WALDEN UNIVERSITY

Core Knowledge Area Module 2:

Principles of Human Development

Student: Richard E. Biehl
Program: Applied Management & Decision Sciences
Specialization: Leadership and Organizational Change
Faculty Mentor: Dr. Gary Gemmill
KAM Assessor: Dr. Carolyn Calloway-Thomas

November 2002

Core KAM 2: Principles of Human Development

SBSF 8210 - Theories of Human Development

Abstract - Breadth

The breadth component outlines the core principles of human evolution and development; outlining biological, social, and cognitive areas of development. The central emphasis is on the integration and interplay of these developmental perspectives as an interacting system that demonstrates its own emergent properties not otherwise predictable from the unique perspectives. The measurement of time and space is offered as an integrating example before proposing cognition and language as another example to be pursued in the depth component.

Core KAM 2: Principles of Human Development

AMDS 8222 - Leadership and Human Development

Abstract - Depth

The depth component looks at the evolution of human cognition, beginning with the historical failure of reductionist scientific approaches to adequately explain consciousness and cognition and moving toward a quantum explanation that views mind as a direct emergent property of the electrical and chemical complexity of the brain. It then looks at how the biological evolution of increasing complex brain structures has led directly to the development of language capability; often using functions of the brain that have evolved for very different purposes. The way the brain has evolved makes language both necessary and inevitable. As a negotiated medium, language enables social structures and organization that would otherwise be impossible. The depth discussion culminates by pulling together these threads into a working model that leads directly to the analysis of the quality management professions that will follow in the application component.

Core KAM 2: Principles of Human Development

AMDS 8132 - Prof. Practice in Leadership and Human Development

Abstract - Application

The application component uses two specific case studies to illustrate the working of the memetic evolutionary model developed in the depth component. Specific benchmark words – quality, customer, supplier – are used to illustrate professional versus layperson usage and meaning; and to introduce the idea that the development of professional groups and their specialized languages are an expected and inevitable outgrowth of the same forces of human development that drove biological evolution earlier. Professions are seen as memetic species and described in ecological terms analogous to biological evolution.

Walden University **Doctor of Philosophy Program of Study**

Name: **Richard E. Biehl** Student ID Number: **062-50-5682** Enrollment Date: **December 1999**

Program: **AMDS** Specialization: **Leadership and Organizational Change**

Course Number	Course Title	Quarter to Be Taken	Credits	
Core KAMs				
SBSF 8110	Theories of Societal Development	Winter 2000-2001	5 Done	
AMDS 8122	Cross-cultural Aspects of Organizational Change	Spring 2001	5 Done	
AMDS 8132	Professional Practice and Organizational Change	Spring 2001	4 Done	
SBSF 8210	Theories of Human Development	Winter 2002	5	***Active***
AMDS 8222	Leadership and Human Development	Winter 2002	5	***Active***
AMDS 8232	Prof. Practice in Leadership and Human Development	Spring 2002	4	***Active***
SBSF 8310	Theories of Organizational and Social Systems	Summer 2000	5 Done	
AMDS 8322	Current Research in Organizational Systems	Fall 2000	5 Done	
AMDS 8332	Professional Practice and Organizational Systems	Winter 2000-2001	4 Done	
SBSF 8417	Research Seminar I: Human Inquiry & Science	Winter 1999-2000	4 Done	
AMDS 8427	Research Design in AMDS	Spring 2000	5 Done	
AMDS 8437	Data Analysis in AMDS Research	Summer 2000	5 Done	56
Advanced KAMs				
AMDS 8512	Classical and Emerging Paradigms of Leadership	Summer 2002	5	
AMDS 8522	Current Research on Leadership Development	Summer 2002	5	
AMDS 8532	Application of a Theory of Leadership Development	Fall 2002	4	
AMDS 8612	Model of Organizational Change & Development	Summer 2002	5	
AMDS 8622	Current Research Model Org Change & Development	Transfer In	0 Done	
AMDS 8632	Application of an Organizational Change Model	Transfer In	0 Done	
AMDS 8712	The Case Study as a Research Technique	Summer 2002	5	
AMDS 8722	Case Study Research in Leadership and Org. Change	Fall 2002	5	
AMDS 8732	Leadership or Organizational Change Case Study	Winter 2002-2003	4	33
Electives				

Transfer Credits

Course Number	Course Title	Quarter	Years	Institution	Grade	Credits	Total Credits
ECTI Program	Walden ECTI	-	1997-1999	Walden University	4.0	9 Done	
							9

Dissertation:	Implications of Systems and Complexity Theory on Organizational Process Maturity	30
Minimum Quarters of Enrollment: 10	Grand Total Credits	128

Student's Signature: Richard E. Biehl Date: Status as of May 2002

FYA/FM Signature: __________ Date: __________

Program Director's Signature: __________ Date: __________

VPAA's Signature: __________ Date: __________

Learning Agreement Approval Form

Received via e-mail on September 6, 2001…

Just a quick note to inform you that your KAM 2 Learning Agreement was approved and processed by OAA. Please keep a copy of this message for your records, and don't forget to enclose a printout of this confirmation with your completed KAM. - Stacey

Sender: ccallowa@win.waldenu.edu
X-Mailer: QUALCOMM Windows Eudora Light Version 3.0.6 (32)
Date: Fri, 31 Aug 2001 09:42:44
To: la@waldenu.edu
From: Carolyn Calloway-Thomas <ccallowa@waldenu.edu>
Subject: KAM Learning Agreement Submission

First assessor comments:
Richard Biehl's Learning Agreement is solidly built, challenging and insightful. Based on his work thus far, I am confident that he will write a beautiful KAM.

Student Information
Submission date: 08/30/01
Student name: Richard Biehl
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1st Assessor: ccallowa@waldenu.edu
Track: AMDS
Specialization: Leadership and Organizational Change
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KAM number: 2
Initial KAM: No,_not_initial_KAM
KAM title: PRINCIPLES OF HUMAN DEVELOPMENT
Estimated completion date: 11/01/01

Approved Learning Agreement

Self-Evaluation: Knowledge Area Modules (KAMs)

Student Name: Richard E. Biehl Date: November 2002

KAM: #2 Title: Principles of Human Development

1. What knowledge/experience did you bring to this KAM? How did you capitalize/expand on this base?

I had considerable experience in the organization of professional communities, being very active in many of the professionals groups and societies in my field. I was interested to learn how my experiences in these fields mapped into basic human development, although I had a completely different outcome and direction in mind when I began. I was well grounded in the kind of sciences that I needed to lean to develop this KAM, being particularly weak in the physical and biological sciences needed to write the depth component. One of the reasons that this KAM took so long to write is that I immersed myself in the science materials related to cognition; an investment of time that I am very glad I made.

2. Describe the quality of the **Breadth** section in the light of the intellectual and communication skills demonstrated in this KAM.

Much of the work we do here at Walden is oriented toward helping us see the world as a system, and to approach our social change focus as the implementation of systemic change. Well, the breadth component of this KAM clearly showed me the range of thinking that can be covered under such a system-thinking model. I was simply amazed at the range of issues and fields of knowledge that I needed to tap to get a complete picture of human development. Virtually nothing in our history remained outside of my view during the readings I did for this KAM. An impact of this is that this KAM ended up taking longer to write than any of my previous KAMs, even my initial KAM. But I'm very excited about the picture that has emerged here, and feel like it will influence my post-Walden work more than any other research I've done in my three years here to date.

3. In the **Depth** section, what key ideas/concepts most engaged your thinking and imagination relative to your area of study?

The area of *memetics* is fascinating. I love ideas, but I've never before tried to place the growth of ideas into an evolutionary setting; and the cognition work in the depth component created a direct link between biological evolution and memetic ideas. I love the idea that the most advanced human traits can be seen as the (dare I say *routine*) continuation of a natural process that started with our earliest origins and continues today.

4. Expound on the most meaningful theoretical construct studied and applied to your professional setting in the **Application** section. What can you do differently/better as a result of this KAM?

I can communicate better with my clients today than I could earlier. Awareness of the concept of unitization has helped me better identify and diagnose communication difficulties on large projects in which I advise. By seeing the differences people are trying to communicate using the same words, I am better able to intervene by invoking words and phrasings that help ease any cognitive dissonance created by the multiple uses of similar words. It has helped me close some gaps between professionals and laypersons with whom I work.

5. Briefly describe the most important **Social Issue** covered in this KAM.

For me, the most important social issues is just beyond what I've written here. I've started applying what I've learned to the field of second language learning. The concept of *voice onset time* explored in the depth component is the center of an understanding of what's going on in the second language community regarding vocal and language accents. I've learned enough writing this KAM to be able to participate in a project here at the University of Central Florida to develop a neurolinguistics on-line course for the ESL masters program in the foreign language department (I certainly don't know enough to compete in the biology department, but I can hold my own in the language department when discussing cognition and neuroanatomy). We're using the concept of VOT to help English teachers understand what's going on with their learners' accents, and why it can be such a struggle for learners to get past these accent issues. For me, this is a wonderful reward for the effort put into this KAM.

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Chapter 1

Introduction

Overview

This knowledge area module looks at cognitive aspects of human development, focusing on understanding the technology of language and how it affects our cognitive and social being. Humans are great thinkers, but the ability to think in new ways was clearly a large part of what it meant to become human. The ability to reason, foresee, and be self-conscious had to develop in order to reach the cognitive level that we currently associate with humanity. This raises the chicken-and-egg problem of cognition: Was humanity pushed into existence by an ever improving cognitive ability in support of expanding actions, or did humanity pull itself into existence by developing through its actions increased need for more cognitive capability?

Within the study of cognition, the development and meaning of language plays a particularly important role. Educators have learned the importance of language in structuring the constructivist networks needed for basic and advanced learning. Organizational development specialists are increasingly relying on language and metaphor in shaping the thought processes of individuals and organizations. (Bolman & Deal, 1997; Clancy, 1989) This KAM explores the implications of this shaping for the development of specialized language and vocabulary as a defining element of a profession and its members.

KAM Objectives

Specific high-level objectives for this KAM are:

1. Compare and contrast the variety of theoretical areas associated with human development in order to identify a framework for analyzing cross-disciplinary issues related to cognition and language. (Breadth)

2. Explore and discuss the implications of this framework for developing a cognition-linguistic model for analyzing and understanding the development of professional social groups in modern society. (Depth)

3. Apply the resulting model to the case of a specific profession, making observations on applicability and further improvements of the model. (Application)

Breadth Objectives

This breadth component explores the large variety of theories that deal with human development. The aim is to look for how different aspects of human development inhibit or support other aspects of human development; a kind of systems theory of human development.

Specific breadth objectives are:

1. Explore and categorize the various theories for understanding human development described in the literature, including biological, socio-cultural, cognitive, and psychological perspectives.

2. Compare and contrast these theories to develop a framework that integrates common or shared themes that are impacted by more than one of these theoretical areas (e.g. speech requires aspects of all four categories, religion is both psychological and socio-cultural).

3. Identify components of this framework that emphasize cognitive development generally, and language development specifically, for further exploration in the depth component.

Structurally, this breadth component introduces the major categories of developmental theory individually, before comparing and cross-classifying aspects of each theoretical area for the purpose of identifying threads of support or inhibition that cross theoretical boundaries and constructs in the conclusion. The conclusion emphasizes the cross-theoretical aspects of language development, emphasizing cognitive impacts for further development in the depth component.

Human Origins

Somewhere between 10 and 20 billion years ago, our universe of energy in spacetime came into being, probably as a result of some boot-strapping quantum fluctuation that we do not yet understand. Regardless of its origin, the stage was set for all of the necessary steps that would lead to the origin and development of humans. Humanity, however, would be a late entry character in the story of the universe.

The beginnings of our origins would see the early energy of the universe take the form of matter in a rapidly expanding space. Due to the local curvature of the spacetime around this matter, exotic objects would be created, evolve, and die: stars, galaxies, clusters, super-clusters. The death of some of these stars as supernova provided the dramatic conclusion for this first part of our origin - an infusion of the heavy elements into interstellar space.

The second phase of our origins, the dawn of our solar system and planet, was made possible by the presence of these heavy elements in the region of space from which our sun and its planets were formed. Only the late generation stars like our sun contain the elements necessary for the formation of life as we understand it. It was the radiation from our sun, coupled with the primordial environment found on the earth, that allowed the early vestiges of life to form on our planet 3.5 to 4.5 billion years ago.

Primitive life forms could only have come about under conditions like those found on the early Earth. Reactions that led to the formation of the needed nucleotides and amino acids could only have occurred in the Earth's reducing atmosphere. The presence of oxygen in the early atmosphere would have prevented the dawn of life since molecular oxygen would have caused the decomposition of these carbon-based molecules.

The on-going development of life on earth has continued to be played out random scene by random scene up to the present day. From the earliest vestiges of life eventually came the first cells that were able to reproduce themselves. These earliest of cells, most likely fermenting bacteria, used the carbon-containing primordial environment as a source of needed energy. Eventually, chloroplasts evolved with the ability to photosynthesize, proliferating the availability of oxygen in the earth's atmosphere. This oxygen supported the evolution of the process of oxidizing glucose into carbon dioxide and water that supported far more efficient production of adenosine triphosphate (ATP) molecules; dramatically increasing the energy available to the increasingly complex organisms.

Molecular oxygen, that during the period of the early Earth would have prevented life from taking hold, is essential to the development of more and more complex life forms with their concomitant need for greater amounts of energy. Life's increasing need for nutrition, brought about by more and more complex metabolic processes, caused the need for the evolution of locomotion and extended sensory capabilities. Within another 2 billion years, the eucaryotic cell, with its nucleus of DNA, allowed for the tremendous proliferation of life forms made possible by the advent of sexual reproduction.

Up until this point, life had been developing exclusively within the vast oceans on the surface of the Earth. The presence of our moon created the survival incentive for life to evolve an ability to withstand the withdrawal of water. With the tides rising and falling each day, many marine life forms found themselves stranded on those early beaches. Most perished, unable to adapt because of tidal actions measured in hours rather than eons. But eventually, as is bound to happen in any random process, a primitive life form survived this trauma. Life had established a beachhead.

The reptile's evolution of the shelled egg made the proliferation of life on land possible by limiting life's dependence upon the sea. The demise of the reptiles, with the extinction of the dinosaurs, 65 million years ago allowed mammals to flourish. With the more complex visual and auditory systems of the evolving mammals came a sensory modeling of the environment which directly led to the ability to reason, judge, and be self-conscious. The development of long-term memory brought about the ability for abstract and conceptual thought. Humanity appeared as a logical step in this process. The shift from the evolution of the individual to the evolution of the group – of culture and society – was a natural by-product of the cooperation enabled by the shift from physical to mental features; of the development of conceptual reasoning and abstraction; and the development of the language skills needed to further that evolution.

Ferris (1988) suggested that humanity's societal state of evolution and development not be viewed as an end-state, but as just another step in the evolution of the universe. He posits that life such as humanity has undoubtedly evolved elsewhere in the universe, and that the cultural, psychological, and technological reaching out into the universe is the evolutionary step needed for these multi-faceted life systems to connect into one vast universal life consciousness. If so, then societies are simply the building blocks of a galactic organism or consciousness.

He compares the emotions of love and curiosity to illustrate the subtle ways in which evolution plays out through functions that appear to be less than survival-oriented. Love – the love of poems and great literature – is a key part of humanity's culture and heritage. Yet love's ultimate function is to perpetuate and advance our species through the evolutionary tunnel. The curiosity that has propelled science and technology to pinnacles, can be likewise be viewed evolutionarily as a form of galactic outreach ensuring humanity's survival as a component of a larger emergent life form. "Life might be the galaxy's way of evolving a brain." (p. 379)

Regardless of whether one accepts such a conjecture, evolution has laid the groundwork for a discussion of the details of humanity's development. In the following sections, this KAM explores human development through four disciplinary filters: 1) biological, 2) socio-cultural, 3) cognitive, and 4) psychological. It then focus on language and the origins of language against the backdrop of those filters.

Scientific Storytelling

All of the information conveyed in this KAM is taken from modern texts that try to tell the story of the past. Thompson (1996) warns us that in our age of science we can easily forget that what actually unfolds in science is a story that may be more or less true. This approach to storytelling, at its base, is no different than the mythic and religious stories of our ancestors. The data may be more accurate today, but storytellers have always tried to make their stories as real as possible. Details might be wrong, but they will be corrected in future tellings. Having said that, what follows is a story of human development.

Chapter 2

Developmental Disciplines

Introduction

The general epistemology of this KAM is scientific. Science, deduction, and informed inference can, and does, lead to effective discussion and learning about the origin and development of humans. This perspective is a modern one, and has itself been evolving since the Renaissance, with many, even today, resisting the conclusions and inferences of the most modern of sciences: quantum mechanics.

Descartes (1596-1650) saw animals as automata that could best be described using a mechanistic view. Humans had intellectual capacities and reasoning that set them distinctly apart. He denied the physical but granted humans a mind (1987, p. 17), seeing it as the manifestation of an immortal soul, a direct creation of God. If humans were to understand humanity, it would be through religion. Animals, as machines, were a subject for philosophy and science.

With the development of the science of the Renaissance, Descartes' position was to be challenged as scientists looked more and more at animals, and more and more at humans, and inevitably observed similarities and began to draw conclusions about structure and function. Within a century of Descartes' analysis, Le Mettrie (1709-1751) was agreeing with the mechanistic view of animals, but was seeing humanity as only differing in complexity from those mechanistic animals. "A man (is) distinguished from the ape and other animals only as the ape himself is distinguished from the other animals." (1994, p. 41) He saw humans as, in many ways, more animal in nature than many animal species, noting the complete dependence of newborn humans. (p. 47)

Le Mettrie's theme was that much of the complexity of humans rested in language. "What was man before the invention of words and knowledge of language?" (p. 41) Again, he was identifying a difference in complexity of communication rather than an absolute differential between humans and animals. "Everything (could be) reduced to sounds or words which fly from the mouth of one through the ear of the other into the brain; which receives at the same time through the eyes the shapes of the bodies of which these words are arbitrary signs." (p. 41) Language was the most complex of the complexities that separated humans and animals.

Within another century, Pasteur was differentiating life as a specific process to be studied. (McFadden, 2001, p. 10) Working with yeast as part of the brewing process, Pasteur identified specific features in the chemistry of live yeast that clearly differentiated the living organism he was studying from an analogous chemical compound. When the crystals that make up yeast were synthesized in the laboratory, they appeared roughly equally as left-handed and right-handed molecular structures. The same crystals in yeast always occurred as left-handed. These systems isolated entropy in specific ways unseen in non-living matter; such patterns were characteristic of life.

Pasteur had drawn a line between chemistry and biology. The *biological* was more than a *chemical* process; and microbiology and biochemistry as separate disciplines were the result. These disciplines continued the trend in reductionism in science as a primary epistemology in the understanding of humanity and life. Such reductionism would reign unchallenged for another hundred years.

While the reductionist study of life produced both theoretical and practical outcomes, it also led to the increasingly unavoidable conclusion that the life being studied was dependent upon an extremely complex set of circumstances and conditions to explain its origins and evolution. Reductionism led to increasingly discrete components that became less and less likely to occur and so actually became harder and harder to explain. This led to the twentieth century explanations that converge at current thinking about the mechanisms and probabilities of humanity's origins. The anthropic principle and quantum mechanics that are discussed in the introduction to the depth component highlight these perspectives.

A developmental discussion that includes quantum mechanics will bring the discussion full-circle back to Descartes' position that "there is a great difference between the mind and the body, inasmuch as the body is by its very nature always divisible, while the mind is utterly indivisible." (p. 59) Until recently, taken as a quaint depiction of mind-body duality in a highly religious age, quantum mechanics has shown that Descartes was very much on the mark. This issue is pursued in more detail in the depth component.

Mechanisms of Development

Before getting into the specific disciplines of human development, the mechanisms that drive those disciplines need to be defined and explored in order to illuminate exactly what is happening in the changes that are characterized by each discipline.

Coevolution

A key developmental driver is the idea of *coevolution*, or the notion that changes in one species or domain can and do initiate changes in other species or domains, and that such interaction needs to be understood and addressed in order to appropriately discuss change in any single context. This systems-oriented viewpoint describes interactive change as being driven by both positive and negative feedback interactions across species or domains.

Kampis and Csány (1990) describe the debate over coevolution as characterizing the mechanism as either extremely rare, or as among the most common of developmental drivers. Opponents of the coevolutionary viewpoint argue that there are few real coevolutionary events, while proponents claim that coevolution is the central basic event of evolution. System theory tells us that evolutionary events can't be interpreted completely within single populations. Kampis and Csány argue that systems theory supports coevolution, with populations being the key components of relevant study. (p. 394)

Adaptationism

Another key mechanism of development is the concept of *adaptationism*, or the idea that development is driven by changes that continually adapt an organism or domain toward being a better fit with the environment or circumstances in which it finds itself. Jablonka, Lamb, and Avital (1998) warn against thinking of the environment as passive in this adaptive relationship. Most Darwinist thinking describes selection as choosing from amongst alternatives that are more or less adaptive to the environment in which the adapting individuals find themselves. In fact, much neo-Darwinist thinking places the environment in a very active position; actually guiding much of the adaptation taking place.

Examples of adaptive mutations, in which genomes actually adapt differently based on the environment in which they mutate, provide examples of extreme levels of interaction between organisms and their environment. The evolution of culture and oral traditions are an example of extended Lamarkian inheritance, where knowledge and ideas are adapted and inherited by inter-generational transfer at the other extreme of the continuum. Less extreme adaptations that involve the environment include the evolution of genes that can turn themselves on and off depending upon changes in the environment.

Jablonka, Lamb, and Avital assert that evolution itself has adapted these forms of adaptation to the stresses involved in the relationships between individuals and their environment. (p. 208) For stresses that are relatively short relative to the lifespan of an individual, evolution prefers to use the physiological triggers of genes being turned on and off to control adaptation. For long stresses, where the environmental changes involved last many generations, evolution prefers the more traditional genetic evolution. The type of environmental change drives the type of adaptations that evolve; a bi-directional relationship. Once the environment is linked to adaptations, and coupled with the coevolutionary dependencies seen across species and niches in the ecosystem, evolutionary theory is today very different from the traditional simplified models originally proposed by Darwin and his co-theorists.

While accepting adaptationism as a key driver of development, Pinker (1997) also warns against presuming a functionalist purpose behind such adaptations. Not all aspects of morphology, physiology, or behavior should be attributed to be adaptive optimal solutions to some original problem presented during evolution or development. Many observed functions that might be reverse-engineered from existing species or domains are likely to represent evolutionary drift, developed as a systemic by-product of some other adaptive change in the history of the organism or domain. Pinker agrees with the assertion that adaptationism drives much evolution and development, he simply insists on a logical separation between those adaptations and any resulting functions that take advantage of them. (p. 165-166)

Variation

Gould (1996) argues for *variation* as a primary mechanism of development. While many view the results of successful development as central to any discussion, Gould asserts that the trends and stories illustrated by unsuccessful groups are important to an understanding of developmental change. While many describe developmental change as the branching of alternatives, he sees a more divergent and robust collection of possibilities; an “evolutionary bush” from which periodic branches emerge. (p. 64) Between any two developmental nodes, a relatively straight branch of descent can be drawn. But this branch is usually drawn in hindsight, and largely ignores the bushes along the way through which the branch passed. The collection of variations depicted in the bush is a truer picture of what is going on during the coevolution and adaptationism that is driving change.

Descent & Selection

Coevolution, adaptationism, and variation drive change through *descent*. Darwin (1859) argued that it wasn't enough to simply observe the descent of change. The descent of changed characteristics is relatively obvious to any observer who chooses to look. One needs to understand the means through which such descent occurs in order to make sense of the long-term changes that are observed all around us. Darwin offered *selection* as the bridge between random adaptationism and observed descent of characteristics. (p. 3) Natural selection prunes Gould's bush so that branches emerge from a bush that would otherwise simply continue to grow bigger and bigger.

Natural selection leads to extinction or divergence, never staticness. It drives improvement into otherwise divergent and ever-varying adaptationism. Coevolution drives systemic effects so that individual lines don't evolve and change independent of other lines. Gould's bush is intertwined in ways that make individual divergence rare. These mechanisms of development result in a wandering system that is driven by continual change. Development is a scanning and searching of alternatives presented by a world of constant change.

The functions that we assign to some of those changes say more about our own worldview and expectations than about any intention or purpose inherent in the constant change itself. This opportunistic searching is at the heart of any particular discussion of development, whether biological, socio-cultural, cognitive, or psychological.

Biological Development

The story of the development of humans first requires the existence of humans, and so begins with biological development rooted in evolution. Gould (1983) credits Charles Darwin (1809-1882) with the establishment of the *fact* of evolution while he proposed the *theory* of natural selection. "Darwin acknowledged the provisional nature of natural selection while affirming the fact of evolution." (p. 255)

Punctuated Equilibrium

The concepts of evolution developed early on through observation and comparison of existing contemporary species and careful retrieval and study of the fossil record. The biggest problem with this approach was the absence of clear linear fossil records depicting the steady development of species that were expected in the early investigations. Huge gaps were seen in the fossil record. Because such gaps were unexpected, they presented problems in early evolutionary studies.

By 1972, Gould and Eldridge had turned this problem into a scientific opportunity with their theory of punctuated equilibrium. They argued against a smooth or gradual pace of change in evolution, instead suggesting a jerky or episodic explanation. The development of biological species was characterized by geologically sudden origins followed by long periods of stasis. Such periods often lasted millions of years during which few changes occurred among contemporary species across ecosystems. These long periods of stasis were what was showing up in the fossil record as gaps.

Gould and Eldridge weren't arguing against evolution; they were asking that the scientific method be applied to evolution more rigorously. (1993, p. 223) Early evolutionary studies, they argued, were tainted by the simple expectation that the fossil record would be smooth and linear. Holes and gaps in the fossil record were seen as problems for the theory. There was simply no reason that such an expectation needed to be true. Gould and Eldridge proposed the motto, "stasis is data," (p. 223) and simply pointed out that the stability implied by the fossil gaps were the single most common palaeontological phenomena observed. A proper scientific theory had to include such a common observation.

Using their punctuated equilibrium, the newly revised theory of evolution now made predictions that included the very gaps that were presented as problems by the old theory. (Gould & Eldridge, 1993) Gould (1983) described the "inertia of large populations" (p. 260) as precluding the kind of systemic gradual and constant change that early evolutionary theorists had expected to find.

Embryological Recapitulation

While the fossil record allows a glimpse of evolutionary change, it does not actually allow for its direct observation. To understand human development in terms of evolutionary development, one looks at the development of the embryo. Embryonic development is dependent upon the ability of genes to turn on and off at important points in development. Evolutionary change is driven by the engine of gene mutations altering the form and manner of gene expression.

Small changes in gene expression have big and significant impacts upon development. As such, evolutionary biologists believe that genes expressing themselves in early embryonic development represent the older roots of evolutionary development. Natural selection favors change in late development simply because each change impacts smaller and smaller portions of the whole system once that system is fairly developed. The developing embryo will, therefore, be expected to resemble more general evolutionary forms during its earliest development, and to enable more unique and species-specific structures as it nears full development. It recapitulates, or retraces, its own evolutionary development. Each individual passes through its entire genetic heritage while in embryonic development.

Richards (1992) describes how recapitulation can be used to explain and illustrate the way biologists organize and understand the various life forms and genetic expressions they observe and study. Two different contemporary species will be unique expressions of gene identify. However, if at some point just prior to final development they expressed more similarity than seen in the fully developed individuals, a homologous resemblance is noted that indicates a common lineage. The resemblance doesn't mean that one of the species descended from the other, but that there was likely a common species from which both evolved.

This is the basis of the evolutionary tree of life. A hierarchy develops (e.g. species, genus, family, class, order) that can be used to explain the genetic and fossil records, particularly in identifying developmental similarities and gaps. Two species in the same genus resemble each other genetically more than either resembles a species in another genus. The lower in the tree one must go to discover a common origin between two species, the more different those two species are, and the earlier in embryonic recapitulation the two species must be studied to observe the similarities in origin. Two species in the same order but in divergent classes will present few similarities.

Darwin (1859), not yet using the term recapitulation, observed these homologies and groupings as *communities*, noting that the "community of embryonic structure reveals community of descent." (p. 449) This concept will be a central focus in the depth component of this KAM when the origin and development of consciousness and language are explored. Each will be dependent on many pre-existing structures and cognitive functions found across the entire primate class, and so will be seen as having origins long before the evolution of humans.

Morphogenesis

Understanding the organization and interdependencies of species development leads to the hierarchical tree of species through homologous structure observed through recapitulation. But where do those species come from? Bremermann (1973) describes the growth of forms – morphogenesis – as a property of all dynamical systems. The system of genetic life can be expected to transition among a variety of states according to dynamical laws; dynamics that we describe using the concept of evolution. (p. 29) Evolution explains the system in transition.

Species, then, explain the system not in transition, but stable. Evolution passes through dynamical states, with a species being a temporary snapshot of these states when it finds an attractor. Because there are many species, we know that each species can only be optimal locally. (p. 33) Evolutionary biologists describe such local optimums as *niches*. In a dynamical system, it takes considerable energy to drive the system away from a local optimum. The system will typically remain stable for long periods, only periodically being disturbed enough to find a new attractor. This dynamic exactly describes Gould and Eldridge's punctuated equilibrium.

A key problem in such a dynamical system is explaining its origin: What drove the first state change that initiated the system? In popular terms: What created life? McFadden (2001) argues an explanation of the origin of life requires quantum mechanics. In fact, he goes so far as to call life the only macro-world macro quantum system. This theme is picked up and explored in the depth component of this KAM.

Social & Cultural Development

Biological development, driven by natural selection, eventually resulted in functions, capabilities, and dispositions that gave rise to social and cultural developments within and across the species that were developing. Whether or not such developments are characteristic of human development, or can be traced to earlier forms through the evolutionary tree, is a question of timing. The driving selective mechanisms are of interest regardless of any position taken on the timing of such developments.

Potts (1988) outlined four interacting life systems, the development of which offered selective advantage that would have favored the eventual socialization of species developing them: 1) locomotion and habitat, 2) reproductive, 3) brain technologies, and 4) foraging diets. (p. 7) His focus of analysis was on early hominid activities in the Olduvai regions of modern Kenya. The early hominid locomotion was bi-pedal, and habitation was generally in open vegetation environments. Their continual interaction, even if in small numbers, was inevitable under these conditions.

The reproductive system of early hominids resulted in offspring that were highly dependent on their parents for survival, necessitating economic bonding of, at least, male-female pairs in order to assure the success of reproduction. These early hominids were already heavily dependent on complex tools for hunting and gathering food, and so symbolic representation and language would have been important for transmitting the abilities and techniques of such tool making and use to each successive generation. Finally, with a diet that included hunted protein and gathered starch, specialization of foraging and hunting skills would have exceeded the general capacities and time available to individuals.

While the use of these four evolving systems provided selective advantage that favored their continual development, they also gave rise to the selective pressures that would result in socialization. Hominids exercising these advanced systems in isolation simply would not fare as well as those who developed mechanisms for cooperation and cohabitation. Once developed, Potts speculated that a "premium was placed on cooperation, language, and socially accepted means of delayed reciprocity which characterize human societies today." (p. 249)

Home Base Hypothesis

This predilection toward cooperation as an integrating element of these four systems is embodied in the Home Base Hypothesis, characterized by Potts (1988) as the establishment of centralized social homes that provided a spatial location and focus for food exchange, food consumption, and other social activities in relative safety. Such home bases existed in human history and pre-history for over two million years as the precursor of relatively modern hunter-gatherer groups. With the hypothesis built upon food gathering and food sharing requirements, the food technologies of modern humans have eliminated the need for such centralized home bases as a means of survival, such an evolutionary past has done much to shape modern human behavior, no longer completely dependent upon the variables controlled through such behaviors.

Early evidence for the Home Base Hypothesis is found in the archaeological record left by early protohuman hominids. (Isaac, 1978) As early as the period of the Kay Behrensmeyer site in Kenya, and other Olduvai sites studied and reported by Mary Leakey, Zinjanthropus was practicing behaviors characterized and explained by the Home Base Hypothesis roughly 1.7 to 2 million years ago. Important support for the hypothesis comes from the extensive evidence that stones and meat were being carried over fairly long distances. (p. 99) Stones of significant size are found at sites several kilometers from their geological origin, having been transported to central locations in sometimes large numbers.

Evidence is also available of animals of diverse species that would have been unlikely to have naturally been found collocated during the period. Bones are found in large numbers. Many, if not all, of these animals had to have been transported to these locations; presumably still containing meat rather than simply as debris. The transport of such large numbers of bones for the purpose of consolidating debris is inconsistent with the behavioral patterns of any known contemporary, or historical, species or group. Isaac suggests that such evidence offers direct support for a conclusion that food and stone tools were being systematically transported to protohuman sites throughout this period.

This evidence leads directly to the Home Base Hypothesis. While there is no way to go back and actually observe the behaviors and intentions implied by such a hypothesis, it is possible to piece together the logic of the hypothesis from available records and observations in ways that no other hypothesis seems to fit nearly as well. (Isaac, 1978, p. 99-103) Clearly almost two million years ago, at least some hominids were carrying things around over extensive distances, illustrating that the bi-pedal locomotion necessary for freeing the forelimbs was already stabilizing in populations. Some hominids were making stone tools in the same areas in which large animal carcasses were present. The presumption that at least some of those stone tools were used to remove meat from those collocated animal carcasses seems reasonable. Even if the association between the tools and the food is discounted, the record still clearly indicates that hominids were carrying around food and concentrating it in localized places.

Isaac points to this logic as clearly indicating that early protohuman hominids were diverging dramatically from the dominant primate practice of consuming food while ranging, usually very near the location in which the food had been caught. (p. 100) The natural question then, to which the Home Base Hypothesis is offered as an answer by paleontologists, is: What evolutionary advantage would such consolidating behaviors offer?

The Home Base Hypothesis embodies a model where food sharing is the central element. This capability required a tool to serve as a carrying device in order to gather enough food to be worth sharing. Isaac attributes to Richard Lee of the University of Toronto (without a citation) the suggestion that the invention of such a carrying device (e.g. a bark tray perhaps) was the basic turning point that enabled the evolution of humans. (p. 102) Cutting tools would have been needed in the field for cutting up larger animals for transport to the home base; presumed to be necessary because the fact that the typical hominid would have had trouble carrying more than 30 kilograms at a time. Additional tools would have been needed for cutting up these larger animal parts that were carried to the home base.

The Home Base Hypothesis tends to concentrate on animal consumption because of the presence of direct evidence for this food supply in the record. Evidence also exists for the consumption of plants at home sites; primarily observed tooth wear and analogy with modern hunter-gatherer food patterns. Both plant and animal consumption involved more and more complex tools as sites appear later and later in the archaeological record. Isaac describes this increase in tool complexity over time as an indicator of the increasingly complex cognitive and cultural development of hominids as they evolved toward becoming human.

Isaac sees three direct paths from the behaviors implied by home-base thinking to the social development of modern humans. (p. 106) First, the ability to share information would have conveyed an evolutionary advantage in the home base setting, necessitating an eventual evolution of language ability. Communication would have fostered improved social adjustments among individuals now collocated at the home base, and even would have allowed for the use of misinformation to be shared. Second, such social exchanges that might involve either information or misinformation would have provided advantage to those individuals able to recognize and act upon reciprocal social obligations created through such communication. This eventually would result in an ability to calculate complex and lengthening chains of contingency and obligation into the future, based on communications in the present and past; an essence of complex modern social structures. And third, the need to procure the food and other resources necessary for child-rearing would have necessitated particularly strong relationships between mates, eventually giving rise to the arrangements of human marriage.

The Home Base Hypothesis can never be proven; but its explanation of the data in the archaeological record is comprehensive and self-consistent, and the hypothesis fairly accurately predicts the development and existence of most social structures and relationships observed in early human civilizations. It describes the evolutionary advantages of home base practices in terms of shelter from predators, and the feeding and care of the young; both significant problems in any explanation of an evolution of hominid toward humans. It also offers a driving force to the specialization and division of labor that appears in many protohuman and human populations.

Potts (1988) describes the home base as providing for a predetermined area for the focus of activity, which in turn allowed for the primary spatial setting in which social activity would have developed among collocating individuals. This social activity among such interacting collocated individuals would have led to an exchange of diverse resources, and ultimately to a separation or specialization of the skills required to acquire and adapt those resources. This food sharing drove the evolution of complex social reciprocity. (p. 249-251) Without such drivers, observations that can be generalized from many modern ethnographies of contemporary and historical social groups would remain unexplainable.

Cognitive & Psychological Development

The above discussion of biological evolution helps explain the origin of our species in terms of the big picture of genetic evolution across the plant and animal kingdoms. The Home Base Hypothesis helps explain how and why we live in the social groupings and structures in which we find ourselves. But neither model describes what it is that makes us decidedly human; different in a major qualitative way from other species that have evolved their own unique genetic and social structure. *Homo sapiens* are taken to be more than just the next incremental evolutionary step beyond some previous evolutionary developmental line. The differences tend to be not physical, but mental. Our cognitive make-up, itself a product of biological evolution, is where the distinction is most often described.

Mammalian Cognition

In an attempt to better understand human cognition as a result of evolution, Tomasello (1999) analyzed cognition in the broadest human lineage; mammalian, and then primate. The broad range of similarity was as striking as the specifics and power of the differences. (p. 15) Because all mammals share common cognitive capabilities, we know that such capabilities are very old in the evolutionary lineage; most being present in the small early mammals that opportunistically emerged from the evolutionary bush some 65 million years ago when the period of the dinosaurs was ending.

Mammals exhibit extensive cognition of their physical environment. (p. 16) They remember the location of things they have encountered, and can follow objects through space even when invisible because of some blockage or obstruction; indicating that mammals, in general, operate beyond Piaget's sensorimotor period. By noting similarities and differences among objects, mammals can categorize objects using multiple criteria; and can understand and work with small quantities. They take novel detours and short-cuts through space, and can use insight to solve problems they encounter; showing that they operate beyond Piaget's concrete operational period, exhibiting full formal operational capabilities.

Mammals also all share a broad range of social cognitive capabilities. (p. 17) They recognize individuals in social groups, and typically form direct social relationships involving kinship, friendship, and hierarchy. They can predict the behavior of collocated individuals based on the emotional state and physical movements of those individuals, and they can use social and communicative strategies among group members to compete for desired resources. They also engage in social learning; learning from each other using demonstration and guidance.

It can be difficult to imagine a full range of small mammals exhibiting such sophisticated cognition some 50 million years before even the dawn of primates. The difficulty of observing these cognitive behaviors in mammals of different species can easily create the impression that such capabilities are part of our unique humanness. To those who see the uniqueness of humans in our cognition, an understanding of early mammalian cognition can be humbling.

Primate Cognition

Tomasello found further cognitive similarities to humans when he focused his attention specifically on the primate branch of mammalia. (p. 17) In addition to all of the cognitive capabilities exhibited by all mammals, primates can categorize objects into logically relational categories that go well beyond the concrete characteristic categories available to all mammals. In addition, "only primates understand external social relationships in which they themselves are not directly involved." (p. 17) Where all mammals can understand relationships between themselves and other second-parties (e.g. kin, friend, dominant), primates can understand and act on such relationships between two other individuals.

As a result of such capability for social cognition, primates can selectively choose social relationships that will give them advantages in other third-party relationships. For example, an adult primate might treat the competitor of the group's dominant male poorly in order to gain favor from the dominant male. Such cognitive behavioral characteristics, common across all primates, evolved more than a million of years before the earliest proto-humans; thus removing an expected barrier to the Home Base Hypothesis.

As primate cognition becomes better understood, the distinction between primate and human cognition become increasingly important. Tomasello (1999) outlines common human cognitive capabilities *not* exhibited among primates. Primates don't gesture or point to an object in order to draw the attention of others to it; nor will they hold up an object in order to get a conspecific to notice or pay attention to it. They don't, as many humans would, bring conspecifics to a location in order to show them something. "They do not do these things," hypothesizes Tomasella, "because they do not understand that the conspecific has intentional and mental states that can potentially be effected." (p. 21) This difference represents a major turning point that appears to cognitively separate humans from the rest of the primates.

Non-human primates are both intentional and causal beings, and yet they don't define their world in intentional and causal terms. This is why primates don't show things to conspecifics; they don't see their actions as able to cause intentional or causal states in others. They see their conspecifics as animate beings capable of spontaneous action; and actually understand the emotional and locomotive behaviors they exhibit. This is the basis for the understanding of simple relationships exhibited among all mammals, and the particular understanding of third-party relationships among primates. What they don't understand, which humans do clearly understand, is that other primates are in the process of pursuing goals and exercising mental models the same way they are. Without such an understanding, non-human primates simply have no basis for ever trying to affect the intentions or attention of other individuals.

Human Cognition

This intentional-causal cognition "seems to be unique to humans." (Tomasello, 1999, p. 23) While all primates can understand the relationship between two events from the standpoint of one being antecedent to the other; only humans can understand intentionality or causality as the variable that mediates between the two. Humans focus less on the antecedent event, and more on the underlying cause or intention of the actor. This means that in order for cognition to be considered human in the evolutionary past, some primate needed only to develop this particular very narrow additional capability. Mammals had evolved an understanding of concrete and characteristic relationships. Primates continued to evolve, adding third-party and logical-abstract relationships. Humans only needed to add an appreciation of intention to these existing cognitive skills. The result, over the history of the evolution of our species, was an explosion of function and capability enabled by that particular insight.

This capability would have conferred an enormous competitive advantage for the earliest humans to exhibit it, even over species with very similar other capabilities to those early humans (e.g. Neandertals). Interacting individuals who could take advantage of their shared understanding of each other's intentions could predict and control events in ways not possible without such cognitive capability. One non-human primate would never try to distract another because there is no conception of being able to alter the intentional state of another.

Among early humans, distraction might have been a common competitive technique precisely because of the cognitive awareness of intention and causal relationships. Observation of the behavior of others, coupled with the awareness that there were unseen intentional states that must be driving those behaviors, would result in individuals internalizing those perceived mental states and emulating the behaviors whenever the same mental states applied to themselves; the earliest form of social learning.

With the rise of social learning, relationships and actions would be able to grow increasingly complex. The more complex, the broader the applicability to more situations, and the more complex the behaviors could result. This accumulation of social or cultural learning is common among humans anywhere they are found. Without an understanding of conspecifics as having intentional mental states, the logic of language could not have emerged. Language only makes sense to the extent that one wants to affect the mental state of another. Our cognitive capability to recognize the intentionality of others lays the groundwork for developing language. Language doesn't make us human; but the cognitive capabilities that make us human lead directly to the development and use of language. The depth component will pick up this thread.

Phylogeny vs. Ontogeny

In humans - in almost all primates, in fact - most physical and cognitive development takes place after birth. During this period of development, each individual interacts extensively with its environment. As a result, who we are as individuals is affected by both our phylogeny, or genetic origins, and our ontogeny, or our personal life cycle. Humans have evolved in such a way that the two perspectives become equally important to understanding the capabilities and interactions of our genes, brains, and environment.

Our personal development, our ontogeny, is capable of incorporating our own learning as we develop. We're not born knowing anything other than how to learn from our environment. While that makes human infants highly dependent upon others for survival, it also means that the actual environment into which we are born is less critical than it would be if we were born hard-wired for some particular environment. Humans are well designed for living in a variety of environments, and are capable of adjusting to significant variations and changes of environment during a single lifetime. No other species on earth exhibits such flexibility.

With the advent of our cognition of intentional mental states, we became human. In the process, human society, culture, and knowledge exploded across the world. The very skills that allowed humans to thrive in diverse environments during a lifetime, also enabled us to dramatically alter our environments on the same scale. Generation after generation have altered the environment and made our ontogeny more and more complex, all while seeing little change in our phylogeny. The result today is that humans seem so dramatically different from other forms of life on earth that the commonsense view is that humans are both quantitatively and qualitatively different from any other species. Critical distinctions offered include our language, culture, brain size, technology, and a host of other factors. All of these, though, rest on the basic cognitive skill, evolved in phylogeny and used in ontogeny, of being able to recognize that others are like ourselves: intentional causal agents.

Chapter 3

Interdisciplinary Themes

It would be oversimplifying human development to try to describe change in terms of the biological, social, cultural, cognitive, or psychological dimensions described in the previous chapter. These developmental disciplines interact to form a complex developmental system in which specific changes in human development occur. Many of the properties of humanity that are described as significant actually occur as emergent properties of the interactions of these disciplines. As such, understanding human development requires an appreciation of systems theory, and of the interactions that result in emergent and self-organizing outcomes.

Systems Theory

This section introduces and explores the major writings in systems theory, focusing on the ability of systems thinking to draw together the array of dimensions and variables discussed in the developmental disciplines discussed above into a coherent model that can be used to explain specific and varied situations encountered when studying human development. Of particular interest here are the various issues and concerns that surround discussions of highly complex systems that can exhibit self-organizing behavior, and how such behavior can explain the interaction of the developmental dimensions developed in the previous chapter.

General Systems Theory

Boulding (1956), describing what for him was a very contemporary problem, outlined the growth and expansion of fields of knowledge in various sciences coupled with an increasing need to specialize in order to be successful in the practice of any single science. He described a growing need, felt by many across multiple disciplines, to somehow systematically identify a set of constructs that could be used to challenge and communicate information across disciplines; some set of descriptions "somewhere between the specific that has no meaning and the general that has no content." (p. 11)

Bertalanffy (1956) states that "it seems legitimate to ask for a theory, not of systems of a more or less special kind, but of universal principles applying to systems in general." (p. 1) Such a set of constructs, or framework, would enable interested parties to identify similarities and overlaps across multiple disciplines; allowing disciplines to benefit from the conceptual progress made by others. Likewise, such a cross-discipline comparison might identify gaps and opportunities in one's own discipline that might otherwise take extensive time or effort to identify, often after pursuing countless dead-ends.

Boulding's alternative was a scientific world in which increasing specialization and detail drove practitioners farther and farther apart. "One wonders if science will not grind to a stop in an assemblage of walled-in hermits, each mumbling to himself words in a private language that only he can understand." (p. 12)

Bertalanffy (1956) describes General Systems Theory as "the formulation and derivation of those principles which are valid for 'systems' in general." (p. 1) Bertalanffy, and others at the time, were noticing certain structural and content similarities across a variety of scientific fields. They attributed many of these similarities to the fact that each distinct field was a system of knowledge, and they shared a belief that there should be common elements of structure and theory within any system. "The isomorphy we have mentioned is a consequence of the fact that, in certain aspects, corresponding abstractions and conceptual models can be applied to different phenomena." (p. 2)

Many of the aims espoused for General Systems Theory were pedagogical; tying the cross-systemization of the sciences to support and integration of fields and thus better science education. But in terms of knowledge content, the early aim was to develop unifying principles that would cut across disciplines; allowing concepts to flow across boundaries to enhance knowledge. Constructs so shared could help answer questions, as well as point to questions as yet unasked. "This theory brings us closer to the unity of science." (p. 2)

Characteristics of Systems

Ackoff (1960), taking a holistic approach, defines a system as "any entity, conceptual or physical, which consists of interdependent parts." (p. 1) He goes on to emphasize that systems theory is mostly interested in systems that can display activity; or concrete physical realities. "A physical entity is considered as a system if the outcome of its behavior is conceptualized as the product of the interaction of its parts." (p. 2) Ackoff later (1995) defines a system as any combination of components, the decomposition of which would remove its essential defining features.

More mathematically, Laszlo (1975) offered a means to specify a system through its parameters and relations, each of which could be described by a domain of values of a set of attributes. Relations among those attributes constitute the functions that are available and supported by the system. The structure of any such system could be described by reference to the system itself, any of its subsystems, or to the suprasystems of which it is a part. Everything outside of these descriptions would constitute the system's environment.

Sutherland (1973) describes a categorical view of systems thinking that avoids Ackoff's holistic simplicity without resorting to Laszlo's mathematical abstraction. Categories such as emergence, hierarchy, feedback, entropy, and equilibrium all contribute to the heuristic toolset of the systems theorist. (p. 50)

The General Systems Theory can itself, then, be described as a system that can be discussed at all of these levels of detail; whether holistically, as an endeavor to understand systems generally; categorically, as a delineation and naming of each identified isomorphy that contributes the main findings of the field; or abstractly, by formalizing the logic with which such constructs can be defined. Systems thinking can take place, and be fruitful at any of these levels.

Meta-Systems & Hierarchy

Klir (1975) describes a set of five general characteristics of systems than can be used to define and describe the invariant portions of any system definition:

1. A set of variables that describes the system and a granularity with respect to space-time organization for viewing and manipulating those variables,

2. A description of the system's activity, described in terms of time functions that describe the changes that take place in the system within the space-time frame described in (1),

3. A description of the system's behaviors in terms of time-invariant relationships between past, present, and future values for system variables at appropriate levels of granularity,

4. A state-transition structure for the system that describes the states of system variables and their next possible states within the system's specific space-time granularity, and

5. A description of the variables required for the system to interface with higher-order systems of which it is a part, or with which it carries out interactions.

Klir's characteristics describe a meta-system that describes common aspects of all systems. An interesting aspect is the inclusion of space-time granularity as a fundamental distinction within the taxonomy. It allows for multiple definitions of systems that, on the surface, might too easily be judged to be the same system.

For example, the system definition describing a human being on the scale of hours is a markedly different system than the one that defines the human being on the scale of years or decades. A social group viewed on a day-to-day basis is clearly a different system than the same social group viewed over decades. A society viewed on a scale of years will be systemically different from the same society viewed from the historical perspective of centuries.

The distinction and difference aren't only in the level of detail. The focus of the system description is entirely different at the various scales, and completely different aspects of action, behavior, and interaction are important. Klir acknowledges the obvious need to map each of these system definitions to each other, and views the transitional rules or procedures as themselves constituting a system — actually a meta-meta-system — that can be studied. Many fields (e.g. history, economics, anthropology, etc.) actually spend much of their effort studying the potential time-invariance of such meta-meta-systems.

These descriptions of systems, meta-systems, and meta-meta-systems constitute a hierarchy of systems that Klir asserts can ease the study of "such phenomena as growth, evolution, self-reproduction, self-organization, adaptation, and learning." (p. 32) The distinctions among phylogeny, genealogy, and ontogeny – different temporal aspects of describing humans as systems – are an example of such a meta-system described by this KAM.

Types of Systems

Ackoff (1995) emphasizes the importance of systems thinking in understanding complex systems. He offers an understanding of systems dynamics through a model of three types of systems: mechanistic, organismic, and societal; each of which carries different meaning in an understanding of human development.

Mechanical Systems

Mechanical instruments, devices, and machines that may contain an arbitrary number of working components, each representing systems of their own on smaller scales, make up the range of mechanical system. Mechanical systems are characterized by serving some function. They have no purpose of their own, just function. The range of functions might include some that are unintended by the designers of the system; but never does the mechanical system take on a purpose of its own.

Most of the systems described using phylogeny and ontogeny in this KAM are examples of mechanistic systems. Biological evolution drives naturally selected change in phylogenic development; but such change is only described by the functions that emerge from such change. No inherent purpose is attributed to genetic change; just function. New genetic combinations enable new functions to emerge in individuals, who are then more or less selected by the natural environment in which those functions are exhibited. Physiology describes function, not purpose. Life is a mechanical system; up to a point.

Organismic Systems

Organismic systems are individual living beings, made up of myriad physiological subsystems. Many of the component subsystems are actually mechanical systems. Ackoff's example is the human being, a subsystem of which is the respiratory system. This subsystem has a function; respiration. The whole human can be said to have a purpose, or mission.

Although Ackoff limits his discussion to humans, most life forms derived from biological evolution (but not all) can be described as organismic systems. To the extent that a living organism demonstrates a survival instinct or will-to-live, coupled with a reproductive instinct; the organism can be described as having a purpose. The individual physiological subsystems of such individuals lack such purpose, providing their function instead. The system's purpose is an emergent property of the combination of the physiological systems.

Societal Systems

Larger organizations of collections of organic individuals are societal systems. The components of the societal system are generally smaller societal systems, or else individual organismic systems: people. Societal systems have purpose. Such purpose is not completely dependent upon the individual purposes of the organismic systems that comprise it.

Ackoff describes the friction that ensues when one looks at the differences in purpose between individual organismic systems and the societal systems of which they are a part. A dyad of two individuals will exhibit properties and characteristics held by neither individual. The collective purpose will be unique relative to the personal purposes of the individuals. The same is true of any organismic systems collective. The scope and scale of such systems affects the dynamics of their makeup and interactions, often in interesting and unpredictable ways.

The fact that the same organismic individual can be a component of multiple societal systems means that at any given time, an individual is a part of multiple possible contradictory purposes. Larger societal systems can even be seen to treat component individuals as though they were only mechanistic systems; serving a function, but having no specific purpose of their own. This dynamic explains many organizational behaviors where individual members sometimes feel treated as less than human. Such conflict of purposes (e.g. personal, group, family, state, company, church) within single individuals is an emergent property of the developmental models being explored in this KAM. Such dynamics are created from the models, and then further define the environment in which continued development occurs.

Interdisciplinary Example – Time

The way we measure time, today and throughout our history, provides an illustration of the interaction and interdependence of the developmental disciplines outlined above. In particular, we saw in biological evolution that traits in common across species are taken to be older in history than more unique modern traits. The tracing of time illustrates this principle, with the oldest vestiges built into the oldest biological mechanisms, and the newest apparent only in the advanced cultural artifacts of humanity.

Astronomical Time

The root of our time measurement, the year, is an astronomical accident. Life formed on earth as it orbited the star from which it gained the energy necessary to create life. The time needed to complete one of those orbits was a natural unit of time measure waiting to be discovered long before any life form began to emerge from evolution. The length of the year is a fixed measure on earth. It's possible that for any life on any planet, the length of the year could not vary too far from our observed length, since the period is a function of the size of the planetary orbit, and the energy received on the planet is a function of the shape and size of that orbit. Too short a year (i.e. smaller orbit) would result in a planet too hot for evolutionary forces to be successful in creating life. Too long a year (i.e. larger orbit) would result in too cold an environment. While there could likely be some variation, the length of the year for any species on any planet couldn't be too wildly different that the year observed on earth.

The next units of time, the month (or more precisely, the moon) and the day, also have astronomical origins, and become increasingly important to life on earth. The revolution of the moon around the earth, and the rotation of the earth on its axis, define stable units of time that precede the evolution of life. However, such motions also caused the tidal forces in the earth's oceans that resulted in the selective pressure for life to evolve beyond those oceans and on to the land. The month and day were early critical factors in the evolution of life; so early that most life on earth has some biologically engineered dependency on timeframes of roughly a day and a month. Such dependencies include reproductive cycles and circadian rhythm cycles; most life beyond certain levels of complexity exhibiting day-night or night-day sleep and activity behaviors.

The fact that such behaviors and patterns are seen across all forms of life is an indicator of the early origins of such time clocks in evolution. For most of the history of life, time only needed to be understood in terms of years (i.e. seasonal cycles), months (i.e. lunar cycles), and days (i.e. earthly rotations, day-night). All of the other forms of time measurement observed among humans represent relatively modern additions to the time tracking story.

Cognitive Time

The introduction of the days of the week into thinking about time involved both cognitive and psychological acts. Cognitively, breaking the month into roughly four weeks would have corresponded to the phases of the moon that were readily available; not that such regular cycles would have necessarily been used to denote the passage of time. Human cognition readily recognizes patterns, and measures relative progress. Recognizing the moon's cyclical shifting from *new* to *full* would have been unavoidable, resulting in, at least, the delineation of the 28 day month into two 14-day periods. Likewise, recognizing whether the moon were closer to *new* than to *full* would have again broken those 14 day periods into two 7-day periods. The 7-day week was a natural expectation of the human brain's wiring to see cycles and relative rates.

The *naming* of the days of the week was an accident of psychology and history; the days having been named by a culture firmly entrenched in astrology. The days were named for the seven planets known to the early Greeks (the five visible planets, plus the sun and moon). (Boorstin, 1983, p. 14-15) The fact that the days of the week were not named until the time of the Greeks, a relatively recent occurrence in human history, illustrates a selectivity in the invention of such cultural artifacts. Earlier cultures were equally capable of recognizing and naming the units of time represented by the day, but didn't do so; presumably because the concept offered too little utility in those societies. With the advent of complex social arrangements in Greek culture, the need to be able to identify and categorize specific days of the week and month became necessary, and offered selective advantage.

Social Time

The invention of the *hour* lies further back in human history, and owes its value as a unit of time to the biological evolution of primates, the social evolution of collocated individuals into cooperative groups, and the cognitive development of the cycle and rate observations discussed above. The cycle of day and night would have been obvious to any observer, and in fact is wired into the evolution of most animal and plant species. Early humans would have cognitively recognized the morning (i.e., a.m.) and afternoon (i.e., p.m.) as readily as they recognized the waxing and waning phases of the moon. The need for individuals to cooperate and coordinate their schedules through the day would have eventually required a granularity of time much more discrete than the roughly six hour intervals defined by the astronomic cycles already discussed. Further subdivision was required: the *hour*. Selective pressure was present to invent the hour, but there wouldn't have been any particular reason why it would have the length it does. The length of the hour represents an interesting interaction of biological and cognitive evolution.

Breaking the day into hours involves counting units. Counting doesn't necessarily have to involve numbers. Numbers are a relatively recent invention of human cognition. Early mammals could count, counting being the representation of some quantity. Schmandt-Besserat (1999) describes the history of counting as passing through stages of numberless counting, to concrete counting, to abstract counting with numbers. (p. 17) Early hominids use of numberless counting shows up in their artifacts; the most common being notches made in some material to represent the quantity of something. The notches aren't numbers; they are simply indicators of increasing quantity. The order and shape of such notches carry no meaning. In concrete counting, tokens are used to represent the thing being counted (e.g. six twigs represent the six sheep taken to the field. twelve small stones represent the twelve families in the next village). There are no numbers yet, just comparative analogs that can be transported and compared. This form of counting was dominant in human history by the time of the Sumerians; the symbols for such tokens etched into clay tablets that can still be read by archaeologists today.

Inevitably, with the increasing complexity of human cognition and social structures, the need to count would have exceeded the physical and logistical limitations of token-based counting. Assigning a name to each quantity, or *numbering*, involves much more complicated cognition; abstraction of the quantity itself from the thing quantified. According to Schmandt-Besserat (1999), "numbers had to be invented." (p. 10) One way to be able to transport these invented numbers, avoiding the need to share and carry tokens for every quantity, would have been to use something that everyone always had with them; their bodies. It is at this point that numbers intersect biological evolution.

Archaeologists have found notched poles or tablets, that reveal the numbering systems of their creators. Such records don't exist for early numbering systems that would have been based on the biological body, requiring theorizing about these earliest number systems from contemporary analogies. A contemporary example, reported by Schmandt-Besserat (1999), is the Paiela of Papua New Guinea. The Paiela today count with their bodies; using a fixed system that starts with the thumb of their left hand

and moves up over the head, and down the right arm to the tip of the right hand. The system includes 28 unique entries (e.g. left side of the neck is *seven*, right elbow is *twenty*). While the system can only be used to count to 28, and not beyond, it is a completely abstract number system where the number represented is independent of the things counted. The existence of such a number system in a contemporary society illustrates the likelihood that many such systems were probably invented by early humans to name and track numbered quantities. The efficacy of such systems would have been determined by the quantifying needs of the people who invented and used the system.

For the Paiela, the range of numbers available in their system is sufficient for their needs. In fact, had the Paiela invented the hour, we would likely live in a 28 hour day. But we happen to live in a world where institutions and economics of developing human societies needed a numbering system that could easily represent numbers much larger than 28. The system that became dominant was that of the Babylonians; a system based broadly on groups of sixty. (Boorstin, 1983)

Scott (1958) reports, describing clay tablets written during the early Hammurabi period of Sumeria, that this number system was defined and in use as early as 4,000 years ago. These tablets contained numbers that only made sense once it was determined that they were written using a numeric base of 60. The squares of the ordinal numbers were written as 1, 4, 9, 16, 25, 36, 49, 1-4, 1-21, … 2-24; where the last three values represented 64, 81, and 144 respectively. Such numbers show that the Sumerians had developed a complex numbering system, and that they had developed the abstract concept of place-values in the writing of numbers. The place-value concept was lost, needing to be reinvented by the late Greeks almost two thousand years later; but the number system took hold.

Where did the Sumerians get their system of sixties? Using the Paiela as a modern analogy for anatomy-based numbering systems, Boorstin (1983) describes the origins of the Babylonian system in biological evolution. Primate evolution resulted in a hand that had three key characteristics: a) five digits, or fingers, b) three joints or sections per digit, and (most importantly) c) the thumb in opposition to the other four digits. As humans developed the cognitive need for abstract numbers, and body counting offered a way to carry numbers without the logistics of notches or tokens, the use of the hand could have naturally led to the system of sixties that was dominant in numbering by the time of the Sumerians.

Human Time

The five digits of the human hand make *five* a natural counting number. If the opposing thumb is used to point to, or indicate, each of the joints on the other four fingers, then *twelve* would have become a natural counting number. If the fingers of the second hand are used to count the number of cycles through the joints on the first hand, then *sixty* (e.g. 12 x 5) would have emerged as a natural counting number. Finally, if the opposable thumb were used on the second hand to count the first hand iterations, then *144* (e.g. 12 x 12) would have emerged as a natural counting number, and larger numbers would have been difficult because the capacity of the hand-finger system would have been reached. This is precisely the numbering system of the Sumerians; based on 5's, 12's (our *dozen*), 60's, and 144's (our *score*). The important selective advantage for such a system would have been that it optimized the definition of numbers that would have been in common use on a human scale.

Ewing, Gehring, and Halmos (1994) describe the incorporation of this number system into Greek astronomy by Hipparchus of Nicaea. (p. 7) Ptolemy had already shown that the radius of a circle, if used as a secant, could be used to divide a circle into six identical slices. Greek astronomers, needing more discrete measurements of the stars and planets they were observing, used the Sumerian *sixty* to divide each of the already identified slices. This resulted in the 360 degree circle (e.g. 6 x 60).

The same 60 was used to divide the degree into 60 minutes of arc, and the minute of arc into 60 seconds of arc.

The Greeks also used the Sumerian number system to divide the day, choosing the natural value of 12 to represent the number of hours that would be used. The invention of the mechanical clock in the 13^{th} century necessitated further divisions of the hour. (Boorstin, 1983, p. 42) Again, the system-of-sixties was used to divide the hour into 60 minutes (i.e. represented as 12 groups of 5 minutes with the numbers on the original clocks), and sixty seconds per minute.

A result of all of this is that the thoroughly modern human cognitive act of measuring time is defined by an ancient accident of biological evolution; the evolution of the primate hand. The primate hand is the origin of the hours and minutes on our clocks, the dozen eggs in our basket, the degrees of longitude and latitude on our maps, and a host of other numbering and counting schemes used throughout our culture. A different hand would have led to a different human development. A four fingered hand might have given us an 18 hour day, and 36 minutes per hour. In that case, 18 and 36 would now seem as natural a measure of time as 24 and 60 seem today; and there would be nine eggs in a dozen.

The Sumerian number system provided a basis for measuring time, but didn't determine the exact values of the units that we use today. The choice of values was likely based on social considerations that looked at the usefulness of the values involved. The Sumerian number system could have been used to develop an alternative clock with five or 60 hours in it. On the scale of Greek society, though, the hours wouldn't have been as useful. If measuring time was to offer selective advantage to society, it needed to measure time in a manner that was useful; particularly before the invention of modern clocks.

Many human activities take place on the scale represented by the hour of the twenty-four hour day (i.e. the time to go to the market, to fetch water from the community well, to prepare and eat a meal, to collect or chop firewood, to gather in the societal common area, etc.). In turn, the actual duration of these activities was partly determined by the size and scale of the social groups in which the humans measuring time were living and interacting.

Yzerbyt and Lories (1998) generalized this notion of scale to define a series of temporal bands that define time in terms of different levels, each having their own relevant uses and advantages. (see Table 1) For most social activities, the Social Band of day, week, and month would be appropriate timescales. For personal activity, their Rational Band, smaller units in terms of hours and minutes are most important.

Table 1 – Time bands and levels

Duration	Orientation	Band
Month		Social Band
Week		
Day		
Hour		Rational Band
10 min.		
1 min.	Task	
10 sec.	Unit task	Cognitive Band
1 sec.	Cognitive operation	
100 msec.	Deliberation	
10 msec.	Neural circuit	Biological Band
1 msec.	Neuron	
100 micro sec.	Organelle	

Adapted from Yzerbyt & Lories, 1998, Figure 1.1 (p. 4)

The fact that Yzerbyt and Lories define so many of their time levels using numbers in base-10 illustrates how our modern numbering systems have changed. To count things in extremely large or small quantities, the system-of-sixties loses its power. As the Greek numbering system gave way to the Latin system in human history, cognitive development was able to pursue additional concepts and ideas unavailable under the earlier system.

In the modern base-10 system, the milliseconds and microseconds of Yzerbyt and Lories' more detailed Cognitive and Biological Bands could be represented. The absolute smallest unit of time in quantum physics, 10^{-43} seconds (Planck's Constant), couldn't be represented using thumbs and fingers. The larger numbers in use today; 10^{100} (Googol) and 10^{Googol} (Googolplex), can only be thought of and defined using the base-10 system. Biology initiated counting with numbers, and cognition took over. Cognition defined what to count, but socialization determined the appropriate scale. Time, then, is an example of the interplay of the developmental disciplines outlined in this breadth component. Biology drives *numbers*, cognition drives *counting*, and socialization determines the scale of *measuring*.

Chapter 4

Cognition & Language

The focus of this breadth component has been the interplay of the biological, socio-cultural, cognitive, and psychological elements of human development. The depth component that follows will focus on particular paths through these dimensions; emphasizing the language-enabling interactions of biological and cognitive evolution, as well as the socio-cultural developments enabled, and often defined, by language.

There are numerous theories and positions regarding the interdependencies in the development of language as an interplay of biology, cognition, and socialization. Kegan (1982) highlights language acquisition versus cognitive development, noting the differences in language acquisition and learning between young and older children. Younger children treat language as an appendage to the self, while older children use language as the integral medium of social exchange or interaction; part of the definition of self in action. The evolution of such cognitive developmental patterns echoes socialization pressures in the developing environment.

Adler, Rosenfeld, and Towne (1986) describe the way that language shapes our world, our cultural perspective, and our impressions and status in society. The way language shapes our world, in turn, alters the way we define and use language. There is constant interplay among the developmental disciplines that can only be best described using the system theories described above. Armstrong (1999) categorizes such interplay theories into two broad categories that define a continuum for discussion. (p. 17-18)

Theories that fit the *continuity hypothesis* are those that describe the gradual development of a biological capacity for language, with a slow and incremental development of language within the ancestral lines that led to modern humans. At this end of the continuum, gestural or signing precursors to language become part of an ancient chain of development that eventually crossed a threshold to be considered as language. This approach provides for a smooth transition in the evolutionary story, but provides little support for trying to understand what language is, or where and when it started. If gestures and body signs are early versions of language, then what is it that we consider particularly unique about human language?

Theories that fit Armstrong's *saltational or punctuated hypothesis* describe a sudden or discontinuous appearance of the capacity for language, most often coinciding with the evolutionary appearance of anatomically modern humans. Such an approach requires a clearer definition of language in order to define the boundary of punctuated emergence. It precludes calling the gestures or signs of any species a language unless it fits that emergence definition.

Armstrong points out that a set of meaningless items that can be assembled into meaningful words is a basic underlying feature of language in many writings on linguistics (p. 18). The question that permeates his theoretical continuum is: At what point, and in what ways, did these meaningless symbols take on meaning as language? While much discussion rests on the evolution of the anatomical elements that are obviously necessary for language, one must also address the cognitive aspects of the establishment of such meaning. Remaining to be established is whether the biological development drove the cognitive evolution, or the development of cognitive capabilities enabled the use of signs and symbols in such a way that selective advantage was given to individuals who possesses more language-capable anatomy.

Greenwood (1984) sees the strongest interrelationship between the cognitive and socio-cultural dimensions. He describes the common use of language as a common paradigm for describing what culture is like. He also identifies the thinking that goes into language as a critical factor in the development of culture, arguing that one without the other could not exist. We are cultural because we can think through meanings associated with language, and we do so largely because we have social and cultural drives and goals that are better met through such use of language. (p. 152-153)

The depth component will pursue language first through the filter of biology and cognition, and second through its enabling facility for social interaction that drives continuing cognitive development. The story that unfolds will emphasize Armstrong's continuity hypothesis as biological evolution drives the never-ending unfolding of increasing neural complexity that brings about cognitive development and language. It also will illustrate Armstrong's punctuational hypothesis, as particular neural developments enable behavior changes that trigger the discontinuous development of mind and communication that provides a context for proto-language gestures and signs to become communicative language. Finally, the cognitive basis for the unitization of concepts in language will provide the foundation for discussion of increasingly professional and specialized languages in modern society, a viewpoint that will lead to the application component and its look at the language-specific features of the software engineering profession.

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WALDEN UNIVERSITY

Core Knowledge Area Module 2:

Principles of Human Development

AMDS 8222 - Leadership and Human Development

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Annotated Bibliography

The journal articles annotated in this bibliography were selected in order to provide detail coverage of the linkages of evolution, cognition, and language raised in the breadth component. These themes will be further explored throughout this depth component.

Bickerton, D. (2000). Resolving discontinuity: A minimalist distinction between human and non-human minds. *American Zoologist, 40*(6). 862-873.

Bickerton begins his analysis with the observation that human behavior is quantitatively and qualitatively different than any other species that has ever evolved on earth. He describes differences in cognition and consciousness and the myriad behavior and adaptive differences driven by those evolved capabilities. Noting that many primate species have such capabilities in limited ways, he asks what could drive the obvious qualitative differences across species. The problem, generally noted across the literature, is time. The changes observed in humans have evolved in too short a timeframe to not be related in origin.

"Either every differentiating human characteristic … has evolved separately, with a separate history, separate selective pressures, and separate and distinct adaptations to satisfy those pressures, or else some single factor has intervened, some factor which of its nature would trigger profound changes in all antecedent cognitive capacities." (p. 863) A common origin in evolution, that supports the complex development, is needed in order to explain the observed complexity and qualitative differences across species.

Bickerton "hypothesize(s) a single polyfunctional mechanism" (p. 864) to explain the jump from pre-existing hominid capabilities to modern human capabilities. If there exists multiple complex development in a species, the basic statistics of evolution makes it increasingly unlikely that those developments occurred independently in limited evolutionary time. There is likely a common evolutionary development that enabled or drove the feature or capability development that eventually differentiated the species.

As examples, Bickerton uses language, intelligence, and consciousness. Many consider these development in *Homo* to be qualitative differentiators from other hominid lines, and from all primate lines. However, rudimentary capabilities are seen in all three developmental areas in most primates alive today, and are likely to have been found in early primates and hominids leading up to the emergence of *Homo sapiens*. The differences today appear to be simply quantitative, except that the differences are of such a magnitude to account for a major qualitative difference in the way we see our species.

Bickerton's hypothesis requires that there be a single evolutionary development to account for such developmental differences. Too little time has passed since the split of the early hominid lines from the general development of primates – fifty to three hundred thousand years depending upon the theoretical basis of discussion – to account for the development of such an array of complex capabilities independently from each other. The probabilities and mechanisms involved simply call for a single evolutionary change that eventually enabled the observed complex capabilities. In fact, because the capabilities being discussed are so evolutionarily complex, that single enabling change must have occurred very shortly after the primate-hominid split, and have occurred relatively quickly.

What changes were occurring in the hominid line during the period in question? The physical archaeological record shows that the most dramatic change taking place during the last half million years of primate-hominid evolution has been the expansion of the cranium, with a presumed corresponding growth in brain size. Bickerton doesn't suggest that an increase in brain size *caused* the evolutionary developments that led to the advanced cognitive functions seen in humans. Rather, he asks what selective advantage such growth must have had. What developmental features would have been enabled by such physical growth that would have provided individuals with larger brains reproductive advantage over those without them?

If such features were found to experience a threshold effect; meaning that the capabilities enabled were dependent upon the brain achieving some threshold size before they could emerge, then the growth of the brain would have eventually triggered dramatic evolutionary changes in the species once that size had occurred. Since such a dramatic and sudden explosion of capability is exactly what Bickerton and other evolutionary biologists are trying to explain, a single factor threshold effect seems plausible as an explanation for the emergence of humanity.

Looking at his three example functions from a cognitive standpoint, the common thread Bickerton identifies in all of them is an ability to maintain brain activity over extended periods of time without the necessity to drive such activity with external stimuli. Such capability "permit(s) the autonomous life of the mind." (p. 870) Such cognitive functioning requires, at the least, a significant quantitative increase in the number of neurons participating in such functioning; and may require additional qualitative differences that might emerge from this quantitatively larger self-organizing network. Such quantitative-qualitative change is precisely what Bickerton is looking to explain.

Bickerton concludes – tentatively, suggesting further research – that the development of characteristically human cognitive capabilities rests on the historical development of stimuli-independent cognitive activity that emerged from increases in brain size in the early hominid line. Such capability allowed early humans to form conceptual concepts and groupings that are unavailable to brains dependent upon external stimulation for exciting neural patterns. The early advantages of even such proto-cognitive function would have provided sufficient selective pressure to continue size development across primates.

A threshold effect, somewhere among the late *Australopithecus*, quickly ratcheted humanity into existence over a very short evolutionary period. Bickerton offers no suggestion regarding exactly how such capability emerge in the growing brain of primates and early hominids, nor of any particular threshold mechanism. This depth component will explore that particular issue using McFadden (2000) below.

Gathercole, V. C. M.; & Whitfield, L. C. (2001). Function as a criterion for the extension of new words. *Journal of Child Language, 28*(1). 87-125.

The way individuals learn language, and the order in which they acquire particular words and usages provides a window into cognition. Gathercole and Whitfield (2001) report an experimental study in which they expose both children and adults to novel vocabulary in order to observe the key features of novel words that were associated with new word acquisition.

Their study used arbitrarily created artificial nouns for which they could control the presentation and perception of meanings. Typically, new words were presented in the context of pictures of physical objects in such a way that the researchers could: a) control each participant's view of the object, b) control the language used to describe the object, and c) control whether or not the function of the object was clear or ambiguous.

They found distinctive differences in word acquisition between four year olds, nine year olds, and adults. The youngest participants typically drew conclusions about the meaning of novel words from their visible shape of the objects in the study. They were most likely to attribute meaning to artificial nouns according to the extent that the objects physically resembled other objects with which they were already familiar. Even when presented with clear functional information about the object, these youngest children weren't dissuaded from their perceptions of meaning based on shape alone.

Nine year old children in the Gathercole and Whitfield study demonstrated a different set of abilities than four year olds. Like the youngest children, these older children seemed unable to use information provided about the function of the presented objects to categorize and learn the new novel nouns. However, unlike the youngest children, the older children were effected in their interpretations by the syntax used to describe the objects (e.g. *some* TIV vs. *my* TIV). The youngest children failed to pick up on the quantitative and qualitative information available in such syntactic differences. The older children took advantage of such syntactic information to override the visual cues that were being provided. When such cues were contradictory, the older children gave precedence to the syntax cues.

Adults, unlike the children, interpreted new nouns almost exclusively using information presented about the function of the artificial objects. When the function was intentionally left ambiguous, adults in the study took their information primarily from syntax cues; and from visual cues when syntax cues were unavailable. The researchers found other patterns (oversimplified here for the sake of annotation) consistent with the generalizations described above. The ability of some nine year olds to use function to derive meaning, of seven year olds in the study to use combinations of visual and syntax cues, and other variations were not common enough to invalidate the notion that individuals learn new nouns using strategies that are dependent on their cognitive development at any given age.

Particularly interesting about the Gathercole and Whitfield finding is that it appears that ontological cognitive development appears to recapitulate phylogenic development in ways described at the end of the breadth component. Early mammal brains developed the ability to recognize and categorize extensive objects based on shape and visual appearance. Later in evolution, primates evolved the cognitive ability to use richer qualitative and quantitative data in categorization. Finally, human cognition evolved the ability to reason about function to override other less information-intensive categorization schemes.

Our human ontological development, according to Gathercole and Whitfield, recapitulates that evolution. Young children, those around four years of age, have the ability to conduct basic and simple categorization based on visual cues presented in their environment, but are unable to pick up on more intensive qualitative cues or functional displays also available in the same environment. As children age, somewhere between seven and ten years of age, they improve their ability to pick up on qualitative cues and rely less and less on simple visual signals. By adulthood, human cognition easily categorizes objects in the environment based on their perceived function, even when such function is in conflict with visual and syntax cues also available.

This depth component looks at the acquisition of language among adults working in professions. This study indicates that, among adults, function plays a central role in the categorization and acquisition of new vocabulary; and that such acquisition is a partial recapitulation of our own cognitive evolution. If that pattern holds, then this depth component may be able to look beyond function-in-cognition, toward meaning-in-culture, as a basis for further extending language. This pattern would build on the continued cognitive evolution discussed in this depth component toward the cultural evolution of memetics. While this thinking extends beyond the findings discussed by Gathercole and Whitfield, it seems a natural extension of their findings, and will be explored throughout this depth component.

Henrich, J.; & Gil-White, F. J. (2001). The evolution of prestige: Freely conferred deference as a mechanism for enhancing the benefits of cultural transmission. *Evolution and Human Behavior*, *22*(3). 165-196.

Classical evolutionary writings present survival-of-the-fittest as a key paradigm for understanding species development and variation; first with general environmental fitness among lower and earlier species, and then with dominance theory among socially interacting species. The paradigm of the dominant male having the greatest reproductive success is the focus of such reasoning. Henrich and Gil-White extend the notion of fitness to include the more human-oriented information exchanges required of cultural transmission; and posit *prestige* as a driving force in such development and variation.

Henrich and Gil-White argue that as the human species developed a cultural capacity, it would have been necessary to develop an inter-generational transmission capability that assured accurate transmission of positive cultural traits to act as a counterpart to accurate genetic transmission. Evolution would have favored and selected for such capability. Human ancestors would have evolved to become highly specialized at cultural transmission because individuals who lacked such capability would have failed to achieve the evolutionary advantages of culture and so would have experienced less reproductive success.

Prestige – or freely conferred deference – evolved as a psychological alternative to dominance, argue Henrich and Gil-White, precisely because dominance assured genetic reproduction while minimizing cultural transmission. The dominant male beating back others in the social group is the classic view of dominance theory; also represented by submissive behaviors such as grooming, or yielding food or space. A problem in such dominance behaviors is that no cultural transmission takes place; limiting the ability of the species to transmit culturally learned lessons.

The alternative to showing submission to the dominant is to show free deference to the prestigious. Individuals will try to emulate, or model, those individuals who they perceive to be the most skilled or knowledgeable in important selected domains. Modeling requires direct observation and proximity, and so behaviors will developed to encourage models to allow the necessary close proximity for observation and emulation. The resulting deference encourages models to allow continued proximity among followers.

In time, and to increase selective efficiency, individuals will come to select models based on the observation of their existing deference clientele. The ability to select models based on such prestige observations lowers the start-up costs of social transmission. Individuals continually refine their choice of models based on the long-term or on-going success of their models' actions within the pertinent domain.

Prestige rests on the continuing admiration available from followers. Prestigious models will work to further enhance their perceived skills because such improvements bring an increase in deferential clients. The constant desire for proximity and sustained observations continues to bring the model more benefits. It also creates incentives for other less known and followed models – those that are less prestigious – to improve their skills to obtain more clients; often at the expense of the leader. Likewise, leading models will limit the size of their clientele to manageable numbers.

A strong hunter with one or two followers will still likely be a strong hunter. The same hunter with twenty followers will fail completely as their entourage scares away all of the available prey. The prestigious model will, therefore, increase the social costs extracted from each marginal follower in order to optimize the benefits of prestige. Additional followers will choose less prestigious models simply because the social start-up costs are perceived as a better trade-off. In this way there is constant change and flux in the model-follower relationships across a social group.

With constant change in relationships, and varying model lessons being learned within any given knowledge domain, there will be variation. The best combinations of model selection and learning will be selected at the expense of less effective models. Because the choices are inherently subjective and personal as they occur, natural selection will eventually develop the psychological capabilities to drive this system.

Up to this point the discussion of dominance versus prestige can be attributed to a distinction that can be drawn within any species. Any socially interacting species would be expected to gradually evolve the characteristics being described, and indeed Henrich and Gil-White describe such activities among many species, particularly among primates that present with social systems and characteristics. But the prestige and deference systems inherent seen in human interactions appear qualitatively different than their counterparts among the primates. In fact, Henrich and Gil-White argue that the exchange and competition for prestige has been a driving force – in an evolutionary sense – in cultural development and transmission. What difference can account for the extensive explosion in social complexity seen in *Homo*?

Henrich and Gil-White argue that the difference is language and the impact language has had on the development of prestige-based deference relationships. Their explanation addresses not just social learning as seen across many primate species, but "*direct* social learning." (p. 172, authors' emphasis) This includes all forms of learning that occur directly between individuals, starting with simple imitation and copying that can occur without language, up to goal emulation and means reasoning that can only occur with a theory of mind and supporting language. Henrich and Gil-White refer to the transfer as "infocopying," (p. 172) and include any social exchange where clients can "consciously acquire verbal knowledge and arguments" (p. 172) from their models.

Such infocopying has evolutionary advantages because more variation is introduced when the subjective beliefs and preferences of both model and client are included in the transfer. Pre-linguistic observation and copying will result in accidental variation, but not directed variation based on beliefs and reasons being exchanged among parties. Other than language, the capability to infocopy is dependent on two skills readily seen in most primates; 1) the ability to rank conspecifics based on their perceived abilities, and 2) the ability to show selected deference to individuals within the social group. These two abilities allow the individual to properly discriminate and interact with individuals within the group likely to promote and encourage selective advantage over time. The addition of language empowered this existing capability to drive massive change in relatively short evolutionary time; using what Henrich and Gil-White refer to as "prestige-biased guided variation." (p. 175)

They predict certain market forces driving certain interactions among models and clients in a prestige-driven system. Deference toward models provides public cues to new entrants, lowering the cost of entering into the system. Conferred benefits toward models creates incentives for individuals to attempt to attain status and prestige through behaviors that will draw clients. Many will fail because they choose to emulate the wrong skills or capabilities. Those that succeed will draw clients, and the resulting interactions will ratchet up the knowledge domain. The most adaptive behaviors will become the dominant, and the cycle will continue.

The presence of prestige-biased deference, coupled with the presence of language, explains the existing common psychological feature of humanity to defer to those seen as strong in a domain, and of those strong in a domain to on-the-surface defer to their clientele to retain that clientele at the optimal level. The existence of "gurus" in existing professional environments discussed in the application component of this KAM will be an example of this phenomena at work.

Hernadi, P. (2001). Literature and evolution. *SubStance, 30*(1). 55-71.

Part of the evolution of human cognition, beginning somewhere in the development of general primate cognition, involved the ability of a thinker to imagine and play out alternative scenarios and to explore the implications of available options under those scenarios. Cognition had to invent fiction. Hernadi (2001) sees literature as the culmination of those capabilities, and so describes the important role that literature, or literary thinking, has played in the evolution and development of human cognition.

To Hernadi, literature enhances the brain's capacity for expression, providing a selective advantage as literary individuals became able to out-compete their less literary peers in the biological tests of life and survival. And since literary thinking is typically socially shared thinking, individuals who participated in such sharing, even if only receivers of such thoughts, would generally carry some of the biologically selective advantage of such participation. To Hernadi then, our species' modern love of literature has strong biological and evolutionary roots: "The pleasure of succumbing to literary seduction has long served as a psychological reward for what was once and perhaps still is a biologically advantageous thing to do." (p. 56)

Although Hernadi explores several aspects of literary thinking, the one most important to this depth component is the fact that literary thinking typically virtualizes first, second, or third-persons. This ability to see others as motivated and goal-oriented individuals is the central aspect that many use to define the emergence of humanity. Supporting Hernadi's description, the breadth component explored first-person thinking as central to mammalian cognition, second-person thinking as representing the bridging point of primates within mammalia, and finally the ability to recognize third-person relationships and motivations as a central theme in the emergence of human cognition. Literature emphasized these cognitive developments, and assured their continued development.

The fiction of literature decoupled even this thinking from the real world, requiring the ability to think, visualize, and share images of ideas and experiences that only exist in the mind. The boundaries between reality and visualization eventually evolve into the social realities of truth and deception; with deception in literature eventually playing a role in real world social relationships. Using this approach, Hernadi has posited a central role for literature and literary thinking in the development of both human cognition and social structure – central themes of this KAM.

Under this role, literature would have coevolved with other features of the human brain and consciousness, as well as social exchange developments. It required the development of the ability to verbalize both semantic and episodic memory, and to make such verbalizations gratifying enough to engage receivers in listening to, and internalizing, such literary exchanges. If engaging enough, such literary exchanges would motivate listeners to new thoughts and behaviors. This literary impact on non-literary behaviors and actions is central to the role Hernadi ascribes to literature in human evolution. Literary traditions "have thus been nurturing the human propensity for self-sacrifice well beyond the genetically coded call in many animal species for altruistic behavior." (p. 65) Altruism becomes a human characteristic developed through the cognition of literary virtual worlds and stories. Our love for the heroes, and disdain for the villains, is etched into our genes by evolutionary cognition. Citing

Dawkins' concept of the *selfish gene,* Hernadi sees the development of gene complexes that promote a readiness for self-sacrifice as counterintuitively a sign of such selfishness; an altruism that is unique to humans. Other primates limit their altruism, if it can be called that, to defense of their own offspring and other local family group members.

Hernadi acknowledges that such altruistic behavior, if encoded to play out prior to producing off-spring, would be a selective disadvantage to the gene pool. For this reason, evolutionary mechanisms would be predicted to favor those individuals who have passed child-bearing years. One would expect, posits Hernadi, that the effects of literature should vary based on age; the young exploring the hedonistic affects of stories and images, and the old being inspired to altruistic behaviors. Such actual behaviors are characteristic of virtually every society on the planet. It turns out that such a dichotomy, often referred to as a generation gap, is hard-coded in our genes by evolution.

Hulstijn, J. H.; & Laufer, B. (2001). Some empirical evidence for the involvement load hypothesis in vocabulary acquisition. *Language Learning, 51*(3). 539-558.

Different instructional tasks can be classified differently based on their effectiveness in achieving desired learning outcomes. Hulstijn and Laufer (2001) looked at the vocabulary acquisition patterns among students of English as a Foreign Language (EFL), focusing on the concept of depth of processing. Through this approach, they were researching the chance that a new word learned in lessons was retained in long-term memory, not because of the length of time it was held in short-term memory, but by the shallowness or depth with which the word was processed during learning. Such increased loads were observed to affect the richness with which materials were coded in long-term memory, and so the broader range of concepts under which the learned word could be retrieved and used correctly.

After providing an extensive literature review, Hulstijn and Laufer conclude that there is general agreement in the field that the storage and retrieval of new information is dependent upon both the richness and number of associations that are built between the new and old knowledge in long-term memory. The term they used was *elaboration*, as they explored both the quantitative and qualitative aspects of vocabulary learning. In their study, they found that learning could be affected by processing load regardless of whether the learning was intentional, or incidental to the perceived learning tasks.

The most effective tasks were those that required the deeper levels of processing. Simple dictionary assignments, where students were asked to look up words they didn't know, resulted in minimal retention of new vocabulary. Increasingly complex tasks resulted in higher retention rates. It was the purpose of their research to explore explanations for such improvement paths.

Hulstijn and Laufer propose their *Involvement Load Hypothesis* as a motivational-cognitive construct that explains involvement in learning vocabulary through three components or dimensions: need, search, and evaluation. By operationalizing these three dimensions, they were able to construct a scale that accurately predicted the effectiveness of various learning tasks in EFL settings. They found that retention improves in a learning tasks depending upon who has set the task and so how the student will perceive need, whether or not the word or words targeted need to be searched through a rich and diverse set of concepts, and whether or not the word needs to be compared to other already known or unknown words. The greater the processing load, the greater the retention.

Recognizing the time required in pedagogy to increase load for words being learned - it's simply a lot more complicated to offer high load learning versus the load required to look words up in the dictionary - Hulstijn and Laufer recommend that teachers consider high-load pedagogies for central or theme words in lesson plans, and high-priority concepts in curricula. In the context of this KAM, this recommendation helps in understanding some of the differentiated vocabularies of the professions being discussed. Professionals have an edge in learning their own specialized vocabulary precisely because they tend to learn their words under higher involvement loads; further differentiating professionals from non-professionals.

Kuberski, P. (2000). A worldly mind: Natural history and the experience of consciousness. *SubStance, 29*(1). 7-22.

Cognitive scientists who explore the basis of consciousness are participating in a general mind-body debate and exploration that has its roots in the earliest philosophical disciplines. Kuberski (2000) looks at some of the natural history of this debate, focusing less on attempts to describe consciousness in terms of physiology, and more on explanations drawn from the ways that we experience and discuss consciousness.

Kuberski describes the way the mind-body distinction has been viewed in terms of language, noting that the problem itself has been defined as a distinction between physical and nonphysical things, leaving debaters to wonder at how these two phenomena can be integrated. At one extreme of the debate are those who see consciousness as purely physical. Consciousness is *simply* or *merely* our own observation of a physiological process in the brain; therefore there is no non-physical process that needs to be explained. Debate over. At the other extreme in the debate are those who view consciousness as the manifestation of a non-physical entity that can’t be reduced to any physical explanation. Attempts at such reduction rest on the assumption that the thing to be explained doesn't exist. Debate pointless.

Describe the problem differently using different language, posits Kuberski, and a different debate ensues. The mind-body debate rests on reductionist thinking anchored in a pedagogy that sees the world as physical and yet is frustrated by everyone's inability to reduce consciousness to such terms. Letting go of this basic pedagogy is difficult. The problem itself is so etched into the language we use to think about the problem, that we lack the cognitive tools to redefine the problem itself outside of this framework. Kuberski describes many current cognitive scientists as waiting for more data. (p. 8) With enough reductionist data in the future, they argue, the problem will eventually be resolved. This particular deferral of the problem has a long history.

Kuberski argues that our failure to understand consciousness is due to conceptual misunderstanding of the problem; something that will never be resolved by waiting for more reductionist data. He describes the current thinking as "a kind of language-game" (p. 9) that not only can't be won, but can never end. Instead, he suggests that the problem of consciousness be rethought in terms of emergent properties that go far beyond the individual reductionist characteristics already explored in depth. Consciousness is not *merely* the interworking of neural synapses any more than evolutionary biology is *merely* the interworking of random variations in DNA molecules. Yes, reductionist science has built up a wealth of accurate and useful information needed to describe and explain both of these complex systems. But the systems themselves are much more than the combination of their physical parts.

The functions that are most interesting in both systems aren't physical; they're emergent properties that are only describable as complex and self-organized relationships. Kuberski points out that early scientific thinking about DNA was that it embedded the basis for construction of an organism. Today, that knowledge is attributed more broadly to the entire cellular system in which that DNA is embedded. DNA is critical to life; but DNA alone can't produce life. Cellular life emerges from the complex relationships between every component of the cell, including DNA. Kuberski applies the same logic to consciousness. Early cognitive scientists looked for consciousness in the neurons. Neurons are essential to consciousness, but they alone can't make an individual conscious. Consciousness emerges from the complex relationships that are formed by billions of neurons in the brain interacting using other chemical and electrical properties that are also present among those complex interactions. Consciousness is an emergent property of those interactions that can't be reduced to any of its physical components.

Such complex emergent systems – both evolution and consciousness – can't be explained in reductionist terms. Complex systems past a certain threshold become unpredictable; but not unreal. Consciousness is part of a physical system even though it can't be reduced to physical components. Minds become conscious when they reach a certain threshold of complexity, and a breakdown in some relationship within that complexity can result in the loss of consciousness. This depth component, in part, explores a suggested basis for the emergence of consciousness from such complexity. The properties involved will be those of quantum mechanics; a physical theory that itself often gets trapped by its inability to describe the physical world of uncertainty using the scientific language of reductionist certainty. The science is clear; but as Kuberski describes, the language used to discuss such science creates the impression that debate rages between two extremes. The way language itself can define knowledge, and any debate about that knowledge, is a key theme in the rest of this KAM.

Lestienne, R. (2000). Chance, progress and complexity in biological evolution. *SubStance*, *29*(1). 39-55.

Biological evolution involves the development and exploration of species across environmental niches. Lestienne looks at the mathematics and system dynamics of complexity to neutrally describe much of what is found in the evolutionary record. He then explores the idea of progress - a non-neutral, more normative concept – and the way many have described evolution as a progressive movement, as though there were some goal to all this progress.

Describing complexity in terms of change and algorithms, Lestienne sees chance in systems that can not be summarized. A system governed by chance is one that can not have an algorithmic expression shorter than a simple recitation of the actual components of the system. For example, the only way to represent a system described by a dozen rolls of dice is to actually roll dice a dozen times. Evolution is a chance system if the only way to evolve a particular species is to carry out the actual steps and history of evolution.

Complexity looks at the length of the minimal algorithm capable of describing a system. The more complex system requires a longer algorithm to be described. Lestienne notes that these two definitions together results in the maxim that systems are increasingly complex to the extent that they are governed by chance; chance systems being only describable through complete recitation. However, complexity in the mathematical sense is not Lestienne's target. He seeks to discuss complexity in biology and evolution; a concept that must go beyond math.

The complexity that Lestienne seeks is the complexity of integrated hierarchy. Natural systems (citing Atlan) construct complexity by reducing their own internal redundancy, using the result to increase complexity through new and interacting components. Since redundancy can be algorithmically described using a simple expansion, the resulting interaction necessarily requires a longer algorithm – the system is more complex. This reduction in disordered redundancy (e.g. entropy) must be paid for by increasing entropy elsewhere (citing Prigogine); such increased complexity can only occur naturally in open systems; in biological life.

Along with this reduction of entropy, Lestienne sees biological complexity as arising not just from an increase in structure and hierarchical levels, but from the fact that the biological levels are not completely autonomous. If organs could function autonomously from the conditions of their tissue, or the tissues perform independent of the cells from which they are constructed, biological systems would be highly integrated structures, but one would not need the mathematical language of complexity to describe them. In fact, evolution has driven the development of highly complex structures that are constantly battling thermodynamic forces to remain in existence. The fact that particular species are living while others are extinct is often a function of chance interacting with such complexity.

Lestienne next takes up the subject of *progress*; or directionality to evolution. Darwin denied any directionality to the interplay of variation and selection. Variations in genetic materials occurred by chance. Selection could act on these chance variations, but could not direct them. Modern Lamarkians view the relationship as more two-way; with selection providing a feedback loop that influences subsequent variations. The conditions under which such selection occur can be described as a framework within which variations occur; giving the entire system an appearance of having purpose. This idea is summed up in the popularist notion that, somehow, humanity represents some kind of pinnacle of evolutionary development; that we are somehow the top of the heap – evolutionarily speaking.

To Lestienne, drawing heavily from Gould, such progress is an *illusion* enabled by our ability to see patterns easily, and our innate desire to see ourselves as special. In fact, the history of life on earth is largely the story of bacteria. Bacteria were the only life forms for almost the first 2 billion years of life's 3.5 billion year history. Multi-celled life has only existed from about 580 million years. Humanity for only tens of thousands of years. This sequence can be used to infer a certain development over that history, with humanity at the culminating end of the trail.

However, even today, bacteria are still the dominant life form on earth. The actual mass of bacteria on earth (some $2x10^{14}$ tons) is roughly one million times the combined mass of humanity on the planet. There are more bacteria in our stomachs than there are humans on earth. Humanity is not the paradigm for life on earth, regardless of how we choose to view ourselves sociologically or theologically. We're an anomaly, and perhaps a temporary one.

Large intelligent animals are a rarity in evolution. In fact, cataclysms have tended to eliminate many evolved large species on a fairly regular basis. The extinction of the dinosaur at the end of the Cretaceous Period is simply the most commonly known example of a common trend; "large sizes were a major hindrance to survival in catastrophic conditions." (p. 47) In the long-run, larger species are poor adaptations to the realities and complexities of life in our biosphere. After major cataclysms on earth, surviving life continues to evolve on earth. Such evolution quickly fills in ecological niches emptied by the cataclysms. If evolution were truly progressive, the replacements would be expected to function much like the previous round of species. In fact, this doesn't happen. If humanity were suddenly wiped out, we would be replaced by evolution, but not with any life form likely to even resemble humanity.

The evolution of life reduces largely to chance and complexity then. To the extent that there is an objective trend wherein life becomes increasingly complex, one can argue progress. But equating progress with growing complexity largely empties the concept of meaning for many of the proponents of progress in evolution. In this way, Lestienne argues that if there is progress, it is simply the progress of being "on the road to infinite complexity." (p. 52)

He closes by stating his opinion that it would be "paradoxical to affirm chance is the sole motor of evolution, and then to apply the notion of progress to the latter." (p. 54) Evolution is a nonlinear dynamic system driven by chance. Nonlinear dynamic systems typically result in self-organizing complexity. Though we'd like to attribute progress to our own development, the concept is not necessary for an adequate explanation of the evidence.

Nohara-LeClair, M. (2001). A direct assessment of the relation between shared knowledge and communication in a referential communication task. *Language and Speech, 44*(2). 217-236.

Nohara-LeClair (2001) explores a model of interpersonal verbal communication that looks at the ways our perception and belief about each other's knowledge plays a role in the effectiveness of any communication. Specifically, she looks at how shared knowledge between two communicating individuals increases as communication continues, and the ways in which our assumptions about the level of shared knowledge between ourselves and someone with whom we are communicating become more accurate as we continue to communicate.

This experimental study is developed from the perspective that any level of communication between two people is dependent, at least in part, on any mutually shared understanding of the relevant knowledge being sent as part of the communication. As we communicate with each other, we must always be in a position to gauge how much shared knowledge we have in common with the individuals with whom we are communicating. We then design and formulate our messages within the context of that shared knowledge. This results in the ability to assess how much shared knowledge exists between ourselves and others to be a key component of effective communication.

Communication is explored by Nohara-LeClair in terms of both *presence* and *community*. With presence, communication is explored between collocated individuals; with participants going through a “grounding process” (citing Clark) that allows them to establish levels of shared knowledge. Communication increases and becomes more efficient as the grounding process establishes levels of shared meaning and knowledge within the communication. Their experiments noted the ways in which communication was altered when third-parties were added to situations in which the third person had not gone through the grounding process already experienced by each original dyad. Conversations needed to revert to their level of communication that was evident prior to grounding; generally with more words used to express concepts, and less efficiency resulting from the loss of a presumed shared framework. After further grounding, such efficiencies were regained.

Nohara-LeClair’s comments regarding community communication paralleled their discussion of present communication; offering findings that can be used in this KAM to explore communication among professionals; even those not collocated. Participation in a profession creates a form of extended presence; a level of conceptual grounding that allows individuals who have identified themselves as being within the same profession to immediately gain some of the efficiencies of grounding. Specialized vocabularies, and models of shared knowledge derived from the practice domain of the profession, allow professionals to communicate in ways not available among laypersons to the profession. Adding third-party laypeople to such communications results in similar degradation of efficiency as the benefits of shared knowledge are lost. Attempts to maintain the efficiency can result in a lay person’s perspective likely being that professionals are speaking in jargon meant to confuse or exclude them.

Many of us have experienced such an effect when trying to speak to a group of doctors or lawyers or other professionals.

The communicative model offered by Nohara-LeClair is powerful because it explores a richness that is much more complicated than simply looking at the knowledge of each person in a conversation with some overlap of shared knowledge. Such a simplified view explains some basic communication, but lacks the richness required to explore and understand conversations that we all participate in everyday that seem more complicated. An important finding of their experiment is that shared knowledge is never better than an assumption by either party; and that two parties are rarely likely to assume the same level of shared knowledge. There will always be levels of overestimated shared knowledge, and underestimated shared knowledge, that affect the effectiveness of our communication strategies that are based on those assumptions.

Nohara-LeClair's finding that communication becomes more effective and efficient as shared knowledge is increased is typically associated with the increase of shared knowledge through the reduction of shared ignorance about the topic under discussions. Her finding also points to an aggregation of the impacts caused by the improved accuracy of our assumptions regarding shared knowledge as well. The more accurate our assumptions about shared knowledge, the more communication energy can be expended on reducing shared ignorance. Any of us who have experienced a protracted and exhausting conversation that ultimately didn't accomplish anything new have experienced this affect.

These findings carry implications for the application component of this KAM. The ability of individuals within a profession to communicate efficiently is dependent upon correct assumptions regarding shared knowledge, as well as efficiency considerations associated with specialized language that can only be realized if those assumptions are generally correct. Nohara-LeClair found that the expressions individuals used to communicate were largely a function of the level of shared knowledge between the communicating individuals. This has direct implications for the specialization of language with any profession. The application component looks at these factors.

Pullum, G. K.; & Scholz, B. C. (2001). More than words. *Nature, 413*(6854). 367.

In this short exploratory essay, Pullum and Scholz (2001) look at several characteristics of human language that make it quite unique when compared with the communication patterns of primates, and with computer languages generated by humans. Their primary position is that language is much more than its lexicon.

What makes human language unique is its use of syntax and grammar to drive variation and recombination of words into novel, unpredictable, and infinite variety. The explicit combinations of words available in a language is countably infinite. Available syntax and grammars seem to increase that number. But a factor that makes human language particularly infinite – uncountably infinite in fact – is the way ambiguity can be introduced into words and phrases without losing overall communication. Even sentences with nonsense words in them can still be meaningful language.

Beyond differences in words, Pullum and Scholz see a role in the “malformations in syntax” (p. 367) in enriching language. The mistakes people make in their use of language, words, and grammar; lead to new coinages, patterns, and usages that expand and become part of language. Natural language; as language is used, not as it is formally described; is what makes human language unique. An ability to unambiguously map words to world conditions can be seen (and trained) in many primates. Such an ability is not simply characteristic of human language. Even our machines can be taught to use unambiguous words and grammars to produce formal language. Such formal languages, argue Pullum and Scholz, are the basis for the various computer languages that have been created by computer scientists over the years.

While human languages exhibit rigorous lexicons, and formal syntax against which any particular combination of words from the lexicon can be described as correct or not; what really makes our language uniquely human is the ability to represent and process natural ambiguity. This ability, easily carried out by even the youngest child, can't be taught to other primates and can't be formalized into computer code; even by the best supercomputers.

Computer languages and processing can be made impressively complex; complex enough to convince lay people that language has been computerized. But these attempts are still, strictly speaking, about fixed lexicons and rigorous application of formal rules. The fact that formal rules can be written to simulate ambiguous language doesn't mean that computer scientists have mastered human language. Quite the contrary, the harder such scientists have to work to simulate the next level of language ambiguity, the more impressive human language capability truly becomes.

Rotman, B. (2000). Going parallel. *SubStance, 29*(1). 56-79.

Rotman (2000) looks at two modes - the serial where one thing follows another, and the parallel where many occur together – and ties their apparent dichotomy together in a discussion of cognitive and cultural human development. Rotman explores the relationships between the serial and parallel in cognition, culture, and modern digital computing; focusing particularly on the shift in contemporary culture toward images and thought processes that are increasingly parallel, and decreasingly serial. The shift is so dramatic, to Rotman, that he goes so far as to suggest that we are entering a period of "posthumanity" (p. 59) in the way we think and communicate.

He rationalizes this position by exploring the relationship between the serial and parallel in cognition and communication. He points out that each mode is largely define in relation to the other, creating a dualism that resolves itself in the specific context in which communication occurs. Individual thoughts and practices can be generally described using either model, but will be best described using one or the other in any given context. The serial is seen in this context as discourse and the use of language. The parallel is seen as the use of images and pictures in which multiple stimuli and themes are depicted simultaneously, relying on human cognition to select and filter important details and meanings. Language, or the serial, can be used to describe and depict the images and pictures. Pictures and images can convey a sequential story or theme. The serial can contain the parallel, and the parallel contain the serial. The dominant side of the duality will be determined by the context of the communication.

Rotman describes what he sees as "the explosive growth of parallelists and visualist thinking within contemporary, technologically-based culture" (p. 59) driven by "a massive and ongoing application of serial-based digitization." (p. 59) Modern computers, generally a purely serial technology, are typically used to create images and pictures that convey information in parallel. Modern computer scientists are working diligently to perfect parallel computing; the breaking up of sequential problems into chunks that can be processed by serial processors working in parallel in order to emerge from that parallel process with answers to the original serial questions. Each mode is seen within the other. This is the dichotomy that Rotman describes as currently "going parallel." (his title)

Rotman describes the explosion in parallel and holistic thinking that is coming to dominate modern human culture; a shift that has actually been ongoing thought a history of biological evolution, followed by cultural evolution, and culminating now in our technological evolution. From oral traditions, to books, to radio, to television, to video games, to virtual reality; our cultural means of communication has been shifting from the serial to the parallel. The business conversation of earlier generations, becomes the business memo of the recent past, and is most likely to be a PowerPoint presentation in the current generation. The serial shifts toward the parallel, where cognitive acts are required to extract meaning from the richness of the parallel channels.

This depth component will explore the concept of unitization in the development of language. Unitization can be viewed, in Rotman's terms, as the serialization of multiple parallel concepts. New words capture complex multi-threaded ideas and allow them to be reused serially. If so, human cognitive evolution has been playing out the serial-parallel duality from the beginning; and Rotman is simply noting its most recent manifestations in our technological culture.

Stumpf, M. P. H. (2001). Language's place in nature. *Trends in Ecology and Evolution, 16*(9). 475-476.

In this survey article, Stumpf (2001) describes a game-theoretical approach to understanding human language in evolution, and the variables of selection that would have led to the development of a universal grammar, distinctive to human language and communication. Stumpf described the close links between language development and cognitive evolution to conclude that human language must be explored and understood as a biological phenomena, not simply a cultural characteristic of humans. He suggests that the study of language must concentrate on identifying modes of diversity in language (mutations) and mechanisms for understanding why certain changes take hold while others do not (selection). He is basically proposing the study of the evolution of human language; not using evolution as a metaphor, but as a scientific model no different than that used to understand the lineage of *Homo sapiens* from *Australopithecus aferensis* through *Homo habilus*.

He explores such evolution by looking briefly at the development of lexical structures, syntax, and grammar; with universal grammar as a special case. Noting that many species of animals exhibit rudimentary language capability, Stumpf observes that human language is the only language that is symbolic. Non-symbolic languages represent every instance of concrete thought or expression as a distinctive sound (word). Abstract thoughts or expressions are absent. A non-symbolic language is possible to the extent that unique words can be invented for every thought to be expressed. Smith (1999) emphasized that only a symbolic system can be used to convey an arbitrarily large number of different messages. (p. 20) Von Bertalanffy (1981) echoed the need for the freedom to produce large numbers of arbitrary messages, noting the evolutionary origins of symbolic systems for survival selection. (p. 69)

Human language has evolved to be symbolic. Grammar is what we call the rules that allow different symbols to be combined into more involved utterances and combinations of ideas. The lexicon of language is no longer limited by the number of words, but by the combination of such words available under the rules of grammar. An underlying universal grammar provides a framework, a solution space, within which language can vary while continuing to be seen as human language in form.

The universal grammar of nouns and verbs, for example, will have advantage in the language game whenever the number of events to be represented exceeds the number of words available. The symbolic language that uses such a universal feature will be able to represent the number of ideas denoted by the product of the number of nouns and the number of verbs; an extremely large number. If the universal grammar model is expanded to include other general forms of human expression (e.g. nouns as subject or object in the same utterance; adjectives and adverbs as extended modifiers) then the permutations available for human language become virtually infinite even with very limited lexicons.

Stumpf explores game theory as a mechanism for such study. Language features have selective advantage to the extent that they promote the continued use of themselves across individuals and generations. As variation is encountered, dialects and differences in language develop that themselves have advantage proportional to the ability of collocated individuals to understand and propagate the varied language features.

Stumpf's analysis is powerful because it clearly directs language research toward the rigorous disciplines and models of evolutionary biology. That line of thinking provides the basis for the opening chapters of this depth component. Human language isn't a cultural artifact layered onto our biologically developed cognitive brains. It is an integral component of both our cognitive functioning, and our biological structure. A human brain without language simply doesn't look like a human brain with language; making human language a biological function amenable to evolutionary analysis. This depth component undertakes an outline of such an analysis.

Turner, F. (2001). Transcending biological and social reductionism. *SubStance, 30*(2). 220-235.

Scientific reductionism has expressed wonderful historical power and richness in explaining the origins and conditions of human life and experience. Turner (2001) explores the contrast between such reductionism shifting our knowledge of more and more human experience into genetics and neurology, and the discovery of emergent properties that violate that reductionism while enabling its richness to unfold.

For Turner, historically reductionist thinking in both the biological and social sciences has explained a great deal and served humans well. However, those very successes have brought such thinking close to its own end in explaining the richness of the universe and our place in it. Materialism, he argues "was simply the best guess, at one stage of the development of science" (p. 222) of what would maximize understanding and extend knowledge. The materialist presumption and reductionist epistemology empowered the sciences. Biology, chemistry, and physics, and the scientific method generally, were made possible by the assumption that reductionism would explain a materialist universe. With such an assumption came the ability to posit conditions using a bottom-up methodology that would then be validated or invalidated through top-down reductionist inquiry. Because the universe was seen as fixed, inquiry could take direction from discrete reductionist findings.

A weakness in this approach, according to Turner, was its expectation that the material world being explored was unchanging, or at least only changed according to fixed rules that could be discovered and understood. In fact, the universe doesn't work that way; and twentieth century science started to discover the boundaries where such reductionist thinking would break down. The emergent properties of complex and self-organizing systems can't be explained through reductionism. Turner applauds the shift, noting that the reductionist science of a materialist universe was increasingly specializing in studying the very very small, or the very very large. Science in the twentieth century shifted largely into the study of things that were outside of the human scale. Areas of study at the human scale were lost in the shuffle of presumed solidity and lack of interesting change.

Principles of evolution and ecology, according to Turner, represent turning points in study of the universe. "Evolution, for the first time in history, has given an intelligent account of how novel realities could come into being." (p. 223) He views evolution as a universal freedom from lack of change, and a breaking point for reductionist science because of the complexity and adaptiveness of the systems involved. Science needs adaptive theories to describe this new universe. Chaos and complexity theories, quantum mechanics, nonlinear dynamics all provide a new language and perspective for studying and understanding these emergence-oriented system changes. When Turner uses evolution as a paradigm for anti-reductionist change, he doesn't limit himself to biological change. He discusses evolution as a driving mechanism of systemic change and improvement on many scales. Evolution drives change in systems by experimenting and changing individuals.

Turner offers *time* (citing Fraser) as an example of non-biological evolution that vastly predates the final evolution of human time discussed in the breadth component. The earliest universe had no time. The special theory of relativity tells us that photons moving at the speed of light experience no time; they are atemporal. However, quantum mechanics also tells us that through all space, including the space occupied by the massless photons, there will be clouds of subatomic particles coming into and going out of existence. These particles experience time, but not a time that yet exists in the universe; they are prototemporal. We know they experience time because they must obey the uncertainty principle which provides for a maximum time during which they can exist without violating the laws of physics through their existence. By obeying the law, they remain absent from the universe; but such behavior necessitates that they experience time, even if the universe does not yet share in that experience.

The existence of such particles, even if only very briefly, invokes the Pauli exclusion principle to keep them apart for their brief lives; otherwise there would be no meaning to saying that the particles ever existed separately, even in principle. The necessary separation of two brief particles necessitates the existence of space. "A non-spatial world, if everything thinkable within it is to remain logically consistent, must generally generate a spatial world." (p. 225) A spatial universe, even if extremely small, will demand the existence of time in order to measure the durations required for photons to travel across space. Photons, themselves timeless, result in a spatial universe in which time measures their passing.

This evolution of time happened during the earliest and smallest fraction of a second according to our current reckoning; although at the time there would have been no time scale against which to assert that one unit of time were large or small. From then, time evolved relatively slowly, but importantly through the growth of the universe. Thermodynamic principles demanded that time *seem* to pass, even though general relativity tells us that spacetime simply *is*. System mechanics, particularly biological evolution, must observe this passage of time, and so we evolved with a sense of past, present, and future. Verb tenses in human language are a direct outgrowth of this temporal evolution. By the time that humans were trying to measure time in the ways introduced in the breadth component, time itself had already undergone an extensive evolution that began with the birth of our universe.

Turner's other example of non-biological evolution is evolution itself. He notes that it is interesting that one of the earliest biological evolutionary scientists, Lamark, laid groundwork in the principles of the inheritance of acquired characteristics. While such principles fell toward disfavor in explaining genetics, they have been resurrected as the principle model of cultural and social inheritance; the dominant form of human evolution in the last 30-50 thousand years. The shift from evolutionary thinking from Darwin to Lamark - from genetics to memetics – is the major thrust of this depth component.

Wang, X. (2002). Developing a true sense of professional community: An important matter for PM professionalism. *Project Management Journal, 33*(1). 5-11.

A profession is often described in terms of its members sharing a body of knowledge and standards of practice, a code of ethics that may involve certification or licensure, and a commitment to ongoing and continuing education and development. Wang (2002) argues that beyond these basic and mechanical characteristics common to professions, a profession is mostly a community exhibiting its own culture and patterns of behavior.

As opposed to simply a job group, or even occupational area, professional activities much more directly impact the lives and self-images of those who choose to participate in the profession. Wang sees professional activity as central to the life interest of its practitioners. Professionals usually see themselves as what they practice; their profession being an end in itself rather than simply a means toward other ends. As a result, professionals will typically associate themselves with what they do rather then who they do it for. They'll look to others in their profession as their reference group; gaining more from professional recognition than from any employer recognition. Lastly, Wang describes a fading of the lines between work and non-work lives for professionals. If employment isn't self-defining, then job can be something outside the self. But for professionals who are what they do, there is no life beyond work. Personal lives become enmeshed with professional practice; and an increasingly large portion of social groups and interactions for the individual will be drawn from the profession.

Writing specifically about project managers, Wang notes that the ambiguity of the role of a project manager in our economy, and the large diversity of individuals who carry out that role in organizations, serves as an impediment to project managers gaining status as professionals. A large cadre of dedicated project managers strongly desire to be viewed as professionals, and yet often are not because of the lack of clarity of exactly what such a profession would mean for those who do project management, but don't consider themselves professional project managers. Wang proposes that a specialized term be invented for the professional sub-cadre, but acknowledges that it is unlikely.

So, although project management has a body of knowledge, codes of ethics and certifications, and continuing education; it struggles to be viewed as a profession. Professions like medicine, law, and architecture don't struggle in the same way. You can't be a doctor, lawyer, or architect in our economy without entering the profession. Anyone can be a project manager; and so the ones who view what they do as a profession remain bogged down by the practitioners for whom such practice is just a job. This issue will be directly relevant in the application component precisely because software engineering is another example of a profession in which professional status isn't a barrier to entry.

Wenger, E. C.; & Snyder, W. M. (2000). Communities of practice: The organizational frontier. *Harvard Business Review*, *78*(1). 139-145.

The corporate world has seen significant growth and discussion of the role of teams in promoting organizational effectiveness. In this article, Wenger and Snyder (2000) explore this phenomenon, and look beyond it, to describe *communities of practice*. These communities, usually self-organized groups of individuals sharing knowledge and expertise among each other, contribute to an organization's knowledge. Wenger and Snyder write of these communities as managers trying to consider how and when formal organizations should promote such informal exchanges.

Wenger and Snyder describe these communities as contributing to problem solving, promoting the sharing of best practices across an organization, and helping to develop professional skills across the community of practitioners. If well supported, such communities across an organization can even support formal recruiting and skill retention objectives. What makes such groups particularly interesting is the contrast in their makeup and operation when compared to more traditional work groups and teams within organizations.

Communities of practice tend to exist exclusively to promote and enhance the skills and knowledge of their members. Participation is typically through self-selection; and continued participation is usually a measure of the enthusiasm and career drive of each individual member. While Wenger and Snyder suggest means in their article for formal managers to promote and encourage such behaviors, the means available are typically limited to providing a workplace infrastructure where such groups and behaviors can emerge naturally. Attempts to force the phenomenon simply result in traditional committees and task force structures; even if named as communities.

These groups of informally organized people who share expertise, and interest, for their combined purposes represent more than teams, and less than professions. This middle ground is why Wenger and Snyder's descriptions are useful in this depth component. Although they are addressing the usefulness of communities of practice in management theory, their inclusion here is because communities of practice, as described by Wenger and Snyder, represent a form of proto-profession. As this KAM, particularly the application component, explores the software engineering quality profession, this distinction will be useful.

Young, K.; & Saver, J. L. (2001). The neurology of narrative. *SubStance, 30*(1). 72-84.

The physiology of the human brain is intimately involved in our ability to think about the world and its relationships to ourselves and our surroundings. Young and Saver explore the way, through narrative, individuals tell stories – as internal mental interpretations of the world, and as spoken shared myths and wanderings – about the world that integrate their knowledge, beliefs, feelings, and reasonings; all mental acts with apparent neurophysiological underpinnings.

The authors associate narrative, or storytelling, with several forms of memory that they associate with advanced human cognition. Generic memory serves as a background of facts and experiences that form a foundation for the more specific episodic memories that are tied to specific time and place. Out of the combination of generic and episodic memory, Young and Saver describe autobiographical memory emerging to tell the "story of one's life." (p. 74) Such memory tells the story of self in ways typically unavailable to the young child who is capable of generic and episodic memories but can't yet weave a story together to provide meaning to the events and experiences of life. More advanced memories are experienced in words - "narrative-motivated words," (p. 74) – and are integrated into an individuals social fabric and interactions.

Young and Saver go on to illustrate the physiological underpinnings of such memories, and the storytelling enabled by them, using four dysfunctions seen in narrative abilities that are known to be associated with specific brain injury or trauma. The first two are both associated with damage in the amygdalohippocampal system. In one, *arrested* narratives are a clinical manifestation in which the narratives shared by an individual are accurate, but only up to the point at which the injury was incurred. Stories shared by such individuals are truthful, but only using facts and interests known or held by the individual prior to injury. Such individuals are often described as "frozen in time." (p. 76) Illustrating the way such narratives are a window on consciousness, individuals exhibiting arrested narratives are also seen to keep the same interests and dispositions over extended periods of time, often decades. An inability to weave new autobiographical memories appears to result in the actual experiences and thoughts that would have formed the basis of those memories, for all practical purposes, being lost as well.

Another possible clinical manifestation of injury in the same system is *unbounded* narrative. Such individuals are able to weave rich and complicated narratives of their autobiographical self, although they seem completely unconstrained by the accuracy or truthfulness of the facts and experiences they use to weave such stories. These individuals are always unaware of their disability, simply filling in gaps in their autobiographical memories with fictitious information and often mutually contradicting details. Young and Saver liken such narrative to the real-world equivalent of dreaming, where the veracity of what is being said usually remains unchallenged and so seems reasonable while being experienced.

Damage to the orbitofrontal cortices can result in stories that are *under*-narrated. Where most individuals are known to be constantly analyzing possible scenarios and ways of expressing themselves, this dysfunction involves a failure to properly analyze and evaluate narrative choices. Under-narrators are typically unable to connect emotional and rational thoughts. They adequately construct narratives from autobiographical memory, but seem unable to invest emotional meaning to those narratives; and consequently make inappropriate choices regarding their expression.

Sufferers are seen to simply express themselves with the first version of an idea to be generated consciously. Little or no evaluation is applied to memory usage. The first response available that seems relevant to a situation is the one uttered, often with severely negative social consequences since the first thoughts encountered in memory are often negative criticisms or self-serving interpretations of a situation. As with the previous dysfunctions, Young and Saver illustrate that such dysfunction affects more than just narrative ability. The disconnect between rationality and emotion seems to affect everyday reactions to the on-going surroundings. The presentation of desirable or repellant objects fails to elicit an expected emotional or physiological response, even as individuals are capable of describing the reasons such items should be desired or repelled.

The fourth narrative dysfunction described by Young and Saver involves damage to the dorsolateral frontal cortices. Individuals with such injury often lose the ability to put together what is going on around them in the world in such a way that any form of meaningful narrative emerges. These *de*narrated individuals can't organize their experiences in any meaningful way, although they are known to experience the world's sensory experience quite normally. They don't speak unless spoken to, and will typically only move in response to strong physiological needs.

Young and Saver use these narrative dysfunctions to illustrate the importance and role of narrative in our cognitive and social make-up. "Narrative is the fundamental mode of organizing human experience" (p. 78) and the loss of narrative ability is a loss of self. "To desire narrative reflects a kind of fundamental desire for life and self that finds its source in our neurological make-up." (p. 80) Young and Saver use these dysfunctions to illustrate our mind's ability to decouple reality and narrative – physical motor responses from envisioned behavior - in ways that can be dysfunctional; but that can also be viewed as "evolutionarily advantageous." (p. 80) Such decoupling – the ability to explore different response narratives to every real-life situation might be the evolutionary origin of our ability to express ourselves in literature.

Chapter 1

Introduction

Overview

Within the study of human development, the coevolution of cognition and language is particularly important, both for the enduring biological evolution of modern humanity and for the socialization enabled by the cognition-language capability unique to humans.

The breadth component of this KAM explored the basic mechanisms within which the biological, cognitive, and socio-cultural aspects of human development played out, and the interactions and interdependencies that can, and did, affect our development as a species. This depth component will explore a subset of those interactions; specifically the role that cognition played in the development of language, and the role language plays in enabling and defining social groups. The application component will then review the software quality engineering profession as a specific social group under that interacting model.

Depth Objectives

The depth component of this KAM further explores the principles of any role of language and symbolism in the development of cognitive structures within individuals and social groups.

Specific depth objectives are:

1. Explore and contrast the different theories of cognitive and language development with an emphasis on impacts on the formation of social groups.

2. Evaluate the extent to which various key elements of the framework developed in the breath component can be used to map aspects of those theories to individuals and groups.

3. Analyze and synthesize the resulting mapping to create a model for analyzing and defining the role of cognition and language in the formation and maturing of a profession in modern society.

Looking Ahead

The following chapter, *Evolution and Cognition*, looks at the evolution of human cognition, beginning with the historical failure of reductionist scientific approaches to adequately explain consciousness and cognition (as seen in the on-going prevalence of the mind-body *problem* in the philosophical and new-age literature) and moving toward a quantum explanation that views mind as a direct emergent property of the electrical and chemical complexity of the brain. Chapter 3, *Cognition and Language*, then looks at how the biological evolution of increasing complex brain structures has led directly to the development of language capability; often using functions of the brain that have evolved for very different purposes. The way the brain has evolved makes language both necessary and inevitable.

As a negotiated medium, language enables social structures and organization that would otherwise be impossible. Chapter 4, *Language and Socialization*, explores this theme before Chapter 5, *Socialization and Professional Groups*, pulls together these threads into a working model that will lead directly to the analysis of the software quality engineering profession in the application component.

Chapter 2

Evolution and Cognition

Failure of Reductionism

The study of the biological and sociological evolution of the human species explored in the breadth component was based on an epistemology that focused on understanding the function, origin, and interaction of an ever-growing list of components and subsystems. McFadden (2001) observed that the historical advances in chemistry and microscopy taking place as the story of evolution has unfolded in the past 200 years has actually driven the life sciences toward the reductionist epistemology. (p. 10)

As reductionism reduces the scale and scope of analysis to lower levels of detail, it reaches its point of ultimate failure. Reductionism in science can explain a great many things, but it can not explain what happened in the first few milliseconds of time to create the universe in which we find ourselves, and it can not explain the on-going existence and recurrence of life. Reductionism can take apart any living thing and explain how every piece works, right down to the biochemical level, but it never divulges any mechanism that can be analyzed as an explanation of life. If reductionism can describe, but not explain, life; then, in what way can the obvious existence of life be integrated into a working hypothesis and understanding of the universe that is otherwise highly explainable using such reductionist views?

Anthropic Alternatives

One answer involves the very obviousness of life's existence, both in us, and all around us. Evolutionary theory has demonstrated that a broad array of accidents and experimentation has needed to exist in the biological record in order to develop and specialize the array of species that exists on our planet. Reductionism in science has shown an amazing sensitivity to initial conditions in everything from the subatomic charge of the electron to the advanced macroscopic balance of internal temperatures associated with warm-blooded animals. Change the initial conditions just slightly, and evolution replays with entirely different results. Could the universe as we know it have evolved without such extensive life? Yes and no. The universe clearly could have evolved without life, but it hadn't.

Anthropic Principle

Our knowledge of the universe presupposes our own existence within it (echoing back to the position of Descartes that was used to introduce the breadth component of this KAM). Breuer (1990) discusses this perspective, generally now identified as the Anthropic Principle. The universe must be viewed as being constructed in a way that enables intelligent life to emerge in some form; not necessarily as humanity, but in some type or form. Quite simply, if this were not so, we would not be here to debate it. (p. 3) Breuer describes the two schools of thought that exist among anthropic studies today. (p. 8-9)

First, the *Weak Anthropic Principle* states that simply because there are intelligent observers in the universe, the universe must possess properties that permit the development of such observers. The weak version of the principle carries back to Descartes' *cogito ergo sum*, observing the illogic of trying to describe observers in a universe unable to develop and support such observers. On its face, the weak version is undeniable.

Second, the *Strong Anthropic Principle* goes further, stating that the structure of the universe observed by science is essentially fixed by the condition that at some point in its unfolding it will inevitably produce intelligent observers. While the weak version can be used to at least imagine a universe without observers, the strong version denies the possibility. A universe without observers couldn't exist. Such a non-universe would be trapped in a quantum superposition (see below) similar to what current astrophysicists believe to have existed as the precursor to our inflationary Big Bang universe. No observers; no collapse of the universal wave function; and no universe.

Anthropic Research Pedagogy

The purpose of this KAM is not to debate the strengths and weaknesses of either version of the Anthropic Principle. What makes it meaningful here is what Breuer (1990) refers to as a "research pedagogy" that can be developed using the Principle in its two forms. (p. 38) As stated above, reductionist science can not explain everything it sets out to explore. Observations remain uncategorized under existing models and theories. Theoretical constructs remain untested. Information at the margins remains a thorn in side of science.

Breuer suggests that the Anthropic Principle allows these marginal and peripheral observations and theories to be included in an expanded pedagogy that relates information to one of three layers: 1) the conventional science layer where experiment and observation establishes facts, as in physics and chemistry; 2) the weak anthropic layer, where science can't explain the observations, but variations of the fact seem plausible without sacrificing the universal structure necessary for intelligent observers to evolve, and 3) the strong anthropic layer, where the information can not be explained through science, and any variation at all seems to preclude the development of intelligent life. The goal of scientific research is to move information and knowledge from the strong, to the weak, to the scientific layer. Under this pedagogy, every piece of information has a place until science can move it toward the first scientific layer.

Noteworthy in this pedagogical model, according to Breuer (p. 10), is the extent to which so many observable properties of the world and universe actually belong in the scientific layer. Showing the actual strength of reductionism, most characteristics of the universe can be explained using only a few basic scientific laws and observable facts. However, it is those very facts that today most challenge scientists seeking a complete and unified theory of the universe. Many entries in the anthropic layers revolve around the values of various constants in nature (e.g. speed of light, charge of electron, mass of subatomic particles). Having values that are well defined in the scientific layer, an explanation of why these values are what they are, and their fundamental importance to the emergence of life, anchors them in the anthropic layers of the model. Within the last century, though, many of these facts have teetered on the edge of shifting completely into the scientific layer. Quantum mechanics offers hope that these values will soon be explained by science as readily as the laws of acceleration and force that Newton moved out of the anthropic layers over 300 years ago.

Quantum Mechanics

McFadden (2001) offers quantum mechanics as an alternative to a reliance on anthropic alternatives to explain the failure of the reductionist approach to explaining life in the universe. (p. 101) Quantum mechanics can accurately predict the motions of electrons and protons in deoxyribonucleic acid (DNA) that initiate the mutations that drive evolution. In fact, McFadden describes life as the “only macro-world quantum system,” (p. 220) because life is the only quantum system where the actual effects of the measurements and interactions characteristic of quantum mechanics can be observed to be at work.

DNA Replication & Mutation

Genetics is driven by the accurate replication of DNA in live cells undergoing mitosis. Evolution, as explored in the breadth component, is driven by the selective adaptation of the results of mutations in the DNA structure that are then replicated in the mitosis process. Quantum mechanics offers an explanation for why such mutations occur, and how often they are seen to occur naturally. DNA replicates by splitting down the middle of the helix structure and rebuilding two new structures by matching the nucleic acids in each split structure with the appropriate second half; reproducing the "base pairs" that made up the original DNA molecule.

Quantum mechanics indicates that at any given time, all atomic structures are subject to slight variability in their makeup. All atoms are seen to shimmer among a collection of possible quantum states. Typically, changes to the atomic structures are unobservable in the macroscopic world because quantum mechanics forbids detail knowledge of atomic structure and location simultaneously (e.g. the Hiesenberg Uncertainty Principle).

The base pairs in DNA are atomic structures subject to the quantum fluctuation effect. With the number of DNA molecules involved in a living organism, and the frequency of DNA replication (e.g. human DNA replicates about six times per hour throughout our lives), such quantum fluctuation can, and will, inevitably have an effect. Electrons can quantum tunnel to different locations on each molecule. If this happens to happen at the instant that mitosis is attempting to interpret the molecule to decide what nucleic acid is required to make a match during mitosis, the result can be that the wrong nucleic acid is selected. By the time the replication is complete, the original molecule has returned to its normal state (it is required to do so by the Uncertainty Principle or else the change could be observed in the macroscopic world), and the base pair in the replicated DNA will appear to be wrong (e.g. Adenosine-Guanine rather than Adenosine-Thymine, or Thymine-Cytosine rather than Cytosine-Guanine).

To the observer in the macroscopic world, the DNA has spontaneously mutated. Quantum mechanics predicts that this will occur in approximately 1 in 10,000 base pair replications (.01%). By itself, this mutation rate would prevent the evolution of complex cells and life; and so evolution has selected for cells that include proofreading enzymes that identify and correct many of these incorrect base pairs; bringing the effective natural mutation rate down to 1 in 1,000,000,000 replications. This prediction based on quantum mechanics is roughly the actual mutation rate observed in nature. Findley, McGlynn and Findley (1989) report the frequency of random mutations in nature to be between 10^{-9} and 10^{-6} in prokaryotes, and 10^{-6} and 10^{-4} in eukaryotes.

McFadden (2001) notes that the "errors that escape the correction machinery are the source of naturally occurring mutations; and their source is *quantum-mechanical*." (p. 66, author's emphasis) Quantum mechanics becomes "the fundamental basis for life" (p. 66) and the "driving force of evolution." (p. 66)

Individual vs. Population Evolution

The observed mutation infrequency in DNA makes it difficult to discuss evolutionarily driven changes in individuals, although the number of changes evident in each individual will still be substantial given the large number of genes and alleles found in the complex structure of any individual. Statistically though, McGlynn and Findley (1989) suggest that the effects of evolution are best described at the level of populations, since that which is statistically unlikely in the individual becomes statistically expected in the population. (p. 128)

McFadden (2001) notes that many quantum systems appear to make major leaps before and after relatively stable periods. (p. 72) This may offer quantum mechanical support for Gould and Eldridge's (1993; and Gould, 1996) punctuated equilibrium model of evolution introduced in the breadth component; with natural selection working at a higher level of abstraction to select new species from among available alternatives (i.e. the *bush* instead of the *branch* metaphor). Dawkins (1976) denied the broader population evolution possibilities, remaining true to the core principle that evolution is driven by the mutation and selection of single genes within individual organisms. He describes species selection as an emergent property of the interaction of individual mutations. Quantum mechanics supports both views, emphasizing the predictability and certainty of the underlying mutation process.

Reductionist vs. Quantum Effects

Whichever view is finally accepted, the reality of Gould's *bush*, or the emergence of Dawkins' *species*, the reductionist approach to understanding evolution is left with explaining the reasons behind the punctuated patterns seen in evolution. In particular, how did some of the earliest evolutionary steps get taken during the invention and development of life on earth?

McFadden (2001) explores the case of the adenosine monophosphate (AMP) molecule. (p. 75-78) This essential biochemical is created through a series of 13 independent biochemical reactions that must each occur in the correct order, with none of the steps creating a byproduct considered useful by biochemists. How did evolution, normally described as making small incremental steps of progress, manage to develop such a complex mechanism in a single leap? It is cases like these that present the greatest conceptual challenges to evolutionary biologists when relying only on the traditional reductionist pedagogies. When quantum mechanics is included in the discussion, the issue resolves itself.

Quantum Superposition

Quantum mechanics predicts that all mass-energy is constantly undergoing quantum fluctuations that allow it to behave and interact in different ways and combinations depending upon the actual combinations created during those fluctuations. The Uncertainty Principle forbids such quantum effects from being observed, but places no upper limits on their complexity if left unobserved. Since the actions under discussion are unobservable, there is nothing to prevent multiple possibilities from being explored; even if those possibilities are mutually incompatible or contradictory. The mass-energy can be said to be in a superposition of multiple possible states. Observing the system requires only one of those states to be observed, and so the quantum superposition state collapses to a single mass-energy state in the macroscopic world. The *observation* discussed in quantum theory need not involve any conscious being. Observation can include any interaction with other mass-energy systems that require the original system to be in a particular state.

It is beyond the scope of this KAM to explore all of the intricacies and influences of quantum mechanics. However, superposition is needed here precisely because it explains the emergence of complex structures in evolution without intervening simpler steps. In the case of the AMP molecule discussed by McFadden, the various atoms and molecules that make up AMP are constantly in the process of going in and out of various quantum states; there exists a superposition of states for the collective.

Basically, the permutations of biochemical combinations needed to make AMP in nature are constantly being 'explored' in the hidden quantum superposition states of the involved mass-energy. If one or more of the intermediate products had a useful purpose in the environment in which they are being explored, the process would collapse into a single macro-state as the invented molecule interacted with its environment in some useful way. But because all of the intermediate steps involve non-useful products, the result is allowed by the Uncertainty Principle to continue exploring its superposition states. Finally, one of the explored superpositions would be AMP, and it would react to its environment. Such a reaction would be the observation that pulls the quantum state back to the macroscopic world. In the macroworld, AMP appears suddenly as the result of 13 linear and dependent biochemical reactions. What the reductionist approach couldn't begin to explain is seen as a natural product of quantum mechanical effects.

Quantum Cell-Life System

While quantum effects can explain the punctuated nature of evolution, the more basic question remains: What started it all? What originated life at all from the inanimate chemistry of the universe? Quantum mechanics offers the same explanation as that needed to evolve the AMP molecule: quantum superposition. In the absence of life, quantum superpositions were relatively unconstrained in the complexities they could achieve without violating the Uncertainty Principle. As a result, vast permutations of atomic and molecular organization could have been occurring at any given time, each building up vast chains of complexity that would make the evolution of AMP appear trivial. Billions of molecular permutations could be explored by otherwise small and simple sets of chemicals. Eventually, and adherents of the Strong Anthropic Principle would say inevitably, one of the superposition states would involve the ability to replicate. Such replication would be an observation; and so the superposition of states would quickly collapse to a single macrolevel state of a self-replicating set of molecules. McFadden observes that only such an event would be able to halt the ongoing drift through the quantum multiverse. (p. 268) Without some chain of involvement such as replication, mutational events would forever stay in the quantum realm. Life would be the result.

Once the quantum wave function has collapsed, Darwinian natural selection takes over. Quantum explorations leave no historical trace. The result of the wave collapse appears, in our macro-universe, to have been synthesized spontaneously. Life's critical dependence upon quantum effects remains hidden from view. What makes living matter unique, when compared to inanimate matter, is this ability to take advantage of quantum measurements in the quantum multiverse in order to direct action explicitly in the classical universe. Life is, therefore according to McFadden, the only classically observable quantum system.

Consciousness & Cognition

The last issue to be addressed in this chapter before moving on to the specific language-cognition discussion is the first issue that was raised in this chapter; namely, the failure of reductionism to adequately explain core concepts in our self-image as a species. The human mind or consciousness has plagued philosophy and science for thousands of years. Our inability to explain the differences and similarities between body and mind has been an area of on-going research and debate.

McFadden reports on research that has been looking at the relationship of brain to mind, or consciousness. (p. 286-290) Central to much of that research is the issue of voluntary action, or how the brain can cause the body to perform specific voluntary actions that are obviously under the control of the conscious mind. For example, if I choose to lift my finger it is a voluntary and conscious act. Or is it?

Researchers who study such acts while monitoring brain activity have been finding interesting results. Subjects are typically studied so that they can report their conscious thoughts and actions while their detail voluntary actions are recorded and mapped to their self-report conscious observations. Controlled studies have found that voluntary actions, like lifting a finger, are reported by subjects as being initiated roughly 200 milliseconds before any physical stimulus is present for the voluntary act. This fits with the popular common sense notion that the conscious act must precede the voluntary motion.

There is a problem with this interpretation, however. In these studies, researchers measure actual brain activity independent of the self-reporting of conscious activity coming from the subjects. These measurements show that there is specific neural activity associated with the observed voluntary acts some 400-500 milliseconds before any physical reactions are observed. This means that the choice to act precedes the conscious choice by some 100-200 milliseconds. The voluntary initiation of motion is a subconscious act. The free-will nature of the act, it turns out, is when the conscious mind chooses not to stop the action.

This finding is consistent with the belief that most animals can carry out voluntary acts, even though they are not attributed with having consciousness. It also helps explain how so many voluntary acts we carry out through a typical day can go completely unobserved by our conscious minds. Free will, or choice, is an experience of the conscious mind interpreting and intervening in the actions of the subconscious mind. In order to do this, the mind needs access to the entire brain's current state. With billions of neurons firing, how can this form of measurement be accounted for (the classic mind-body problem rephrased)?

Penrose (1989) suggested that what we call the mind is actually a quantum-mechanical system at work. With the billions of neurons that make up the brain each firing electrically on their own timetable, there exists one large electric field through the area of the brain. That electric field is describable as an electromagnetic wave function subject to all of the functions of quantum theory, including superposition, when unobserved. The neurons in the system can fire in any systematic pattern, and the wave function can experiment with multiple simultaneous alternatives; unless a specific observation of wave state is made in which case it must collapse to a single possibility. Perhaps, researchers are now suggesting (McFadden, 2001; Penrose, 1989; Zohar, 1991), consciousness is the emergent property of the superposition wave function collapsing to a single macroworld possibility.

McFadden (2001) suggests three properties that must hold for such an explanation to be viable: a) the brain must generate an electromagnetic field that encompasses a significant portion of our neurons, b) our consciousness must be a product of that field, and c) the emergent consciousness in the field must be able to influence subsequent neuronal firing.

The first condition – the presence of an electromagnetic field - is readily met; as evidenced by the routine use of electroencephalogram (EEG) monitoring in health care today. The wave function measured by these devices is very stable, meaning that there are enough individual neural firings being measured that distinct firings, or concentrations of firing, across the brain do not disturb the resulting field.

This has implications, still to be worked out in the research, for the size of brains that might exhibit consciousness in looking at the second condition. Too small a brain will have few enough neurons contributing to the field that concentrated firings in localized areas of the brain could perturb the field, resulting in a loss of field stability. If so, consciousness could not emerge in small-brained species. Likewise, the EEG shows that the strength of the electromagnetic field in the brain is very weak. This would place an upper effective limit on the size of a conscious brain. Brains that are larger than necessary would not result in more conscious power, because the inner neurons would not have the strength needed to contribute to the overall field. There would be diminishing returns as the brain grows larger. Quantum mechanics may ultimately explain why hominid brains grew so large through evolution, and yet do not seem to have grown larger since the introduction of the genus *Homo*. A conscious brain is neither too big, nor too small, for a single quantum wave function to develop and persevere over the life of the individual.

An additional implication of size on quantum effects would be that natural selection should favor keeping important autonomous functions (e.g. take a breath, beat the heart, digest the food) within the deep inner core of the brain. Evolutionary biologists have long noted the recapitulated order in which the earliest primitive brain functions are found in the oldest core tissues within the human brain. To say that these functions evolved earliest in these core portions, and that latter functions evolved in the expanding brain, is a descriptive statement. If offers no explanation as to why it should be so. There were certainly other distributed function scenarios available to natural section. A quantum-mechanical view of consciousness helps explain the selective advantage of the core recapitulated brain; namely, that the inner core of the larger human brain is too deep within the tissue to be effected by changes in the electromagnetic field taking place much closer to its surface. As a result, natural selection has favored a conscious being who can't choose to stop his or her own heart or regulate his or her internal temperature.

Beyond brain size issues and the impact of size on quantum implications within the system, the second condition – that consciousness be a property of the electromagnetic field in the brain – is also readily met; as evidenced by the routine use of magnetoencephalography (MEG) measurements to monitor the specific portions of the brain that are active during any particular conscious activity. The correlation between specific neural firings (in MEG measurements) and the strengths and locations of the electromagnetic field in the brain (in EEG measurements) is indisputable.

McFadden's third condition – that consciousness must be able to influence subsequent neuronal firing – is still controversial and under investigation. The voltages involved in firing a neuron from a complete rest state are significant enough that there is no suggestion that consciousness could control the firing of any single neuron in the brain. More likely, shifts in the quantum field that constitute consciousness could be subtle enough to just nudge neurons into firing that are already very close to their action potentials, or stop such neurons from firing by pulling enough energy to inhibit the effect. If so, quantum-based consciousness could influence the firing of neurons that are already in the process of participating in the various processes and feedback loops that already exist throughout the brain at any given time. Returning to the above example, consciousness could stop one or more of the neurons from firing that are necessary to lift the finger.

McFadden observes that in order to know a species is conscious, that consciousness must be able to communicate. (p. 308-310) Language is a necessity for cognition. Scientists who observe individuals who have been deprived of language during development find these individuals lack more than just language, they lack most of the advanced cognitive structures that we associate with being human. Human cognition involves observation, categorization, and unitization of concepts and observations drawn from stimuli. Language is what we call the brain's underlying cognitive structure with which this is done.

Nelson (1996) observes that every stage in the development in a child's life – from early infancy through adolescence – is associated with cognitive changes that are usually made apparent in improving language capability. Young children acquire vocabulary and grammar, gaining narrative and dialogic abilities as they age. Eventually we develop the mechanisms of formal argument. Each of these is an outward linguistic sign of internal cognitive function developing. (p. 86-87) He doesn't claim that cognition is totally dependent on language, but points to the relationship between the two as being very powerful. (p. 87) "Language amplifies and advances thinking in directions it would otherwise not be able to go." (p. 87)

Jackendoff (1996) outlines three ways in which language helps humans think. The first is the simple act of communicating with others. Such communication dramatically expands the range of data and applications available for cognition. This communicative use of linguistics provides much of the social function of language, but only opens the door to its more important cognitive functions.

The second way that language helps us think is through the creation of conceptual structures that are available for attention. Jackendoff compares hypothetical experience of humans to those of other species without language. Both can experience the world in similar ways; experience common sensory stimuli and evoking similar emotional reactions. But only humans can pay attention to, and reflect on, what is happening. Language clusters the neural network necessary to tie together experiences using information much broader than simple environmental stimuli. Language provides the index to a complex internal encyclopedia. We, therefore, experience the world very differently, and that experience affects the development of our cognition and consciousness. (p. 195) Without language, there is no basis for our being able to pay attention to what we are conscious of. (p. 197)

The third way Jackendoff describes language as helping cognition is in its ability to give definition to conscious precepts. Humans are characteristically abstract thinkers; and yet we seldom realize that most abstract concepts can only be defined linguistically. Jackendoff isn't talking about obscure scientific abstractions at this point; although he would likely include such concepts in this category (or perhaps define a new fourth category of language impact). Rather, he discusses everyday constructs; such as expressing *familiarity* with something, discussing *self-control*, or learning that one had a *hallucination*. (p. 204) These are all real-world experiences that can only be expressed linguistically. Language enables abstraction; a hallmark of human cognition and consciousness. This relationship is the subject of the next chapter.

Chapter 3

Cognition and Language

With the human brain made up of billions of neurons, understanding cognition requires offering an explanation of how these billions of neurons can work together in an ordered fashion to create the thinking and consciousness that we view as cognition. Each individual neuron exhibits a sigmoidal activation pattern, meaning it crosses a threshold when it becomes active, but that it can't exhibit different gradations of active. To the neurons around it, a neuron is either on or off. Levels of inhibition or excitation that don't affect this on/off choice only occur within the neuron.

Even with this limitation that they can only be on or off individually, the neurons in the human brain can form some $10^{7,000,000}$ neural activation patterns. This is more than enough to account for the monitoring and control of the millions of sensory stimuli available to the typical individual at any given moment, and it can include an extensive long-term memory structure. But we don't experience millions of stimuli; we see a tree. We don't remember millions of sensations; we remember our birthday party. How does the human brain, with its billions of neurons, select from among all of the available patterns to focus on what we come to believe are our thoughts and memories?

To make choices, the neural patterns in the brain have to be able to compare excitation patterns and select among alternatives. Simple comparisons are possible as long as patterns can encode OR logic (i.e. either of two options) and AND logic (i.e. both of two options). These simple comparison logics can easily be built by connecting only a few sigmoidal neurons. But to make choices from among comparisons, the brain must be able to recognize and code XOR logic (i.e. exactly one of two options and not the other; pronounced *eXclusive OR*).

On-center, Off-surround

The brain accomplishes these logical forms through the use of a particular neural anatomy that provides for an effective interaction of neurons in support of the required complexity: on-center off-surround anatomies. Such anatomies are not unique to humans, having evolved first in early fish to help solve certain locomotive and muscular challenges.

The on-center off-surround anatomy takes advantage of the resonant character of the brain; its nonlinear continuous feedback and feed-forward architecture that results from billions of neurons each interacting with hundreds or thousands of other neurons. On a local basis, the on-center off-surround anatomy consists of a neuron firing and simultaneously inhibiting the firing of neurons around it in a series of rings of neurons extending out three or four neurons from the center. The few neurons closest to the center will be inhibited the most, with inhibition falling off with distance from the center. Conceptually, this means that a firing neuron will tend to be localized within concentric rings of non-firing neurons. In fact, whether or not these inhibited neurons are firing depends upon the total pattern of interactions that these neurons have with the hundreds or thousands of other neurons with which they interact.

The effect of this anatomy is that while an individual neuron exhibits only an on/off choice, the collection of neurons in an on-center off-surround complex can exhibit varying degrees of "on-ness;" allowing the complex to participate in the more complicated XOR logic required of cognition.

Habituation

Another capability required for cognition to emerge from the labyrinth of billions of neurons is the ability to not just think about something, but also to *stop* thinking about something (using *think* in the neural sense, not the conscious sense). Neurons accomplish this through an explicit feature of their biochemistry known as habituation.

A neuron firing isn't simply a switch being turned on; it is the release of specific neurotransmitters that exist in only finite quantity in each neural synapse. A neuron firing must inevitably (and quickly) stop firing. Also, neurons firing repeatedly quickly find subsequent firing thresholds less and less effective. Any inhibition role these neurons play in the on-center off-surround anatomy is quickly turned off, enabling other local neurons to fire if other conditions are right. Such firing elsewhere can inhibit the original neuron from firing again.

Habituation guarantees that the patterns of neurons firing and being inhibited from firing are constantly changing; and on-center off-surround anatomy guarantees that such changes of pattern are constantly propagated throughout the brain.

The pattern of total neural activity at any given moment – its resonance – is constantly changing and affecting itself through nonlinear feedback and feed-forward mechanisms. In this way, the neural anatomy of the human brain is constantly evaluating the $10^{7,000,000}$ possible states that can be represented within the neural anatomy of the brain.

<u>Expectancies</u>

Such constant evaluation of states would not necessarily result in cognition if it were simply random seeking. A third property of the brain needed for cognition, in addition to the on-center off-surround anatomy and habituation, is the encoding and use of expectancies within those pattern states. The brain patterns of individual neurons firing and being inhibited from firing at any given moment can be viewed as the brain's resonance; its total state as an emergent property of all of its individual states.

States through which the brain passes that are cognitively useful – meaning that they feed back on themselves and reinforce other state patterns – gradually become easier to manifest and initiate than novel state patterns. The firing of the brain is not random-state seeking. It seeks prior states as though those states are expected to be seen again. Given two possible next states, the neuroanatomy is predisposed to pursue previously fired states. If such states fit with sensory stimuli and other neural feedback, the process simply continues with on-center off-surround habituation driving continuous state changes. All of this happens typically at the level of the subcortical nervous system; we are not aware of it.

But when the stimuli and feedback available to the brain don't match the resonance as expected, a rebound occurs as the varying state differences feed back and feed forward in different, and unexpected, excitation and inhibition patterns. New state and neural interactions are suddenly used beyond those that would normally be seen, and those new neural interactions are strengthened to become more preferred neural states, and *learning* occurs.

Loritz (1999) describes how a suddenly unexpected situation causes the "harmonious resonance to collapse … caus(ing) a rebound making it possible for the cerebrum to accommodate new information." (p. 88) All of this happens in the microscopic world of neurons, but can be seen in the human world whenever a pianist makes a small mistake while otherwise playing mindlessly, a gymnast subtly misses a step, or a lesson in a classroom suddenly 'clicks' for a child.

The sensory, or mental, world failing to meet expectations – as encoded in the brain's current state patterns – drives learning; whether that learning is being attempted consciously or as simply the human individual's normal growth and interaction with their environment. Neonates are constantly learning because everything about their environment is contrary to their expectations. We stop learning – typically as adults - when the variations we experience are less severe than the natural ambiguities that our brains have encoded in our neural patterns.

For real-world *book learning*, we retain an ability to learn throughout life because the content of what is being learned is forever novel and unexpected. But for internally evolved systems, particularly those that resolve ambiguities and draw distinctions among incoming stimuli, expectancies and rebound can be predicted to eventually place limits on learning. The very neural systems that have evolved to resolve differences among stimuli eventually treat the novel as simply an expected variation among otherwise expected stimuli.

This will have major impact in language when the notion of *critical period* is raised as a limitation to individuals learning new or second languages after a certain age in youth. Similar critical period research has been done on vision. Both language and vision are, neurally, largely about detecting signals among millions of simultaneously incoming stimuli and assigning meaning to those detected signals. Again, we don't see light, we see the tree. We don't hear sound, we hear words. What we see and hear, and our ability to see and hear new things, will be contingent upon what our brains expect to see and hear.

On-center off-surround neural anatomy, coupled with the continuous state change brought about by habituation, provides the neural architecture for the brain to implement the XOR processing needed for core cognitive processes. This anatomy guarantees that the brain will not fixate on a single pattern, and that choices will be available among different stimuli. The emergent functions of such choices include noise suppression, contrast enhancement, edge detection, pattern invariance, and other decision/selection processes from which cognitive functions are built. The mechanisms of expectancies and rebound learning provide for the brain to be able to do something with those cognitive functions.

<u>Language</u>

The specific cognitive function being explored in this KAM is language. The XOR architecture of on-center off-surround anatomy coupled with habituation enables the neural capabilities needed to have language. It enables contrasts to be enhanced so that distinct sounds can be deciphered from among the thousands of auditory stimuli being received by the brain at virtually any given moment.

An example of such contrast enhancement is the late night dripping faucet in an otherwise quiet and sleepy house. Under normal daytime conditions the brain would ignore such a sound as meaningless background noise. But in the contrast of the quiet night, the brain singles out the sound and amplifies it, further exacerbating the contrast, causing further contrast enhancement. The dripping doesn't actually get any louder, but to the light sleeper contrast enhancement will result in a perceived cacophony.

In the anatomy of on-center off-surround, the band-limited noise excites particular neural patterns in the neural systems involved in hearing. The neurons around these are inhibited by the firing of the central neurons. With no other sounds present, there aren't other neurons in the system firing and thereby inhibiting the neurons involved in hearing the drip. The absence of such lateral inhibition causes the system to feedback on itself and over-concentrate on the one sound available for detection.

The opposite of auditory contrast enhancement is auditory noise suppression, or white noise. The exact same neural connections, when presented with a collection of similar sounds without apparent edges in contrast, will hear the sounds, but will emphasize the off-surround inhibition; causing the neural patterns to suppress each other so that no sound emerges as an enhanceable contrast. The neural patterns represent the sound heard, but don't propagate a consistently strong excitation pattern to overcome the local off-surround inhibition. We hear, but don't know we hear.

The brain's ability to suppress what it doesn't need to hear and to detect edges and enhance contrasts in what is left is critical to the brain's ability to detect distinct words in language. Loritz (1999) describes this ability as "being near the essence of cognition." (p. 109)

To understand what the brain is doing when it hears language, it is important to not think of language as a series of disjointed words. The brain doesn't hear that way. Instead, humans hear language (neurally, not perceptually) as a streaming continuous sound being constantly monitored by the brain. This requires that the so-called *silence* between words and other sounds be thought of as part of the sound stream. In fact, the brain places a particular importance on the *hearing* of such silences.

Vocal Onset Time

The human brain hears silence as sound, and places a premium on the edges and contrasts created by such silences. The detection of each silence is important to each individual listener. Known as the vocal onset time (VOT), the interval of silence before the initiation of new sounds is relatively fixed among individuals in a language group. Different sounds will be perceived differently depending upon the length of the silence before and after the sound, and the ratio of that duration to the VOT of the individual language.

The presence of such silences interspersed throughout vocal communication isn't surprising when one considers the neural signals and muscular responses necessary to create vocal sounds. Neural transmission and muscle reaction take finite, if small, amounts of time. Between any two muscular adjustments there will inevitably be short periods of no sound formation. These subtle gaps simply happen too quickly to be perceivable consciously by either speakers or listeners; but it is precisely these gaps that create the contrastable edges necessary for human brains to detect and amplify spoken language over other sounds available in the environment.

Most human languages break sounds into two phonemic categories – voiced or unvoiced – based on whether or not they are contrasted against silences with durations less or greater that the language typical VOT. The typical VOT in English is around 25 milliseconds. (Note that conscious thought in humans requires around 300 ms. of neural activity, so VOT distinctions discussed here are far below the threshold of conscious awareness.) Sounds will be perceived differently based on where they fall against their VOT perception. Certain sounds are interesting precisely because they depend on timing distinctions that are actually very close to the VOT boundary (e.g. in English, the *d* can be heard as a *t* if quickly pronounced; as in *learned* being perceived as *learnt*.) (Loritz, 1999, p. 112)

Between two human languages with similar VOT (e.g. English and Chinese), individuals may not understand each other but will recognize all of the sounds being made. Between two languages with dissimilar VOTs (e.g. English and Spanish) there will be sound distinctions each makes that will simply be unheard by the other. Because the VOT of Spanish is nearly 0 ms., Spanish hearers will not differentiate among sounds in English that rely on the 25 ms. VOT boundary for recognizing differences. For example, Spanish hearers will pronounce the English words *shit* and *sheet* the same, to the embarrassment of seekers of paper. It's not that their ears can't detect the difference, it's that their neural systems don't choose to differentiate and enhance the difference. The two distinct sounds to an English hearer are simply perceived as two variations on the same sound by the Spanish hearer. Riney and Takagi (1999) found a significant correlation between VOT and measures of speaker foreign accents, indicating that a speaker's ability to learn a new language with or without an accent may be tied specifically to differences in VOT rates.

Certain other human languages differentiate three different phonetic categories, with two VOT boundaries. Thai and Bengali, for example, have two VOT boundaries; one near 0 ms. and another at around 25 ms. The brains of these hearers can simply differentiate more meaningful and distinct sounds than hearers of other languages. The speakers of these languages will be using sounds that English speakers don't recognize as part of language.

Language Cognition

Loritz (1999) observed that such VOT distinctions in hearing probably developed quite early in vertebrate evolution. The basic mechanisms are subcerebral and rely on simple dipole (e.g. AND/OR logic) mechanisms that exist in a wide range of contemporary vertebrate species. He suggests that the ability to differentiate narrowband periodic sounds (e.g. rustling leaves) from wideband aperiodic sounds (e.g. twig snapping as predator steps on it) would have offered selective advantage to any early species evolved enough to have the necessary dipole neural connections for drawing the distinction. (p. 114)

With the evolution of the polypole (e.g. AND/OR/XOR) on-center off-surround anatomy, the cognitive capabilities of contrast enhancement and expectancy would have further developed auditory analysis in ways that would enhance the ability to use language. One cognitive requirement of language is that a hearer be able to hear dramatically different sounds coming from multiple individuals and recognize them as the same words. As modern humans processing such a capability, we tend to take such auditory analysis activities completely for granted.

In fact, the on-center off-surround anatomy has evolved such capability quite naturally. The neural complexes involved in hearing language naturally enhance all of the contrasts built into language by the naturally occurring VOT. The wave patterns of every word (speaking of *waves* only metaphorically), while dramatically different for multiple speakers, seem very much the same when contrast enhanced. Exaggerated peeks and valleys look very much the same after contrast enhancement; forming an idealized phoneme that establishes a cognitive expectancy. As language is heard, the brain constantly contrast-enhances the individual sounds, resulting in matches against expectancy even though each individual speaker *sounds* different from every other.

This ability to deform incoming stimuli to match expectancy patterns is a central feature of evolved cognition enabled by the on-center off-surround anatomy. It supports not just language; but also vision, by filling in details of images; and memory, by connecting facts in long-term memory into conscious threads. Each successfully interpreted signal further strengthens the expectancies on which it is based. Taken to the extreme, we can accidentally hear what hasn't been said, see details that aren't there, and remember things that haven't happened. With the exception of circumstances involving mental illness, such mistakes are trivial compared to the millions of such cognitive conclusions derived from this neural architecture by every individual every day.

Bilingualism illustrates the complexity and interaction of language expectancies and memory expectancies. The relationship is complicated by the fact that expectancies are partly a function of the stimuli present and the context of the stimuli. A balanced bilingual can switch between contexts, meaning that a full new set of expectancies can take hold cognitively, in centiseconds. This is too fast for conscious reaction, but much slower than the differences in VOT that often signal the change of context.

There are many such interactions between language cognition and memory that are created by the on-center off-surround anatomy. In particular, Loritz (1999) described a memory implication, called *bowed serial learning,* that affects the neuroanatomy required to remember any serial string (e.g. list of number or letters, collection of sequenced sounds). Because of the lateral inhibition that is characteristic of each neural interaction, items in a serial list will be inhibited by each other more or less depending upon where they are in the list. Items at either end of the list are inhibited by nearer items toward the center, while items in the center are inhibited from both sides. As a result, items mid-list receive the maximum inhibition, often resulting in enough inhibition to prevent the entire neural complex from firing; thus preventing the serial list from taking form in cognition.

The most significant impact of the on-center off-surround anatomy is encountered in this situation. Since inhibition tends to extend only three or four neurons from the center, it means that the maximum inhibition will be achieved about two or three neurons from either end of a serial list. As a result, the on-center off-surround anatomy has trouble building lists involving more than four (plus or minus two) interactions. Longer serial lists simply exceed the physical capacity of neural interconnectivity as advanced brains have evolved.

The compensating mechanism in cognitive evolution is *unitization*. The brain is able to chunk small serial lists together by creating higher-order lists, the components of which are chunks that are themselves serial lists. In this way, the on-center off-surround anatomy can track a list of sixteen items as five different serial items, the fifth of which is a list of the first four unitized serial lists. No single list exceeds the neuroanatomical limits, and yet lists of arbitrary length and complexity can be built. This is how we remember telephone numbers (i.e. 111-222-3333), social security numbers (i.e. 111-22-3333), and the alphabet (e.g. ABCD-EFG-HIJK-LMNOP-QRS-TUV-WXYZ).

Unitization and Perseveration

What is most fascinating from a language standpoint is that the exact same neuroanatomical configuration will explain the emergence of phonemes, syllables, words, phrases, sentences, and conversations. This transition from a discussion of the on-center off-surround anatomy and its implications for neural processing of any serial list to more complex cognitive functions that are dependent on such lists requires this mechanism of unitization as well as an additional mechanism; perseveration.

Unitization is the chunking of memory based on the physical limits of the neural interconnections. Since the bowed serial learning curves implemented by the on-center off-surround anatomy limits the transient memory span to roughly four items, the brain must chunk elements of memory into units no larger than this.

In this way, unitization provides for the needed neural structures for human language; as the sentence unitizes (typically $N<4$) multiple phrases, which unitize words, which unitize syllables, which unitize beats, which unitize sounds, which unitize the combinations of muscular actions needed to make those sounds. With these unitized levels, arbitrarily long sentences can be uttered in series without violating the limitations of the brain's on-center off-surround anatomy.

Unitization alone can't account for the serial action of such cognitive structures, though. As described above, the strongest link in the series of neurons is the first one because it receives the least lateral inhibition when compared to the other neurons in the series. Why, then, doesn't the brain simply get hung up repeating the first element in the list? It does. In language, we see this effect as a stuttering, and we consider it a dysfunction. With the inhibition of subsequent sounds in the serial list, why don't we all constantly stutter?

The answer is neural perseveration, whereby the activation of each neuron inhibits itself, thus reducing the inhibition of the next neuron in the serial list, increasing its relative strength in the list. Thus the second item follows the first which is followed by the third, as the inhibition pattern propagates down the serial list.

Cognitive Rhythm

A neural ability to store, retrieve, and process a serial list of arbitrary length still doesn't provide a sufficient neural architecture to support language. It does not provide for a controlled pace. Neural firing of the necessary unitized sounds in the 300-500 milliseconds it would take to speak a complex sentence doesn't result in language because the process is simply too fast. Serial neural connections that measure action in a few milliseconds must be adapted somehow to result in serial *behaviors* of considerably longer duration; even if still in only tenths of a second.

The problem is one of converting an act that, on the surface, can be viewed as a single simple act and instead viewing it as an action start, an action duration, and an action stop. A simple brain can take these three actions, but only a more complex brain can control and coordinate these actions.

In evolution, the problem was initially solved by the earliest vertebrate fish. We commonly think of a fish as swimming through the water by moving its tail back and forth; a single simple action. The selective advantage brought about by the increased locomotion surely would have selected for the trait; but how did the fish do it? If the cerebral motor commands in these early fish had said to curl the tail to the side, that alone wouldn't have resulted in improved locomotion. Indeed, some higher function needed to recognize that the tail was already turned far enough that the tail could be told to stop turning; subsequently being told to turn the other way. It wasn't the movement that was novel at this point in evolution. It was the controlled stopping of a motor command that was novel. A new higher order cognitive tool – the cerebellum – was evolving to monitor and control motor commands. The earliest vertebrate brains evolved a cerebellum in order to create rhythmic movement. (Loritz, 1999)

With the introduction of rhythmic structures, neural serial units could now be produced as serial behavioral units because each unitized action could be extended from the single action (e.g. thought) to the time-extended behavior (e.g. start-duration-stop). The sentence that could be represented cognitively in milliseconds could now be delivered over the longer fractions of a second or seconds required for language. Each distinct sound now is produced by a motor command to start the sound and a separate motor command to stop the sound. Because neural action is required for the next sound start motor command to be generated, a delay inevitably results between sounds. This delay is the vocal onset time (VOT) described above.

Language is dependent on the synchronization of these motor commands with the necessary cerebellum controlling commands. The higher cerebellum commands actually fine-tune the motor actions that are producing the sounds that are typical of language production.

Neural structures operate in an on-center off-surround anatomy, creating the necessary unitization to build longer and longer serial lists through hierarchies of units involving roughly four neurons each. Perseveration creates a wave gradient that propagates down the serial list during production, and rhythmic start-stop commands between motor control and higher cerebellum functions allow these cognitive neural structures to be performed as serial behaviors. The timing rhythm and the sliding gradient will be critical cognitive functions in many of the higher-order cognitive capabilities, particularly as language advances and becomes more complicated.

Language Rhythm

Language emerges from these developments as the production of serial unitized chunks of concepts that are produced as meaningful sounds (or other motor commands, as in sign language). Language is the rhythmic production of consonant-vowel phone sets that have been unitized into syllables, feet (i.e. upbeat, downbeat), words, and phrases. These units are produced in the correct order because perseveration drives an inhibition gradient that drives the productive behavior down the serial gradient. The start-stop rhythm is so important to language production that Loritz (1999) suggests that we shouldn't be surprised that all of the living species that seem to exhibit some language or protolanguage capability are all bi-pedal. (p. 139) The rhythm of language production is closely tied to the rhythmic neural functions in the evolved cerebellar brain.

<u>Universal Order</u>

The cognitive structures involved in the rhythm and gradient-driven serial behavior continues to be observed in higher level cognitive functions that are involved in complex language. Lehmann (1978) studied the various serial permutations in which the brain can assemble subject, verb, and object to form sentences in any language.

While there are six possible permutations of the construct series, the subject-verb-object (SVO) structure appears more often (as in English), with the subject-object-verb (SOV) being the next most common (as in Japanese). (p. 269) His explanation for such an observation is based on the idea that the sentence is a bowed serial list using the on-center off-surround anatomy, and that the list is usually headed by the topic of the sentence, or the causal expression against which the sentence is a response. The topic will be subject to the least lateral inhibition, resulting in a trend (not without exceptions) to produce the gradient-driven subject first. (p. 22-24) He strengthens his observation by noting the rarity of subject-final (OVS or VOS) languages. (p. 269)

Sinclair-de Zwart (1973) analyzed languages that were based on structures other than SVO and SOV and found that even in languages where any permutation is permissible, the SVO or SOV structure were almost universally preferred for resolving ambiguity. (p. 14-15)

Also noting a strong, almost universal, preference for SVO structure, Bickerton (1981) pursued the serial list gradient model to analyze cognitive reasons for such preferences. He noted that even simple serial topic gradients in the earliest protolanguages would have quickly exceeded the cognitive and productive capacity of the evolving brain.

The serial lists that could be built using early protolanguage cognitive constructs would have been simple compared to the more complex thoughts preferred for selective advantage in evolution. Biologically-based sounds would inevitably evolve to cognitively-based words as longer and more complex cognitive lists developed. Whole new cognitive domains would have developed as unitization connected ever-longer conceptual lists in cognition. (p. 290)

Bickerton chose not to study simple SVO or SOV constructs, but to instead look at the longer serial list chains that would have been needed to capture increasingly complex thought streams. Through this analysis, he studied the ever-growing noun-verb-noun-verb-noun (NVNVN) serial lists where the concept of subject and object become contextually based – determined by where the on-going noun-verb chain is broken. The topic gradient caused the subject to appear first, and how the longer list was divided (on average) determined the typical verb-object order. The bowed serial list, therefore, would predict SVO and SOV as the most common structures in language; without forbidding the other permutations. (p. 292)

Bickerton also looked at the conceptual impact of such lengthening serial lists as being driven down topical gradients based on constantly fluctuating inhibition patterns. As lists extend, nouns would inevitably refer back to earlier nouns in the list. Developing pronouns for such references would economize the neural connections required to reference concepts; a pronoun requiring a simpler set of neural connections because it only needs to refer to the concept of the original noun. Likewise, the topic gradient would remain more stable if some of the verbs in the gradient could be subordinated to others in the list. The shift of some of the verbs toward being adverbs would further economize the neural connections needed to maintain the serial list and drive the necessary production gradients.

Bickerton's analysis of evolutionary drivers for early biologically-based protolanguage toward more evolved and complex human languages based on advanced cognition does a very good job of mapping to actual observed functions and frequencies of characteristics in the world's modern human languages. This certainly doesn't prove that the on-center off-surround anatomy, gradient-based, bowed serial list is needed for language, but it offers very strong support.

Loritz (1999) took this analysis beyond the neurolinguistic serial list gradient to see if similar characteristics came into play at the level of full sentences (the linguistic view) or the conversation (the sociolinguistic view). He notes that the communicative structures usually maintain the primacy of their topic in the gradient. Old information tends to come before new information in conversation. This is consistent with the topic being the most activated, least inhibited, subnetwork in the neocortex just as the subject tends to activate all of the topics in phrase-level gradients. He suggests that there might be a selective advantage in evolution for language and cognition to evolve to get this most important or pressing information out first. (p. 158-160) Thus the value of language in cognition is the expanded social constructs that are enabled by the communication capability; the social subject of which is addressed in the next chapter.

Chapter 4

Evolution and Language

Evolution Reframed

The evolution discussed thus far in this KAM has been the evolution of biological organisms. Dawkins (1976) framed the discussion of evolution around, not the good of the species nor even the individual, but of the individual gene. He described the predominant quality of the successful gene as "ruthless selfishness." (p. 2) Dawkins analyzed evolutionary mechanisms broadly, looking for aspects that could be recognized as independent of biology. He would later go on to apply this generalized model to ideas.

Central to Dawkins' analysis was the concept of a *replicator*. Replicators are able to make copies of themselves, and a key aspect of such copying is that there be imperfection. A replicator that always copies itself perfectly can never change, even for the better. No replicator actually wants to evolve, it simply goes through the process of its own imperfect copying and the competition for the resources necessary to survive and continue replicating in the environment. Also, speed of replication is important. Too fast a replication process over-consumes the environment; and too slow a replication process is simply overwhelmed by competitors. Successful replicators, then, must have sufficient longevity, adequate speed, and just less-than-perfect copying fidelity. (p. 17-19).

In biology, the replicator is the gene. Genes are responsible for their own survival and replication. They survive to the extent that they continue to invent bodies and species in which they can thrive in the environments in which they find themselves. Natural selection simply describes how some genes end up more successful than others. The gene is a "survival machine" (p. 21) that at some point in the distant past invented the cell to protect itself and assist in its replicating process. Even the invention of sexual reproduction was ultimately invented by genes as a new way of mixing and improving their survival possibilities. (p. 26)

Dawkins' focus was on the allele; any portion of a chromosome that could potentially last for generations and serve as the unit of natural selection. This focus on portions of chromosomes, rather than simply entire DNA strands, served two purposes in Dawkin's thinking: 1) it allowed the changes in genetic material caused through successful sexual pairings of individuals to not be viewed as disruptive of gene longevity, and 2) it recognized that the shorter the unit of DNA, the longer the survival possibilities, because of reduced probabilities of error and mutation during replication. In this way, individual genes can be seen as existing over extremely long periods of time. Most of the alleles of modern humans exactly match alleles found in a wide array of species throughout our biosphere. Very few genes are truly unique to our modern evolution. They continually replicate, often recombining in new patterns, sometimes changing slightly through mutation.

Any gene that acts in such a way as to increase its own survival in the gene pool at the expense of others will tend to survive. Dawkins sees genes as *selfish*, always willing to increase their own survivability at the expense of other genes. This doesn't imply any kind of on-going battle among genes in the gene pool. Support and cooperation can be an important survival strategy. The survival strategies employed by genes must take into account the entire environment in which a gene finds itself, and this includes the presence and actions of all other genes in the gene pool. (p. 40) Selection will always tend to favor genes that cooperate with each other. (p. 50)

Just as the gene invented the cell in the distant past, all other biological development can be described as the attempt of genes to increase their own survival chances. As a survival machine, our bodies are an expression of our genes' strategies for longevity and transmission. Because genes ultimately determine how our bodies, including brains, are built, they exert complete long-term power over human behavior. (p. 64)

<u>Memetic Evolution</u>

Dawkins points out that biologists have worked with the ideas of genetic selection and evolution for so long that they tend to not see that biological evolution is but one form that evolution can take. (p. 208) By separating the concept of replicator from biology, Dawkins laid the groundwork for a broader discussion of evolution that can extend well beyond biology.

Building on his discussion of our bodies as survival machines for our selfish genes, he extends the idea of genes to include elements of cultural transmission. He defines the *mememe* as the unit for such cultural transmission, or a unit of imitation. The idea of evolutionary survival value now extends beyond the gene pool to the *meme* pool. Those ideas with the greatest psychological appeal will replicate and survive. Memes exhibit all of the characteristics that Dawkins had laid out for any replicator; an ability to survive over long periods (longevity), an ability to be replicated at an appropriate speed to not overwhelm the environment or be overcome by competitors (fecundity), and an imperfection of transmission to allow change (mutation).

As with genetic evolution, the ability of a meme to replicate copies of itself is far more important than the actual longevity of any given copy. (p. 208) Likewise, the continuous mutation of memes allows for a diversity that will require both competition and cooperation. History is full of examples of ideas that have come and gone, some sticking and flourishing as new branches of science or art, others withering quickly and being forgotten. Such survival or extinction of ideas parallels the paths displayed in biological evolution, including great and sudden leaps after long static periods (e.g. paradigm shifts; Gould's punctuated equilibrium).

To the extent that Dawkins described biological evolution as the survival machine of genes, Blackmore (1999) continued the metaphor to include cognitive evolution as the survival machine of memes. She asserted that the laws and principles of evolution must apply equally to memes as they do to genes; a form of Universal Darwinism. (p. 17) Memes jump from one individual to the next through cultural transmission just as genes jump from one individual to the next through sexual transmission. They vary over time, exhibit relative selective advantage over each other, and they are often retained and passed on from one generation to the next.

As with biological evolution, any intended purpose is largely an illusion of hindsight. Memetic evolution isn't looking for the perfect idea any more than biological evolution is purposively looking for higher-order species. Memes simply grab cognitive attention, making individuals that serve as host continually rehearse and rerun the idea or thought embodied as the meme. The theme song from a bad sit-com is just as likely to stick in one's mind as the formula for gravitation; in fact it is more likely to do so simply because of its more frequent presence in the mind.

In fact, Blackmore identifies the notion of *contagion* with memes. (p. 45) Memes can be described as spreading through a population of individuals using the infection analogy. Contagion differs from simple imitation because contagion can trigger unintended behaviors and responses that impact the population in ways which are not controlled, and certainly would not have been anticipated. Memes do appear, at times, to exhibit purposive trickery, combing with each other to create what Blackmore refers to as memeplexes, increasingly complex ideas that can be imitated and passed on with widening and deepening purposes that increases their survival value and ability. The proliferation of memes among individuals results in a form of social learning that crosses individuals to encompass an entire group population.

Pinker (1994), not using the concept of memetics explicitly, applies evolutionary thinking to the development of language. He sees elements of heredity in the development of languages over time, with inherited syntax and vocabulary containing variations that can only generally be described as random mutations. Language rarely changes intentionally, and not everyone who speaks a language sees each change and shift as a positive improvement. He also describes a role for isolation effects when populations speaking an otherwise common language become geographically isolated from each other.

To Blackmore (1999), this signals a need to keep general evolutionary theory separate from the specifics of biological evolution. (p. 30) Cultural evolution can be viewed as the selfish replication of memes, just as biological evolution was seen by Dawkins as the selfish replication of genes. Putting these two evolutionary threads together, genes create and propagate minds and minds create and propagate memes.

Blackmore acknowledges three weaknesses in the evolutionary analogy of memes: 1) the exact unit of transmission of memes is unknown, 2) the mechanism for transmission is unknown, and 3) the evolution of memes is Lemarkian, not Darwinian. The first two problems may simply represent the need to further study the meme model in order to better understand its working. In reality, the mapping of the human genome is still a work-in-progress, and the specific mechanisms in which base pairs along a DNA strand actually act on inheritance remains elusive. A parallel lack of understanding in memetics is not such a daunting problem.

The problem of Lamarkianism is more fundamental. The fact that the very nature of the transmission of memes involves alterations that occur within an individual are faithfully transmitted to the next individual makes memetic evolution different than genetic evolution. To the extent that memes ultimately affect the environment in which genes replicate, it could be that the limited inheritance associated with genetic evolution was just a short-term blip; much like Newton's gravitation and Kepler's laws of motion in physics were the bedrocks of science for so long, only to be subsumed under Einstein's general theory of relativity.

Inheritance of acquired characteristics is more efficient in memetics precisely because ideas don't have to wait entire generations to be transformed and improved. The pace of memetics is extremely fast compared to its slower genetic counterpart. Genetics needed to move slowly in order to assure the long-term survival of viable species. Having endured with our large brains, the limitation of the genetic inheritance of characteristics is now painfully slow.

Memetics & Language

To Blackmore, memetics helps explain the origins and development of language in ways that remain elusive if genetic evolution alone is considered. (p. 82-83) Theories of evolution that look at language must always find some form of survival or selective advantage for genetic traits. Language was needed for communicating broader and more complex thoughts among populations that were expanding their social structures and relationships. However, the expansion and delineation of such social relationships was needed in order to provide the fabric in which language could develop. Expanding brain sizes correlated with much of this development.

Genetic evolution sees the relationship and looks for advantages that are presumed to have been present under the genetic paradigm. Memetic evolution sees the survival of memes as a driving force for all three. It offers the *why*, just as self-organizing adaptive systems theory offered the *why* in genetics. In this sense, *why* isn't purposeful, it is explanatory. (p. 108) Memes help explain the evolutionary growth in human brain size, the development and growth of language and language-related technologies, and the development of social groups in which language could be negotiated, and in which memes could then thrive. Memetics provides for the selective advantage of large brains, complex language, and social institutions in which they can function.

Evolutionary Systems

The idea of memetic evolution as an alternative to genetic evolution, built upon the same generalized principles and mechanisms of development, is a powerful model. However, the evolutionary systems so described need not be considered as separate. Jablonka, Lamb, and Avital (1998) offer a four-tiered inheritance model that combines these evolutionary views into a single systems model of evolution.

The lowest level inheritance system they describe is the *epigenetic inheritance system* (EIS) in which cellular phenotypes and component constituents can replicate themselves. All cellular life is dependent upon such inheritance being in place in order for the basic workings of cells to be established. Without the EIS, there would be no cells in which higher levels of inheritance could take place. The next level in the Jablonka, Lamb, and Avital model is the *genetic inheritance system* (GIS) in which DNA transcription and replication provide the mechanism for inheritance. The GIS is the traditional level at which Darwinian evolution is driven by mutational changes that provide selective advantage in the environment.

It is the EIS underlying the GIS that provides a foundation for understanding how many GIS mutations are found to be opportunistic or adaptive for the individual (as introduced briefly in the breadth component). Without the EIS level there would be no available mechanism for the inheritance system to interact with the environment independent of the genetic process. While science can't explain exactly how the EIS works compared to the much better understood GIS level, its apparent workings are consistent with many of the types of adaptive mutations observed by geneticists and otherwise unexplained by simple genetic inheritance. The quantum measurement effects described above are likely to be part of the firmer explanation of these phenomena that emerges from the research over the next few years.

The first two levels of the Jablonka, Lamb, and Avital inheritance model, the EIS and GIS, are all that is needed to explain evolution from the origin of life up through fairly complex organisms that we would refer to as ‘lower animals.’ As life forms become more complex though, their *behavioral inheritance system* (BIS) describes the interactions of various patterns of behavior with the basic biological capabilities enabled by the GIS level. Such behavioral patterns include the social learning and cognition described in the breadth component.

The BIS is both influenced by, and influences, the GIS level of inheritance as certain behaviors provide actual selective advantage, and behaviors alter the survivability of collocated individuals. While genetic change in the GIS enables different behaviors, certain advantageous behaviors will also be genetically assimilated by the GIS. Advantages gained through alterations of behavior become genetically endowed when the behaviors are selective enough to ensure only the survival of offspring from those who practiced the behavior. Jablonka, Lamb, and Avital describe the path such assimilation takes from random or ad hoc behavior, to instinct, to gene-specific mechanism.

The final level of the Jablonka, Lamb, and Avital model describes the *language inheritance system* (LIS), and they ascribe it only to *Homo sapiens*. The significant aspect of the LIS is its interaction with the BIS; with behaviors influencing language, and language influencing behaviors. Such interplay is at the heart of the professionalization of language explored in the application component. With the combination of the four inheritance levels, the Jablonka, Lamb, and Avital model provides a mechanism for discussing and understanding inheritance and evolution that is open to far more than the simple genetic change often envisioned as being the focus of such a discussion. It allows evolution to be applied to behavior, socialization, and language as much more than a metaphor; entirely consistent with the memetic view that language and idea transmission are the ultimate target of all evolution.

Together, the model offers an explanation for an evolutionary path that fits the prevailing model of how and when language developed, without violating the central tenets of evolution that language should have evolved through the mechanisms of coevolution, adaptationism, variation, and selection introduced in the breadth component. In one direction, genetics (GIS) enabled behaviors (BIS) that brought about language (LIS). In the other direction, language (LIS) influenced behaviors (BIS) that enabled selection for different genetic patterns (GIS). One need not posit the traditional one-directional selective advantage model of biological evolution in order to explain the fairly rapid and specialized development of language in our biosphere. The bridge between genetics and language is behavior; specifically, socializing behaviors that would have created the cooperative and cognitive environment in which language would develop.

Chapter 5

Language and Socialization

The breadth component introduced social develop in humans with its discussion of the Home Base Hypothesis. Individuals who lived in small localized groups experienced certain selective advantage over those who did not. The absence of evidence of alternative social structures in early hominid development does not mean that there were no alternatives, only that if they existed, they left no evidence of themselves. This means the idea of a home base can not be refuted and must remain a hypothesis.

However, the prevalence of such social groups throughout the fossil record, and their dominance in human groupings today, offers clear support for the belief that the social groupings of humans today has its developmental roots in those early hominid gatherings. The reason humans still gather in these ways is because of the significant selective advantage offered by such behaviors. Humans have evolved in social settings, and need to be understood through such socialization.

Klein (2002) described the growth of socialization and innovation brought about by the development of language as the single leap that could be attributed to the 'big bang' in the relatively sudden evolution of humans. (p. 272) This shift was driven by the neural changes described in the prior chapter, driving the "rapidly spoken phonemic language" as the key development trigger for humanity. (p. 271) As a medium of memetic exchange, language can not be separated from the development of socialization.

Social Development

The development and evolution of language in humans is intertwined with the development of human social structures. Hurford, Studdert-Kennedy, and Knight (1998) discuss the nature of the social matrix in which language arose, noting that language can exist only in groups of individuals. Each individual negotiates meaning during the process of communicating, and new meanings are established only to the extent that groups agree on those meanings in usage. Midgley (1978) described language as beginning when the cluster of more or less essential properties were brought to bare on the survival problem. Socialization drove language development, and language development required socialization.

As described throughout the breadth component, the genetic capacity and motivation to enter into social practices gave rise to an ability to develop language. Also, in the reverse feedback loop, the early development of language gave rise to the abilities to cooperate and live in social groupings. The development of language and the emergence of social structures and groups can not be separated. Individuals living together without a means to communicate can hardly be referred to as a social group.

The functions of socialization and language are likely to have co-evolved, meaning that the earliest social groups would only have needed very primitive communication ability to experience selective advantage over other individuals or dyads in their environment. Armstrong (1999) discusses early gestural signs as the likely earliest means of communication. Those signs were likely quickly enhanced through verbal sound. Early sounds need only have been simply grunts and whimpers in order for the emergent properties of unitization and expectancy to take over and allow more words and grammatical structures to emerge. Language could have evolved very slowly, taking moderate steps as individuals communicating in richer ways experienced every increasing selective advantage. This evolution from simple signs toward rich language structure is described by Armstrong as the continuity hypothesis.

Culture Through Language

The evolution of language enabled the development of culture, important here for the ensuing shift from genetic Darwinian selection to memetic Lamarckian selection. Greenwood (1984) described language as a paradigm for culture, pointing out that without one, the other can't exist. (p. 152-3) Culture requires language, just as McFadden showed consciousness does. Language is central to human development. This isn't to say that language is the defining characteristic of humanity; just that the defining characteristics, whatever they may be chosen to be, are usually enabled and enhanced by our development of language.

Adler, Rosenfeld, & Towne (1986) discuss the ways in which language shapes our world and provides our cultural perspective. Language is a key determinant in social impression formation whenever we meet new people or encounter known people in new situations. We judge an individual's credibility, status, and power through language; both by how individuals communicate, and how they serve as the subject for communication. For individuals working in professions, the profession itself defines a certain expectation that is often language based. We speak of the 'jargon' of professions, acknowledging that what often defines such a social group is the uniqueness with which its members communicate with each other. Beyond the words chosen, the ideas that can be expressed are usually dictated by the use of language itself. To a certain extent, a profession can be defined in terms of the ideas it focuses on, and the language it uses in discourse. The application component will look at this issue.

Dimensions for Looking at Socialization

This depth component set out to identify dimensions within human development that could be used to analyze and better understand the formation and maturing of professions within our modern society and economy. Four common themes have come up again and again in the breadth, and this depth, component:

1. Mechanisms of Development. The breadth component started out with the various mechanisms of development; coevolution, adaptationism, variation, and descent. The terminology was drawn from the literature of biological evolution, but these concepts repeatedly applied to all forms of evolutionary development, up to and including modern culture and behavior.

2. Serial vs. Parallel. Serial developments often result in the emergence of a parallel or unified structure. Individual serial quantum-chemical reactions give rise to an emergent AMP enzyme. Billions of serially firing neurons give rise to a parallel consciousness. The bowed-serial-list gives rise to words, sentences, and conversations in which much is designated and understood in parallel. Individuals form social groups that have emergent group properties not seen in the individuals. The history of development often includes the unitization of the serial into the parallel.

3. Individual vs. Population. Throughout evolutionary development, there has been interplay between individuals and the populations in which they develop. Genetic mutations that provide selective advantage in individuals ultimately give rise to new species of populations. Individual memetic mutations (e.g. ideas) develop in individuals and take hold across populations, giving rise to new ways of thinking and behaving (e.g. memetic species).

4. Language-Behavior-Genetics. The Jablonka, Lamb, and Avital model illustrates the importance of systems thinking generally, and the interplay of language and behavior specifically. Each layer drives the others in a bi-directional feedback loop affecting development. They describe their third tier in terms of genetics, but not in a way that would be inconsistent if the broader concept of memetics were substituted.

The application component will look at the software quality engineering profession through the filter of these four dimensions, with a continued emphasis on language as a critical mediating factor in development. The intent will be to see whether issues and concerns prevalent in that profession can be better illuminated and understood using the framework of development. The expectation is that they will, given the prevalence of these dimensions in all of the historical areas of human development. If so, then the development and maturing of a profession can be viewed as a natural extension of the on-going process of development that has been explored in this depth component.

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WALDEN UNIVERSITY

Core Knowledge Area Module 2:

Principles of Human Development

AMDS 8132 - Prof. Practice in Leadership and Human Development

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Chapter 1

Introduction

Overview

Within any study of human development, the systemic interaction of language and cognition must play a central role in modeling and understanding what it means to be characteristically human. The breadth component of this KAM looked at the various developmental disciplines that interact in our understanding of human development, and demonstrated that additional emergent functions and features can be better understood as the systemic interaction of variables within and across those disciplines. The depth component specifically explored the development of socialization and language as such emergent properties of the development of the human cognitive system in evolution.

Application Objectives

This application component applies the principles of individual and social group language systems to the exploration of the role of specialized language and symbol systems in the dynamics of professionalization and specialization of fields of knowledge in society. As cases for analysis, this component will explore the quality management and software engineering professions using the framework developed in the depth component.

Specific application objectives are:

1. Identify and compare defining elements of a profession in modern society, with an emphasis on the role of cognition and linguistics on the evolution of the profession.

2. Analyze and describe the general quality, and specific software quality engineering, professions using the model generated in the depth component.

3. Describe the efficacy of the generated framework/model and provide recommendations for revision or further development.

The Cases

This application component looks at the role that language plays in the emergence and cultural definition of a profession. This is accomplished through an analysis of two specific cases that I have been involved with in the recent past; and in which I believe that the concepts and ideas raised in the depth component can be used to illuminate my actual experiences in these two projects. Each dealt with the specialization of language as a professional activity; and each resulted in a finding that language both defines and differentiates individuals in different professional occupational groups. This KAM has provided me with background and a foundation for better understanding and further exploring those findings.

Masters Project

The original idea for this viewpoint came out of research that I conducted at Walden as part of my masters work in 1998 and 1999. (Biehl, 2000) At the time, I was looking at two professions, education and quality, to see how the definition and use of terminology influenced the way they perceived and worked through various problems related to organizational change.

As part of the growth of awareness and action for educational reform in the 1980's, the American Society for Quality had formed an Education Division of quality professionals working in the field of quality, but having interests in education and educational reform. In a newsletter column, division president Greg Hutchins issued a challenge to quality professionals: "Education is a world unto itself. It has its own distinct culture, messages, processes, concerns and attitudes. We need more people in divisional leadership that can broach the world of business and education - people who know the secret handshakes between the two." (Hutchins, 1996, p. 3) My research project was an attempt, on my part as a quality professional, to forge a partial bridge between these two diverse disciplines. In the process, I learned that the way we define and use language can go to the heart of how we define ourselves as professionals. This case is explored in Chapter 2.

Dictionary Project

I gained additional insight into the role of language in a profession working as a contributing editor for a dictionary project (Omdahl, 1997) within my own software quality profession. What seemed like a mechanical exercise to collect and define hundreds of terms and concepts within my profession took on new meaning as I researched and wrote this KAM. The cognitive concept of *unitization* better informed my experience of delineating the *jargon* of a profession. Ideas and thoughts associated with the negative connotations associated with *jargon* in our society became infused with the power of cognitive unitization in my profession. This case is explored in Chapter 3.

Dimensions for Looking at Professions

This knowledge area module set out to identify dimensions within human development that could be used to analyze and better understand the formation and maturing of professions within our modern society and economy. Four common themes have come up again and again in the breadth and depth, components:

1. Mechanisms of Development. The breadth component started out with the various mechanisms of development; coevolution, adaptationism, variation, and descent. The terminology was drawn from the literature of biological evolution, but these concepts repeatedly applied to all forms of evolutionary development, up to and including modern culture and behavior.

2. Serial vs. Parallel. Serial developments often result in the emergence of a parallel or unified structure. Individual serial quantum-chemical reactions give rise to an emergent AMP enzyme. Billions of serially firing neurons give rise to a parallel consciousness. The bowed-serial-list gives rise to words, sentences, and conversations in which much is designated and understood in parallel. Individuals form social groups that have emergent group properties not seen in the individuals. The history of development often includes the unitization of the serial into the parallel.

3. Individual vs. Population. Throughout evolutionary development, there has been interplay between individuals and the populations in which they develop. Genetic mutations that provide selective advantage in individuals ultimately give rise to new species of populations. Individual memetic mutations (e.g. ideas) develop in individuals and take hold across populations, giving rise to new ways of thinking and behaving (e.g. memetic species).

4. Language-Behavior-Genetics. The Jablonka, Lamb, and Avital (1998) model illustrates the importance of systems thinking generally, and the interplay of language and behavior specifically. Each layer drives the others in a bi-directional feedback loop affecting development. The third tier is described in terms of genetics, but not in a way that would be inconsistent if the broader concept of memetics were substituted.

This application component looks at the quality management and software quality engineering professions through the filter of these four dimensions, with a continued emphasis on language as a critical mediating factor in development. The intent is to see whether issues and concerns prevalent in these professions can be better illuminated and understood using the framework of development. The expectation is that they will, given the prevalence of these dimensions in all of the historical areas of human development. If so, then the development and maturing of a profession can be viewed as a natural extension of the on-going process of development that was explored in the depth component.

Chapter 2

Case Study: Education vs. Business Professionals

Introduction

This section explores my masters research project at Walden University during 1998. One of the factors considered during that project was whether or not a group of educational change agents would approach change definition and management from the same perspective as a set of business-oriented people with some background in quality management disciplines. As part of my study, two independent cohorts of individuals were asked to define specific terms used in the context of quality management and change. At the time, I was simply looking for differences in definitions that might illuminate factors that contributed to successful or unsuccessful outcomes in educational change initiatives.

Here I reflect on that study against what I've learned in this KAM regarding language as a medium of both communication and cognition. Generally, the more experienced business cohort turned out, in the language of the depth component, to unitize richer and deeper concepts under the terms being explored; and their model for applying those terms to the situation of educational change differed accordingly.

Background

The concept of customer or supplier is ambiguous. Even within the quality management profession, just as there are many competing meanings for *quality*, there are many competing meanings for both *customer* and *supplier*. Beyond any possible technical definition of the terms, there exist many additional perceptions of meaning. An explanation of these concepts among the general public would be broader still. As such, a definition of customer and suppler in the context of education had to emerge from my project's survey activity and eventually serve as a definition for the sake of the project results.

At issue in such a definition is the distinction between stakeholders who place demands on a system, and customers who have requirements of the system. The latter is a subset of the former. To state that a particular stakeholder isn't a customer of a system doesn't preclude a discussion of that stakeholder's legitimate demands on the system. Vendors expect to be paid by organizations they do business with, but they don't expect to be considered customers of those organizations. The vendor is traditionally considered a supplier of the system.

An organization that ignores the demands of its suppliers is in trouble, just as an organization that ignores the requirements of its customers is in trouble. But the way in which these two scenarios plays out will be very different. Quality management is, in part, the balancing of customer requirements against supplier demands. Too much emphasis on the customer results in no suppliers as they in turn seek different customers who will meet their demands better. Too much emphasis on the suppliers and the neglected customers look elsewhere to have their requirements met.

A quality organization must balance these factors, but the balance is usually weighted toward the customers. The customers are the reason the organization exists. Quality management involves developing the perspective and procedures necessary to provide maximum customer value while optimizing the involvement and satisfaction of all suppliers. A problem arises when the definition of a system's customers and suppliers are ambiguous. In the absence of clear distinctions among customers and suppliers, any system will suboptimize itself. Energy is misdirected toward satisfying suppliers who are incorrectly or inappropriately identified as customers.

The long-term viability of recent educational reform movements - including privatization, vouchers, charter schools, and accountability through competition - may rest on the clarity and accuracy of the customer-supplier models underlying each reform. Each reform possibility stands to optimize a small portion of the system at the expense of the outcomes of the overall system.

The problem isn't the identification of any particular customer. Quality management techniques can be used to maximize value to any customer. Whether students, parents, teachers, administration, colleges, or the business community are chosen as customer isn't the issue. Value to any of these stakeholders can be maximized. But value cannot be maximized to all of them. Building a customer-supplier model for education entails prioritizing the demands of all of these stakeholders, deciding in the process who the primary customers are, and to what level other stakeholders are also customers of the system. Quality management techniques can then be used to build a control system and re-optimize that system around this new clearer definition.

If educators don't know or aren't aware of who the customer is, then it's not possible to build control systems around the voice of the customer. The absence of such a voice for the customer prevents continuing improvement activities from directing efforts at the customer, instead usually focusing on internal voices such as administration and bureaucracy.

West-Burnham and Davies (1994) feel that "the problem of defining the customer in education is probably more semantic and conceptual than operational." (p. 12) Defining such a complex issue as semantic serves to illustrate that even researchers acknowledging the importance of quality and customer principles to education often fail to agree on the depth or complexity of the problem.

Different researchers draw different conclusions. Some conclude that students are the customers of education (West-Burnham & Davies, 1994; Seymour, 1992), while others conclude the opposite, including among the stakeholders virtually everyone except the students (i.e. parents, teachers, administration, employers). (Leslie, 1992) Fram and Camp (1995) leave it to each educational establishment to identify their own blend of customers based upon their own unique circumstances.

Today, there is no general agreement on who the customers and suppliers of education are. Sirvanci (1996) asserts that “a critical step in implementing quality in an organization is the identification of current and potential customers” (p. 99) before offering a criteria for discussing the student as customer. Some define employers as customers, parents as suppliers, and students as products. (Bailey & Bennett, 1996)

Evans (1996) identifies several key skills as being of concern in implementing TQM in an educational setting, including an overall focus on the customer, the ability to identify customers, and the ability to understand customer expectations and requirements, an appreciation of the distinctions among internal and external clients, a willingness to listen to the voice of the customer, and an understanding of the relationship between customer satisfaction and employee satisfaction. He concludes that even the faculty of educational programs at our schools of education do not really understand the quality management principles they are teaching our future educators.

Description of Activity

My study included looking at the way definitions of quality-related terminology differed across two cohorts; one drawn from the education community with no particular background or training in quality disciplines, and another drawn from the business community, each having expertise in the quality-related disciplines but no particular background in education.

A three-round Delphi survey was administered independently to each of these two cohorts asking them to define the terms *quality*, *customer*, and *supplier*. Respondents were also asked to identify stakeholders in the educational change arena who would fit the resulting definitions for customer and supplier.

Project Findings

The definitions that resulted after three survey rounds among the education cohort were:

Quality: "Ensuring customer satisfaction through the creation and maintenance of continuous improvement thinking and culture as a result of preparation, planning, and excellence in achievement; providing or approaching the top level value."

Customer: "Any individual who legitimately has expectations of, or benefits from, the work within a given system, receiving the end product or results of the actions or activities within that system."

Supplier: "A person or organization that performs a task or service for, or performs the necessary components required to produce a product demanded by, a customer."

When applying these definitions to the various stakeholders that had been identified during the first two rounds, the education cohort members ranked the following lists of customers and suppliers for education:

Customers: "Students, Parents, Society / General Public, Teachers / Instructors"

Suppliers: "Teachers, Administrators, School Boards, School System Support Staff"

Among the business cohort, resulting definitions were more complex:

Quality: "Meeting and exceeding the needs and expectations of current and future students and key stakeholders, through a culture leading to products and services having major emphasis on processes and their improvement; customer orientation; and team/individual involvement."

Customer: "Anyone (or group) who receives services (including knowledge, skills, abilities students have when they leave) provided by teachers, schools, or the school district; or those who purchase, procure, or receive a product or service, based on their needs."

Supplier: "Those, external or internal, who provide or support the development of superior products or services to anyone within the system."

The business cohort members ranked the following customers and suppliers for education:

Customers: "Students, Society (at large), Parents / Community, Businesses"

Suppliers: "Teachers, Administrators, Educational Process Developers, Students"

Discussion of Findings

There are definite contrasts between the study results for the education cohort versus the business cohort. Generally the business cohort results can be seen as including more technical, or disciplinary, detail than those of the education cohort.

The education cohort's definition of *quality* is soft and goal-oriented. References to "top level value," and "excellence in achievement" are general expressions seen in many popular discussions of quality. The business cohort's definition include more specific and technical perspectives that are (at best) implicit in the education cohort's thinking. Inclusion of "emphasis on processes," "customer orientation," and "team/individual involvement" are considered key dimensions of quality among professional practitioners.

In their definition of *customer*, the education cohort again stayed general, focusing on the "receiving of the end product" or output-side of quality. The business cohort included receiving products or services "based on their needs," a more technical view of customer as the source of requirements rather than simply the receiver of product. This requirements-based view is more common among quality professionals.

The definitions of *supplier* showed similar contrasts among education and business cohorts. The education cohort fell into a common approach of defining suppliers in terms of their juxtaposition to customers, as in “produce a product demanded by, a customer.” The alternative definition provided by the business cohort placed the supplier as supplying “to anyone within the system.” The focus on *system*, and the fact that the customers of the supplier *within the system* aren’t the same as the customers *of the* system, is a more technical view of supplier-customer relationships often not perceived by layperson views on quality management.

The final contrasts can be seen between the ranked lists of customers and suppliers to the educational system. The educators prioritized parents, as second only to students, as customers of the system. The business cohort ranked them considerably lower, in particular identifying parents as simply a special subset of the *community* customer. The distinction is more than simply ranking. To educators, the parents appear as a primary and direct customer. To the business cohort, parents were secondary and indirect customers. This distinction is significant, and represents a vastly different way of viewing the educational system by these stakeholders.

Educators also took a vary narrow and local view of suppliers, focusing on individuals only *within* the educational system as staff or elected representatives. Quality professionals would describe such a view as very parochial, because there are few opportunities to improve a system where all of the key suppliers are seen as working *within* the system. The business cohort, on the other hand, identified external suppliers – primarily education process developers. The biggest difference between the two cohorts was the fact that the business cohort identified students as among the top four system suppliers; where the education cohort had not even discussed students as suppliers.

With students as *both* major customer and major supplier, the business cohort was defining a more complex and richer system that was being described by the education cohort. This cohort, with the deeper knowledge inherent in the ways they were selected for participation, were exhibiting richer and deeper meanings with the same terminology. Using the language of this KAM, experienced quality professionals were *unitizing* broader and deeper constructs under the same apparent words. Put another way, the professional and educators were using the same *phonemes*, but meaning completely different *words*.

Chapter 3

Case Study: Software Quality Dictionary

Introduction

This section explores a dictionary development project in which I participated during 1996 and 1997. The project produced a 1997 edition (Omdahl, 1997) of a previously published 1989 edition of a quality dictionary targeted to an audience of software quality professionals. The project mission was to provide a comprehensive list of defined terminology used by software quality professionals.

Our efforts were coordinated by the Quality Council of Indiana, and membership on the editorial staff was comprised of representatives of the major professional societies having a significant interest in the software quality profession (see Table 1). I was recruited into the project because at that time I was on the board of the Software Division of the American Society for Quality, and I served as associate editor for the *Software Quality Professional* quarterly professional journal published by that society. I also held a voting position on the Software Engineering Standards Committee of the IEEE Computer Society.

Here I reflect on my participation in that project, particularly upon the aspects of *unitization* embodied in the discussion of language development in the depth component. Issues raised there regarding Hulstjin and Laufer's (2001) *Involvement Load Hypothesis* and its impact on vocabulary acquisition, Nohara-LeClair's (2001) emphasis on the grounding process of mutually shared understanding in language use in interpersonal communication, Wang's (2002) discussion of professional communities developing their own culture with specialized vocabularies, and Wenger's (2000) view of what I called *proto-professions* within communities of practice communicating through nontraditional and informal pathways, all provide a foundation for explaining many of the discussions and outcomes that I still think through regarding the dictionary project. Five years later, this KAM has provided me with insights that help explain the ups and downs that our team experienced as we pursued our creative mission.

Background

This project was oriented specifically to understanding the use of terminology and vocabulary among software quality professionals. Underlying the approach, therefore, was a shared understanding of *professionalism* embodied in the team's work.

Maister (1997) offers a number of perspectives for thinking about professionals, from the behavioral aspects of professional*ism* to the knowledge-based aspects of what a professional should be able to deliver. It is in both of these senses that he states that "the opposite of the word *professional* is not *unprofessional*, but rather *technician*." Maister looks at this gap and finds passion and caring among the characteristics expected of the professional, yet not penalized when absent from the technician. The professional feels a commitment to quality, a pride in the work, and a commitment to the client that is over and above those needed to fill a job. A *true* professional exhibits behaviors that make these beliefs and commitments visible to all around. "Professional is not a label you give yourself - it's a description you hope others will apply to you."

Maister asserts that "while others may seek *jobs*, the defining characteristic of professionals is that they seek *careers*." [author's emphasis] He challenges professionals to seek perspectives from which work life can be viewed as challenging, even fun. "All it takes to find the fun is a little energy, ambition, drive, and enthusiasm. So scarce are these characteristics that they are today the dominant competitive advantage for both individual professionals and firms."

Whether for internal group planning, or external firm management, Maister's descriptions support the range of activity from recruitment of professionals, goal and objective setting, peer development and support, skill-building, and termination of relationships that are no longer working. Focusing on professionalism, independent of any particular profession such as software quality, he offers tools that can be quickly adapted and adopted for personal career planning, and organizational development among professionals.

Maister identifies a particularly powerful two-dimensional model for identifying what kind of practice a professional desires; either as tool for planning a new practice direction, or as a diagnostic tool for understanding the dimensions of an existing practice. The model is based on a medical analogy of pharmacist, nurse, psychotherapist, and brain surgeon. The two dimensions include the degree of customization necessary to solve client problems and the degree of client contact required in the delivery of services.

The model doesn't exclude working day-to-day in all four quadrants implied by these two dimensions; rather, it offers a framework for understanding and evaluating the various work accomplished by individuals and groups. The role of pharmacist involves execution of standard processes with a low level of client contact needed (e.g. standards compliance reviews). The role of nurse emphasizes standardized processes that require a high degree of client interaction (e.g. peer review or JAD session facilitation). The role of psychotherapist deals with customized processes emphasizing diagnosis using a high degree of client contact (e.g. project review or audit). The role of brain surgeon emphasizes customized diagnosis with a low level of client involvement (e.g. risk review and assessment). Maister directs his readers to place their own activities into differing quadrants; and evaluate the fit against career aspirations and skill capacities.

Many software quality professionals, wanting to be recognized as brain surgeons, find themselves often dispensing the prescriptions. Maister's emphasis for professionals is to move through the model by continually developing and enhancing skills while also continually adapting to the needs of clients; developing better and more enjoyable practices through continuous improvement and growth.

Such continuous change is specifically addressed by Hohmann (1997), who sees software professionals as problem solvers, and endeavors to explain the behaviors of, and relationships among, such individuals as best represented using a sociological model that includes both problem-solving behaviors as well as social and goal-oriented beliefs and values. When integrated, these perspectives offer a mental model for continuously improving the efficiency and effectiveness of the methods practiced by such professionals.

Hohmann offers his Structure-Process-Outcome (SPO) Framework as a tool for integrating these methodological and cognitive perspectives. Process brings together methods and cognitive models. The richer and more experienced the cognitive models of the professional, the less formalized and intricate the associated methods need be. Outcomes represent the end results of processes, and vary in form and content based on the needs of the processes and experiences of the professional. Structure provides the form and content for defining the processes and outcomes and the interactions among them.

Hohmann describes the problem-solving process of the software professional as a need to understand the problem to be solved, designing a solution to that problem, and then verifying the solution once it has been implemented. While the SPO Framework applies as a model to each of these perspectives of the professional's task, Hohmann pays particular attention to the need to design solutions. It is here that he identifies the greatest challenge to understanding the work of the software professional, "the greatest mysteries regarding just what and when these designs emerge from the minds of each professional." Hohmann's central theme is that "increasing your understanding of your own mental processes will enable you to become a more effective developer."

Experienced professionals "have larger and more sophisticated cognitive libraries" at their disposal for identifying and solving problems. They can use these libraries in order to perform better leveling; "the shifting among different levels of generality or abstraction during problem solving." Their increased domain experience allows them to quickly determine what aspects of each problem exhibit the greatest complexity, bringing their strongest cognitive capabilities to bear on the most needed parts of each problem. Experienced professionals "not only know to solve the 'hard part' of the problem first, but they also correctly identify what the 'hard part' is." Less experienced novices tend to focus on the wrong aspects of many problems, in the wrong order, creating very messy and less efficient paths through their solution spaces.

Hohmann offers advice to move individuals along the path from novice to experienced professional: "A professional cares deeply about their client and works to ensure his or her needs are fairly and accurately met - whoever the client may be." Hohmann describes the responsibility of professionals to both lead and follow, to manage and improve themselves and their relationships with others, and to conduct their work with competence and integrity.

Weinberg (1988) offers a view of professional software developers that fits with the models offered by Maister and Hohmann. He begins with his own definition of professional as someone "having great skill or experience in a particular field of activity." Like Hohmann, Weinberg offers his views "as an exercise in self-examination for the professional."

Looking at the various technical skills and paradigms required of experienced programmers, Weinberg challenges professionals (as if anticipating Hohmann's focus on the professional's cognitive library) to explore and understand their meta-paradigms. Meta-paradigms include such skills as the use of analogy, tracing and retracing one's own thought processes, induction from special cases to general rules, deliberately widening one's circle of intellectual associates, actively seeking to know what others have done and using such work as a starting point, and attempting to communicate with others using paradigms in order to clarify one's own thoughts.

He offers his own personal reflection in the form of ten personal principles, his *Precious Programming Principles*, the tenth of which states that "every programmer has at least ten personal principles, but only one programmer in ten thousand is willing to take the time to write down even one." Weinberg challenges professionals to reflect on, and share, their own meta-paradigms and principles.

Any paid programmer will use the technical skills and paradigms of the field, but only professionals will develop and consistently use such meta-capabilities. They provide and strengthen the structural component of Hohmann's SPO Framework. Weinberg challenges professionals "spend a part of (their) working day examining and refining (their) own methods." In the process, each will uncover their own secrets that will make the pursuit of their profession more successful.

"There's much the professions could learn from one another, if only they shared their secrets." Weinberg draws analogies with other professions as a way of exploring that which makes programming a profession. Citing two apparently contradictory paradigms of medicine to not give up treatment too soon and to not stick with one treatment too long, Weinberg observes that "the secret of their secrets lies not in the secrets themselves, but in knowing when to apply each one. Maybe it's not *know-how* … but 'know-when'." [author's emphasis] Even Maister's technicians can know the secrets, but only experienced professionals with Hohmann's extensive cognitive libraries will appreciate when to use them.

Weinberg laments the fact that there are many programmers working for pay who should not be referred to as professionals. "The point is not merely that there are people out there passing as professional programmers who shame us all, but that *few managers have any way of telling if they're talking to one of them or one of us*." [author's emphasis] "Somehow, if programming is ever to be treated as a profession, the public - and programmers themselves - will have to be educated."

Curry and Wergin have edited a volume that speaks to the role education, and a defined body of knowledge, play in developing and sustaining the credibility of any individual working within any specific profession. With ASQ's certification programs and their emphasis on bodies of knowledge, certification examinations, recertification requirements, and codes of ethics, the scope of the profession is tightly bound to knowledge and education.

Curry and Wergin (1993) explore various aspects of the building of professional status and credibility through education. Written for a more academic readership, they provide a wide range of information and perspectives for anyone interested in exploring the impact of education, and educational agendas, on the definition and credibility of a profession. They draw together a variety of theories of professional education. A key theme seen in such a review is that many schools in the professions emphasize techniques and practical knowledge. Case studies in business schools, medical residencies, and architectural practicum all emphasize learning the right ways to conduct professional practice. They cite Schön's view that a more useful professional education would be one that emphasizes a more generic *thinking* process that could apply across professions, rather than simply a body of knowledge to be mastered.

Schön (1986) describes a problem statement that seems familiar to many quality professionals. In any profession, there are many manageable problems that lend themselves to solution using the theories and techniques readily available within the knowledge base of the profession. These "high ground" problems stand in stark contrast to Schön's "swampy lowland" of messy problems that defy technical solution using the current knowledge of the profession. "The irony of this situation is that the problems of the high ground tend to be relatively unimportant to individuals or society at large, however great their technical interest may be, while in the swamp lie the problems of greatest human concern."

Schön looks at traditional professional education, of using theory to teach practice, and turns it around. By analyzing effective practice, more effective theories of professional action become possible. This isn't accomplished by formal research studies into the actions of professionals, but by the day-to-day reflection on practice carried out by every professional. Anticipating Weinberg, Schön declares that a profession can be strengthened by encouraging and institutionalizing such broad-based self-reflection.

Typical actions by professionals can be characterized as knowing-in-action. Practitioners exhibit their ability to perform within their profession every day. Schön uses the term *professional artistry* to describe the occurrences where competent practitioners exhibit extraordinary competence that is unique in uncertain circumstances. “What is striking about both kinds of competence is that they do not depend on our being able to describe what we know how to do or even to entertain in conscious thought the knowledge our actions reveal.”

Professional knowledge is embedded in the action and need not be articulated or explicated each time it is applied by the professional. In fact, attempts to describe such knowledge actually turn it into something else. “Our descriptions of knowing-in-action are always *constructions*. They are attempts to put into explicit, symbolic form a kind of intelligence that begins by being tacit and spontaneous. Our descriptions are conjectures that need to be tested against observations of their originals." [author's emphasis]

Instead of attempting to understand someone else's knowing-in-action, Schön emphasizes our own ability to look at our own professional actions. "It is sometimes possible, by observing and reflecting on our actions, to make a description of the tacit knowing implicit in them." Such reflection can lead to the development of personal principles as described by Weinberg, and meta-paradigms as described by Hohmann.

Schön takes an additional step beyond simple self-observation. He looks at those special situations with unknown or unusual circumstances during which our professional practice is extended into Schön's professional artistry. "All such experiences, pleasant and unpleasant, contain an element of *surprise*. Something fails to meet our expectations." [author's emphasis] It is in these situations that our attention is triggered, and actions that usually remain hidden even from our own observation suddenly become available for reflection. "We may reflect *on* action, thinking back on what we have done in order to discover how our knowing-in-action may have contributed to an unexpected outcome." [author's emphasis]

What Schön describes is a need to teach practitioners to seek such opportunities for reflection in real-time so that they can continually improve everyday activities and practices. "In an *action-present* - a period of time, variable with the context, during which we can still make a difference to the situation at hand - our thinking serves to reshape what we are doing while we are doing it. I shall say, in cases like this, that we reflect-*in*-action." [author's emphasis] Such reflection-in-action builds our mental models and improves our professional practice.

Schön writes about recognizing that knowing-in-action can be influenced in real-time by effective reflection-in-action. Enabling continual and ongoing improvement, a hallmark of professional practice, requires teaching professionals to conduct their practices in an action-present during which they bring reflection to bear during each action taken and decision made. Reflective practice enables us to find our own versions of Weinberg's meta-paradigms and principles, allowing us to take Hohmann's "journey", enabling us to feel a pride in our work and offer our services to our peers that represent the hallmarks of Maister's *true professionalism*.

Description of the Activity

The team for this project was assembled by drawing representative volunteers from the major quality and software professional societies (see Table 1). Eighteen editors ultimately comprised the editorial board for the project.

Table 1 – Societies promoting software quality professionalism

Society	Description	Membership
American Society for Quality	The oldest professional society dedicated to quality professionalism, having its roots in the Deming and Stewart quality initiatives of the early 1950's. Each of its 16 professional divisions covers a specific knowledge domain within the profession, including the Software Division. It's 30+ professional certification programs include the Certified Software Quality Engineer.	150,000
IEEE Computer Society	A subgroup of the Institute of Electrical and Electronics Engineers (IEEE), this professional group tends to focus on the broadest software engineering disciplines, usually leaving hardware issues to the broader society.	100,000
Association for Computing Machinery	A comprehensive computer professional society emphasizing all aspects of hardware, software, and communications capabilities.	75,000

The primary project activities included an extensive multi-round Delphi exchange among the eighteen editorial board members coordinated by the editor-in-chief. Each of us was assigned certain functional specializations, with sufficient overlap of coverage to assure that all related disciplines were covered by at least three primary editors.

The first six months were generally spent expanding the entries included in the draft dictionary. Sources from throughout the industry were searched for terminology and usages that were considered significant to the software quality profession. The second six months were spent largely drafting and redrafting entry definitions; and it was during this period that many of the entries added during the early rounds were eliminated. The criteria included identifying definitions that were felt to be too general to be included in a specialized professional dictionary; those where the professional usage of a term was too similar to the definition associated with vernacular usage. Reference was often made to general published standards and dictionaries (see Table 2) to assure that entry definitions kept were more specialized than general usage. Undifferentiated entries were eliminated, noting in the editors preface that “these definitions have been excluded since adequate definitions already exist in these areas in thousands of readily obtained standard references.” (p. iv)

Table 2 – Specialized standards and dictionaries used

American National Standards Institute (1987). *Quality systems terminology*. ANSI Standard A3-1987. Milwaukee, WI: American Society for Quality.

American National Standards Institute (1994a). *Quality management and quality assurance – vocabulary*. ANSI Standard A8402-1994. Milwaukee, WI: American Society for Quality.

American National Standards Institute (1994b). *ISO 9001 Quality Systems - Model for Quality Assurance in Design, Development, Production, Installation, and Servicing*. ANSI Standard Q9001-1994. Milwaukee, WI: American Society for Quality.

Institute of Electrical and Electronics Engineers (1990). *IEEE standard glossary of software engineering terminology*. IEEE Standard 610.12-1990. New York: IEEE.

National Institute of Standards (1996). *Malcolm Baldrige National Quality Award: 1996 criteria for performance excellence*. Washington, DC: US Department of Commerce.

The final project draft was reviewed by a broader panel of roughly 50 reviewers; and the final publication went to press in late 1997.

Project Findings

The final 1997 edition of the *Quality Dictionary* included over 2,000 specific entries with definitions that were unique or specific enough to the quality profession to be included in this specialized dictionary. A review of those entries finds the same general distinctions that were evident in my research study case previously. Table 3 contrasts the entries looked at in the previous case - *quality*, *customer*, and *supplier* - with a current Internet-based popular dictionary. All three show the deeper levels of complexity and unitization predicted by the discussion in the depth component, also in similar ways as observed in the previous case.

Discussion of Findings

The richness of unitization evident in the dictionary entries can be seen in these three examples. The definition of *quality* includes the deeper concepts of *conformance*, *need*, *satisfaction*, and *requirements.* The definition of *customer* includes the key concepts of *value-added*, *producer* vs. *user*, and *organization*. The definition of *supplier* includes *internal* vs. *external*, *sourcing*, and *use in production*. These are critical components of these definitions that are important and significant to quality professionals. While these concepts are not excluded from the popular definitions of each term; they are at best, implicit. This helps account for the differences in communication and meaning when quality professionals use these terms, as opposed to their popular use in the vernacular.

Table 3 – Comparison of entry definitions, Omdahl (1997) v. Merriam-Webster(2002)

Entry	Omdahl (1997)	Merriam-Webster (2002)
Quality	1) Conformance to requirements and fitness for use. 2) Features and characteristics of a product or service that determine its ability to satisfy stated or implied needs. 3) Degree to which a product, function, or process meets the customer's or user's requirements.	degree of excellence, or superiority in kind; a distinguishing attribute
Customer	1) A nonproducer user of a supplier's product or service. 2) Another organization within a supplier, if the value added equipment, product or service is to be used operationally, or is to become part of the product of the receiving organization. 3) Entity that receives a value added product or service.	one that purchases a commodity or service
Supplier	1) An entity that provides a product or service, usually a value added raw material to be used as part of production, to a user or customer. 2) The source of information services and materials used in a process. May be internal or external to a company, organization, or group.	one that provides for, makes available for use, or satisfies the needs or wishes of

Sampling of the dictionary entries in this case quickly shows that quality professionals use, and think of, terms and words applicable to the profession in ways that are very different than the way that a layperson makes use of these same words. The web of semantics placed around words by the professional is determined by the richness of the concepts and interplaying meanings required by the word in the contexts in which it is used by the professional. This notion is captured by the popular notion of professional *jargon*; but is also predicted by the language model developed in the depth component. The next section will turn to the connection to that model.

Chapter 4

Conclusion

These two cases, with their similar findings in the case of the three benchmark words used for analysis, highlight the accuracy of the four-point model introduced in the depth component:

1. Mechanisms of Development. The breadth component started out with the various mechanisms of development; coevolution, adaptationism, variation, and descent. The terminology was drawn from the literature of biological evolution, but these concepts repeatedly applied to all forms of evolutionary development, up to and including modern culture and behavior. The depth component extended evolutionary development conceptually forward to memetic evolution, or the evolution and reproduction of ideas.

The neuroanatomy of the bowed-serial-list necessitates the mechanism whereby new words are coined, or the meanings of existing words are extended, to include complex concepts that require more cognition than can be handled by existing physical neural networks. The words represented in these two cases illustrate this concept in the extension of existing words to take on broader or deeper meanings.

2. Serial vs. Parallel. Serial developments often result in the emergence of a parallel or unified structure. Individual serial quantum-chemical reactions give rise to an emergent AMP enzyme. Billions of serially firing neurons give rise to a parallel consciousness. The bowed-serial-list gives rise to words, sentences, and conversations in which much is designated and understood in parallel. Individuals form social groups that have emergent group properties not seen in the individuals.

The history of development often includes the unitization of the serial into the parallel. Again, the words analyzed in these cases illustrate the concept of unitization working in modern language. Without the expansion of the meanings of words in professions (i.e. a parallel construct), it would take full sentences or paragraphs (i.e. serial constructs), to express the concepts currently embedded in these individual words.

3. Individual vs. Population. Throughout evolutionary development, there has been interplay between individuals and the populations in which they develop. Genetic mutations that provide selective advantage in individuals ultimately give rise to new species of populations. Individual memetic mutations (e.g. ideas) develop in individuals and take hold across populations, giving rise to new ways of thinking and behaving (e.g. memetic species).

As the sample words in these cases illustrate, words help define professions as separate memetic species; populations that exchange memes (e.g. the genetic material of ideas) among each other that can't be exchanged in similar ways with individuals outside of the species (e.g. profession). This property of exchange becomes a property of the population not necessarily seen in each individual in the population. Indeed, memetic evolution differs from biological evolution specifically in that individuals can become members of more than one species (e.g. one can be a quality professional, *and* a sports enthusiast).

4. Language-Behavior-Genetics. The Jablonka, Lamb, and Avital (1998) model illustrates the importance of systems thinking generally, and the interplay of language and behavior specifically. Each layer drives the others in a bi-directional feedback loop affecting development. The third tier is described in terms of genetics, but not in a way that would be inconsistent if the broader concept of memetics were substituted.

Professionals behave differently than lay people in the very ways predicted by these models. Language differences, such as those describe above, drive professionally local behaviors that can result in the further evolution of ideas. Such memetic development eventually leads to further specialization and bifurcation of the memetic tree. Not all individuals follow every branch of this emerging tree, just as biological evolution created new species without necessarily wiping out those already existing. In biology, one sees species adapted to broad general environments and other developed to experience a single specialized niche. This form of ecology, what Rubenstein and Wrangham (1986) refers to as *socioecology*, applies to professions as well other life arenas.

Ecology of Professions

Barnett, Mischke, and Ocasio (2000) offer a model for understanding the founding and growth of organizational collectives based on principals of organizational ecology. Their model ties the strategies and structures of the collective organization to the formation and growth rates of those organizations, highlighting competition among collectives for members as the key factor in the model.

Their focus for strategy is on whether an organization chooses to adopt a generalist scope of interest, or a narrow specialized scope. They show that these strategies result in particular blends of collective organizations in given industries or interest areas. In segments where generalist strategies are dominant, few organizations will be seen to be meeting the needs of most interested members. Where specialization is dominant, there will be many organizations needed to adequately fulfill the needs of the available membership. Likewise, the impact strategy has on the number of organizations present will also be paralleled by an impact on the size of such organizations.

The size of any given collective is determined by the number of interested potential members who both find the organization and choose to join it. Barnett, Mischke, and Ocasio describe the way in which the likelihood of finding a collective organization can be described using the organization's selected strategy. In any search for an organization based on potential member interest, a more general organization will be identified more often than a more specific organization. Generalist collectives simply subsume a greater number of interest areas under their scope.

In terms of the likelihood of joining a collective once it has been found, Barnett, Mischke, and Ocasio describe how potential members will typically join the first organization they identify that satisfactorily meets their need, "even if there is a collective organization somewhere that is even better suited." (p. 327) Since broad merely satisfactory collectives will be more common than narrow optimal ones, potential members will typically join satisfactory generalist collectives more often than optimal narrow ones. The outcome of this social matching process, Barnett, Mischke, and Ocasio conclude, is that as organizations allow their strategy to become increasing general, the likelihood of obtaining members increases.

Barnett, Mischke, and Ocasio also discuss another aspect that affects membership acquisition: contagion. Because the social matching act is inherently ambiguous — meaning that potential members can never be sure they are choosing the right collective to join — potential members are very likely to respond to social cues when making such decisions. Near-joiners will be pulled into the organization proportionately to the volume of joiners. Since collectives using generalist strategies will be found and joined by more potential members, the contagion affect expands this growth advantage in favor of generalist collectives.

Barnett, Mischke, and Ocasio move away from collective growth rates to also discuss the affects of strategy and size on the rates at which new collectives are founded. A potential collective member may innovate — create a new collective — if no satisfactory collective can be found during the social matching process. Citing March and Simon; Barnett, Mischke, and Ocasio point out that "innovation will not be considered while ever there is an existing collective that can offer a satisfactory solution." (p. 329) They are describing a competition between organizational founding and growth; or the "classic ecological trade-off." (p. 329, citing Hannan & Freeman) This competition will be especially impacted by the growth of collectives that have adopted the generalist strategy because their advantage in securing growing memberships will inhibit the founding rate for new collectives.

This impact is mediated when generalist collectives first appear; a path-dependency. In domains where early collectives form around special interests, the founding rate of new collectives is found to be high. Domains where generalist collectives are founded early, see much lower founding rates for other collectives within the domain. "The ultimate variety of collective strategies in a given domain depends on an apparently minor difference in initial conditions: the arrival time of the first generalist." (p. 331)

Once formed, Barnett, Mischke, and Ocasio see the mortality rate for collectives to be low, regardless of strategy, but for different reasons. Large general collectives tend to persist because they are well-funded and embody considerable organizational inertia. Small specialist collectives tend to run on a minimalist approach that makes them low-cost and able to operate with minimal inputs. Both factors lead to the longevity of collective organizations.

Barnett, Mischke, and Ocasio speculate, admittedly beyond the scope of their own research, on the role that organization mortality might play in their model. There might be domains where specialization of interest is in the long-term best interests of members. There could be long-term corrective mechanisms at work that would disband generalist collectives in favor of specialist collectives. Citing Nelson and Winter, they observe that evolutionary economics would predict such a mechanism. "If mortality works to correct the generalism bias, then historical differences are temporary frictions rather than long-lasting path dependencies." (p. 331) Allowing for such correction, Barnett, Mischke, and Ocasio present a solid model for observing and explaining the founding and growth processes surrounding collective organizations tied to the interplay of the general-to-specific variances in strategies adopted those organizations.

<u>Closing Thoughts</u>

As a working professional active in professional organizations, I take pride in the development and specialization of my field. I'm sure that most professionals feel the same way. While working on this KAM has not deterred such pride, it has caused me to rethink its foundations and sources. Last year, I tended to view the growth of knowledge and organization of professions as evidence of a radical shift in human development from its roots in evolution and the survival strategies of adaptation. Today, I see the development and growth of professions as the actual on-going presence of that evolution and adaptation continuing in the Earth's biosphere.

Human development isn't the radical shift; it's the explosive continuation of something that began seemingly countless eons ago. That early fish that needed the neural structure to keep its tail from winding too tight, brought about the mechanisms that today drive professional specialization and research growth among humans across the globe. This KAM has explored our use of language, the unitization of more and more complex concepts within the words of that language, the grouping of individuals who specialize in collections of ideas, and the continuing development of those ideas through communicative learning. These emergences were not only *enabled* by our human origins, but were *necessitated* by them.

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