fit our adaptive needs. All futures share a common past: and thus memory gives us a handle on any possible future.

It has been objected, however, that the universe is indeed deterministic and predictable, but so complex that no animal can exactly predict its behavior, and that the very complex nervous systems of the higher animals developed precisely in order to improve their predictive powers. Such an argument produces an interesting dialectic, which might be worth following. It could be replied to the objection that the nervous systems of human beings are many orders of magnitude more complex than the physical universe they are,

it is claimed, designed to predict. There are billions of times more possible brain-states in a single human brain than there are particles in the physical cosmos: the relations of the brain's parts carry usable information, whereas the relations between particles in the physical universe do not.

There might, however, be a rejoinder to this argument, in turn. Human brains are part of the universe, and they merely make the job of predicting it more difficult without altering, by their presence, its actual determinateness. The fact that a major function of human brains is to predict the complex behaviors of each other, in no way weakens the proposition that the world is predictable.

But even this argument can be countered. For it implicitly yields the point that the world is in practice unpredictable, because any mechanism complex enough to predict events outside itself would also be so complex as to pose an insuperable problem to another predicting-mechanism, unless that other mechanism were in turn more complex still. It would not, moreover, be able to predict its own behavior. If Apollo gives prophesies, we should perhaps believe him, because he knows the mysteries of things and all human thoughts. But if Zeus, who also knows what Apollo is thinking, and who thus knows what Apollo will do, makes a contrary prophesy, we should believe Zeus instead. But Zeus does not know what Zeus will do, so perhaps we should not even believe Zeus after all.

Our original objector might still be able to argue that the predictability of events is only theoretical, not practical. But this argument must fail, too; for when we are dealing with the whole universe, the practical is the theoretical: if something is practically impossible for the whole universe, that is a way of saying it is theoretically impossible.

Finally, our antagonist might fall back to the position that future events are determined but not predictable. But since predictability would be the only conceivable scientific test of determinateness, such a statement would be semantically empty. A system whose complexity is increasing faster than any theoretical prediction-system could operate would therefore not be fully determined. In such a universe free choice based on memory would be a powerful survival strategy.

The peculiar logical form of this digression-which uses the infinite regress as a way of proving a negative proposition by means of a reductio ad absurdum- illustrates the peculiar predicament that the human brain at once evolved to handle and at the same time helped to create for itself. The very structure of the thinking process itself reflects the increasing levels of complexity the brain was called upon to deal with.

Human information processing is, therefore, (7) hierarchical in its organization. In the columns of neurons in the sensory cortex a plausible reconstruction of the world is created by a hierarchy of cells, the ones at the base responding to very simple stimuli and passing on their findings to cells programmed to respond to successively more complex stimuli. Likewise, motor decisions are passed down a long command-chain of simpler and simpler neural servomechanisms.

The co-ordination of these hierarchical systems in which many kinds of disparate information must be integrated, some requiring more processing-time and some requiring less, requires a neural pulse within which all relevant information is brought together as a whole. For instance, in the visual system many levels of detail-frequency, color, and depth must all be synchronized, or we would not be able to associate the various features of a visual scene[4]. Thus brain processing is (8) essentially rhythmic. That these rhythms can be "driven" or reinforced by repeated photic or auditory stimuli, to produce peculiar subjective states, is already well known.

More controversial in detail, but in general widely accepted, is the proposition that the brain's activities are (9) self-rewarding. The brain possesses built-in sites for the reception of opioid peptides such as enkephalin-the endorphins-and also other pleasure-associated neurohumors such as the catecholamines. It also controls the manufacture and release of these chemicals, and it has been shown that behavior can be reinforced by their use as a reward. The brain, therefore, is able to reward itself for certain activities which are, presumably, preferred for their adaptive utility. Clearly if this system of self-reward is the major motivating agent of the brain, any external technique for calibrating and controlling it would result in an enormously enhanced mental efficiency: we would, so to speak, be able to harness all our intellectual and emotional resources to a given task. (Indeed, we will argue later that this is exactly what an esthetic education, including an early introduction to metered verse in the form of nursery rhymes, can do.) It is, we believe, precisely this autonomous and reflexive reward system which underlies the whole realm of human values, ultimate purposes, and ideals such as truth, beauty, and goodness.

Associated with the brain's capacity for self-reward is (10) that it is characteristically reflexive. It is within broad limits self-calibrating (partly because of the habituation response). And it seems, unlike a computer, to have a more or less general capacity to convert software into hardware-short-term memory into long-term memory, for example-and vice-versa, to examine by introspection its own operations, so that its hardware can become its input or even its program. In the brain the observer problem becomes most acute: in fact we might define consciousness itself as the continuous irresolvable disparity between the brain as observer of itself and the brain as the object of observation. The coincidence between the words for consciousness and conscience in many languages points, incidentally, to the relationship between self-awareness and self-reward.

The human nervous system, we know now, cannot be separated from the human cultural system it was designed to serve. Its operations are (11) essentially social. It is not only specific skills and communicative competences that are learnt in a social context, but also the fundamental capacities of arousal, orientation, attention, and motivation. Clearly we possess genetic proclivities to learn speech, elementary mathematical calculation, and so on; but equally clearly we require a socio-cultural context to release that potential. On the other hand, human society itself can be profoundly changed by the development of new ways of using the brain: take, for instance, the enormous socio-cultural effects of the invention of the written word. In a sense, reading is a sort of new synthetic instinct, input which becomes a program and which in turn crystallizes into neural hardware, and which incorporates a cultural loop into the human nervous circuit. This "new instinct" in turn profoundly changes the environment within which young human brains are programmed. In the early stages of human evolution such new instincts (speech must have been one) had to wait for their full development while sexual selection established the necessary elaborate vocal circuitry in the cortex. Later on we were able to use our technology, which required much less time to develop, as a sort of supplementary external nervous system. A book is a sort of R.O.M. chip we can plug in to our heads.

One of the most exciting propositions of the new brain science is that human information processing is (12) hemispherically specialized. Here some important distinctions must be made. There are strong logical objections to the popular and prevailing view that the right brain is emotional while the left brain is rational, and that artistic capacities, being emotional, are located in the right brain. Both sides of the brain are capable of rational calculation: it is surely just as rational to "see" a geometric proof-which is the function of the right brain-as to analyze a logical proposition-which would be done on the left. And both sides of the brain respond to the presence of brain chemicals, and thus both must be said to be "emotional" in this crude sense. The right brain may be better able to recognize and report emotions, but this capacity is surely a cognitive one in itself, and does not necessarily imply a judgment about whether it feels emotions more or less than the left. Above all, art is quite as much a rational activity as it is an emotional one: so the location of art on the "emotional" right is surely the result of a misunderstanding of the nature of art. More plausible is the position of Jerre Levy, who characterizes the relationship between right and left as a complementarity of cognitive capacities[5]. She has stated in a brilliant aphorism that the left brain maps spatial information into a temporal order, while the right brain maps temporal information onto a spatial order. In a sense understanding largely consists in the translation of information to and fro between a temporal ordering and a spatial one-resulting in a sort of stereoscopic depth-cognition. In Levy's view, the two "brains" alternate in the treatment of information, according to a rhythm determined by the general brain state, and pass, each time, their accumulated findings on to each other. The fact that experienced musicians use their left brain just as much as their right in listening to music shows that their higher understanding of music is the result of the collaboration of both "brains," the music having been translated first from temporal sequence to spatial pattern, and then "read," as it were, back into a temporal movement. The neurobiologist Gunther Baumgartner suggests that the forebrain acts as the

integrating agent between specialized left and right functions, and it is in this integrative process that we would locate the essentially creative capacities of the brain, whether artistic or scientific. The apparent superiority of the isolated right brain in emotional matters may well reflect simply the fact that emotions, like music, are temporal in nature and their articulation requires the sort of temporal-on-spatial mapping that is the specialty of the right.

Finally, human information-processing can be described as (13) kalogenetic (Turner), a word coined from the Greek (KALOS), for beauty, goodness, rightness; and (GENESIS), genesis: Begetting, productive cause, origin, source[6]. Another word for this characteristic, coined in jest as an etymological chimera by Pöppel, is monocausotaxophilia, the love of single causes that explain everything. William James called it "the will to believe." Laughlin and d'Aquili use the term "the cognitive imperative," or the "what is it?" syndrome, while Zollinger has identified it in the scientific urge to confirm and affirm a given hypothesis, rather than to deconfirm it (as Karl Popper would have us do). Baumgartner's notion of the integrative function of the forebrain also partakes of the same idea. The human nervous system has a strong drive to construct affirmative, plausible, coherent, consistent, parsimonious, and predictively powerful models of the world, in which all events are explained by and take their place in a system which is at once rich in implications beyond its existing data and at the same time governed by as few principles or axioms as possible. The words that scientists use for such a system are "elegant," "powerful," and , often, "beautiful"; artists and philosophers use the same terms and also "appropriate," "fitting," "correct," "right," all of which can translate the Greek (KALOS).

If this tendency is a true drive, then according to the theory of reinforcement, it is an activity for which the brain rewards itself; and if there were techniques by which the endogenous reward system could be stimulated and sensitized, then those techniques would enable us to greatly enhance the integrative powers of our minds.

Any candidate for identification as such a technique would have to meet certain qualifications. First, it would probably be culturally universal, since it would be based on neural and biochemical features common to all human beings[7]. Second, it would be very archaic, identifiable as an element of the most ancient and the most primitive cultures. Third, it would be likely to be regarded by its indigenous practitioners as the locus of an almost magical inspiration and as a source of wisdom; it would have the reputation of having significantly contributed to the efficiency and adaptiveness of the societies in which it is practiced. Fourth, it would be associated with those social and cultural activities which demand the highest powers of original thought and complex calculation, such as education, the organization of large-scale projects like war and co-operative agriculture, and the rituals which digest for social uses the dangerous and valuable energies implicit in sexuality, birth, death, sickness, and the like.

Metered poetry, the use of rule-governed rhythmic measures in the production of a heightened and intensified form of linguistic expression, nicely fulfills these requirements. Jerome Rothenberg's collection of ancient and "primitive" poetry, Technicians of the Sacred[8], contains poems or excerpts from poems from about eighty different cultures, past and present, in Africa, North and South America, Asia, and Oceania; W. K. Wimsatt's excellent collection of essays, Versification: Major Language Types, describes the metrical features of Chinese, Japanese, Hebrew, Greek, Latin, Slavic, Uralic, Germanic, Celtic, Italian, Spanish, French, Old English and Modern English, and apologies (p. 17) for omitting the Vedic-Indic verse system, the Arabic, including Swahili, and the Persian[9]. Metered poetry is a highly complex activity which is culturally universal. One of us (Turner) has heard poetry recited by Ndembu spirit-doctors in Zambia and has, with the anthropologist Wulf Schiefenhovel, translated Eipo poetry from Central New Guinea[10]. He reports, as a poet, that the meter of Eipo poetry, when reproduced in English, has much the same emotional effect as it does in the original. Such a minute correspondence between poets in such widely different cultures surely points to an identical neurophysiological mechanism.

In nearly all cultures, metered poetry is used in the crucial religious and social (and often economic) rituals, and has the reputation of containing mysterious wisdom; the learning of major poetic texts is central to the process of education in nearly all literate traditions. Much work-farming, herding, hunting, war, ship-handling, even mining-has its own body of poetry and song.

It may be objected, however, that we have simply lumped together many different uses of language under an artificial category of poetry. This objection is strongly negated by the fact that poets themselves, who ought to know, can recognize the work of their alien colleagues as poetry, despite cultural differences. But we do not have to rely only on the reports of qualified native informants. Objective and universal and specific traits can be identified across the whole range of poetic practice throughout the world and as far back into the past as we have records. From these universal characteristics we can construct a general definition of metered poetry which will hold good from the ancient Greeks to the Kwakiutl, and from Racine to Polynesia.

The fundamental unit of metered poetry is what we shall call the LINE. We distinguish it by capitalization from the normal use of the word, because some orthographic traditions do not conventionally write or print the LINE in a separate space as we do; and in other traditions there are examples of a long line divided by a caesura into two sections, which would, in terms of our classification, actually constitute a couplet of LINES. There are also examples of what we would call a single LINE divided in half on the page. The LINE is preceded and followed by a distinct pause (not necessarily a pause for breath), which, despite the presence of other pauses within the line, divides the verse into clearly identifiable pieces. Turner, for example, can readily recognize the LINE-divisions of poetry in languages he does not know, when it is read aloud. The LINE unit can contain

from four to twenty syllables; but it usually contains between seven and seventeen in languages which do not use fixed lexical tones, or between four and eight syllables in tonal languages, like Chinese, in which the metrical syllable takes about twice as long to articulate. Most remarkable of all, this fundamental unit nearly always takes from two to four seconds to recite, with a strong peak in distribution between 2.5 and 3.5 seconds. A caesura will usually divide the LINES in the longer part of the range; sometimes (as with Greek and Latin epic dactylic hexameters), the unit will be four to six seconds long, but clearly divided by a caesura and constituting for our purposes two LINES.

Turner has recorded and measured Latin, Greek, English, Chinese, Japanese, and French poetry, and Pöppel has done so for German. Less systematic measurements, by syllable-count, have revealed fully consistent results for Ndembu (Zambia), Eipo (New Guinea), Spanish, Italian, Hungarian, Uralic, Slavic, and Celtic. An average syllable in a non-tonal language takes about 1/4 second to articulate, and in a tonal language about 1/2 second, though recitation traditions vary in this respect. The Ndembu LINE averages ten syllables; Eipo poetry favors an eight- or twelve-syllable line; in Spanish the epic line of the *Poema de Mio Cid* is about fourteen syllables, but most other poetry is octosyllabic or hendecasyllabic (eight or eleven); the classic Italian line is the eleven-syllable endecasillabo; Hungarian uses lines between six and twelve syllables long, with a preference for eights and twelves; Slavic has octosyllabics and decasyllabics, with an epic long line of fifteen to sixteen syllables; Celtic has sevens, eights, nines, and some longer-lined meters. [12]

Among the traditions we have measured more closely, the results are as follows, giving a range of different meters:

Japanese

Epic meter (a seven-syllable line followed by a five-syllable one) (average)	3.25 secs.
Waka (average)	2.75 secs.
Tanka (recited much faster than the epic, as 3 LINES of 5, 12, and 14 syllables) (average)	2.70 secs.

Chinese

Four-syllable line	2.20 secs.
Five-syllable line	3.00 secs.
Seven-syllable line	3.80 secs.

English

Pentameter	3.30 secs.
Seven-syllable trochaic line	2.50 secs.
Stanzas using different line lengths	3.00 secs., 3.10 secs.
Ballad meter (octosyllabic)	2.40 secs.

Ancient Greek

Dactylic hexameter (half-line)	2.80 secs.
Trochaic tetrameter (half-line)	2.90 secs.
Iambic trimeter [13]	4.40 secs.
Marching anapests	3.50 secs.
Anapestic tetrameter (half-line)	2.50 secs.

Latin

Alcaic strophe	3.90 secs.
Elegiac couplet	3.50 secs.
Dactylic hexameter (half-line)	2.80 secs.
Hendecasyllabic	3.80 secs.

French

Alexandrine (12-syllable)	3.80 secs.
Decasyllable with octosyllable (La Fontaine)	3.00 secs.

German

(Sample of 200 poems, collected by Pöppel)

LINE-length of under 2 seconds	03%
LINE-length of 2-3 seconds	73%
LINE-length of 3-4 seconds	07%
LINE-length between 4 and 5 seconds [14]	17%

This fundamental unit is nearly always a rhythmic, semantic, and syntactical unit, as well: a sentence, a colon, a clause, or a phrase; or a completed group of them. Thus other linguistic rhythms are entrained to the basic acoustic rhythm, producing that pleasing sensation of "fit" and inevitability which is part of the delight of verse, and is so helpful to the memory. Generally a short line is used to deal with light subjects, while the long line is reserved for epic or tragic matters.

It is, we believe, highly significant that this analysis of the fundamental LINE in human verse gives little or no significance to breath, or "breath-units," as a determinant of the divisions of human meter. Thus our commonsense observation that breath in speech is largely under voluntary control, and that one could speak anything from one syllable to about forty in one breath, is vindicated. Systems of verse based on breath-units, such as "projective verse" and many other free-verse systems, therefore have no objective validity or physiological foundation.[15]

The second universal characteristic of human verse meter is that certain marked elements of the LINE or of groups of LINES remain constant throughout the poem, and thus serve as indicators of the repetition of a pattern. The 3-second cycle is not merely marked by a

pause, but by distinct resemblances between the material in each cycle. Repetition is added to frequency to emphasize the rhythm.

These constant elements can take many forms. Simplest of all is a constant number of syllables per line, as in Hungarian folk poetry; but here the strict grammatical integrity of each line is insisted upon, as if to compensate for the absence of other markers. Some verse forms (for instance, that of the *Poema de Mio Cid*) have a fixed number of stressed syllables per line, with an unfixed number of unstressed syllables. Other meters (most European ones, for example) use small patterns of syllables, distinguished by stress or length, to make feet, creating a line out of a fixed number of feet. Tonal languages, like Chinese, distinguish between syllables of an unchanging tone and syllables which change tone, and construct meters out of repeated patterns of changing and unchanging syllables. Celtic poetry uses prescribed cadences; Old English uses systematic alliteration. Many languages use some system of assonance, especially rhyme, which usually marks very strongly the ending of a line, and thus forms a strong contrast-spike to divide off one line from the next. Hebrew poetry uses semantic and syntactical parallels between its pairs of half-lines. Often many of these devices will be used at once, some prescribed by the conventions of the poetic form, others left to the discretion and inspiration of the poet. No verse-convention prescribes all the characteristics of a line, so every poem contains an interplay between prescribed elements and free variation.[16]

Sometimes, as in the Spenserian stanza, or in the Greek or English ode, or in the invented stanzas of Donne or Yeats, a whole group of lines of different lengths will itself constitute a repeated element. When lines of different lengths are used together, as in Milton's *Lycidas*, the rhyme (which stresses the integrity of the line) and the foot are given especial emphasis to compensate for the variation in the fundamental pulse-as if to insist on the threshold dividing the carrier-wave from mere "noise." And in variable-lined verses there is usually a normal-length line which acts as an unconscious constant against which the exceptions are measured as such.

At this point, it should be indicated that some of the characteristics of metered poetry do not apply to songs and lyrics derived from a song tradition. Music has its own form of organization. Which diminishes the importance of the line at the expense of the musical phrase. But in those traditions where we can see poetry emerging from song, such as the Latin lyric, there is an interesting tendency, as the musical order is forgotten, toward the establishment of the characteristically poetic forms of organization: the regular line, with variations, the distinction between different types of syllable (long and short, stressed and unstressed, totally changing or unchanging), and the rest. Thus the fact that songs do not conform to the limits of poetic meter is negative proof of the relation of language and meter.

The third universal characteristic of human metrical verse is variation, or, more precisely, a pseudolinguistic generativeness created by the imposition of rules, which makes possible significant perturbations of an expressive medium. Robert Frost put it very well, in a negative way, when he described poetry without meter as being like tennis without a net: the net introduces a restriction which is paradoxically fertile in the elaboration of groundstrokes which it demands, and significant in that it distinguishes legal from illegal shots.

Variation does not necessarily mean departure from the rules (Romantic and Modernist theories of art sometimes make this mistake). Variation does not occur despite the rules but because of them. Freedom never means a freedom from rules, but the freedom of rules. It is important here for us to distinguish our general position from that of sociobiological and other purists of the genetic-deterministic persuasion on one hand, and from the pure cultural relativists, behaviorists or otherwise, on the other. Genetic determinists would be likely to assume, once a human universal such as metrical verse is pointed out to them, that this behavior indicates the presence of a set of biological constraints which act as an outer envelope, restricting possible human behaviors within a given repertoire, large or small. Cultural relativists would tend to deny the existence of such a human universal, or would be inclined to dismiss it as an analogous response to similar problems or stimuli, or as an artificial product of the investigator's definitional vocabulary and research method.

We would adopt a third position, which is already hinted by our use of the word "pseudolinguistic." For us, the similarities between metered verse in different cultures are real and do indeed indicate a shared biological underpinning; but unlike the genetic determinists we do not regard this shared inheritance as a constraint, nor as an outer envelope restricting human behavior to a certain range. Rather, we would regard it as a set of rules which, though derived from the structure of the human auditory cortex and the brain in general, does not restrict, but enormously increases, the range of possible human behavior.

At first glance, this position might appear paradoxical. How can the range of possibilities be increased by the imposition of rules governing their use? If rules are rules, then they must surely deny certain previously possible behaviors, and therefore decrease the total number of them.

The paradox is easily resolved. A mathematical analogy will help. Given four possible behaviors, A, B, C, and D, only four alternatives exist. If we now impose a rule, which is that these behaviors can only be performed two at a time, suddenly and strangely there are now not four but six alternatives: AB, BC, CD, AC, BD, AD. Of course, this is cheating, in a sense, because before we mentioned the rule we never hinted that behaviors might come in groups. It could be pointed out that if we are talking about sets of

behaviors, in fact sixteen possibilities exist: the ten already mentioned, the four groups of three, the whole group together, and the null set. But this is precisely what the rule has done: it has created the group of behaviors as a significant entity, as a behavior in itself, and therefore expanded the repertoire from four to six. Furthermore, those six permitted combinations now stand in relation to ten non-permitted ones, and their correctness marks them out as valuable and special, as opposed to the "incorrect" permutations. Thus the rule has introduced a) a greater repertoire of behaviors than was previously possible and b) a marker of significance and value. All game-rules work in this way, creating possible scenarios and desired goals out of thin air.

The linguistic rules of phonology, grammar, and the lexicon work in a generally similar way. Linguistic rules are, to an extent, arbitrary and culture-bound: but Chomsky has shown certain invariant characteristics in the way in which human languages use syntactical subordination, which are no doubt biological in origin (and probably related to the hierarchical nature of human brain processes). Meter, with its cultural variations in the syllabic markers but its invariance in LINE-length, shows a similar interplay of cultural and genetic forces, and, more important, it produces a similar increase in the repertoire of behavior and a similar capacity to create significance.

In fact it is this general strategy by which the DNA molecule of life and the nervous systems of the higher animals attained greater complexities than the physical universe out of which they evolved: by making permutations of elements significant through highly restrictive "rules," and therefore increasing, as it were, the "cardinality" of the number of bits of information that the organism could hold. We find, for example, a similar interplay between genetic and cultural factors in the human recognition of colors: a rather restricted set of anatomically-determined color sensitivities is combined by culture into a large, and often idiosyncratic, repertoire of tints and shades, many of them with strong ideological significance. The range, variety, and combinations of colored pigmentation used in animal ritual behavior attests to a corresponding extension and valorization of color distinctions among the higher animals.

Thus metrical variation can be seen as a code, or communicative device, and the various elements of meter can be neatly described in terms of information theory. The three-second LINE is the communicative medium or "carrier-wave," which must be distinguishable from mere "noise" or the random transmissions around it, by the recurrence of a pause at the LINE-ending, by the many regular metrical features-syllable-count, stress, quantity, tone, systematic assonance, etc.-that we have described, and by the coincidence of semantic, syntactic, and rhythmic units with the LINE unit. Metrical variation is the "message" which is transmitted upon the communicative medium-like a radio-transmission, it consists of a systematic distortion of a regular medium or wave, which nevertheless remains within the regular parameters of the medium so that at all times the transmission is distinguishable from random noise.

The "message" that metrical variation conveys, however, is rather mysterious. If it is a code, what kind of code is it? Metrical scholars have attempted to discover exact relationships between individual metrical variations and the semantic content of poetry.[17] But their conclusions have been disappointingly vague or arbitrary, reminiscent, in fact, of musicological attempts to assign fixed meanings to different musical keys, signatures, and variations, so as to make a symphony describe a scene or conduct an argument. Here the analogy between metrical and linguistic significance breaks down. certainly a connection between metrical (or musical) and linguistic meaning exists, and in some cultural traditions (English Augustan poetry and European Romantic music, for instance) artists have developed a self-conscious repertoire of metrical or musical codes to convey specific meanings. But other traditions do not possess such codifications, or else use the same specific devices to convey entirely different ideas.

The predicament of the critic, in fact, can be likened to that of a viewer of a visual artifact who is so convinced that what he is looking at is a page of writing that he does not realize that the artifact is actually a picture. Perhaps it is a picture of something he had never seen (or never noticed), and thus his mistake is a natural one. But the attempt to extract a sort of linguistic meaning out of the planes, lines, corners, masses, and angles of a picture would be frustratingly arbitrary-especially if he had a whole series of paintings of different subjects, in which the same visual elements were used for entirely different purposes; the same curve for a face, a hillside, and the sail of a ship. Linguistic meaning and pictorial meaning are based on codes so fundamentally different that no code-cracking algorithm that would work on one could possibly work on the other. Their mutual intelligibility cannot be sought in the direction of analysis, but only within the context of a synthetic whole which contains both of them.

What we are suggesting is that a linguistic type of analysis of meter, as of music (or painting, e.g., Chinese landscape painting), is likely to be fruitful only when the composer has arbitrarily imposed linguistic meaning on the elements of his composition; and that the meaning of metrical variation must be sought in a fashion much more like that of the recognition of a tune or the subject of a picture.

That is, metrical variations are not significant in themselves, like sememes: but rather they form, together, a picture-like Gestalt which is a distinct representation of something that we can recognize; and thus, like pictorial representations, or music, they are much less culture-bound than linguistic codes. But here, excitingly, we encounter a paradox stemming from the gross structure of the human brain. Poetry, being an art of language, is presumably processed by the left temporal lobe of the brain. But meter, we are suggesting, carries meaning in a fashion much more like that of a picture of a melody, in which the meaning inheres more in the whole than in the parts. There is no "lexicon" of metrical forms: they are not signs but elements of an analogical structure. And this kind of understanding is known to take place on the right side of the brain. If this hypothesis is

accurate, meter is, in part, a way of introducing right-brain processes into the left-brain activity of understanding language; and in another sense, it is a way of connecting our much more culture-bound (and perhaps evolutionarily later) linguistic capacities with the relatively more "hardwired" spatial pattern-recognition faculties we share with the higher mammals.

It is in the context of this hypothesis that we wish to introduce the major finding of this essay, which explains, we believe, the extra-ordinary prevalence of the 3-second LINE in human poetry.

If we ask the question "what does the ear hear?" the obvious answer is "sound." What is sound? Mechanical waves in the air or other medium. But this answer is not very illuminating. We can, for instance, perceive mechanical waves by the sense of touch: it would be as inaccurate to say that a deaf man "heard" a vibrating handrail with his fingers, as it would be to say a blind man "saw" a fire with the skin of his face. What characterizes hearing as such is not that it senses mechanical waves but that it senses the distinctions between mechanical waves; just as what characterizes sight is not the perception of electromagnetic waves but the perception of distinctions between electromagnetic waves.

For the sense of sight those distinctions (except for color) are spatial ones; but for the sense of hearing they are mainly temporal. To put it directly: what the sense of hearing hears is essentially time. The recognition of differences of pitch involves a very pure (and highly accurate) comparative measurement of different frequencies into which time is divided. The perception of timbre, tone, sound texture, and so on consists in the recognition of combinations of frequencies: and the sense of rhythm and tempo carries the recognition of frequency into the realm of longer periods of time.

The sense of hearing is not only a marvelously accurate instrument for detecting differences between temporal periods; it is also an active organizer, arranging those different periods within a hierarchy as definite as that of the seconds, minutes, and hours of a clock, but one in which the different periodicities are also uniquely valorized. In the realm of pitch the structure of that hierarchy is embodied in the laws of harmony, and is well known (though it has not often been recognized that "sound" and "time" are virtually the same thing). New discoveries by Ernst Pöppel's group in Munich have begun to open up the role of the auditory time-hierarchy in the structure and function of the brain. Out of this investigation is coming a comprehensive understanding of the general scheduling-organization of the human sensory-motor system, and a fresh approach to the production and understanding of language. We shall first briefly outline the auditory hierarchy.

Events separated by periods of time shorter than about three thousandths of a second are classified by the hearing system as simultaneous. If a brief sound of one pitch is played to one ear, and another of a different pitch is played to the other less than .003 sec. later, the subject will experience only one sound. If the sounds are a little more than .003 sec. apart, the subject will experience two sounds. However, he will not be able to tell which of the two sounds came first, nor will he until the gap between them is increased ten times. Thus the lowest category in the hierarchy of auditory time is simultaneity, and the second lowest is mere temporal separation, without a preferred order of time. The most primary temporal experience is timeless unity; next comes a spacelike recognition of difference-spacelike because, unlike temporal positions, spatial positions can be exchanged. One can go from New York to Berlin or from Berlin to New York; but one can only go from 1980 to 1983, not from 1983 to 1980. Likewise, the realm of "separation" is a non-deterministic, acausal one: events happen in it, perhaps in patterns or perhaps not, but they cannot be said to cause one another, because we cannot say which came first.

When two sounds are about three hundredths of a second apart, a subject can experience their sequence, accurately reporting which came first. This is the third category in the hierarchy of auditory time, subsuming separations and simultaneities and organizing them rationally with respect to each other. But at this stage the organism is still a passive recipient of stimuli; we can hear a sequence of two sounds one-tenth of a second apart, but there is nothing we can do in response to the first sound before the second sound comes along: we are helpless to alter what will befall us, if the interval between the alert and its sequel falls within this range. Unlike the world of temporal separation, which is in a sense a realm of chance and pattern, the world of sequence is a realm of fate and cause. Events follow each other, and their temporal connections can be recognized as necessary, if indeed they are; but there is nothing we can do about it.

Once the temporal interval is above about three-tenths of a second, however, we have entered a new temporal category, which we might call response. For three-tenths of a second (.3 sec.) is enough time for a human subject to react to an acoustic stimulus. If we play two sounds to our subject a second apart, the subject could in theory prepare to deal with the second sound in the time given him after hearing the first. The perceiver is no longer passive, and events can be treated by him as actions in response to which he can perform actions of his own and which he can modify before they happen if he understands their cause. For response to exist there must be simultaneities, a separation, and a further element which might be characterized as function or, in a primitive sense, purpose. The response to a given stimulus will differ according to the function of the responding organ and the purpose of the organism as a whole.

At several places in this analysis it has been pointed out that a given familiar temporal relation-chance, pattern, fate, cause, action, function, purpose-only becomes possible when there is enough time for it to exist in. The idea that an entity needs time to exist in

has become commonplace recently: an electron, for instance, requires at least 10-20 seconds of time (its spin period) to exist in, just as surely as it requires 10-10 centimeters of space (its Compton wavelength). The corollary to this observation is that entities which consist only in spatio-temporal relations are not necessarily less real for that than material objects, for spatio-temporal relations are exactly what material objects consist of too. But though a given period of time may be sufficient for an example of given relation-chance, cause, function-to be recognized in, it is not enough for the concept of the relation to be formulated in. It takes much less time to recognize or speak a word once learned than it takes to learn the word in the first place. Many examples of the sequence or response relation between events must be compared before a causal or purposive order can be formulated and thus recognized in individual cases. But comparisons requires discrete parcels of experience between which the comparison may be made, and since the entities being compared are themselves temporal in nature, these parcels of experience must consist in equal periods of time. In like fashion, the analysis of a picture (for transmission, reproduction, or identification of its details) might begin by dividing the picture up into "pixels" by means of a series of grids of various frequency; the highest-frequency grid representing the limit of the eye's activity, the lower ones increasingly concerned with complex relations between details. The next lowest time-division beyond the .3 second response-frequency must be sufficiently long to avoid falling into the range of the characteristic time-quanta required for the completion and recognition of the temporal relations to be compared. The comparison of experience takes more time than experience itself; the recognition of a melody takes more time than the hearing of the single notes.

This fundamental "parcel of experience" turns out to be about three seconds. The three-second period, roughly speaking, is the length of the human present moment. (At least it is for the auditory system, which possesses the sharpest temporal acuity of all the senses. The eye, for instance, is twice as slow as the ear in distinguishing temporal separation from simultaneity.) The philosophical notion of the "specious present" finds here its experimental embodiment.

A human speaker will pause for a few milliseconds every three seconds or so, and in that period decide on the precise syntax and lexicon of the next three seconds. A listener will absorb about three seconds of heard speech without pause or reflection, then stop listening briefly in order to integrate and make sense of what he has heard. (Speaker and hearer, however, are not necessarily "in phase" for this activity; this observation will be seen to be of importance later.)

To use a cybernetic metaphor, we possess an auditory information "buffer" whose capacity is three seconds' worth of information; at the end of three seconds the "buffer" is full, and it passes on its entire accumulated stock of information to the higher processing centers. In theory this stock could consist of about 1,000 simultaneities, 100 discrete temporal separations, and ten consecutive responses to stimuli. In practice the "buffer"

has rather smaller capacity than this (about 60 separations); it seems to need a certain amount of "down-time."

It appears likely that another mechanism is involved here, too. Different types of information take different amounts of time to be processed by the cortex. For instance, fine detail in the visual field takes more time to be identified by the cortex than coarse detail. (Indeed, the time taken to process detail seems to be used by the brain as a tag to label its visual frequency.)[18] Some sort of pulse is necessary so that all the information of different kinds will arrive at the higher processing centers as a bundle, correctly labeled as belonging together, and at the same time; the sensory cortex "waits" for the "slowest" information to catch up with the "fastest" so that it can all be sent off at once. And this 3-second period constitutes a "pulse."

Beyond the two horizons of this present moment exist the two periods which together constitute duration, which is the highest or "longest-frequency" integrative level of the human perception of time. Those two periods, the past and the future, memory and planning, are the widest arena of human thought (unless the religious or metaphysical category of "eternity" constitutes an even wider one). It is within the realm of duration, that what we call freedom can exist, for it is within that realm that purposes and functions, the governors of response, can themselves be compared and selected. The differences between past and future, and the differences between possible futures, constitute the field of value, and the relations between low-frequency objects and the more primitive high-frequency objects of which they are composed constitute the field of quality.

It is tempting to relate this foregoing hierarchical taxonomy of temporal periodicities to the structure and evolution of the physical universe itself. The temporal category of simultaneity nicely corresponds to the atemporal Umwelt of the photon, which reigned supreme in the first microsecond of the Big Bang. The category of separation resembles the weak, acausal, stochastic, spacelike temporality of quantum physics, within which there is no preferred direction of time: a condition which must have prevailed shortly after the origin of the universe, and of which the quantum-mechanical organization of subatomic particles is a living fossil. The category of sequence matches the causal, deterministic, and entropic realm of classical hard science, whose subject came into being some time after the origin of the universe, once the primal explosion had cooled sufficiently to permit the existence if organized, discrete, and enduring matter. With the category of response we are clearly within the Umwelt of living matter, with its functions, purposes, and even its primitive and temporary teleology, which began about ten billion years after the Big Bang. Once we cross the horizon of the present we leave the world of animals and enter the realm of duration, which first came into being perhaps a million years ago (if it was roughly coeval with speech and with that development of the left brain which gave us the tenses of language). The evolution and hierarchical structure of the human hearing mechanism thus could be said to recapitulate the history

and organization of the cosmos. The history of science has been the retracing of that path backwards by means of clocks of greater and greater acuity.

Cosmological speculation aside, it should already be obvious that a remarkable and suggestive correlation exists between the temporal organization of poetic meter and the temporal function of the human hearing mechanism. Of general linguistic significance is the fact that the length of a syllable-about 1/3 second-corresponds to the minimum period within which a response to an auditory stimulus can take place: this is commonsense, really, as speech must, to be efficient, be as fast as it can be, while, to be controllable, it must be slow enough for a speaker or hearer to react to a syllable before the next one comes along.

Of more specific significance for our subject is the very exact correlation between the three-second LINE and the three-second "auditory present." The average number of syllables per LINE in human poetry seems to be about ten; so human poetic meter embodies the two lowest-frequency rhythms in the human auditory system.

The independence of poetic meter from the mechanism of breathing, which we have already noted, is thus explained by the fact that the master-rhythm of human meter is not pulmonary but neural: we must seek the origins of poetry not among the lower regions of the human organism, but among the higher. The frequent practice in reading "free verse" aloud, of breathing at the end of the line-even when the line is highly variable in length and often broken quite without regard to syntax-is therefore not only grammatically confusing but deeply unnatural: for it forces a pause where neural processing would not normally put it.

But at least there was a clear, if erroneous, rationale for the doctrine of meter as made up of "breath-units." Without this rationale, how do we explain the cultural universality of meter? Why does verse embody the three-second neural "present"? What functions could be served by this artificial and external mimicry of an endogenous brain rhythm? Given the fact, already stated, that poetry fulfills many of the superficial conditions demanded of a brain-efficiency reward control system, how might the three-second rhythm serve that function? And what is the role of the other components of meter-the rhythmic parallelism between the LINES, and the information-bearing variations upon that parallelism?

One further batch of data will help guide our hypothesizing: the subjective reports of poets and readers of poetry about the effects and powers of poetic meter. Although these reports would be inadequate and ambiguous as the sole support of an argument, they may point us in the right direction and confirm conclusions arrived at by other means.

A brief and incomplete summary of these reports, with a few citations, should suggest to a reader educated in literature the scope of their general agreement. Robert Graves speaks of the shiver and the coldness in the spine, the hair rising on the head and body, as does Emily Dickinson. A profound muscular relaxation yet an intense alertness and concentration is also recorded. The heart feels squeezed and the stomach cramped. There is a tendency toward laughter or tears, or both; the taking of deep breaths; and a slightly intoxicated feeling (Samuel Taylor Coleridge compared it to the effects of a moderate amount of strong spirits upon a conversation). At the same time there is a cataract or avalanche of vigorous thought, in which new connections are made; Shakespeare's Prospero describes the sensation as a "beating mind" (the phrase is repeated three times in different places in the play). There is a sense of being on the edge of a precipice of insight-almost a vertigo-and the awareness of entirely new combinations of ideas taking concrete shape, together with feelings of strangeness and even terror. Some writers (Arnold, for instance) speak of an inner light or flame. Outside stimuli are often blanked out, so strong is the concentration. The imagery of the poem becomes so intense that it is almost like real sensory experience. Personal memories pleasant and unpleasant (and sometimes previously inaccessible) are strongly evoked; there is often an emotional re-experience of close personal ties, with family, friends, lovers, the dead. There is an intense valorization of the world and of human life, together with a strong sense of the reconciliation of opposites-joy and sorrow, life and death, good and evil, divine and human, reality and illusion, whole and part, comic and tragic, time and timelessness. the sensation is not a timeless one as such, but an experience of time so full of significance that stillness and sweeping motion are the same thing. There is a sense of power combined with effortlessness. The poet or reader rises above the world, as it were, on the "viewless wings of poetry," and sees it all in its fullness and completeness, but without loss of the quiddity and clarity of its details. There is an awareness of one's own physical nature, of one's birth and death, and of a curious transcendence of them; and, often, a strong feeling of universal and particular love, and communal solidarity.

Of course, not all these subjective sensations necessarily occur together in the experience of poetry, nor do they usually take their most intense form; but a poet or frequent reader of poetry will probably recognize most of them.

To this list, moreover, should be added a further property of metered poetry, which goes beyond the immediate experience of it: that is, its memorability. Part of this property is undoubtedly a merely technical convenience: the knowledge of the number of syllables in a line and the rhyme, for instance, limits the number of words and phrases which are possible in a forgotten line and helps us to logically reconstruct it. But introspection will reveal a deeper quality to this memorability: somehow the rhythm of the words is remembered even when the words themselves are lost to us; but the rhythm helps us to recover the mental state in which we first heard or read the poem, and then the gates of memory are opened and the words come to us at once.

Equipped with the general contemporary conception of brain-processing with which this essay began, with the temporal analysis of meter and its correlation to the hearing-system, and with the subjective reports of participants in the art, we may now begin to construct a plausible hypothesis of what goes on in the brain during the experience of poetry.

Here we can draw upon a relatively new and speculative field of scientific inquiry, which has been variously termed "neurophysiology," "biocybernetics," and "biopsychology," and is associated with the names of such researchers as E. Bourguignon, E. D. Chapple, E. Gellhorn, A. Neher, and R. Ornstein. Barbara Lex's essay "The Neurobiology of Ritual Trance,"[19] in which she summarizes and synthesizes much of their work, provides many of the materials by which we may build an explanatory bridge between the observed characteristics of human verse and the new findings of the Munich group about the hearing mechanism. Although Lex is concerned with the whole spectrum of methods by which altered states of consciousness may be attained-alcohol, hypnotic suggestion, breathing techniques, smoking music, dancing, drugs, fasting, meditation, sensory deprivation, photic driving, and auditory driving-and her focus is on ritual rather than the art of poetry, her general argument fits in well with our own findings.

Essentially her position is that the various techniques listed above, and generalized as "driving behaviors," are designed to add the linear, analytic, and verbal resources of the left brain the more intuitive and holistic understanding of the right brain; to tune the central nervous system and alleviate accumulated stress; and to invoke to the aid of social solidarity and cultural values the powerful somatic and emotional forces mediated by the sympathetic and parasympathetic nervous systems, and the ergotropic and trophotropic responses they control.[20]

It has been known for many years that rhythmic photic and auditory stimulation can evoke epileptic symptoms in seizure-prone individuals, and can produce powerful involuntary reactions even in normal persons. The rhythmic stimulus entrains and then amplifies natural brain rhythms, especially if it is tuned to an important frequency such as the ten cycle-per-second alpha wave. It seems plausible to us that the three-second poetic LINE is similarly tuned to the three-second cycle of the auditory (and subjective-temporal) present. The metrical and assonantal devices of verse such as rhyme and stress, which create similarities between the LINES, emphasize the repetition. The curious subjective effects of metered verse-relaxation, a holistic sense of the world and so on-are no doubt attributable to a very mild pseudotrance state induced by the auditory driving effect of this repetition.

Auditory driving is known to affect the right brain much more powerfully than the left: thus, where ordinary unmetered prose comes to us in a "mono" mode, so to speak,

affecting the left brain predominantly, metered language comes to us in a "stereo" mode, simultaneously calling on the verbal resources of the left and the rhythmic potentials of the right.[21]

Of course, the matter is not as simple as this, even at this level of discussion. The accurate scansion of poetry involves a complex analysis of grammatical and lexical stress, which must be continually integrated with a non-verbal right-brain understanding of metrical stress. The delightful way in which the rhythm of the sentence, as a semantic unit, counterpoints the rhythm of the meter in poetry, is thus explained as the result of a co-operation between left and right brain functions. The "stereo" effect of verse is not merely one of simultaneous stimulation of two different brain areas, but also the result of a necessary integrative collaboration and feedback between them. The linguistic capacities of the left brain, which, as Levy says, provide a temporal order for spatial information, are forced into a conversation with the rhythmic and musical capacities of the right, which provide a spatial order for temporal information.

But the driving rhythm of the three-second LINE is not just any rhythm. It is, as we have seen, tuned to the largest limited unit of auditory time, its specious present, within which causal sequences can be compared, and free decisions taken. A complete poem-which can be any length-is a duration, a realm of values, systematically divided into presents, which are the realm of action. It therefore summarizes our most sophisticated and most uniquely human integrations of time.

There is, perhaps, still another effect at work on the cortical level. The various divinatory practices of humankind (another cultural universal, perhaps) all involve a common element: a process of very complex calculation which seems quite irrelevant to the kind of information sought by the diviner. A reader of the Tarot will analyze elaborate combinations of cards, an I Ching reader will arrive at his hexagram through a difficult process of mathematical figuring, a reader of the horoscope will resort to remarkable computations of astronomical position and time. (The common use of the word "reader" in these contexts is suggestive.) The work of scanning metered verse, especially when combined with the activity of recognizing allusions and symbolisms, and the combination of them into the correct patterns, seems analogous to these divinatory practices. The function of this demanding process of calculation may be to occupy the linear and rational faculties of the brain with a task which entirely distracts them from the matter to be decided-a diagnosis, a marriage, the future of an individual. Once the "loud voice" of the reductive logical intelligence is thus stilled by distance, the quieter whispering of a holistic intuition, which can integrate much larger quantities of much poorer-quality information in more multifarious ways-though with a probability of accuracy which is correspondingly much lower-can then be heard. The technique is something like that of the experienced stargazer, who can sometimes make out a very faint star by focusing a little to one side of it, thereby bringing to bear on it an area of the retina which, though inferior in acuity, is more sensitive to light. The vatic, prophetic, or divinatory powers

traditionally attributes to poetry may be partly explained by the use of this technique. If the analogy is slightly unflattering to the work of some professional analytic critics of poetry-reducing their work, as it does, to the status of an elaborate decoy for the more literalistic proclivities of the brain-there is the compensation that it is after all a very necessary activity, indeed indispensable precisely because of its irrelevance.

On the cortical level, then, poetic meter serves a number of functions generally aimed at tuning up and enhancing the performance of the brain, by bringing to bear other faculties than the linguistic, which we can relate to the summary of healthy brain characteristics at the beginning of this paper. By ruling out certain rhythmic possibilities, meter satisfies the brain's procrustean demand for unambiguity and clear distinctions. By combining elements of repetition and isochrony on one hand with variation on the other, it nicely fulfills the brain's habituative need for controlled novelty. By giving the brain a system of rhythmic organization as well as a circumscribed set of semantic and syntactical possibilities, it encourages the brain in its synthetic and predictive activity of hypothesis-construction, and raises expectations which are pleasingly satisfied at once. In its content, poetry has often had a strongly prophetic character, an obvious indication of its predictive function; and the mythic elements of poetry afford more subtle models of the future by providing guides to conduct. Poetry presents to the brain a system which is temporally and rhythmically hierarchical, as well as linguistically so, and therefore matched to the hierarchical organization of the brain itself. It does much of the work that the brain must usually do for itself, in organizing information into rhythmic pulses, integrating different types of information-rhythmic, grammatical, lexical, acoustic-into easily assimilable parcels and labeling their contents as belonging together. Like intravenous nourishment, the information enters our system instantly, without a lengthy process of digestion. The pleasure of metered verse evidently comes from its ability to stimulate the brain's capacities of self-reward, and the traditional concern of verse with the deepest human values-truth, goodness, and beauty-is clearly associated with its involvement with the brain's own motivational system. Poetry seems to be a device the brain can use in reflexively calibrating itself, turning its software into hardware and its hardware into software: and accordingly poetry is traditionally concerned, on its semantic level, with consciousness and conscience. As a quintessentially cultural activity, poetry has been central to social learning and the synchronization of social activities (the sea-shanty or work-song is only the crudest and most obvious example). Poetry, as we have seen, enforces cooperation between left-brain temporal organization and right-brain spatial organization and helps to bring about that integrated stereoscopic view that we call true understanding. And poetry is, par excellence, "kalogenetic"-productive of beauty, of elegant, coherent, and predictively powerful models of the world.

It might be argued-and this is a traditional charge against poetry-that in doing all these things poetry deceives us, presenting to us an experience which, because it is so perfectly designed for the human brain, gives us a false impression of reality and separates us from the rough world in which we must survive. Much modern esthetic theory is in fact devoted to reversing this situation, and making poetry-and art in general-so

disharmonious with our natural proclivities that it shocks us into awareness of the stark realities. Clearly a poetry which was too merely harmonious would be insipid-for it would disappoint the brain's habituative desire for novelty. But mere random change and the continuous disappointment of expectations is itself insipid; we are as capable of becoming habituated to meaningless flux as to mindless regularity.

Modernist esthetic theory may be ignoring the following possibility: that our species' special adaptation may in fact be to expect more order and meaning in the world than it can deliver; and that those expectations may constitute, paradoxically, an excellent survival strategy. We are strongly motivated to restore the equilibrium between reality and our expectations by altering reality so as to validate our models of it-to "make the world a better place," as we put it. The modernist attack on beauty in art would therefore constitute an attack on our very nature itself; and the modernist and post-modernist criticism of moral and philosophical idealism likewise flies in the face of the apparent facts about human neural organization. What William James called "the will to believe" is written in our genes; teleology is the best policy; and paradoxically, it is utopian to attempt to do battle against our natural idealism. Much more sensible to adjust reality to the ideal.

But our discussion of the effects of metered verse on the human brain has ignored, so far, the subcortical levels of brain activity. Let us substitute, as pars pro toto, "metered verse" for "rituals" in the following summary by Barbara Lex:

> The raison d'etre of rituals is the readjustment of dysphasic biological and social rhythms by manipulation of neurophysiological structures under controlled conditions. Rituals properly executed promote a feeling of well-being and relief, not only because prolonged or intense stresses are alleviated, but also because the driving techniques employed in rituals are designed to sensitize and "tune" the nervous system and thereby lessen inhibition of the right hemisphere and permit temporary right-hemisphere dominance, as well as mixed trophotropic-ergotropic excitation, to achieve synchronization of cortical rhythms in both hemispheres and evoke trophotropic rebound.[22]

Lex maintains that the "driving" techniques of rhythmic dances, chants, and so on can produce a simultaneous stimulation of both the ergotropic (arousal) and the trophotropic (rest) systems of the lower nervous system, producing subjective effects which she characterizes as follows: trance; ecstasy; meditative and dreamlike states; possession; the "exhilaration accompanying risk taking"; a sense of community; sacredness; a "process of reviving the memory of a repressed unpleasant experience and expressing in speech and actions the emotions related to it, thereby relieving the personality of its influence";

alternate laughing and crying; mystical experience and religious conversion; experiences of unity, holism, and solidarity. Laughlin and d'Aquili add to these effects a sense of union with a greater power, an awareness that death is not to be feared, a feeling of harmony with the universe, and a mystical "conjunctio oppositorum" or unity of opposites. This list closely resembles our earlier enumeration of the experience of good metered verse as described by literary people.

If Lex is right, we can add to the more specifically cortical effects of metered verse the more generalized functions of a major ritual driving technique: the promotion of biophysiological stress-reduction (peace) and social solidarity (love). Meter clearly synchronizes not only speaker with hearer, but hearers with each other, so that each person's three-second "present" is in phase with the others and a rhythmic community, which can become a perfomative community, is generated.

Laughlin and d'Aquili connect the mythical mode of narrative with the driving techniques of ritual, pointing out that mythical thought expresses the "cognitive imperative," as they call it, or the desire for an elegant and meaningful explanation of the world;[23] and McManus argues that such practices are essential in the full development and education of children.[24] (Again we might point out that the modernist praise of mythical thought is misplaced; for it values the irrational element it discerns in myth, whereas true mythical thought, as Levi-Strauss has shown, is deeply rational and has much in common with scientific hypothesis.)

The theory of the state-boundedness of memory might also explain the remarkable memorability of poetry. If meter evokes a peculiar brain state, and if each meter and each use of meter with its unique variations carries its own mood or brain-state signature, then it is not surprising that we can recall poetry so readily. The meter itself can evoke the brain-state in which we first heard the poem, and therefore make the verbal details immediately accessible to recall. Homer said that the muses were the daughters of memory, and this may be what he meant. By contrast, the modernist critic Chatman sneeringly dismisses the mnemonic function of metered poetry as being in common with that of advertising jingles. But if advertising jingles are left holding the field of human emotional persuasion, poetry has surely lost the battle-or the advertising jingles have become the only true poetry.

To sum up the general argument of this essay: metered poetry is a cultural universal, and its salient feature, the three-second LINE, is tuned to the three-second present moment of the auditory information-processing system. By means of metrical variation, the musical and pictorial powers of the right brain are enlisted by meter to cooperate with the linguistic powers of the left; and by auditory driving effects, the lower levels of the nervous system are stimulated in such a way as to reinforce the cognitive functions of the poem, to improve the memory, and to promote physiological and social harmony.

Metered poetry may play an important part in developing our more subtle understandings of time, and may thus act as a technique to concentrate and reinforce our uniquely human tendency to make sense of the world in terms of values like truth, beauty, and goodness. Meter breaks the confinement of linguistic expression and appreciation within two small regions of the left temporal lobe and brings to bear the energies of the whole brain.[25]

The consequences of this new understanding of poetic meter are very wide-ranging. This understanding would endorse the classical conception of poetry, as designed to "instruct by delighting," as Sir Philip Sidney put it.[26] It would suggest strongly that "free verse," when uncoupled from any kind of metrical regularity, is likely to forgo the benefits of bringing the whole brain to bear. It would also predict that free verse would tend to become associated with views of the world on which the tense-structure has become very rudimentary and the more complex values, being time-dependent, have disappeared. A bureaucratic social system, requiring specialists rather than generalists, would tend to discourage11 reinforcement techniques such as metered verse, because such techniques put the whole brain to use and encourage world-views that might transcend the limited values of the bureaucratic system; and by the same token it would encourage activities like free verse, which are highly specialized both neurologically and culturally. Prose, both because of its own syntactical rhythms and because of its traditional liberty of topic and vocabulary, is less highly specialized; though it is significant that bureaucratic prose tends toward being arrhythmic and toward specialized vocabulary. The effect of free verse is to break down the syntactical rhythms of prose without replacing them by meter, and the tendency of free verse has been toward a narrow range of vocabulary, topic, and genre-mostly lyric descriptions of private and personal impressions. Thus free verse, like existentialist philosophy, is nicely adapted to the needs of the bureaucratic and even the totalitarian state, because of its confinement of human concern within narrow specialized limits where it will not be politically threatening.

The implications for education are very important. If we wish to develop the full powers of the minds of the young, early and continuous exposure to the best metered verse would be essential; for the higher human values, the cognitive abilities of generalization and pattern-recognition, the positive emotions such as love and peacefulness, and even a sophisticated sense of time and timing, are all developed by poetry. Furthermore, our ethnocentric bias may be partly overcome by the study of poetry in other languages, and the recognition if the underlying universals in poetic meter. Indeed, the pernicious custom of translating foreign metered verse originals into free verse may already have done some harm; it involves an essentially arrogant assumption of western modernist superiority over the general "vulgar" human love of regular verse.

It may well be that the rise of utilitarian education for the working and middle classes, together with a loss of traditional folk poetry, had a lot to do with the success of political and economic tyranny in our times. The masses, starved of the beautiful and complex rhythms of poetry, were only too susceptible to the brutal and simplistic rhythms of the totalitarian slogan or advertising jingle. An education in verse will tend to produce

citizens capable of using their full brains coherently, able to unite rational thought and calculation with values and commitment.

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Footnotes

1This body of theory is developed in J. T. Fraser, *Of Time, Passion and Knowledge* (Braziller, 1975), and in J. T. Fraser et al., eds.. *The Study of Time*, vols. I, II, and III (Springer-Verlag, 1972, 1975, 1978).

2 The following summary of characteristic human information processing strategies owes much to these sources of information:

The proceedings of the Werner Reimers Stiftung Biological Aspects of Esthetics Group.

C. D. Laughlin, Jr., and E. G. d'Aquili, *Biogenetic Structuralism* (Columbia University Press, 1974).

E. G. d'Aquili, C. D. Laughlin, Jr., and J. McManus, eds., *The Spectrum of Ritual: A Biogenetic Structural Analysis* (Columbia University, 1979).

D. E. Berlyne and K. B. Madsen, eds., *Pleasure, Reward, Preference: Their Nature, Determinants, and Role in Behavior* (Academic Press, 1973).

A. Routtenberg, ed., *Biology of Reinforcement: Facets of Brain Stimulation Reward* (Academic Press, 1980).

J. Olds, Drives and Reinforcements: *Behavioral Studies of Hypothalamic Functions* (Raven Press, 1977).

C. Blakemore, *Mechanics of the Mind*, Cambridge University Press, 1977.

3 E. Pöppel, "Erlebte Zeit--und die Zeit uberhaupt," paper given at the Werner Reimers Stiftung "Biological Aspects of Esthetics" conference, January, 1982.

4 Private communications, I. Rentschler, 1981 and 1982.

5 "Biological Aspects of Esthetics" meeting, January, 1982.

6 F. Turner, "Verbal Creativity and the Meter of Love-Poetry," paper given at the "Biological Aspects of Esthetics" meeting, September, 1980.

7 On cultural universals, see I. Eibl-Eibesfeldt, *Ethology* (Holt, Rinehart, 1970).

8 J. Rothenberg, *Technicians of the Sacred* (Doubleday Anchor, 1968).

9 W. K. Wimsatt, *Versification: Major Language Types*, New York University Press, 1972.

10 Presented at the "Biological Aspects of Esthetics" meeting, April, 1981.

11 For instance, in Yanomami contract-chants and Western advertising jingles.

12 W. K. Wimsatt, Ibid.

13 This is a narrative meter, whose actual pauses do not necessarily fall upon the line-endings. In Aeschylus' *Agamemnon*, for example, an 11-line sample contained 15 pauses, and lasted 48 seconds. Thus in practice the LINE-length is about 3 seconds.

14 Probably reflects the statistical effect of lines with a strong caesura.

15 Charles Olson's *Projective Verse* (New York: Totem Press, 1959) is a good example of such free-verse theories.

16 Wimsatt, Ibid.

17 There is an interesting account of various critical theories of meter in the introductory chapter of C. Chatman's *A Theory of Meter* (Mouton, 1965), but it is flawed by a bias against the possibility of biological foundations for metrical usage.

18 Private communication, I. Rentschler, 1981.

19 D'Aquili et al., *The Spectrum of Ritual*, Ch. 4. pp. 117-51

20 "Ergotropic" refers to the whole pattern of connected behaviors and states that characterize the aroused state of the body, including an increased heart rate and blood flow to the skeletal muscles, wakefulness, alertness, and a hormone balance consistent with "fight or flight" activities.

"Trophotropic" refers to the corresponding system of rest, body maintenance, and relaxation: decreased heart rate, a flow of blood to the internal organs, an increase in the activity of the digestive process, drowsiness, and a hormone balance consistent with sleep, inactivity, or trance.

21 John Frederick Nims makes exactly this point in his *Western Wind: An Introduction to Poetry* (Random House, 1983), p. 258

22 D'Aquili et al., p. 144.

23 Ibid., Ch. 5, pp. 152-82.

24 Ibid., Ch. 6, pp. 183-215.

25 Charles O. Hartman, in his *Free Verse: An Essay on Prosody* (Princeton University Press, 1980), like many free-verse theorists, argues against the isochronic theory of meter. But his strictures apply to the lengths of syllables and feet, not to the LINE; and part of his argument is based on the fact that much free verse does not fit any temporal schema. This would not be a problem for our argument, which does not consider such free verse to be poetry in the strict sense. His argument attempts to save free verse, and therefore defines verse in a hopelessly vague way; ours is content to abandon it as verse unless it consciously or unconsciously employs the human and universal grammar of meter. It may be an admirable kind of word play, and it might even be argued that it is a new art-form of our century. But it is not poetry; and if this sounds dogmatic, it should be remembered that dogmatism is only bad when it is wrong.

26 *A Defense of Poetry*.