A Multi-perspective Approach to Knowledge Production
Professor Dr. Bill Seaman

Abstract

Purpose:
To discuss a Multi-perspective Approach to Knowledge Production in terms of a set of cybernetic concepts relevant to the approach; to describe a software system that computationally embodies the approach; and to articulate a research project that pragmatically employs the approach.

Design/methodology/approach:
A definition is provided. The paper uses a survey methodology, exploring relevant cybernetic and contemporary technological concepts. An operational software mechanism (The Insight Engine) is discussed that enables the bridging of transdisciplinary concepts by a user in the service of accretive research —Recombinant Informatics (Seaman's coin).

Findings:
Many cybernetic concepts are relevant to contemporary research into cognition and Neosentience research (*Seaman* & Rössler 2011). More study needs to be undertaken related to historical BCL projects in terms of articulating relevance to contemporary research.

Research implications:
Future research seeks to extend the computational functionality of the Insight Engine, as well as uncover relevant BCL / cybernetic materials.

Practical implications:
The software is unique in the field and already there is interest in its use by differing research communities including the Duke Institute For Brain Sciences, and at Stanford, research under Ian Hodder. (Hodder 2012)

Social implications:
The Insight Engine has potential to be used as a multi-perspective tool for many different fields enabling different forms of distributed, transdisciplinary team-based research.

Originality/value:
This text is valuable to researchers interested in new forms of interface, augmentation of thought and learning via computational approaches; and the development of bridges between novel research areas, including contemporary, historical BCL and other Cybernetic inquiry.

This paper will be broken into the following sections:

1) *A Multi-perspective Approach to Knowledge Production - Definition*
2) *A set of cybernetic concepts relevant to the approach*
3) *The Insight Engine software system*
4) *Process – Interacting with The Insight Engine*
5) *The Applied use of The Insight Engine for Neosentience Research*
6) *Conclusion*

Key Words:
Knowledge Production, Multi-perspective approach, Intelligence Amplification, Computing a reality, 2nd Order Cybernetics

A Multi-perspective Approach to Knowledge Production

Definition:

A Multi-perspective Approach to Knowledge Production can be defined as the use of multiple perspectives or "understandings", in the sense of Understanding Understanding (von Foerster 2003) to help elucidate what is functionally at operation in a particular system, by framing those functionalities through the conceptual projection of differing concepts onto that system. In the case of both historical research at the Biological Computer Lab (Müller & Müller 2007) as well as in Neosentience research (Seaman & Rössler 2011) this overarching methodology provides a series of different approaches to the understanding of the mind/brain/body/environment set of relations. It also seeks to articulate how knowledge of this set of relationalities might be applied to new synthetic or artificial systems thought biomimetics and bio-abstraction. This overarching framework also potentially enables juxtaposition between differing kinds of research methodologies. It often employs metaphorical and analogical treatment of concepts arising through dialogical interaction of a group of researchers, each contributing different knowledge to the study of a particular complex system. This approach may also employ mathematical, statistical, linguistic, philosophical, as well as cultural, sociological, ethological, aesthetic and ethical perspectives etc. to bring a conceptual breadth to the understanding of particular foci. It is an open-order system where new perspectives may be added in, in an ongoing emergent manner. This is achieved not through simplification, but by attempting to elucidate all important functional entailments (Pask 1975) (Rosen 1991) that might contribute to the "steering" or functionality of a particular system that contains systematic recursive elements, as played out though time-based energy and/or information flows. Information here has multiple meanings. (Shannon & Weaver, 1963) (MacKay 1969) The notion of tracing the operative elements contributing to the self-organisation of this complex system is one central framing mechanism.

Cybernetic Concepts relevant to a multi-perspective approach to knowledge production

Cybernetics, a term coined by Norbert Wiener in 1948 (Wiener 1948), has long provided a fertile conceptual space for an operative multi-perspective approach to knowledge production. Ross Ashby in *An Introduction to Cybernetics* points out that Cybernetics was defined by Wiener as "'The science of control and communication in the man and the machine'…Co-ordination, regulation and control will be its themes, for these are of the greatest biological and practical interest." (Ashby 1957 p.1) Ashby articulated a series of salient concepts in his "Introduction" relevant to defining new approaches to *Acting, Learning and Understanding*. He stated that "Cybernetics deals with all forms of behavior in so far as they are regular or determinate, or reproducible," (Ashby 1957 p.1) and he pointed out that "What cybernetics offers is the framework on which all individual machines may be ordered, related, and understood." (Ashby 1957 p. 2) In particular he articulated the concept that cybernetics "offers a single vocabulary and a single set of concepts suitable for representing the most diverse types of system," (Ashby 1957 p.4) and that "it offers a method for the scientific treatment of the system in which complexity is outstanding…" (Ashby 1957 p.5) He was quite explicit in how cybernetics could draw on a multi-perspective approach:

> Cybernetics offers one set of concepts that, by having exact correspondences with each branch of science, can thereby bring them into exact relation with one another… It has been found repeatedly in science that the discovery that two branches are related leads to each branch helping in the development of the other branch. The result is a markedly accelerated growth in both. (Ashby 1957 p.1)

Additionally, one seeks to draw on knowledge from one context and operationally apply it to another in a relevant manner, in particular through the use of analogy and metaphor. It must be noted that often new knowledge arises in the interfacing of disciplines.

Many intellectuals (Wiener, Ashby, Pask, etc.) have defined cybernetics from slightly differing perspectives. (American Society for Cybernetics) In terms of a process-oriented definition of cybernetics, Ross Ashby points out that it is, "essentially functional and behaviouristic":

> Many a book has borne the title "Theory of Machines", but it usually contains information about mechanical things, about levers and cogs. Cybernetics, too, is a "theory of machines", but it treats, not things but ways of behaving. It does not ask "what is this thing?" but "what does it do? (Ashby 1965, p1)

Umpleby provides an overview of Cybernetics, drawing on Ashby's observations:

> Because numerous systems in the living, social and technological world may be understood in this way [by how they behave], cybernetics cuts across many traditional disciplinary boundaries. The concepts which cyberneticians develop thus form a metadisciplinary language through which we may better understand and modify our world. (Umpleby 1982, revised 2000)

This notion of creating a process-oriented, meta-disciplinary approach to communication exploring the relationality between different concepts, environments, systems, processes and their concomitant analogical and/or digital mappings, is central to a multi-perspective approach to knowledge production.

Klaus in discussing cybernetics points to "The theory of interconnectedness of possible dynamic self-regulated systems and their subsystems".[1] (Klaus---------------) Often this interconnectedness follows a flow of information and/or energy-related feedback loops that contribute to the ongoing changing nature of a particular system. Central to a dialogical "negotiation" of cybernetic notions were the Macy Conferences, bringing many research fields into intellectual proximity. Yet, it is only through informed negotiation that conceptual bridges can be built between disciplines, often forging new understandings across differing 'disciplinary' research methodologies.

Pias states:

> Using new terms such as "information", "feedback", and "analogical/digital" as starting points, the participants tried to develop a universal theory of regulation and control, that would be applicable to living beings as well as to machines, to economic as well as to mental processes, and to sociological as well as to aesthetical phenomena. These concepts permeate thinking in such diverse fields as biology, neurology, sociology, language studies, computer science, and even psychoanalysis, ecology, politics, and economy.[2] (Pias-------------------)

Margaret Mead points to this as providing "a form of cross-disciplinary thought which made it possible for members of many disciplines to communicate with each other easily in a language which all could understand." (Mead-----------------)

At the Biological Computer Lab, headed by Heinz von Foerster, a series of the most eclectic of erudite characters worked on problems across diverse disciplinary domains, that directly relate to Seaman and Rössler's *Neosentience* research (Seaman and Rössler 2011) (discussed below). The book *An Unfinished Revolution? Heinz von Foerster and the Biological Computer Laboratory* (Müller & Müller 2007) speaks in depth about the BCL and its premature closing, as well as its seeming obscurity in the history of Computer Science. Yet, the BCL provides a perfect precursor to a multi-perspective approach to "understanding". Von Foerester speaks of research elucidating "cognition"… "The problem which was and is close to the hearts of the people of the Biological Computer Laboratory of the University of Illinois is a clarification of the problems associated in part with "self-organization"… He queries: "is self-organisation a useful concept which may help the elucidation of a multitude of problems closely connected with artificial intelligence, the mechanization of thought [alternately see Pask's *Physical analogues to the growth of a concept*

(emphasis the author)](Pask 1958), automation of perception, intelligence amplification (Ashby 1957), inductive inference machines, cellular organization, growth, evolution, etc." (von Foerester 1962, vii-----------?)

Seaman's *Insight Engine* project (Seaman 2014) seeks to facilitate new forms of inter and intra connectivity across intellectual domains in the service of knowledge production. In the same preface (von Foerester 1962, vii) mentioned above, von Foerster quotes Claude Bernard who states "I am convinced a time will come when the physiologist, the poet, and the philosopher will all speak the same language and mutually understand each other". (von Foerester 1962, vii) Thus Seaman, in the spirit of von Foerester and Gordon Pask in particular, given the breadth of Pask's research—AI, Art, Architecture, Conversation Theory, natural language approaches to learning and computation, etc., seeks to create a self-organising (see also von Foerster's spelling) environment that stimulates insight production by bringing ideas into juxtaposition through human interaction with media-elements loaded into the system, and media-processes that facilitate different functional interactions with those media elements. Central is the suggestion of potential interfaces between disciplines that arise through use of the software.

The bio-functioning of the human body, of an observer, is of a complexity that currently exceeds our ability to fully entail this functionality. This led Rosen to say in *Life Itself* that the body is not a machine. (Rosen 1991) Yet – Seaman sees the body as a not-yet-fully-entailed ultra-complex machine. This machinic metaphor is often taken up in cybernetics. In the summary of the paper *Molecular Ethology – An Immodest Proposal for Semantic Clarification* in Observing Systems, von Foerester points to a relevant complex multi-perspective 'machinic' approach:

> In essence this paper is a proposal to restore the original meaning of concepts like memory, learning, behavior, etc. by seeing them as various manifestations of a more inclusive phenomenon, namely, cognition. An attempt is made to justify this proposition and to sketch a conceptual *machinery* of apparently sufficient richness to describe these phenomena in their proper extension. In its most precise form was presented as a search for *mechanisms* within living organisms that enable them to turn their environment into a trivial machine, rather than search for mechanisms in the environment that turn the organisms into trivial machines…This posture is justified by realizing that the latter approach--- when it succeeds fails to account for the mechanism it wishes to discover, for a trivial machine does not exhibit the desired properties; and when it fails does not reveal the properties that made it fail. (von Foerster 1981)

Here von Foerster gathers ideas that each contribute to a particular understanding of cognition (and computational abstractions of cognition) by articulating operative functionalities of memory, learning, and behavior. In his text he also addresses different operative functionalities across scales; molecular genetic processes as they relate to computation; and provides different definitions for machines – deterministic machines, finite state machines, interacting machines; trivial and non-trivial machines, probabilistic machines, etc.; as well as discusses aspects of phenomenology, neurophysiology and neural net theory, as well as ethology. Concerning cognition, a multiplicity of processes are enfolded in the circular causality of the human.

Von Foerester begins his introduction in part to *Observing Systems* with a self-reflexive loop –

Cognition: ⟶ computations of ⌐──────┐
                              ↑_____|
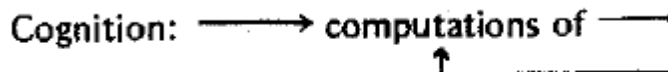
(von Forester 1981b)

This points to the overarching circular causal nature of the complexity of human "steering" (read volition and thought) as well as the internal loops that contribute to this cybernetic steersmanship. He also talks of our current limits and ways to approach those limits:

> Since we have as yet no comprehensive theory of behavior, we have no theory of

learning and, consequently, no theory of memory. Nevertheless,
there exists today a whole spectrum of conceptual frameworks ranging from the most
naive interpretations of learning to the most sophisticated approaches to this
phenomenon. (Foerster 1981b, p. 154)

Von Foerster points to the notion of exploring "recursive functionals" as a "descriptive formalism" because it "provides a bridge for passing through various descriptive domains… it is the concept of energy transfer connected with entropic change that links operationally the functional units on various organizational levels. It is these links conceptual or operational, which are the prerequisites for interpreting structures and function of a living organism seen as autonomous self-referring organism. When these links are ignored, the concept of "organism" is void, and its unrelated pieces become trivialities or remain mysteries." (von Foerster 1981b, p. 184-185)

It appears that the body has a set of "mechanisms" that are functionally consistent in nature. No single discipline as yet can unpack the "deep nature" of the overarching functionality that leads to cognition. In fact it is when disciplines "talk to each other" and share knowledge, that often new approaches that "chip away" at the complexity of biological entailment structures comes to the fore. In particular these seem to be technological approaches including visualization, database navigation and interpretation, and new forms of biological scanning, that are making meaningful breakthroughts. Cybernetics in its elucidation of "circular causal systems" historically presented a methodology to study systems in ways that accept that "living systems' have special qualities that are best understood not from a single mode of disciplinary inquiry, but by bridging disciplines and finding relationality between multiple modes of understanding. This Multi-perspective approach to understanding the body through new knowledge production suggests that when we observe observers we are perhaps taking on one of the most complex of realms.

Von Foerster points to a series of ideas relevant to this multi-perspective approach, and in particular to *the Insight Engine*, discussed in his paper – *Technology: What will it Mean to Librarians*. (von Foerster 1981c or 1971) Here he describes an online Cognitive Memory system exploring Semantic Computations. Seaman's approach in the authorship of *the Insight Engine* has been to first do statistical analysis of texts in the service of computational functionality, but his next proposed stage to the research is related to semantic and syntactic analysis of textual data, as well as including new forms of textual/visual analysis and pattern recognition. One must also mention here Pask's "Thoughtsticker" program which in part provided the potential to navigate subject matter in differing ways (Glanville & Müller 2007), embodied what Pask called "Entailment Meshes."(Scott and Glanville) (Glanville & Müller 2007) Glanville and Scott point out that Thought Meshes "consist of abstractions and distillations of thought processes, which Pask quite intentionally named 'concepts', 'topics', 'analogies' and the like." (Glanville & Müller 2007) They were "about the production and reproduction of concepts— entailment meshes could provide a dynamic model of what it means to know something: not merely the retrieval of structure or content out of a database (the "artificial intelligence" model, one might say) but rather the kinetic re-computation of individualized knowing." (Glanville & Müller 2007)

As we study differing processes we come to know that each time-based process has a multiplicity of potential ways to understand it. Unfolding over time each context has an infinite depth depending on how we project onto it from our ever-expanding knowledge-base. Pask as discussed by Barnes, claimed that a concept contains "an infinite number of other concepts". (Barnes 2007) Von forester in his paper Cybernetics of Cybernetics discusses the properties of an observer:

> It is most gratifying for me to report to you that the essential conceptual pillars for a theory of the observer have been worked out. The one is a, calculus of infinite recursions; the other one is a calculus of self-reference. With these calculi we are now able to enter rigorously a conceptual framework which deals with observing and not only with the observed. (von Foerster 1979, p. 2)

Each new conceptual 'perspective' potentially opens out a new line of thought — a new set of associations which may impact earlier assumptions — embodying Bateson's notion of the "difference that makes a difference." (Bateson 1972) In Observing Systems we see the central tenet of 2nd order Cybernetics:

> Second-order cybernetics is the cybernetics of observing systems. (von Foerster 1981b, p. xvi)

The use of the computer as a tool to help to come to understand the world and in particular our modes of understanding, has also functioned as a unifying "mechanism" across disciplines. Von Foerster facilitated high-level transdisciplinary research across many fields of study. He spoke of "cognition as computing a reality". (von Foerster 1973) If we think of the body as an electrochemical computer, a central concept in Neosentience research, we can ask ourselves what is at operation in the body in terms of mixed modes of sensing and computation that lead to knowledge production and to our sense of sentience? (Seaman 2012) One asks in an ongoing manner what processes are at operation both in the body and in appurtenant technological systems that help lead to "Understanding Understanding"? (von Foerster 2003)

The Insight Engine software system[3]

The complexity of biological study of the body and its relation to artificial intelligence, learning systems, sensing systems etc., especially where differing domains of study have very different publishing arenas, suggested the need to somehow "author" a computational system that could point to relationality between different areas of research and thought, that might not normally be brought together. It is interesting to note that the BCL had many different research projects related to the above research agenda, which unfortunately became lost and/or obscured when the Lab closed. (Müller & Müller 2007) Central to negotiating a cybernetic approach to *Acting, Learning and Understanding* is the act of association, the observation of energy and/or information flows [information here has multiple definitions] (Shannon & Weaver, 1963) (MacKay 1969), as well as the mapping, modeling and articulation of structures and loops related to those flows. *The Insight Engine* attempts to identify potential conceptual relevancies and relationalities that might be overlooked using more traditional research methodologies, and to keep track of ongoing research [use of the system] (thus mapping process-oriented feedback loops) as an iterative/accretive learning system, bringing forward aspects of von Foerster's and Pask's methodologies discussed above. To approach this hugely complex multi-perspective undertaking, Seaman, working as Principal Investigator and Media Researcher developed *The Insight Engine* with Todd Berreth as design consultant & front-end developer, and Olivier Perriquet functioning as research consultant exploring mathematical modeling and computational linguistics. The project is computationally functional after two years of research and programming, with an agenda for the addition of new computational functionality.

Ashby points out that "Cybernetics offers the hope of providing effective methods for the study and control, of systems that are intrinsically extremely complex." (Ashby 1957) One approach is to explore this complexity via the application of a diverse set of biological as well as technological (and other) studies and apply them to new forms of bio-mimetic and/or bio-abstracted machines. This would include computational "learning systems" and "acting" robotic systems that are informed by this study – Seaman and Rössler call this Neosentience Research (described below), expanding on (and/or re-understanding) von Foerster's cognition studies at the BCL and Pask's articulation of entailment meshes. We can think of the authorship of The *Insight Engine* as building a tool to "chip away" at building a more complex tool or set of computational functionalities.

Here transcending the problem of disciplinary research is central and in particular going beyond the limits of publishing domains, as well as specific disciplinary modalities of research— the kind of information explored in a robotics journal may have little to do with biology, physics, or notions of computational "augmentation" of human thought processes. Additionally, such research may

leave out other areas of thought more relevant to the humanities like ethics or philosophy. It was in this light that Seaman began to imagine an "authored" system that could facilitate bridging across conceptual domains via computational statistical analysis of language --- relating directly to von Foerster's "Library" paper discussed above, although Seaman was unaware of his early concepts, being alternately stimulated by the associational trails of Bush's Memex (Bush 1945) (Nyce & Kahn 1991), and the idea of Human Computer Symbiosis discussed by Licklider (Licklider 1960) as the earliest set of computational pre-cursors (although the Memex was never built).

One sees highly developed research domains that do not 'talk to each other' related to important concepts that may be relevant to the future of multiple fields of research. One key to future investigation is in these interstitial zones where people exploring very different perspectives talk to each other about research potentials defining a bridging or common language. This is a continuation of the "cross-disciplinary thought" discussed by Mead above and is a central intellectual tactic that crosses much cybernetic research.

In terms of *The Insight Engine*, the strategy was to reverse engineer what one does as a researcher and seek to create a system that could augment and "amplify" human thought and research potentials, as well as keep track of research by noting each new query and use of the system as an iterative "learning" loop. Here computational practices fall in the service of learning, understanding, and acting through the facilitating of Koester-like bisociational processes— basically thinking on multiple levels simultaneously in the service of creative scientific thought, and exploring processes which connect "previously unconnected matrices of experience…" (Kosetler 1964)

The Insight Engine has a database where data can be entered. This includes the following:

Add Object
Object Name:
Object Buzzword:
Year Authored:
Object Category:
          application
          audio
          database
          document
          drawing
          image
          model
          quotation
          text
          video
          website
Description: enter a textual description of the object
Keywords: enter descriptive keywords
Object Storage Location:
(IE database or remote URL)
Object File:
(upload media/data file to IE database)
Object URL:
(enter remote URL if media/data is located elsewhere)

Currently there are 464 entries, each researcher providing about twenty to begin with, that were solicited by Seaman for authorship and testing of this research. A number of researchers were approached, many providing different yet potentially relevant disciplinary perspectives to the database. A series of historical papers have also been entered.

Process – Interacting with the Insight Engine

The user of the system logs in with username and password. This takes them directly to a graphical user interface. At the moment both Seaman and Todd Berreth have been entering the data into the system so the database is hidden. Later users will be able to enter their own data and move back and forth between the 3d graphical user interface and the database interface.

After logging in the user of the system sees a series of names of researchers and their general area of research. When a researcher is selected from this menu by selecting the "+" sign a 3D "word" swirl (vortex) comes into view. All of the papers and media-objects loaded into the system that are associated with that researcher are visible in this "world". Each media-element has been given a buzz-word title as they were entered into the database. This 3D graphic world can be spun, and scaled by the user of the system, It can also be hidden, so that only the title of the researcher and their research area are visible. Each media-element in the system has a set of key words associated with it that have earlier been designated in the data-base entry system. At the center of the screen is the "word swirl" (vortex) of the researcher or research group that has logged into the system. This is loaded each time as an initial default. This can be closed and an alternate "world of research" can be called in by selecting a different researcher. Next to each "buzz-word" is a letter that represents the kind of media that is being stored in the database. If one clicks on the letter, the PDF of a given paper, and/or the particular media element (e.g.) an image or video etc. instantly opens. One can spend as much time reading this PDF to any given depth or close it back up again. Thus one can easily move through many different kinds of papers and media-elements at the click of the mouse.

Perhaps the most unique use of the system comes next. With two "worlds" of research open, the user of the system can select one buzz-word from one world of research and one from any other in the system. One sees a line connecting these two different buzz-word titles. At this point the two research titles appear at the bottom of the screen. The system is entirely rhizomatic in that any media-element can be brought into adjacency with any other. This also points to the Multi-perspective Approach to Knowledge Production that is made operative via the system's functionality, bringing differing ideas into proximity.

At this point the user can hit a "?" next to these two titles. This sets a computer query in motion. A new world of papers and media-elements comes into view. These represent the media-elements and papers in the entire system that most relate to the two chosen media-elements that have been brought into proximity. When new information is entered into the system, a new statistical analysis is made related to all entries. A computational weighting of relevance is made in software and then the new "word swirl" (vortex) or world of media-elements drawn from the entire database of entered research, becomes visible. Here the human intellect comes into play making decisions about what to keep and/or throw away as well as making new associations related to the research that has come into view. This happens in the mind of the user. In the upper right is a "black hole" icon that functions as a place to throw titles away. Again, each of these titles has the 'initial' of the media-element tied to it. One can instantly read the paper and/or observe the media-element attributed to that chosen buzz-word. One can then decide to save this query, which becomes part of the iterative use of the system. Then the "saved" title – comprised of the two differing research buzz-word sets, takes its place below the researcher's designations as mentioned above thus the history of their queries is captured. The system is accretive and self-organising in this respect, keeping track of decisions made along the way as an iterative process. If a research "group" is using the system, and use the same login and password, they will see the group's choices. At the moment, all of the system is viewable to everyone using it so it is a shared system.

Another menu system is labeled "Haiku". This brings the user to a new graphic interface of lists of key-words that form a sentence. Each part of the sentence can be substituted for another. I have worked for some time to build lists, and perhaps these function somewhat like Pask's Entailment

Meshes. Alternately, other key words are drawn from the papers of a given researcher and are also made available in a differing color for substituting in in the appropriate linguistic slot. This menu is playful in that it can collide many different ideas very quickly. Again the user decides what to keep, and can also store their metaphorical "haiku" as part of their reseach.

There are many future potentials to expand the program's functionality and additional funding has recently come from Bass Connections at Duke – *The Brain and Society* group, for the next year of research (or at least part of it). Seaman's paper entitled (*Re)Thinking — The Body, Generative Tools and Computational Articulation*[4] talks at length about the potentials of the engine and how it relates to Neosentience research by Seaman and Rössler (Seaman & Rössler 2011).

The Insight Engine and its role in Neosentience Research

Seaman and Rössler have been discussing ideas surrounding learning systems for over a decade as explored in their book *Neosentience | The Benevolence Engine* . (Seaman & Rössler 2011) The term "Neosentience" was coined by Seaman. It describes a new branch of scientific inquiry related to artificial intelligence. Seaman and Rössler's book explores the potential of creating an intelligent robotic entity in possession of a form of sentience similar to that of a human being. The juxtaposition of many micro-chapters enables one to reflect on new research possibilities and approaches— what Seaman calls Recombinant Informatics. Seaman and Rössler contend that through deep study of the body and its functionalities as well as through biomimetics and bio-abstraction, that new autonomous machinic learning systems can potentially be generated. This is a paradoxical humanist endeavor, in that one must come to know the body to a metaphorical depth that has never before been articulated. Much bio-mimetic research has been undertaken in the past— the exploration of learning systems, natural language processing, pattern recognition, spatial understanding, and the mapping of neuronal processes, etc.[5] (Müller and & Müller 2007) In this sense their research continues and expands on that of the BCL. Von Foerster certainly knew that it is the cross-pollination of differing research areas that may lead to new understandings. The Insight Engine seeks to facilitate this cross-polination computationally.

This system seeks to embody a collaboration that bridges Neuroscience, Computer Science, the Arts and Humanities at Duke as well as through international collaboration— to enable the digital authorship of a tool to empower insight production, distributed interdisciplinary team-based research and to potentially enable bisociational and polysociational [Seaman's coin] thought. The system enables a user-centric experience, enabling each user to explore the functionality mentioned above and to generate a visual/textual set of associative experiences, by bringing terms and media-objects into visual and conceptual "adjacency", and by also 'intelligently' searching for relevant new terms and media that might be lost to other search mechanisms.

Thus, through a database network of "pre-seeded" media choices one can interact with the system and focus on Neuroscience-only related topics of association, and/or juxtapose texts and images from the arts and humanities — poetic texts, critical/social texts, texts related to ethics, or historical texts from multiple fields— this depends on the initial "curating" of the system, and choices of the interactant. The future goal is to grow the system, with some discussion of including the entire set of researchers from The Duke Institute of Brain Sciences (which funded the first year as an art/science project).

Wiener pointed to mathematics as an operational means to bridge multi-perspective foci in his book *Invention* (Wiener 1993). In this case all of the texts and media objects along with text-based key words undergo statistical analysis and weighting. The user makes a query and the system brings up a series of potentially "relevant" juxtapositions gleaned from multiple research domains, empowered by this computational linguistic approach. Ashby points out that in terms of "Amplifying Intelligence…. Problem solving is largely, perhaps entirely, a matter of appropriate selection." (Ashby 1957) In this case a very complex information domain including over 400 research papers, media objects, and images, etc. can be "negotiated" via 'playful', and pointed user interaction functioning in tandem with algorithmic processes. The Insight Engine maintains

records of selected queries and other elements of interaction open to the entire research community using the system, as an iterative, accretive learning system. The derived queries suggest future research "actions" and bring about change in terms of bridging research domains, thus facilitating a multi-perspective approach to knowledge production. The system is in a continuous state of "steered" [cybernetic] transformation, where the interactant 'drives' the creation of differing internal conceptual "growth" loops.

The Insight Engine is self-organising system. It operates with a mixture of self-regulation, and regulation imposed by the author(s) and initial "curator" of the information in the system --- a kind of seeded "steering". Ashby points out that "regulation and control in a very large system is of peculiar interest to the worker in any biological sciences for most of the systems he (or she) deals with are complex and composed of almost uncountably many parts. (Ashby 1957, 244) Ashby goes on to articulate the notion that "the concepts of selecting, designing, constructing, and building (briefly, in any way being responsible for the eventual appearance of) an actual machine shares a common property, when one identifies and measures the varieties concerned in the process." (Ashby 1957, 252)

Expanding on Cognition and notions of Artificial Intelligence, in this light, Seaman and Rössler consider a Neosentient robotic entity to be a system that can exhibit well defined functionalities: It learns; It intelligently navigates; It interacts via natural language; It generates simulations of behavior (it 'thinks' about potential behaviors) before acting in physical space; It is creative in some manner; It comes to have a deep situated knowledge of context through multi-modal sensing; and It displays mirror competence. It is a self-organising learning system. In the Neosentience book a diagram of particular information flows and a series of active loops have been articulated, to outline the functionality of this active autonomous learning system. (Seaman & Rössler 2011) As Ashby states "The making of a machine of desired properties (in the sense of getting it rather than one with undesired properties) is an act of regulation." (Ashby 1957, 244) In order to best address this complexity and the need to bridge many topic areas in the service of the project, the development of the Insight Engine system was necessitated. Thus we loop back to Ashby's initial discussion of "co-ordination, regulation and control" as central Cybernetic principles, yet we do so in a very open and dynamic manner, enabling human input and informed computational "selection" to be of central importance to the growth of a series of concepts as drawn from differing research domains via the "steered" use of the Insight Engine.

Conclusion

In the history of Cybernetics we see many pre-cursors to the concepts that are enfolded and are relevant to a multi-perspective approach to knowledge production. *The Insight Engine* embodies many of these concepts, and seeks to operationally bring them forward through new forms of interface, differing forms of computational analysis of texts, computational "bisociational' approaches to knowledge production, new forms of database exploration, new forms of visualization and sonification of Data, distributed forms of research, and the development of bridging languages where researchers can comfortably talk across domains to the benefit of each other. Neosentience research seeks to borrow from historical ideas yet make a jump beyond studies of cognition alone, looking for holistic understandings that cross many disciplinary domains, often running in parallel to historical cybernetic approaches. Here conversation is key, as well as an openness to do the work that must be done to have relevant conversations across disciplinary domains.

Many of the ideas at operation in the *Insight Engine* were born in concert with cybernetic approaches to knowledge production. Recombinant Informatics was perhaps already early on explored by von Foerster in his paper *Technology: What Will It Mean to Librarians*. (von Foerster 1971*)* as well as Bush's plans for the Memex (Bush 1945). We now approach these ideas through new forms of database, computational linguistics, and pattern recognition. New scanning

technologies enable the further exploration and elucidation of deep complexity of entailment structures, yet new forms of analysis and visualization of data equally need to be articulated and re-articulated in an ongoing manner – perhaps most related to Pask's *Thoughtsticker* project and the construction of Entailment Meshes. (Scott and Glanville) (Glanville & Müller 2007). The continued exploration of the enfolding of multiple computational processes, the development of scanning technologies with higher resolution and alternate technological workings that transcend current scanning limits, the comparative cross-registering of many different bio-domains across multiple scales (from the nano to the human-behavioral) all play a part in "chipping away" at understanding emergent processes and working toward the elucidation of longstanding biological questions related to cognition and human sentience. Yet, ongoing human discussion, the negotiation of "relationalities" and cross-referencing is key. It is clear that there is a richness to the history of Cybernetic research and in particular to the unfinished work of the Biological Computer Lab, yet how can this research be be picked up and employed in a relevant manner to extend contemporary research? The Insight Engine perhaps in part represents this endeavor, and embodies the notion of a Multi-perspective Approach to Knowledge Production.

Bill Seaman May 22, 2014

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