Pattern Flows: Notes Toward a Model for an Electrochemical Computer — The Thoughtbody Environment

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I would like to acknowledge the fact that this paper was written following a series of dialogues and exchanges with Otto E. Rössler. I have also had a related set of ongoing discussions exploring a broad series of topics with Andrea Gaugusch, in particular her ideas about non-dualism, and our ongoing dialogue have influenced the ideas in this project. Gaugusch and Seaman worked on a related paper that informs this work entitled *(Re)Sensing the Observer — Offering an Open Order Cybernetics* (2) which is soon to be published.

I have also discussed issues of sentience, sensing and issues related to computer science with Ted Krueger, and Stephen Jones.

The following is written from the perspective of an Artist/Philosopher/Researcher(3) collaborating with other artists, designers, scientists and philosophers. Thus in order to form a bridging language designed to function in a transdisciplinary manner of cooperation, the following paper will sometimes be written on the level of metaphor and/or poetic language although it will be highly informed by scientific thought. Susan Leigh Star and Geoffrey C. Bowker in their text *Sorting Things Out: Classification and its Consequences*, define the notion of the Boundry Object:

> *Drawing from earlier studies of interdisciplinary scientific cooperation, we define boundary objects as those objects that both inhabit several communities of practice and satisfy the informational requirements of each of them. In working practice, they are objects that are able both to travel across borders and maintain some sort of constant identity. They can be tailored to meet the needs of any one community (they are plastic in this sense, or customizable). At the same time, they have common identities across settings. This is achieved by allowing the objects to be weakly structured in common use, imposing stronger structures in the individual-site tailored use. (4)*

Thus the importance of the language used to articulate such a project must at times be exacting and at other times be "plastic" enough to enable passage from one research domain to another. The meaning of a word is always in a state of becoming, understood by an observer as part of an ongoing flow of experience as well as falling in relation to the perceptions of others and the history of flows that inform their understanding. It could also be that certain words and/or concepts might not exist in more than one research domain and thus respect for difference and precision should also be employed.

Instead of presuming the "observer" as given, we are interested in examining how the ongoing buildup of language through multimodal patterning and reciprocal action between others and self, becomes the precondition for any meaningful statement. In conversations with Dr. Andrea Gaugusch we have come to call this approach Open Order Cybernetics (5). This self-reflexive perspective on meaning production seeks to be aware of the cultural and social presumptions that have come to inform all understanding — where language intermingles and frames experience in an ongoing open manner. We hope to carefully undertake a self-reflexive loop towards our already undertaken meaningful actions so as to best reflect on a set of concepts from inside of this built-up linguistic frame (6). We are seeking to explore how our concepts about "something" come into existence. Perhaps this is the most important part of the attempt to define this model for an electrochemical computer. Through an open, non-static set of processes, we are obliged to carefully examine a set of presuppositions that we have arrived at, with the potential of shifting our

understandings and applying new knowledge back into a series of diverse domains. (7) In this instance, displacement illuminates placement. The ongoing articulation of the model begins to suggest ways in which we might re-understand ourselves in an open manner.

Modeling the body's functionality on the deepest level of technological potential, and re-contextualizing it in a machinic setting is central to the project. As a deep bridging collaboration between multiple disciplines we seek to be in a profound mode of self-reflection concerning a network of related concepts and relations through this on-going open investigation. The potential is to examine the ramifications of such a self-reflexive loop for epistemology as well as for the main research-areas within cognitive science i.e. language-acquisition, perception, and consciousness.(8) Thus, the construction of the model must take into account concepts related to a complex set of intermingled inquiries.

This paper is a call for the development of a transdisciplinary research team. I am also pointing towards the arts, new sensing technologies and virtual reality as potential tools to enable and extend this self-reflexive approach in an ongoing manner.

We must be aware of the implications of particular questions in relation to the development of a sentient machinic self-reflexivity. Central is the exploration of the development of a machine-based contextual awareness, and the potential for new embodied approaches to learning systems like Rodney Brooks' (and related research team's) Cog at MIT's humanoid/robotics group.(9) Yet, unlike cog, I am interested in the development of an electrochemical substrate.(10) Such a project encourages an embodied awareness of the ramifications of human sentience with the aspiration that it will lead to ongoing human growth and increased self-understanding. Perhaps it is important for an artist to be involved in such an unlikely sphere, in that the poetics of the situation suggest the potential for the production of new knowledge despite the fact that the fabrication of such a model at the highest level of biological relevance, is currently outside of the scope of existing technologies and scientific practices.

A Thoughtbody is a mind/body unity built up through a lifetime of reciprocal forming/framing processes.(11) A perceived "pattern" is the ability of a particular sense (or set of senses) functioning in conjunction with the Thoughtbody to register changes that are encountered over time. This pattern residue may also be operated on from within the system (as opposed to environmental perturbations) establishing an intermingled approach to context that bridges between historical interaction (embodied reciprocal forming/framing) (memory) with current local context and conceptual/linguistic forming/framing. Gregory Bateson in *Ecology of Mind*(12) described the concept of ongoing pattern reinforcement as "redundancy". The Thoughtbody Environment is an environment that is embedded in a larger environment. An embodied relation to others, self, and environment are central to the ongoing production of a multimodal spatial temporal patterning. Language as an open system is a subset of this patterning flow yet becomes deeply intermingled with all experience as a *projective* contextualizing mechanism. Language and understanding are always enmeshed in a flow of becoming. (Seaman and Gaugusch have discussed this concept at length [see (1)]).

Each sense provides a different set of physical relationships or spatial/temporal pattern stimulations that come to be understood via biological means. Edelman in the book *Neural Darwinism* in 1987 stated:

> *Input signals are abstracted and filtered by the sensory transducers, feature extractors, and feature correlators (mainly sensiomotor systems) that form elements of a global mapping system. Active neuronal groups within particular repetoires receiving such signals are selected over others in a competitive fashion.(13)*

The ability of multiple senses to register state changes that are encountered over time enables the forming of an embodied physical context-oriented stimulation pattern. Could it be that each time we encounter a similar or related set of environmental qualities or similar re-contextualized instances, we draw on our memory–based history (our "redundant" state-change residue) of related incidents as well as self-reflection related to those incidents, to *create* current thought? Edelman continues:

> *Successful selection consists in altering the synaptic efficacies of those portions of the network corresponding to such groups, so that there is an increased probability of their response to similar or identical signals at some future time. (14)*

Edelman proposes the following:

> *Coordination and reinforcement of patterns of neuronal group selection must occur among various locally mapped regions of the brain. This is achieved by means of phasic signaling over reentrant anatomical connections between mapped regions.(15)… A central assumption to the theory is that perceptual categorization must both* ***precede and accompany*** *learning. (16)…One of the fundamental tasks of the nervous system is to carry on adaptive perceptual categorization in an 'unlabeled' world — one in which the macroscopic order and arrangement of objects (and even their definition or discrimination) cannot be prefigured for an organism despite the fact that such objects and events obey the laws of physics. A necessary condition for such perceptual categorization is assumed to be reentry between separate parallel systems of local maps serving different modalities, each of which is capable of independent disjunctive sampling of a stimulus domain. In general, however, sufficient conditions for perceptual categorizations are provided only when a number of such maps are linked together to form higher order global mappings that involve both motor and sensory systems.(17)*

Is it that we perform multi-modal pattern-matching via biological means and respond in an appropriate manner based on the emergent recombination of this embodied fragment history of registered experiences and reflections, understandings and abstractions? To what degree can we model the processes that are at operation here? Could an Electrochemical computer be articulated such that it would basically function in a related manner? Here I will call this Electrochemical computer, its unified embodied articulation and sensing system, a *Thoughtbody Environment*.

One asks, is this a computer that we are talking about? Most computers we know of do not have the flexibility of the human mind/body unity to function at a near chaotic state of relevant instantaneous contextual shift. Yet it was Babbage and Lovelace that early on sought to make machinic "computers"—the *Difference Engine* and the *Analytical Engine*. The "computer" they were observing and abstractly modeling was a human being – a person who used thought to make calculations. In 1842, Lovelace posited the notion that a calculating machine could also be employed to explore operative aesthetic processes.(18) As an artist, it seems important to enfold such a focus in the construction of our model — creativity is central to sentience. It must also be noted that Babbage and Lovelace's analogical computer models went far beyond the technological means of production of the day.

In my own research two major projects inform the current project — *The World Generator / The Engine of Desire* with Programmer Gideon May (a virtual world generating system exploring emergent meaning (see http://billseaman.com/), and a second work in progress —*The Poly-sensing Environment*. In this ongoing research with Mark Hansen, Statistical CS at UCLA and Ingrid Verbauwhede, EE at UCLA we have been exploring the creation of a tool to articulate so called machinic perception system — http://www.design.ucla.edu/~fwinkler/PSE/. In the human, often multiple senses function together or in relation to each other. Thus, two or more time-based

patterns derived through physical/environmental relations are registered in relation to each other, and potentially reinforce each other, becoming flows producing state changes. Could an electrochemical computer functioning in conjunction with a "poly-sensing environment" be modeled to reflect this multimodal set of processes? The unity of the thoughtbody is essential. In particular each sense registers a particular field of perturbations. This means that certain environmental relationships stimulate multiple senses (the enfolding of fields) and the pattern of this stimulation reinforces how we come to react to and/or understand that particular repeated or a related set of instances.

Gordon Pask, in his book *An Approach to Cybernetics*, explored the notion of creating a chemical computer in 1961. He stated "Chemical computers arise from the possibility of 'growing' an active evolutionary network by an Electrochemical process."(19) How can we bring about a particular form of function-related growing and/or construction, to facilitate the production of our model?

In 1981 Otto Rössler, in his paper *An Artificial Cognitive Map System*, (20) outlined a fascinating electronic approach which brought together a digital scan converter and a flight simulator to derive an early cognitive map system pointing at the relationship of the memory of context to context explored in real time. His more recent paper entitled *Nonlinear Dynamics, Artificial Cognition and Galactic Export*, outlines a nonlinear dynamic systems approach to the problem of artificial cognition. (21) Rössler's interest in Endophysics has great implications for new understanding of the mind/brain/body/environment relationship. His book *Endophysics — The World as Interface* is fascinating, outlining the concepts supporting his approach. Because endophysics is highly different than exophysics we seek to develop a parallel set of virtual environments that are reciprocally intra-active – this will be the subject of a subsequent paper.

Scott Kelso has also articulated a dynamic systems approach in his book *Dynamic Patterns-The Self-Organization of Brain and Behavior*. He states:

> *Only systems that are pumped or energized from the outside (or, like living systems who happen to possess metabolic machinery, from the inside and the outside) are capable of producing the kinds of patterns and structures that interest us. These are called open, non-equilibrium systems: open in the sense that they can interact with their environment, exchanging energy, matter or information with their surroundings; and non-equilibrium, in the sense that without such sources they cannot maintain their structure or function.(22)*

Kelso continues:

> *In the last twenty years or so, tremendous progress has been made in understanding how patterns form in open, non equilibrium systems, especially by my friend and colleague Hermann Haken. Thanks to him and others, ordinary matter, under certain conditions, has been shown to exhibit lifelike properties…Haken introduced the term 'synergetics' in a lecture given at the University of Stuttgart in 1969. Synergetics is an interdisciplinary field concerned with cooperation of individual parts of a system that produce macroscopic spatial, temporal, or functional structures. It deals with deterministic as well as stochastic processes.(23)*

In returning momentarily to our machinic sensing concept, I find relevant the discussion by Turing of responsive "input" and "output organs" in his description of the *ACE (Automatic Computing Engine)*.(24) Such an embodied approach is central to our model. Yet, Turing also originated a different set of concepts relevant to this project that transcend the notion of

"programming" as we know it. Kelso discusses an interesting paper by Turing that to many is unknown. Kelso states:

> *I am reminded of a famous scientist who was always arguing that the brain is not a Turning machine. When I noted during one of his lectures that there was another Turing, he was quite adamant: 'No, No, there's only one Turing. You know, the Turing of the Turing machine!' After writing some equations on the blackboard describing chemical patterns, he paused and stared at me. 'Ah, I see what you mean,' he said. The equations that he had written on the board were the very ones Turing used to describe 'the chemical basis of morphogenesis' in a paper published in 1952.*

Kelso continues:

> *"Two Turings" refer to the genius who, on the one hand, made significant contributions to programmable computers, and on the other, showed how patterns in nature can emerge without any programmer at all. Only quite recently have the patterns predicted by Turing been observed experimentally, and Turing's theory still figures quite prominently in developmental biology. (25)*

Kelso suggests that "Such spontaneous pattern formation is exactly what we mean by self-organization: the system organizes itself, but there is no 'self', no agent inside the system doing the organizing."(26)

How can our electrochemical computer be constructed/grown in such a manner so that it can reflect the deep complexity of human biological structuring? Could it be that a synthetic genetics of sorts must also be explored?

Kelso develops a strong argument that might be applied to the production of our model for an electrochemical computer in terms of phase space. He posits:

> *A dynamical system lives in a phase space that contains all the possible states of the system and how these evolve in time. A dissipative dynamical system is one whose phase space volume decreases (dissipates) in time. This means that some places (subsets in the phase space) are more preferred than others. These are called attractors: no matter what the initial value of x is, the system converges to the attractor as time flows to infinity. For example, if you stretch a spring or displace a damped pendulum, they will eventually wind down and stop at their equilibrium positions. The attractor in each case is a fixed point or simple point attractor. (27)*

Kelso further states:

> *In short, traditional approaches to understanding cognitive and perceptual processes emphasize static representational structures that minimize time dependencies and ignore the potentially dynamic nature of such representations. The present experiments ranging from vision to speech perception, are a striking testament to the basic concepts of self-organized dynamics such as control parameters, transitions, attractors, multi-stability, instability, and hysteresis… the aim is to uncover generic mechanisms applied across particular cues, modalities, and categories, thus unifying a broad set of data and providing a coherent basis for predicting contextual effects.(28)*

So, the particularity of our model will potentially grow as the mapping potentials of technology grow. One difficult question relates to this notion of the particularity or resolution of the system — does sentience only arise because of the intermingling of all aspects of operational biological complexity? Will any level of functional reductionism keep us away from realizing our goal for the emergence of a machinic sentience or in other words deep self-reflexivity and contextual awareness?

Kelso continues:

Finally, I want to leave the reader with what I hope is a helpful image that is created by the amalgamation of these dynamical models. It is an image, naturally enough of an evolving attractor landscape shaped by a complicated web of interconnected nervous tissue. The tension in the web and the location of its individual fibers are subject to patterns of activation and inhibition that shift and sculpt the attractor layout, which, as we will see, represents large-scale, meta stable patterns of neuronal activity in the brain.(29)

Thus, can we make an electrochemical computer that emulates these concepts? Along with the particular granularity of the equation there are other problems that must be addressed. In terms of microscale events Kelso provides the following concerning Elementary Neurons and Synapses:

Increasing evidence suggests that neurons can communicate without making intimate contact at synapses. Rather than information flowing along structured pathways like electricity flowing along wires in a circuit, such communication, called volume transmission, is more like a radio broadcast... (30)

How can we begin to devise an approach that includes the nature of this specific form of biological functionality? Kelso states:

...The brain is fundamentally a pattern forming self-organized system governed by potentially discoverable, nonlinear dynamical laws. More specifically, behaviors such as perceiving, intending, acting, learning and remembering arise as metastable spatiotemporal patterns of brain activity that are themselves produced by cooperative interactions among neural clusters. Self-organization is the key principle. (31)

He continues:

I believe that only particular kinds of experimental probes are going to offer insight into self-organizing proceses in the brain and how these relate to behavior. One is reminded of Otto Rössler's challenge to neuroscientists that in a complex system such as the brain (with more variables than the age of the universe in seconds), it is almost a miracle to find low-dimensional dynamics. But that is, in fact, the miracle that we seek. In my view, it is the cooperative action of neurons functioning together to create dynamic patterns in the brain that permits this miracle to happen. (32)

Kelso further articulates his position:

Spatiotemporal Patterns of the Brain— The brain is a spatially extended, highly interconnected structure. Measures of correlation dimension from data obtained at one or a few locations (mathematical theorems notwithstanding) are thus limited. Ways have to be found to treat signals emanating from different brain sites and their complex time evolution. To obtain such a detailed understanding of the brain, especially with respect to its functional self-organization, we need, I have argued, three things:

- *an appropriate set of theoretical concepts to motivate how to approach the business of the brain;*
- *a technology that affords analysis of the pattern-forming dynamics of the brain in space and time;*
- *and some clean experiments that prune away complications but retain essence.(33)*

Thus, if we seek to map on the highest level the operations that characterize the working of the human thoughtbody, the potential is to begin to formulate a model to thus fabricate a relevant

Thoughtbody Environment. One of the most difficult questions again deals with reductive approaches in the construction of the model versus attempts to work toward the construction of a model with a parallel set of operative processes to that of the human. Unlike much scientific experimentation in the past that sought to isolate particular neuronal activity, new approaches to the deriving of multimodal flow maps must be considered, and related mapping technologies developed.

Thelen and Smith pragmatically extend and build on a set of ideas directed related to Kelso's thought. They define here a pertinent set of observations in part informed by Edelman's thought in their book *A Dynamic Systems Approach to the Development of Cognition and Action*:

> *Thought is embodied, that is, the structures used to put together our conceptual systems grow out of bodily experience and make sense in terms of it; moreover, the core of our conceptual system is directly grounded in perception, body movement, and experience of a physical and social character.*
>
> *Thought is imaginative, in that those concepts which are not directly grounded in experience employ metaphor, metonymy, and mental imagery – all of which go beyond the . . . representation of external reality.*
>
> *Thought has an ecological structure. The efficiency of cognitive processing, as in learning and memory, depends on the overall structure of the conceptual system and on what the concepts mean. Thought is thus more than just the mechanical manipulation of abstract symbols . . .*
>
> *Human reason is not an instantiation of transcendental reason; it grows out of the nature of the organism and all that contributes to its individual and collective experience: its genetic inheritance, the nature of the environment it lives in, the way it functions in that environment, the nature of its social functioning, and the like. (34)*

Thelen and Smith, in talking about Edelman's concepts: recall that "Edelman makes five central claims about the origin of categories":

> *(a) the system is degenerate – there are multiple disjunctive processes that operate over the same input in real time;*
> *(b) categories develop from the reentrant mapping of these disjunctive samples of the perceptual space;*
> *(c) the making is accomplished through the real-time correlations that exist across the independent samples;*
> *(d) the reentrant maps are activity-dependent – what we perceive depends in precise time-locked fashion on what we do; and*
> (e) *there is always variability in the system. The variability is anatomical, owing to the high connectivity in the system, and dynamic. The dynamic variability is a result of intrinsic continuous activity in the central nervous system and the continuous and changing nature of the input, which insures that the system is never in the same state twice. (35)*

How can we define a model that embodies these observations? The notion of observing the Thoughtbody in relation to dynamic patterns seems to be a fruitful method that potentially could be abstracted to inform the production of our model. The list of observations above informs the formation of a set of driving problems to be solved.

Thelen and Smith provide a fascinating view of memory:

> *Each memory is dynamically constructed from many but not all, of the previously facilitated connections, and as a dynamic attractor may also "pull in" associations not previously included in*

that dynamic category. Because the perceptual categories are themselves probabilistic and context-bound, so are the memories that are based on these categories themselves fluid and inexact. Memory works not as a digital symbol-manipulating machine, but as a dynamic system. " (36)

They state:

We will use Edelman to support our contentions that
(1) during development, behavior is selected from a wider universe of possibilities rather than imposed;
(2) dynamic perception-action mappings are primary in early life;
(3) multimodal exploration is a key process for acquiring new forms; and
(4) *creation and exploration of variability are key elements in the process. (37)*

They continue:

In Edelman's view, categories emerge from the dynamic interaction of groups of neurons; the mappings – the categories – self-organize through their reciprocal interaction with one another. (38)

Thelen and Smith posit:

The key notion here is that the global functions of categorization – memory, learning, and performance – arise dynamically from the reentrant mapping of motor activity along with sensory information from many modalites. More specifically, in early development, movement and sensory signals are completely coupled and act together to form the global maps that are the basis of further development – a notion that is born out not only in the neurophysiology of visual development but in behavioral studies of infants as well. Before applying these ideas to specific aspects of early development – walking, reaching, object knowledge, and language – we consider the theoretical status of categories, and the link – via the Edelman theory – between global dynamics and neural dynamics in development. (39)

We can motivate our body in particular ways in response to particular sensual patterns. This movement is also registered as a body related/environmental pattern over time. Yet we must be clear that such patterns arise and are understood only as a result of a linguistic frame (itself born of patterns) which also intermingles with the build-up of these pattern flows (fields) and informs both their perception and their articulation. The linguistic field is always projected onto environment within thought. There are pure un-named sensations. Yet, central to any becoming is categorical linguistic framing. Historically un contextualized perturbations (pure sensation) are constantly being understood in terms of the categories of reflection that have been reciprocally built-up (40). This build-up is ongoing so both sensual understanding and linguistic framing are in a perpetual state of reciprocal expansion as related to environmental knowledge. This is not to say that language does not have its limits in terms of articulating experience. Transgressing these limitations become one of the driving problems suggesting the need to develop our model for an electrochemical computer. We develop such a model so as to better point at how we actually do function. The attempt to derive such a model also informs and extends our understanding of linguistic practice.

This registering and parsing of multiple sensual stimulations over time forms spatial/temporal patterns of experience. Certain understandings arise in relation to specific repeated qualities of behavior and/or environmental relation (as framed through language and mutual forming relations). Our learning from pattern-perception (field intermingling) and pattern matching (field comparison) begins with our relationship to our early environmental surroundings as well as

social and cultural relations that are imparted by others. We construct our intellectual perception of the world through these layered sense-oriented stimulations in an intra-active manner with others and our environment — this process (build-up) continuously bridges and extends embodied experience in terms of our linguistically informed mindset, and is also in the process of continuous reciprocal expansion and change. One can also not underestimate other relevant processes — abstraction, deduction, abduction, and inference, these conceptual processes are also part of intellectual development. This suggests the need to literally "bring up" our electrochemical computer like a child, in a realm of benevolence.

Thus our embodied experience of these sensual patterns through "reciprocal action" and/or "mutual forming" build-up a linguistic frame to interpret and operate within the world.(41) This process informs all learning and understanding and intermingles a biological sphere with the social and the cultural. Language represents a particular set of patterns that become part of our perceptual pattern learning and memory of multi-modal (intra-field) pattern perception. Language enables the ability to reproduce and/or abstract the qualities that make up these patterns. The understanding of such patterns happens via the body/mind (the human Thoughtbody) thus we are in a unity with our environment — a subject←→object unity...(42) this "world understanding" only exists via our embodied linguistic forming. It takes on different meanings as this linguistic forming grows and changes — thus the world is in a continuous state of becoming. Language becomes a pattern of central importance in that it enables us to reflect on and communicate about all pattern flows (a specific subset of pattern production and reception). Thus to a large degree language use arises out of our understanding of past pattern acquisition (registered, framed, sensual stimulations). We also learn to generate patterns, to reproduce patterns, to abstract and recombine sense-oriented perturbations to stimulate others, or later communicate to ourselves and the world. This informs our ability to articulate meaning through many different forms and qualities of environmental exchange, stimulus and what Gaugusch and Seaman in the *Open Order Cybernetics* paper refer to as "reciprocal forming". In some instances, patterns are generated via the body – handwriting and speech. Alternately, we come to use differing technologies and their pattern generating potentials. I see the potential of the computer to extend our ideas surrounding linguistic forming, understanding and transmission as central to the formation of the model. Thus this open, on-going form of *languaging* the world extends notions surrounding ontogenic coupling. Open Order Cybenetics seeks to be open in its ongoing linguistic self-understanding through a (re)sensing(43) of the observer as well as open in terms of its relation to exchanging energy, matter and/or information with ones surroundings (see Kelso above). In particular, the development of this model for an embodied technology seeks to actively expand self-understanding through transdisciplinary communicative processes and deep self-reflection.

April 11, 2004 and April 29, 2004

Notes:

General Functionality

• What operating system would enable such an electrochemical system œto operate?
• How can such a system be devised to be self-organizing?
• How can differing kinds of neuronal functioning/synapse flows and their shunting mechanisms be explored to model an electrochemical computer?
• How can "volume transmission" be modeled?

• How can the notions of fields of meaning/fields of neuronal activity be used in the development of our model?
• Can an electrochemical model functionally be developed and emulated in an electro-magnetic code space?

Recombinant Patterns of Flow

• How can we design an electrochemical pattern matching, pattern generating, pattern abstracting system? Could this system record change over time as a dynamic electrochemical spatio/temporal pattern [field map]?
• How can we develop a flow potentiality map based on current scientific knowledge?
• How can Edelman's notion of "reentry" be modeled?
• How will the Thoughtbody "understand", communicate and parse pattern, pattern matches, pattern abstraction, language, fields of meaning, etc. via electrochemical activity?
• How will our Electrochemical device make such logical connections and inferences between patterns, structures and differing sensual qualities of pattern production, pattern displacement and replacement, as well as pattern combination and recombination?
• How will we be able to register difference, reflection and enable "machinic" meta-reflection on this difference in an electrochemical environment?
• How will an electrochemical mechanism enable multiple perturbations to be registered, focused on, and later "remembered"as framed within linguistic pattern forming categorization "experiences"?

Sensing System

• How will the Thoughtbody receive and translate/transduce an ongoing, changing set of physical perturbations?
• How can we give senses to this electrochemical Thoughtbody to collect and translate qualities of the surrounding environment and transduce them into a form that can be registered by the Thoughtbody? [44]
• How many simultaneous streams of sensor flow will such a system be able to parse?
• What machinic senses will inform the system?
• Should such a device have a distributed set of "senses" to inform its becoming?
• How does distributed sensing alter the construction of "self".
• Can such receptors be distributed across the world or does proximity /localness have relevance to the system?
• What becomes the measure of the system's embodied behavior?
• Do we want to emulate the human set of senses or do we want to build an extension or augmentation system of machinic senses?
• Should we construct various versions for different studies?
• Might such a system have synthetic senses that are "of themselves" and generally unlike human senses?
• How would the registering of these "senses" become articulate to human interactors?

• Will this system become perturbed at a different state level than humans or be tuned to multiple state levels?
• How will the nature of "focus" and "attention" manifest itself in such a system. – the human doesn't take in all of the flow – they only take in fragment/streams on the highest level of attention.

Relation to an "embodied" Linguistics

• How can our electrochemical device come to differentiate context?
• How can this Thoughtbody become situated and be formed through "reciprocal action" and/or linguistic "mutual forming" processes?
• Can the device understand "linguistic" patterns as intermingled with experience and thus the production of meaning as an on-going, non-static phenomenon?
• How could such a device actively be formed within a mutual linguistic forming process that is both social and cultural?
• What role does proprioception have in linguistic forming?
• Is it possible to parse a series of "expert" systems to interface with the Thoughtbody?
• How can we construct our electrochemical Thoughtbody to build-up meaningful relations and have it come to know context?
• Our new linguistics can be articulated as a set of spatial/temporal patterns that are reinforced by multiple contextual combinations, abstractions, iterations, and most importantly, repetitions in similar but different contexts. Inferences are also central to the learning of language. How can we articulate this in the system?
• Will our electrochemical Thoughtbody communicate through "natural language" or begin to establish a language of its own — a human/machinic creole? [45]
• Will it have an underlying code that enables natural language to function on another level?
• Will this device include a media-linguistics as output to extend the potentials of speech/text?
• How can the electrochemical device experience a "childhood" filled with sense perturbations and mutual formings?
• How will media experience inform the system?

Relation to Environment

• How can we make the system self-aware (or operatively self-altering/self organizing) so that it can "internally" operate on patterns to form and operationally recombine "categories" as well as to establish a meta-pattern flow [time-based meta-fields]?
• Will this device articulate itself via an elaborate virtual environment that is experienced by humans and/or related machines?
• How will contextual understanding be brought to bare to enable relevant new contextual behavior?
• Will such a device be able to interface with electro-mechanical devices and/or standard computers?

• In what manner can our Electrochemical device be interfaced with other non-computational devices?

Relation to the Body as Model

• What aspects of this physical relation between "body" and environment can be retained in such a model and what needs to be "pragmatically" re-understood ?
• To what degree does the "measure"of the biological throughtbody, or the relation of the body to environment, define consciousness?
• It seems clear that such an electrochemical device will need both a Thoughtbody and an ExperienceBody that functions as a unified field of becoming. How do we facilitate this?
• How might a local robotic body with a sense of balance and haptic response system become bound to a larger distributed system? [46]
• To what degree is this device to be based on the workings of the human or abstraction and/or expansion of the human?
• On what level of frequency response will the electrochemical computer be calibrated?
• How will embodied experience be realized?

Relation to other Thoughtbodies

• If we give one device a childhood can it pass on the knowledge without having lived it as embodied experience?
• Should we begin with two Thoughtbody mechanisms so they can also learn to inter-communicate?

Synthetic System

• How could an electrochemical-computer be made with the technologies of today?
• What new tools need to be developed to design and build such a technology (as well as articulate the model for that technology)?
• How can we develop technologies to better track current electrochemical flows in thought.

Philosophy

• Should we potentially move away from a fitness model of adaption to new mutually supportive models of symbiotic human/machine co-adaption.
• To what extent might the device define a unified "self" – or an ability to be self-aware?
• Should an electrochemical Thoughtbody also be in a continuous state of becoming and passing away?
• Should a goal for the device be to re-create itself or create a hybrid sub-self by intermingling with other related Electrochemical ThoughtBodies or functionally coupling with humans?

• Could such a Thoughtbody function forever in an ongoing state of material change and growth?
• Should we author "drives" and an "ethics" into such a synthetic-self?
• Does such an Electrochemical device serve to extend human perception or to take on a new form of synthetic self-awareness and become an intellectual/self-aware entity unto itself?
• Should an electrochemical device be given a set of pre-dispositions, desires, and needs? How might this be done?
• Will this device be able to communicate with humans or will it derive a post-human communication that is self-actuated bridging of human and 'machinic perception'?
• What is the act of creation and how might our Electrochemical computer become creative through pattern understanding and re-application?
• Can our Electrochemical device also produce insight?
• Will such a device have desires?
• What attributes would we seek to avoid in the model?
• To what extent will sonic perturbations become music for the Electrochemical computer?
• Will such a computer find certain perturbations "pleasureable"?
• How can we articulate a benevolent system?

April 11, 2004 and April 29, 2004

(1) Paraphrase from a Forthcoming Paper — *(Re)Sensing the Observer — Offering an Open Order Cybernetics*, by Andrea Gaugusch & Bill Seaman.
(2) ibid
(3) Joseph Kosuth in his text *Art After Philosophy* stated: "The function of art, as a question, was first raised by Marcel Duchamp…With the unassisted readymade, art changed its focus from the form of the language to what was being said. Which means that it changed the nature of art from a question of morphology to a question of function. This change, one from 'appearance' to 'conception' – was the beginning of 'modern' art and the beginning of 'conceptual' art." Kosuth, Joseph, Art after Philosophy (1969) as found in Osborne, Peter, *Conceptual Art*, Phaidon Press, 2002, NYC, P. 233. Seaman in this paper is suggesting the creation of *Art as idea to explore the potential of producing machinic sentience.*
(4)http://weber.ucsd.edu/~gbowker/classification/
"At this site, we present the introduction, first two chapters and concluding chapters of our book on classification systems published by MIT Press in 1999". (Also discussion with Sha Xin Wei concerning Boundry Objects)
(5) From the forthcoming Paper — *(Re)Sensing the Observer — Offering an Open Order Cybernetics*, Andrea Gaugusch & Bill Seaman
(6) ibid (1)
(7) ibid (1)
(8) ibid (1)
(9) see http://www.ai.mit.edu/projects/humanoid-robotics-group/
(10) See also Roy Ascott's concept of Moist Media "We are living on the edge, in complex mixed realties, between cyberspace and material space, between particles and pixels. I would argue that a whole new substrate of our lived experience is being formed from the technologically driven convergence of Bits, Atoms, Neurons and Genes & the Big B.A.N.G. From the artists point of view this is creating a new media universe. The first stage of this convergence can easily be seen as the digitally dry data of the computer

mixes with the wet biology of living systems, producing a kind of "moist media". The advent of nanotechnology, now moving much closer to the forefront of our material practices, brings another dimension to our constructive urge to build new worlds."
http://www.btgjapan.org/links/001.html
(11) ibid (1)
(12) Bateson, Gregory, *Steps to an Ecology of Mind, 1972, Chandler Publishing Company, San Francisco* (p 419-421)
(13) Edelman, G. M., *Neural Darwinism*, 1987, Basic Books Inc. Publishers, New York,
(p. 6)
(14) ibid, (p.6)
(15) ibid, p. 7
(16) ibid p.7
(17) ibid p. 8
(18) BABBAGE, C. 1961. *Charles Babbage and his Calculating Engines: Selected Writings by Charles Babbage and Others.* New York: Dover Publications, Inc. ((Lovelace as found in)Babbage, 1961, p.249).
(19) Pask, Gordon, *An Approach to Cybernetics* With a preface by
Warren S. McCullock, (Massachusetts Institute of Technology)
HARPER & BROTHERS, New York, 1961, (pg. 105)
See also cited by Pask Technical Reports of Contract NONR 1934(21), Elec. Eng. Research Labs., Univ. of Illinois. Also 18 and 32.
Pask also states that D.M. MacKay early on explored analogue connective elements in a computing machine.
(20) Rössler, Otto, *An artificial Cognitive Map System*, Bio systems, 13 (1981) 203-209, Elsevier/North-Holland Scientific Publishers Ltd.
(21) Rössler, Otto, *Nonlinear Dynamics, Artificial Cognition and Galactic Export*, a paper from Rössler sent to Seaman, Division of Theoretical Chemistry, DFH University of Tübingen, Auf der Morgenstelle 8, 72076, Tübingen. F.R.G.
Rössler, Otto, *Endophysics — The World as Interface, World Scientific, 1998*
(dated Feb. 1999, July 14, 2003) Sent to the Author
(22) Kelso, J. A. Scott, Dynamic Patterns, The Self-Organization of Brain and Behavior
A Bradford Book, MIT Press, 1988, p. 4
(23) Ibid (22) Kelso sites Haken as a major influence – I reproduce here his reference to Haken from Dynamic Patterns. —"There are now over sixty volumes in the Springer Series in Synergetics edited by Haken. For an excellent technical treatment see Haken, H. (1983), *Synergetics: An Introduction*, 3rd ed.; and (1984). *Advanced Synergetics*, 2nd ed. Berlin: Springer-Verlag. A very readable and accessible introduction is Haken, H. (1984). *The Science of Structu*re: Synergetics. New York: Van Nostrand Reinhold."
(24) TURING, A.M. 1986. A.M. Turing's ACE Report of 1946 and Other Papers. Volume 10. *In:* B.E. CARPENTER and R.W. DORAN, eds. *The Charles Babbage Institute Reprint Series for The History of Computing.* Cambridge/London: MIT Press, p.36
(25) Kelso, J. A. Scott, *Dynamic Patterns, The Self-Organization of Brain and Behavior*
A Bradford Book, MIT Press, 1988, p. 4
(26) ibid (pg. 8)
(27) ibid (pg. 53)
(28) ibid (pg. 212)
(29) ibid (pg. 218)
(30) ibid (pg. 229)
(31) ibid (pg. 257)
(32) ibid (pg. 259)
(33) ibid (pg. 270)
(34) Esther Thelen and Linda B. Smith*, A Dynamic Systems Approach to the Development of Cognition and Action*, A Bradford Book, The MIT Press, Cambridge, Massachusetts, 1994 (p.165)
(35) ibid (p.167)
(36) ibid (p.203)
(37) ibid (p. 130)

(38) ibid (pg. 143)
(39) ibid (pg. 160)
(40) ibid (1)
(41) ibid (1)
(42) ibid (1)
(43) ibid (1)

Delivered April 27, 2004 in Bilbao Spain in the Ciberart Bilbao conference.

Bio

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