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COMPLEXITY AND CAUSALITY

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Two of the most intransigent problems facing thoughtful scholars and scientists are those concerning complexity and causality. Information measurement theory, as developed during the late 1940s and early 1950s, opened new approaches to the study of complexity but raised several deep questions that remain unanswered: What is the relationship between measures on information and those that describe the structure of redundancy? What is the relationship between maximum information, maximum uncertainty, and the measures on entropy and on randomness and on chaos?

Causality has fared no better. Physicists (e.g., Costa de Beauregard, in this volume) speak lightly of reverse causality where an efficient cause is allowed to follow its effect. Bertrand Russell declares that the concept of causality is a relic of a bygone age.[1] Frederick Burrhus Skinner authored a book, *Beyond Freedom and Dignity*, which proclaims our feelings of freedom to choose are archaic.[2]

This essay centres on the proposal that the results of twentieth century research in the brain and behavioural sciences has a bearing on the issues of complexity and causality. At least some of the difficulties with these concepts that have confronted scholars and scientists can be addressed in a new light. A premise that underlies such a proposal is that complexity and causality, although constructions of brain processes, reflect physical and social realities, since the brain is part of those realities.

Hemispheric Specialization

Currently great interest centres on the distinction between the functions of the right and left hemispheres of the human cerebrum. A number of ways of characterizing the distinction are popular. Fundamental to all of these characterizations is the fact that among most Western males (and to a somewhat lesser extent, Western females) the left hemisphere is prepotent in the verbal mode, while the right hemisphere is more clearly involved in certain types of spatial abilities. Western language is based on the use of the auditory and oral channels; spatial abilities are more visual and haptic.

Joseph Bogen has captured the essence of the distinction between hemispheric processing by the terms "propositional" for the left hemisphere and "appositional" for the right.[3] Linguists and philosophers have analysed the logic of propositional utterances and pointed out the complex relationships between word and object, between nominalization and predication, between phrase structures and other aspects of syntax. I shall attempt to characterize this aspect of complexity shortly and also attempt to detail its relationship to causality.

Apposition and Configuration

But first, what about complexity as it might relate to appositional structure? How does one go about deciding just how complex a face might appear? Or for that matter, how complex is the coastline of the British Isles? In these instances, the degree of complexity depends on the grain, the level of resolution, that is placed on the figure or design which is being perceived or described. Mandelbrot's fractals capture the essence of the perceived forms, but this mathematics does not really provide us with a measure of complexity.[4] In fact, the success of the fractal approach suggests the opposite: complexity *per se* is irrelevant to specifying appositional form.

It also seems apparent to me that the concept of causality is irrelevant in the appositional, configural mode of processing. Does the nose "cause" the eyes of a face? Are the mouths of the Thames and the Wye causally related to one another? How absurd these questions sound, once one has framed them.

It is, of course, an exaggeration to claim that the right hemisphere is limited to processing in the appositional mode. But the finding that such a mode exists, albeit in conjunction with other processing modes, is important. For, if I am correct that the concepts of complexity and causality are irrelevant to appositional processing, then these concepts fail to be universally applicable to all aspects of knowing.

The problem of grain remains. Certainly, the finer the grain of a figure, the more complex the figure appears to be. However, this appearance of increased complexity is most likely an illusion. There is ordinarily a tradeoff between resolution and depth of field. Thus the actual complexity represented within a given frame is ordinarily fixed: show greater resolution of the coastline and there will be less of it that fits onto a page of the atlas. To show more coast, less detail can be included.

To repeat, I believe that the concepts of complexity and causality do not apply to the appositional, figural domain of processing. Then, what about the propositional domain?

Propositional Utterances

In the beginning was the word, and the word was with "being." When an infant begins to use language, he expresses himself in holophrases. The holophrastic utterances indicate some environmental event or some internal state which has captured the attention of the infant. Similarly, there is evidence both in Sanskrit and in Hebrew that a holophrastic "logos" often anteceded its propositional utterance. Thus, "Yaweh" meant "being" before being became "a being" and finally a male causal being who wrought order and havoc in the lives of humans. A holophrase denoting an event or state is nominalized and by way of predication *becomes* a causal agent, a subject acting on an object. Reification, as this sequence is called in psychology, is a universal attribute of human thought. Thus, physiologists observe a biological action of an extract of a gland and give it a name, and biochemists search for the named compound until they identify its chemical composition. Then the identified chemical is tested to determine whether it, in fact, causes all of the reactions originally observed. If not, a new name is coined for the residual effect and the search begins anew.

Note how the process proceeds from being to becoming, from description to causal relation, from simplicity to complexity. Nor is that all. In a propositional utterance, each word is not only constrained by the phrase in which it appears but it implies that phrase and indeed the entire proposition. Thus, subject implies object and is implied by object. Causal finality as well as efficiency characterize propositions. We might even push the analysis further and suggest that the semantic referents of the proposition furnish the material causes for the proposition and that, by way of syntactic rules, formal relationships of ever-increasing complexity are pragmatically established among referents. Aristotle's analysis of causality is propositional analysis.[5]

The Cerebral Cortex and Reflective Awareness

We do not have complete understanding of the brain processes that underlie human propositional language. A few leads do, however, provide a rich source of hypotheses. First, by comparison with non-human primates and other mammals, there is an increased proportion of cerebral cortex with respect to the basal ganglia from which it is derived. This change in proportion is a likely candidate for an increase in reflectivity in human mentation. In fact, damage to the cortex of one hemisphere of the brain, for instance, that involved in vision, can lead to a condition called blind-sight.[6] On the side opposite to the brain damage, patients with blind-sight are able to respond correctly to the location and configuration of large visual cues while completely unaware of the cues. When asked what they do while performing the task, they claim that they are guessing and that they see nothing in the visual field being examined.

Such impairment of reflective awareness is not limited to the visual mode. When damage occurs somewhat more forward in the brain, patients may "deny" the existence of parts of their body on the side opposite to the damage. They may inadvertently catch their arm in the bedclothes while resting and thus are unable to sit up when they want to because of some "unexplained" constraint on their movements. When their arm is released and pointed out to them, they are astonished and treat the arm as a foreign object that surprisingly seems attached to them.

Patients with damage to other parts of the brain show similar disturbances of reflectivity. When the medial portion of the temporal lobe of both hemispheres has been resected, patients display a peculiar defect in memory. They remember everything that is happening as long as they do not become distracted. If distracted, however, everything that has transpired prior to the distraction is no longer accessible to recall — with two major exceptions. One exception is that events occurring prior to surgery are readily accessed. The other exception is that if a skill is taught, the patient will retain that skill intact despite the fact that he has "forgotten" that he ever learned it. He has become unaware of his knowledge.

Still another patient, with a somewhat similar but more restricted resection, eats voraciously, but when asked whether she is hungry or has special appetites, repeatedly assures us that such is not the case. She is unaware of the "causes" of her behaviour. By contrast, patients who have irritative, epileptogenic lesions in this part of the brain tend to be hyper-reflective: they keep voluminous diaries and write long letters to friends and physicians regarding every detail they experience.

Reflectivity allows the distinction to be made between self and other, between subject and object, between cause and effect. But reflectivity *per se* does not necessarily lead to complexity. In order to come to grips with this part of the propositional process being examined in this essay, we need to turn to still other distinctions among brain systems.

The Posterior Cerebral Convexity and the Processing of Information

The distinction between the cerebral hemispheres is, anatomically, the most obvious. However, the mammalian brain is composed of several other distinctive systems that are characterized by more subtle anatomical differences. Despite this subtlety, the differences in processing that distinguish these various systems are as clear-cut as those that differentiate the two hemispheres. Perhaps the most important of these additional distinctions is that which differentiates the posterior cerebral convexity from the frontolimbic forebrain. Let us begin with the functions of the systems of the convexity.

The posterior convexity of the cerebral hemispheres is composed of two rather different types of systems. One type is relatively directly connected to peripheral sensory and motor structures of the body. These systems are commonly called the projection or extrinsic systems of the brain. Their cortical terminations produce the major fissures of the cerebrum that are characterized by a topological representation of the peripheral receptor and motor surfaces, the familiar homunculi, retinotopic, and cochleotopic maps. It is these systems that respond to specific features "extracted" from the sensory input and organize them within a space-time co-ordinate system. It is these "image-processing," mapping systems that allow the organism to relate, via his sense and motor apparatus, to the configurations of the remainder of the space-time world.

Within the brain, as within Einstein's description (in the theory of special relativity) of the physical world in general, space and time form a single set of co-ordinates. Rapid successions of sounds are sensed as simultaneous as are visual and tactile configurations composed by scans. When objects or events are spatially distinct, they can be separately and thus successively attended. However, these perceptions of space-time are not responsible for our experience of duration, which I will elaborate on later.

By contrast, the other type of system has no such direct connection with peripheral structures. This led Flechsig, an Austrian neurologist, to call them "association" systems, within the frame of British empiricist "associationistic" philosophy popular in nineteenth-century Vienna. More recently, the more neutral term, "intrinsic," has been applied, since most of the processing pathways of these systems are limited to circuits intrinsic to the forebrain. Damage to these systems in humans produces sensory-specific agnosias (difficulties in identifying objects and events), apraxias (difficulties in performing complex tasks), and aphasias (difficulties in understanding and in speaking).

When these same systems are damaged in non-human primates, difficulties in categorizing are produced: such monkeys are deficient whenever choices among alternatives are required. These deficiencies are limited to one or another sensory modality (sight, hearing, touch, or taste). There is good reason to believe that these difficulties in categorizing obtained in monkeys are prototypical of the difficulties underlying the agnosias, apraxias, and aphasias (which are also sensory modality-specific) observed in humans.

Choices among alternatives define information. For the purposes of communication engineering. Shannon constructed an extremely useful measure of information as the number of alternatives, binary choices (bits), that are communicated.[7] It is thus technically correct and currently popular to view these intrinsic cerebral systems as information-processing systems.

The measure of information has also proved to be a useful measure of complexity. The greater the number of alternatives necessary to describe an object or event, the more complex it can be considered to be. However, as we shall see shortly, not all structural complexity can be subsumed under the rubric of measures of information.

To summarize: the systems of the posterior convexity of the brain are the image- and information-processing systems by virtue of which we experience complexity within space-time co-ordinates. Image processing furnishes the ground, the representation or map from which space-time co-ordinates are computed and from which complexity is defined. In most people, the categorizing process of the left hemisphere becomes developed, in conjunction with that of the other hemisphere, into logical (from 'logos,' the Greek term for concept, word), propositional thought and communication expressed as language. The categorizing process of the right hemisphere becomes developed, in conjunction with that of the other hemisphere, into rational (from 'ratio,' Latin for reason, computation), appositional thought and communication expressed in music and mathematics.

The Frontolimbic Forebrain and the Structure of Redundancy

On the medial surfaces of the hemispheres where their edges come together, lie additional brain systems whose functions are very different from those of the lateral convexity. These medial or limbic systems ('limbus,' Latin for edge or border) extend, in humans, over the forward poles of the frontal and temporal lobes. Once again, two types of system can be differentiated: those that are relatively directly related to the events occurring in the body and those where processing occurs primarily within the brain.

The input to the limbic systems differs from that to the extrinsic projection systems of the cerebral convexity. The limbic forebrain is connected to the core portions of the brainstem, which are sensitive to a variety of potent chemicals that homeostatically regulate the metabolism of the organism. These homeostatic mechanisms are joined by inputs from the periphery constituted largely of nerve pathways, which when severed, produce analgesia and loss of temperature sensibility. There are two aspects to such sensations. One aspect displays what neurologists call local sign, that is, the sensations can be located in space and time. These extensive space-time aspects of pain and temperature sensation (which philosophers call extensional) are disrupted when the systems of the posterior cerebral convexity are damaged. The other aspect of pain and temperature sensibility (and most likely of other senses as well) is the intensional aspect. It is these intensional aspects that reach the frontolimbic forebrain.

Descriptions of homeostatic regulations and the intensional dimension of sensation do not fall readily into a space-time framework. Rather, the concern is with stability and destabilization. However, cyclicity is involved: an appetitive phase is ordinarily followed by satiety, only to be followed in turn with another appetitive period, and so on. Repetition with a limited amount of variation is characteristic. Circadian and ultradian rhythms of temperature variation have been identified, and they are closely coupled to other metabolic cyclicities, such as those that determine hunger, thirst, respiration, and general motor activity. Over the past decade, cyclicities have also been observed in levels of endorphins, endogenous chemicals with an action similar to that of morphine in protecting the organism from feeling pain.

Cycles vary in duration and the duration of different parts of a cycle is experienced differently. The appetitive phases of metabolic cycles are usually experienced to be longer than the satiety phases, if these are experienced at all. The reverse is true of disruptive experiences: scratching an itch results in pain altogether too soon and the pain appears to last interminably.

In the technical sense in which the term information was used above, these limbic forebrain systems do not process information, that is, they are not involved in categorization, in the construction of choices among alternatives. Rather than processing information, the limbic forebrain processes redundancy, the more or less stable repetition of cycles of this and that.[8]

Repetition displays a structure that cannot be readily measured in terms of alternatives. A few (informationally measured alternative) tones can compose a musical theme, but an almost infinite variety of variations can be constructed on that theme.

Such variations on limbically regulated themes fall to the cortex of the forward poles of the frontal and temporal lobes. By dividing the repetitions in a variety of ways, which groups the repetitious alternatives into a variety of patterns, these brain systems structure redundancy.

The question arises of how to compare redundancy structures and of whether such comparisons would measure differences in complexity. Essentially, the problem becomes a statistical one of comparing the similarity between patterns. There are a variety of statistical procedures ranging from autocorrelation techniques to Prigogine's bifurcation methods[9] that can be applied. Thus, the complexity of stabilities redundantly expressed can be ascertained.

In a similar fashion, the experience of duration can become related to time in space-time by virtue of the functions of the cortex of the frontal and temporal poles. It is when cycles are punctuated by external or internal occurrences and the resulting groupings compared that the experiences of duration can become related to each other and to external cyclicities, such as those that produce the alternation between day and night. Analogue clocks are good examples of the role of punctuation and grouping. If clocks were constructed with only one hand moving in a circle without background, our ability to use them as measures of time would be severely restricted. Divide the circle into 12s and 60s, group the 12s together by means of a short hand, the 60s with a long hand, and one has the makings of an accurate timepiece.

The Relationship between Mind and Brain

During the past decades, two puzzling problems deeply relevant to the issues of complexity and causality have become amenable to resolution. One of these problems is the fact that damage to the forebrain, while severely disrupting whole modes or categories of memory processing, rarely, if ever, produces loss of a restricted, specific memory. The other problem is a more subtle one: what is the relationship between the form of the brain's processing mechanism and the contents of our experience? This second problem was formulated by Wolfgang Koehler, the renowned Gestalt psychologist, as the problem of "isomorphism" and has more recently been the subject of a controversy among philosophers, who ask whether the brain mechanism operates by way of representations or computations.[10] I shall deal with this problem first, since its resolution leads naturally to the problem of the nature of the memory trace.

Philosophers have taken several stances with regard to the relationship between brain and experience. Some have emphasized the close relationship and have, as did Koehler, taken the view that what goes on in the brain is identical to what we experience. Others have been impressed with the radical difference between brain, a material substance, and our more ethereal, fleeting stream of experiencing. These others have formed themselves into four major categories: those who see no way of bridging the gap between the material and the mental; those who indicate how the material brain and mental experience interact; those who can stomach only the material as the real and declare experience to be an emergent epiphenomenon; and those who point out that, after all, even our experience of the material brain is only an experience and thus it is experience that is real and matter is but an inference.

I have elsewhere made a case for considering each of these philosophical positions to be of some merit in that each applies to a limited data set and that a comprehensive view can be attained which includes all of these stances. Such a comprehensive approach is based on the use of computers and musical instruments as analogies. We may ask, for instance, what it is that is identical between the English language that I am using to address my word processor at the moment and the series of switch settings in the processing mechanism of my computer. That there is some sort of identity must be true, since English is displayed on the screen as I type. But if I were to look directly at the series of switch settings, I would certainly not find any resemblance to English there. The binary code of the switch setting has been transformed into an octal code for machine language use and then to some other alphanumeric code for assembling into an operating system, and finally, via several more steps of high-level computer languages, into English. The copyrighted disc which I insert into my word processor has stored these progressive coding operations, which are transferred to the core memory of my computer whenever I wish to use it for word processing.

In a similar fashion, there is little resemblance between the notes written on a musical score, the instrument, e.g., a piano with its keyboard and sounding board, strings and all, and the sonata I experience. Still, there must be some identities that characterize these various "realizations" of the sonata or else we would not be able to repeat the experience.

It is difficult to know what to call that which remains identical in the above examples or in the relationship between brain process and our experience. Plato called it the "ideal." Perhaps, today, the term "in-formation," the form within, is more acceptable.

Isomorphism: Representation or Computation?

Given the identity, that which remains invariant through all of the transformations wrought by coding and recoding, there remain differences between the material computer, with its switches, and the various levels of programming, which are more ethereal and must be realized on a floppy or hard disc, a tape, or by typing on paper. In a sense, a program represents a mental process, and while it is being constructed, it is a mental process. Thus, we can consider computers and programs as analogous to brains and mental operations — but, of course, with the caveat that the wetware of the brain is considerably different from today's computer hardware, both in operation and in constitution.

We are now in a position to examine the issue of isomorphism and whether the brain operates by way of representations or computations. Isomorphism means of the same form. As noted, the operations of a machine, whether a computer, piano, or brain, need not resemble nor be of the same form as the product of the process. Coding operations change form, "transform"; they do *not* create iso-forms. Unfortunately, the situation has been made more complicated by mathematicians who consider isomorphic those transformations that are algebraically linear and invertible (reversible). Therefore, we need to distinguish geometric or true isomorphism from algebraic isomorphism. Most sensory and motor mechanisms of the brain show considerable overall algebraic isomorphism, but this does not mean that the brain processes display the same geometry as do our experience of them.

What then of representation versus computation? Computer programming and the generation of a musical performance are certainly computations in the sense that the operator uses a score or program to operate on the mechanical substrate. And certainly that substrate represents something. In the case of the word processor and the piano, the input to the computer or sounding board is via a keyboard. The keyboard "represents," albeit in a somewhat distorted fashion, the fact that we have 10 fingers, each of which can be separately moved, and two hands that can be separately positioned. In a similar fashion, the sensory and motor apparatus of humans is "represented ," although in a somewhat distorted fashion, by brain "homunculi," spatial isomorphs of these peripheral structures. In short, both representation and computation characterize the relationship between brain and experience.

Perhaps, however, it would be better to call the brain homunculi "presentations " of the patterns of energy transduced by peripheral structures and to reserve the term "re-presentation" for possible recoding of these presentations in memory. But, even then we might find algebraic isomorphism in the re-presentation, although at present we do not know whether this is so. Whatever the answer may be, some sort of coding that leaves in-formation invariant is needed, and I, for one, opt for keeping both representation and computation in our specifications of brain processing, provided we do not envision representation as simply a geometrically isomorphic "photographic" image of that which is being represented.

Whereas the presentation of peripheral anatomy in the brain is dependent on its interneuronal macrostructure, re-presentation is dependent on the junctional and dendritic microstructure, the network properties of the brain. Research during the past two decades has detailed the transforms that characterize the properties of dendritic receptive fields of the cells in the sensory and motor areas of the brain cortex. Some of these properties can be characterized by the linear invertible transformations that result in algebraic isomorphs of the input. Specifically, Fourier and Gabor transforms have proved especially useful in delineating these properties. Such transforms are also used in the construction of optical holograms and, in general, in what is called image processing, whether by computers — or brains. Holograms can therefore serve as analogies for human image processing, the construction of our experienced awareness.

One of the most fascinating aspects of holograms is that they enfold and distribute in-formation over the extent of the encoding structure. Hence the name hologram. Each part of the encoding structure can be used to reconstruct the entire image.

since all of the in-formation is enfolded within each part. Also, the encoding structure is resistant to damage, as the in-formation has been distributed throughout.

A Multiplex Neural Hologram and Distributed Memory Processing

Holographic-like structures help explain the failure to find losses of specific memory traces after even extensive forebrain damage: the process of encoding input to the brain appears to some extent to follow the same transformation rules as those involved in the construction of holograms.

Once again caution must be exercised in interpreting the analogy too literally. The brain cortex is not constituted of a homogeneous holographic-like film. Rather, the cortex is composed of a mosaic of holographic-like patches, each of which is a dendritic receptive field. Thus, the input to the brain is not transformed according to a global Fourier transform but more in keeping with a Gabor transform, which places Gaussian constraints on the otherwise unlimited Fourier infinities. But multiplex holography, as this patchy type of transformation is called, has been successfully used in radio-astronomy and in making optical holograms which have the added virtue of being able to represent movement, that is, change of spatial relationships over time.[11]

Within a holographic patch, space-time becomes enfolded and distributed, as does all in-formation. Image construction and reconstruction is thus an unfolding of an enfolded order. It is this enfolding and unfolding that is critical to the issues developed in this essay: complexity and causality.

Brain, Complexity, and Causality and Their Relationship

First, complexity. Is there any change in the amount of complexity as a function of coding operations in which in-formation remains invariant across transformations? I believe not. If there were a change, it would violate the definitions of the measures of information and redundancy. Thus, the complexity of English is no less nor greater than the complexity of the binary Boolean code that describes the switch settings which process the words I am writing. The binary code is simpler in its elements but more complex in the sequences of patterns necessary to represent any given text. English has an alphabet of 26 characters and more, but fewer parsed patterns are necessary to represent the same text.

Second, causality. In the holographic-like domain, the enfolding of space-time precludes causality. Causes, any of Aristotle's four types, demand the ordinary, sensed space and time dimensions to manifest. When certain computations are performed by the brain in the holographic-like domain, the results of the computations must be transformed into space-time in order to "make sense." This is no different from the procedures used in other image-processing techniques, such as computerized tomography or the use of fast Fourier transforms in statistical calculations.

Finally, we come to the relationship between complexity and causality, a relationship that is portrayed in statistics. The concepts of statistics are based on probability distributions. A Gaussian, "normal" sugar loaf type of distribution is ordinarily thought to reflect randomness. Using as models the paths of molecules in gases or the paths of particles in suspension (Brownian motion), or alternatively, the results of a throw of dice, randomness is equated with unpredictability, absence of determinate cause, and absence of complexity, that is, chaos. When the concern is with the behaviour of individual events, this view of statistics is correct.

However, this portrait misses some important aspects of the entire situation. The overall behaviour of all of the events under consideration is constrained by the walls of the vessel containing the gas or the meniscus of the droplet of suspension. A die is not a marble; a die is a square with six numbered sides. Einstein was wrong when he declared that God does not play dice with the universe, not only because he failed to acknowledge the statistical nature of occurrences as basic but because he failed to realize that when occurrences are observed to be probable, the probability may well reflect the existence of determinate constraints at a more encompassing level.

The issue of determinism is not limited to statistics. The silver grains that make up the film of an optical hologram appear to be arranged chaotically. (If plotted, I am sure that the spectrum of intergrain distances would form a Gaussian distribution.) Only when the appropriate transform is performed can the in-formation encoded in the hologram be experienced as an image.

In a large city, many programmes initiated in radio and television studios are broadcast simultaneously, that is, cast broadly. At any moment in time, a cross-section of the electromagnetic waves carrying these programmes, taken at any location, would resemble a hologram that would not "make sense." Only when an appropriate tuner (sensor) selects and transforms one or another of the electromagnetic patterns can image reconstruction occur. Is it the sensor that introduces causality, or does it just unfold a causality enfolded in the cacophony of electromagnetic patterns? Or is this an unanswerable question?

Summary

It is evident that a great deal can be learned about complexity and causality from studies on the functioning of the brain. For me, the most impressive lesson has been that complexity and causality are not necessarily manifest in every possible ordering of events. And equally important, when complexity and/or causality are not manifest, this does not mean that the ordering is chaotic.

When the behaviour of individual events cannot be predicted but their overall behaviour can, then it is the currently ignored constraints on these behaviours that become of interest. When an event appears to have no determined cause, it may nonetheless be subject to constraints. The concept of degrees of freedom captures this fact. Thus, freedom to choose implies that choices among alternatives (complexity, in-formation) are available and that the chooser is competent (has sufficiently complex structure) to choose. Indeed, freedom entails "response-ability."

Trans-formations leaving in-formation invariant are the key to understanding some orders that appear chaotic. When the transformations are invertible, complexity and causality are duals of other dimensionalities such as inertia (e.g., momentum) and change (e.g., energy) within which complexity and causality are enfolded. If we are to "make sense" scientifically or generally of these enfolded orders, we must know the transformation rules.

Other transformations are due to more arbitrary coding operations that must be kept track of to successfully use the in-formation in its various forms. Both invertible transformations and codes have the virtue of allowing forms different from in-formation, each form better adapted to a particular use. I have chosen to call that which remains invariant and maintains its identity across transformations *in-formation*, but the name is less important than the concept it purports to indicate. Such a concept is critical to understanding the mind/brain issue, which generated this inquiry in the first place.

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