GROUNDING KNOWLEDGE TECHNOLOGY

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Introduction

The tools required to accommodate the rapidly expanding demand for tracking, validating, and utilizing vast stores of communications are profoundly complex. Current applications fall far short of what is needed. Misrepresentation of what the applications can actually provide is abundant. This paper will outline a foundation for grounding knowledge technology in neurophysiology, cognitive neuroscience and stratified complexity theory. With this foundation we expect to offer an objective evaluation of new types of knowledge technologies.

The Proper Grounding of Knowledge Technology

Human communication requires awareness. The problems in representing the contents of human awareness have been consuming. For example, the representation of human reasoning in the form of propositional logics has occupied a great amount of human creativity. Rule based models of human reasoning are closely related to propositional logics. It is not clear however, that propositional logic and rule systems capture all aspects of human knowledge creating and sharing processes.

The conversion of knowledge about value chains and organization structure into business logic and workflow is important. However, the compression of semantic linkage, as expressed in natural language, is not so easily represented as logic and rule productions. A number of problems, such as linguistic disambiguation, are not properly addressed in either standard propositional logics or fuzzy logics. Some leading scholars conjecture that algorithmic processes will eventually lead to complete models of natural intelligence, but not awareness states [1]. Be that as it may, the question I raise here is whether the current mainstream interest in rule-based business intelligence is justified. Is a new foundational paradigm necessary before true computational knowledge technologies are seen in the markets?

Over the last twenty years, experimental cognitive neuroscience and neurophysiology have fundamentally reshaped the scientific view of human reasoning and the experience of knowledge. As a result of experimental science, we now have a better understanding of the architecture that generates and interprets language within the human mind. This architecture can be taken into account as we work on the problems involved in representing semantic linkage. If we can better address the problem of representing semantic linkage, then distance learning and other knowledge-based distributed systems can come into being.

For example, human discourse relies critically on the use of a "time lens" to gather from real-time experience two classes of subtleties of meaning. The notion of a time lens suggests that the experience, and the processing, of subtleties of meaning are complementary in nature and form upper and lower envelopes shaping the coherent states that we experience as awareness. A "Fourier like transform" of energy distributions is a model of the electromagnetic expression of what Pribram refers to as a packet [2]. The transform can be used as a model of a redistribution of energy. The transform carries information from one location to another location. This model may better account for experimental literature on brain and perception. The model also sets up a new architecture for identifying and managing semantic linkage in text collections [30].

In the author's view, the information packet is formed as part of the emergence of autonomous systems from a substructure, knowable as statistical objects, and within an ultrastructure, known as context. The emergence is into a middle layer that appears to us as a complete world. This middle layer is the world we “observe” directly with our senses. The substructure is the organized ecosystem of processes that compose metabolic and other matter-energy transformations at the chemical and quantum levels. The ultrastructure is the ecosystem we identify as our environment.

This “tri-level notion” makes sense if the reader pauses and visualizes what is being said. In the context of knowledge technology, the notion implies that computers need two classes of knowledge artifacts, one being statistical and the other categorical. And on further reflection, we see that these two classes of artifacts each have what the other class does not have. For example, statistical artifacts are not generally stored in a coherent fashion; each statistical artifact is independent.

In the substructure, the meaning of relationship has a different tone than does the meaning of relationship in the middle level. A color or texture may be inherently harmonic as perceived aesthetically; but logical coherence between a specific color and a specific texture is a matter of interpretation.

Coherence is a property of middle world inter-relationships bound together in a contextual binding. As such, the coherence has a root in a specific situation where statistical knowledge is sometimes irrelevant.

Choice between Foundational Viewpoints

The tri-level notion has a theory of change implicit through the joint notion of emergence and dissipation of transient compartments. The transient compartments are thought of as the coherent assembly of components in context. When a context undergoes a change then the coherence of the associated compartment dissipates. Let us look at some specific evidence from neuropsychology for the tri-level notion and compare this notion with the more Newtonian notion of procedural rule sets.

Computational modeling enriches our collective knowledge about the organization of those processes involved in human knowledge creation and sharing. During the 1980's the experimental research on the neuropsychology and neurochemistry of the cerebellum and motor expression circuits gave rise to a number of computational models of the cerebellum as an array of adjustable pattern generators. Consequently, a great deal of detail about the physical processes involved is expressed in the language of rule generation and mathematical algorithms. Other examples exist in research literatures that focus on computational models of the hippocampus, the prefrontal cortex, the visual cortex, etc.

The Houk/Barto model of neuronal connectivity is one example, among others, that illustrate the use of foundational principles in the context of modeling a physical single-level process that is conjectured to be involved in composing, controlling, and expressing motor programs [3]. The single level view of complex systems assumes that all sub-processes follow a specific set of rules and that these rules are deterministic and reducible to classical thermodynamics.

However, it is noted that the cerebellum is one component of a complex structure of systems, and that each of these systems is rich in localized metabolic processes. It is easy perhaps to have the language in which each one of the systems is providing the input to another system. However, the cause of each of these systems' behavior is more complex that this language implies. The complexity is recognized by Houk (personal communication), however the Houk/Barto model is geared towards a Newtonian-like reduction of the mechanics of motor program storage and expression. The use of the Barto neural network architecture allows cause – effect chains to be propagated in a classical way where each effect is the full and complete consequence of some known set of causes. Each cause is enforced computationally as a mathematical computation. The entire model is time reversible and therefore there is not a legitimate notion of emergence – at least not as Prigogine and others define emergence [31]

Holonomic brain theory [2] [4] describes a different type of model. A distributed wave propagates micro signals from the neuron's receptive field along dendrite pathways towards the cell soma. Each micro-dendritic event emanates from groups of synapses to produce a localized Fourier transform. The transform converts wave potential into discrete event potential in the form of pulses. These pulses use channel properties of thousands of dendrites to move the signal. This wave of dendritic events is accumulated as potential energy on the soma side of the axon hillock.

At the soma, an inverse Fourier transform is generated from the conversion of discrete sequences of micro-pulses into a single semi-coherent electromagnetic field. This field is what Pribram calls the information packet. Such a packet has a rich causal binding to the coherence, as expressed in the field, and a metabolic substructure as expressed in metabolic and conformational state-event chains. The inverse Fourier transform is computed as micro electromagnetic events, initiated in dendritic synapses. Each of these micro-events has localized state-event chains governed by protein conformations and neurotransmitter production rates [32]. The field coherence binds all of these localized processes together.

As the electromagnetic imbalance is strengthened, phase coherence separates out various parts of the spectrum, resulting in yet another cascade of localization and discretization into a Fourier type representation. The potential energy is drawn from the neuronal soma into a substrate composed of protein conformational dynamics. Here chemical valences move the potential energy's location, across the hillock where a new field coherence is established.

This field coherence is modeled as a new inverse transform. It is followed by the emergence of a forward transform that provides the weights, or more generally the initial conditions, to elemental pulse generators that produce electromagnetic spikes propagating down the axon. Each forward transform selects a, perhaps quite different, basis. New sets of ecological affordance [5] are generated that conform to environmental conditions present when the forward transform occurs. Information is passed up and down the organizational levels including levels for human mental events and social organizations.

At whatever level, the set of ecosystem affordances can be viewed as a precursor to a rule set. Gibson's [5] notion of ecological affordance was expressed in his research on how optic flow in the retina of a bird is transformed into behavioral reactions as the bird navigates in the world. One could say that a set of rules is involved in guiding the bird's flight. Using this language is at least consistent with rule-based theories of behavior. Reasoning is a type of behavior and thus one could see human reasoning as an instantiation of a specific number of rules. The problem with this language is that the rule becomes what is being explained rather than the behavior of an animal as the animal makes sense of the world.

An alternative language requires that we assume organizational stratification where sequences of events (value chains) occur almost completely within organizational strata. This alternative language is consistent with the notions of value chains [33] in business ecosystems, and with the school of thought, called ecological psychology, that has followed from Gibson's work.

Both the forward and inverse transforms move across organizational scales. Each inverse transform is involved in establishing the structural mechanics of memory stores. Each forward transform is conditioned by the natural reality of the situation at the time of the transform. The non-stationarity of real natural systems is, and can be ignored during the inverse transform. However, the non-stationarity of real natural systems is accommodated (perhaps non-algorithmically) during each forward transform. I conjecture that non-stationarity, the emergence of novelty, and differential viewpoints are not always completely reducible to crisp rules, but Paul Werbos, and others, dispute this [33].

More On Stratified Theory and Cognitive Neuroscience

Of course the exact class of transforms, best suited to model neural phenomenon, is the subject of a deeper discussion. For more on the issue of cross-scale transforms of energy distributions in the brain system I refer to Pribram's core work [2].

The forward and inverse Fourier transform is a first approximation of how organizational levels are integrated and decomposed during the reasoning process. The Gabor transformation is a second approximation [6]. The Gabor transform shapes the Fourier and provides a spatio-temporal boundary to the integration. We take the Fourier as an example of a cross-scale transformation having both local and global aspects and having a scientific grounding in our understanding of coherence and interference patterns that produce the hologram. The Gabor transform is like the Fourier transform in many ways. The Gabor transform is less well-known, but more able to model the complexity that I feel is involved in the cross organizational scale energy transformations supporting human reasoning. The Fourier shows us clearly how local global transformations work in the context of physical holograms. The Gabor generalizes this and may better account for the conveyance of ecological affordance from one scale of organization to another.

The Fourier transform takes an electromagnetic signal and re-expresses this signal as a sum of amplitude and phase modulated waves expressed mathematically as regular sine and cosine functions (of time). The sine/cosine basis is used under the formal assumption that the phenomenon has strictly periodic generators – which is approximately true when one is dealing with light packets at the local level, and a hologram at the global level. The inverse transform takes these summed representations and loses the representation, because the elements are now fully integrated together as a whole. *The nature of the basis is entangled in the sum in the same way as the potential states of a particle's location are entangled in the wave representation used in the language of quantum mechanics.*

Pribram's holonomic theory of brain function has some unresolved issues. The Fourier relies on a specific set of basis functions, that being the cosine and cosine. Moreover, the notion of a forward and inverse transform is an artifact of mathematical formalism, since an electromagnetic wave can be seen in a regularized form, or not, without effecting its status. Pribram's quantum neural wave equations [2, in the Appendix] are stated fully within the mathematics of Hilbert spaces. I feel that this framework is not sufficient to the task of representing the stratified dynamics of the mental experience. Specifically the cross-scale phenomena at the quantum level appear, to me, to be outside the Hilbert formalism.

The localization/globalization transform can, however, be seen as movement between two temporally defined scales of dynamics [37]. These scales are marked by the development of regular patterns of emergence into one scale from the other. The classical example is the atomic (or quantum) scale and the molecular scale. The first scale allows us to look at the dynamics of protein conformation and cascades. The second scale observes the dynamics of phase coherent electromagnetic fields supported by massive numbers of synaptic events [2].

Let us consider some neurophysiology. For some time, a structural order has been observed in the organization of the cerebellum [8, 9, 10]. Furthermore, experimental data, reviewed in [3] suggests that a pattern generator located in the cerebellum produces movement signals. These signals are recorded by microelectrodes in the magnocellular red nucleus, which is located outside the cerebellum in a region nearer to the brainstem.

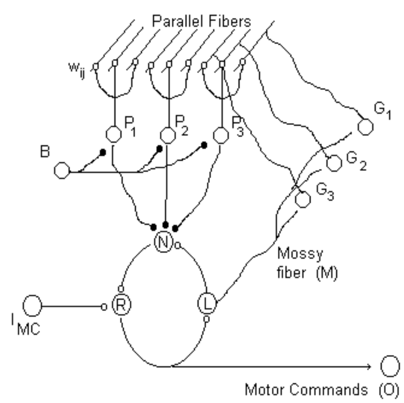

Figure One -- *The Houk/Barto Model of the Cerebellum, modified from [9]*

The experimental data suggests that electromagnetic potential energy is broken down into a set of basic elemental processes that activate substrate "computation" based on structure activity relationships [11, 12]. Following this molecular computation, the state of the substrate has developed a new representation within a derived set of basic elemental processes

The loci of activity may have moved due to transport properties associated with cell structure, again as a consequence of molecular computation. In this new location, an emergent electromagnetic field is formed by assembling a subset of the basic elemental processes according to situational influences at that location. It is as if the thing talked about is the same, but the "language" changes. These changes in language, if my theory is reasonable, would involve emergence and thus cross organizational scale transformations of energy and information.

For the Houk/Barto model of the cerebellum, action/perception describes the activity but does not take into account substrate computations that occur at the molecular and quantum levels of organization. The model accommodates only the conditioning that can be pre-defined algorithmically within the modeling processes. This modeling process takes into account reaction rates as seen occurring at the neuronal and neuronal ensemble level (as does Edelman's excellent work, [13] and thus has some qualities of a stratified theory).

Let us look at the complex detail of the neurophysiology. A recurrent (reentrant) feedback pathway composes a motor program from basic elements consisting of patterns in neuronal bursting. Activated combinatorial maps in the motor cortex control composition algorithmically. Purkinje cells { P_i } innervate their dendrite receptive field into a regular array of parallel fibers from cerebellum sub-cortical cells. Synaptic connections { $w_{i,j}$ } encode associative strengths. Basket cells {B_i } under the influence of the motor cortex, in the cerebral cortex, inhibit a selection of purkinje cells and allow the uninhibited purkinje cells to sample the array of parallel fibers for components of motor expressions that are consistent with combinatorial maps that are active in the cerebral cortex.

These purkinje cells then read out a signal, expressed via its axons, into the receptive field of a group of subcortical cerebellar cells { N } that form a deep cerebellar nucleus. This cerebellar nucleus has reciprocal connections and common dendritic innervations with populations of cells, arranged in columns, located in the cerebral motor cortex (not shown in Figure One). The cerebellar nucleus has excitatory connections to the red nucleus { R } which are located in the mid-brain outside the cerebellum. Environmental impulses {I_{MC}} are received by the red nucleus and these shape the motor commands, which are then projected to an inter-neuron and to muscle fiber (Pribram, private communication).

The shaping of the program's expression by a sensory stimulus is conjectured in [9] to involve a two-stage process whereby the movement signals, recorded at the red nucleus by microelectrodes, are the expression of response patterns composed to meet the demands of motor commands. Continuous feedback from the environment then modifies the expression. A signal is also sent from the red nucleus to the inferior olive (the inferior olive is a group of neurons located outside the cerebellum). The inferior olive receives reinforcement stimulation from various sources and projects reinforcement signals to modify synaptic weights $\{w_{i,j}\}$.

The detail in the neurophysiology should tell us that knowledge technology, particularly change management, involves more that simple rule-firing. Many levels of organized processes are involved in the experience of human knowledge and in human accommodation of change.

Maturana and Varela [14] develop the notion that our perceptual system maintains a "structural coupling" with the environment. An action-perception cycle acts through the boundary between self and not-self. In Maturana and Varela's notion of autopoiesis, the action perception circuit is controlled "almost" completely by structural coupling. Fundamental change in a system can only occur if the structural coupling is altered in some way.

Fundamental change comes about as individuals express themselves within a community and within an environment. At a different time scale, different from the human cultural time scale, the Houk/Barto model provides a reasonable description of the processes involved, at the level of the individual. But the individual is within a community and within an environment. Stratified complexity theory helps us understand general conditions related to ensemble expression at whatever level of organization is of interest.

After careful consideration, involving several decades, I now feel that the Houk/Barto description does not answer deep questions about what all of this neurophysiology has to do with individual awareness. I now argue that such questions can only be answered if one is willing to consider stratified complexity theory.

There is a "minimal complexity" required, to describe the multiple levels of organization within a single framework. However, once this minimal complexity is accepted, then there is often a reduction of the degree to which our descriptions are complicated by abstraction and ill-founded formalism. Imagine if stratified complexity theory was implemented as a framework for text routing and retrieval. The returned queries would be far more precise and the recall far more complete (as I have been able to demonstrate in a few trial benchmark studies). Thus the overall task of "knowledge management" could be reduced in cost and the natural complexity of knowledge technology might become manageable.

What such a simplification requires is the abandonment of the pure, but entrenched, concept that complex natural systems such as social systems and economic systems can be modeled as if they are Newtonian. It requires the acceptance that knowledge management has less to do with computer algorithms and more to do with human communication.

Explaining the Discontinuity of Change

In the previous section, a network model of one "subsystem" of the brain is described. The purpose of this description is to provide a specific context for using the tri-level paradigm to address a central open question regarding the 'discontinuity" of the stimulus pattern from one location to another. This discontinuity was first noticed by Walter Freeman in his study of the olfactory system of rabbits [15] and then later in other neuronal subsystems [16]. It was noticed that the stimulus patterns generated by olfactory bulbs were lost during the transfer of the signal from receptor cells to inter-neurons in route to the olfactory cortex.

The specific discontinuity of a signal pattern might be a generic property of a transfer function that samples a specific part of the electromagnetic spectrum from dendro-dentritic field interaction and encodes information from this spectrum into structural activity relationship (SAR) information at the level of protein conformational states (see Figure Two). As suggested above, this encoding is a Fourier-like decomposition of the potential energy into a recipe that is then propagated via a pulse wavefront along dendritic channels to the axon hillock. It is conceivable that at the axon hillock, the pulses, and the encoded information are placed into some type of micro-environment where a process of reorganization may occur [17].

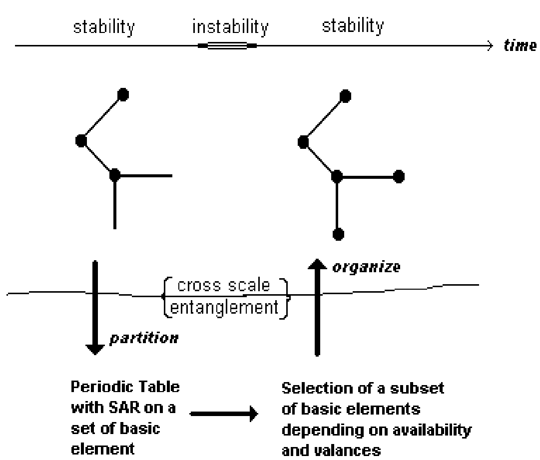

Figure Two -- Special Episodic Sequence Where An Organized Whole Briefly Dissipates Into A Substrate And Then Reorganizes

The elements of the sequence are initiated and terminated by cross-scale events [11].

We have pointed out that the neuropsychological literature provides strong evidence that subtleties of meaning are encoded in biological and environmental media as statistical-like or categorical-like artifacts. It is not easy to say what the natures of these biological artifacts are. But it is necessary to recognize two disjoint classes of these artifacts; statistical and categorical. The lower class of artifacts is about the substructural invariance in the world and the upper class is about the non-stationarity of the situations in which substructural invariance seems to be manifest in observables.

We have pointed out that categorical artifacts, unlike statistical artifacts, are not generally stored in a complete fashion. A weak structure of inter-relationships between categories is present. Unlike statistical artifacts, which require many instances to form a specific artifact, the categorical inter-relationship does not even have a full single occurrence from which to form it. Information is simply incomplete. We know the "ultrastructure" of observable events only from knowledge of how things move about. It is like the "invisible hand" that controls economic change.

So how is all this related to Knowledge Technology?

Following the theoretical model given above, any knowledge technology should have two classes of artifacts. The statistical artifacts are those things in common between exemplars of a category and are stored as logical atoms. These atoms are not yet composed into a situational logic, but "are prepared for" composition by structural features that are expressed functionally. The categorical artifacts can be organized into collections, which we call category policies [35].

By making a distinction between these two classes of artifacts, we find the upper and lower envelope of the event of awareness in a temporal constraint, the bounding of the event within some duration. In our interpretation of neurobiological literature (given above), the lower artifacts are encapsulated consequences of substructure. They are the results of direct experience of the commonalties of situations as processed by the brain, and are "stored" without synthesis. They are the substances of memory. We remember the color "red", or the "subtlety of meaning" that is a "tree". The upper artifacts, elements of ultrastructure, are elements of a model of the ecosystem that gives the contents of awareness contextual meaning. In the neurobiological interpretation, this awareness is dependent on structural coupling [14] between the self and the not-self.

The two classes of artifacts must be entangled through social discourse. The discourse acts as a time line where one or more humans make an interpretation of the experiment of the past under the expectations of the future. The knowledge is experienced by the human, not the machine – simply because, it is argued, the machine is a simple system not capable of such experience.

Written communications often have ontological differences from our informed intuitions about awareness. For example, noun words imply a separation of concepts having well-defined boundaries, and yet it is hard to find a true boundary between the objects in one of our mental spaces. These differences, between neuropsychology and logic, can be appreciated through reflection about the natures of computing, sign systems and natural phenomena [29].

So how can this difference be accounted for while making judgments about the viability of new knowledge technologies? We suggest that the two kinds of knowledge artifacts, substructural and ultrastructural, be generated and composed into sign systems. Then the logical atoms of the substructural system can be developed statistically and assembled into dynamic categorical policies (representing the ultrastructural system) to represent the discussions of a community. It may be this simple in the abstract, but of course; there is a natural complexity that must be appreciated. The Prueitt voting procedure [35] is the simplest form of this tri-level account.

We can be aware of the contents of a time lens, but cannot always project meaning from some mental state into words. There is good neuropsychological evidence for this. There is evidence from a reading of category theory and logic that suggests that meaning cannot be projected into standard closed formal notation, in spite of some logicians' misuse of the word “semantics”. According to the evidence, as we have interpreted it, a mental state is a spectral lens that is performing transformations of the consequences of generators (or carriers) of metabolic, conformational and energetic states into and out of a spectral energy domain [2]. One may not be able to observe the actual generators. All one can observe is the spectral state of “middle world” things.

An analogy made in quantum-neurodynamics may be useful here. States in the spectral domain consists of energy frequencies and amplitudes. In this domain, the actual energy frequencies are encoding and relating the properties of the full contents of instances of actual awareness, including perceived causes and anticipated consequences.

Routing and Retrieval of Data

So now we return to questions about how a neurobiological model might serve as a metaphor for the design of new software systems. The text retrieval programs funded by various governments, beginning in the early 1980s, developed the search methodology that we see in today's web search engines. The graph of the relationship between precision and recall is the standard way to measure the effectiveness of web retrieval tasks. The precision falls off steeply as one expects more recall. Unfortunately, everyone sees this poor performance when one does a search on the web.

All current methodologies produce precision recall graphs that bow in below the straight line connecting the point (0,1) with (1,0). This is a concave graph, and indicates that the probability of getting the next element in a retrieval list correct (assuming this notion of correct is available - of course) is less than the ratio of available correct elements to incorrect elements.

The tri-level algorithms provide precision-recall graphs that are convex. To obtain convex precision-recall graphs, the characteristics of computation must be better aligned with the true characteristics of human discourse and cognition. This means, in essence, that the semantic linkage between what are otherwise independent logical tokens, the words in the search string, can be better accounted for by a tri-level search engine.

The Prueitt voting procedure reflects a specific philosophy. The interpretation of the constrained assembly of a bag of logical atoms (inference) is to be made by the application of the voting procedure in the presence of a category policy. This computational procedure produces a ranking of the categories into an assignment policy. As should be expected, non-computational aspects of the awareness event are not captured in the formalism and depend on human intervention. This leads us back to the user and to our joint work with Russian logicians on perceptual acuity and induction engines [30].

Some Historical Background

The reader is reminded of the early mathematical models of theoretical biology that were developed in the 1950s and 1960s. These models involved differential equations, switching nets and category theory. Detailed work on specific neural circuits revealed certain general systems properties including: 1) associative learning, 2) lateral inhibition, 3) opponent processing, 4) intra-anatomical neuromodulation, and 5) cross-level resonance [18]. While these late twentieth century advances have proved significant, it is argued that the attractiveness of, and the hope for, a single theory of brain function, perhaps based on the computer metaphor, misled basic research in cognitive science.

For example, Lynn Nadel makes a point to frame the current interest, in how learning and memory is organized, as a counter intellectual current to long held dominant scientific positions that, incorrectly, hold there is but one general long-term memory system [19]. In his analysis, analysis shared by others [20], the fixation of memory theorists on the possibility of a single model can be traced to, the absence of, operational definitions of what is a "system" Nadel's conclusions, also shared by others, is that multiple memory systems exist; memory is involved in all or most of neural processes; and that experimental methods have defined the functional and architectural characteristics of distinct types of learning and memory.

General system properties have motivated the field of artificial neural networks and the related fields of computational control theory. The theory of embedding fields, Stephen Grossberg's original formulation of a methodology for modeling neuronal networks, envisioned the development of a body of computational algorithms that described the neuropsychology, the neurochemistry, as well as other experimental evidence, regarding the mechanisms involved in human perceptual and emotive actions [21, 22].

In some schools of thought, theories of field dynamics and ecological psychology were used to extend and overcome some of the limitations of early methods. Central to these limitations are the various forms of a "vector representation hypothesis" that assume vector space mathematics to be sufficient for modeling biological activities. The early methods depend strongly on this notion of a vector representation of the stimulus trace, but the notion of a vector representation has not provided the complete mathematics of neuronal computation. Specifically, no general theory of micro to macro transformations of information has yet developed that fully captures the essential notions of emergent computation and cross-scale entanglement.

Bits and pieces of a general theory do exist, though scattered in different disciplines. For example, notions of cross-scale entanglement exist in the historical literature of quantum mechanics. In the various schools of ecological psychology, behavioral cycles are described as having a supporting substructure and having an open environment in which cyclic behavior is expressed. Furthermore, behavioral cycles are seen to have distinct modes and to be emergent from an interaction between environment, self and substructure. Action/perception cycles are seen in ecological physics and psychology. Partition/organize cycles are seen in models of molecular computation [23].

The notion of cross-scale entanglement arises from the logic of quantum mechanics and gives rise to various "quantum metaphors" for looking at consciousness and awareness. The cross-scale entanglement issues, as well as empirical evidence on the formation of compartments and the stratification of matter and energy in time, lead us to restate many fundamental questions about the relationships between psychological objects of investigation and physiological objects of investigation.

Academic schools of artificial life and emergent computing make definitive contributions to a general theory of micro-to-macro and macro-to-micro transformations. Many interesting and valuable results are obtained. However, these schools of thought have never successfully addressed such issues as enigmas seen in quantum mechanics, such as Bell's inequality. Bell's inequality formalizes a time-backward flow of information (or instantaneous transfer of information) from one quantum mechanical event to another. Nor do these schools successfully address some hard questions posed by Penrose [24] about non-algorithmic aspects of human awareness and social communication.

Conclusions and Strategy for Future Work

My work has focused on the ecological theory of perception, a school of thought founded by J. J. Gibson and related to the work of Alfred North Whitehead and Charles Sanders Peirce; and on the neuropsychological experimental literature. The ecological school and the neuropsychological literatures can be seen to support the viability of computational models of human knowledge-sharing that have organizational levels and rare cross-scale transformations (of information). The transformation of energy in a hologram is a physical example of cross-scale events. But why can a transformation of energy distributions be used as a means for experiencing knowledge? How are specific energy distributions and information related? Are the views expressed here the basis for a science of knowledge?

One can imagine that occasional cross-scale transformations are projecting ecological affordances (the structure of within scale causation) from one level of organization to another. The set of such affordances are expressed in value chains and knowledge life cycles [36]. However, we conjecture that the value chains in business systems cannot be reduced to tangible elements only. Some intangible assets are also present and must be accounted for in knowledge management methodology [33]. This accounting is best made by humans, and the results encoded into knowledge ontologies.

Human reasoning is considered as consequences of a complex process and representable as explicit rules only in an approximate sense. Database and SQL type business rules provide some value to organizations, but then the same system of rules enforces an unavoidable limitation when the need to know is greatest, for example when there is a crisis.

To obtain a full understanding of our theory of stratified complexity, it is necessary to review the contributions of the Russian semiotics schools, including the foundations of applied semiotics [24]. It is here, in the author's opinion that the underlying foundation for knowledge science has advanced further than any other place. The work in Russia has been and will continue to be delayed due to the terrible economic conditions in Russia. However, this delay need not impede our integration of the Russian work with our perceptions on the physical basis for human reasoning (discussed above.)

As a first approximation, the Russian logic and semiotics schools can be organized into three parts. The first part has to do with the semiotics of reflexive control [26] and has deep historical significance in military philosophy. The second part has to do with the semiotics of control and a theory of intermediate languages [27]. An intermediate language is a computational language that is sufficient to describe the various behaviors of an object under control. The third, and for the author the most significant, is the development of Quasi-Axiomatic Theory (QAT) by Victor Finn and his colleagues [28].

A new paradigm may explain more of the experimental literature in neuroscience. This new paradigm describes technology architecture for text understanding, and for a general class of computational aids to human reasoning and information gathering.

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Biography

Paul S. Prueitt, Ph.D. works in technology areas that include technology evaluation, product definition, software conceptual and logical design, programming team building and management, collaborative tools and algorithms. He has taken a broad view of general systems theory, artificial intelligence, machine linguistics and algorithms, and is aware of the core algorithms of leading edge information push /pull technologies. He has addressed architectural issues, data modeling, programming, artificial intelligence, signal/image compression and processing, and knowledge technology implementations.

Paul has designed, prototyped and implemented commercial software systems targeted at integrating retrieval technologies, data mining and text/image understanding technologies. He has consulted for government agencies in the areas of artificial and synthetic intelligence and knowledge management systems. While in academia, he taught over 60 university level classes in mathematics, physics and logic. He developed collaborative systems on the Next computer and in the Next and Objective C development environments. At Georgetown University (1990-93), he was Director of the Neural Network Research Facility. He designed and coded simulation packages for research on artificial intelligence and behavioral neuro-dynamics. He used object classes to model concurrent processes, and communications between concurrent processes within transputer assemblies.

He has published articles on artificial and biological neural networks, knowledge engineering, information extraction and retrieval, decision theory, data mining, distributed computing, and human factors design methodologies. He discovered a database procedure called the voting procedure. The voting procedure supports the formation of statistical inference and reinforcement learning, and the automated routing of textual information. It is based in part on the neuro-psychology of human perception and on Russian core research in areas of semiotics and logic.