Navigating a Transdisciplinary Field of Fields — Thoughts Surrounding the Media, Material Qualities, and Potentials of the Contemporary Text

A Transdisciplinary Field of Fields

We have often spoken of interdisciplinary, cross-disciplinary, and multidisciplinary inquiry in the past. In transdisciplinary[1] research, a series of disciplines are bridged. Because no singular discipline or history of that discipline can be used to articulate the emergent work that is arising, the term transdisciplinary is used, suggesting that such study goes beyond any individual discipline or coupling of disciplines.[2] Transdisciplinary research brings a set of disciplines together in the service of emergent knowledge production by engaging different contributions from the arts, the sciences, and the humanities through the articulation of "boundary objects." Susan Leigh Star and Geoffrey C. Bowker in their text, *Sorting Things Out: Classification and its Consequences*, define the notion of the boundary 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. [3]

The potential is to develop a series of both human and computational processes to augment transdisciplinary education. In this research, we also seek to employ generative systems enabling creative output, specific forms of search capability, and intelligent associated juxtaposition as another set of potential overarching strategies. The collaboration of artists in transdisciplinary research becomes one of many intersecting “perspective” vectors forming a complex intellectual topology. The outcome of the research arising from such processes may have an impact on many different fields, depending on how the work is parsed, framed, and ultimately contextualized. Artworks produced in conjunction with such research can potentially be articulated as Conceptual art[4] and/or inform poetic artistic production as a secondary manifestation, where the artist is “inspired” by the research to make “related” works of art. Alternately, questions central to the sciences and the humanities can potentially be addressed, and later, specific knowledge can be folded back into the individual disciplines, expanding the ongoing definition of each of many differing fields.

Neosentience

Perhaps one of the most interesting overarching questions that forms a central nexus for future research in many disciplines concerns our human sentience. How is it that we come to know the world, experience its multiplicity of contexts, become creative, share empathetic concern for our fellow humans, as well as learn and grow as an ongoing pursuit? As we seek to un-pack human sentience from a multiplicity of disciplines and domain specific perspectives, how can we apply this knowledge to new technological systems? How can we best approach the authorship of tools to augment our knowledge; re-address the potentiality of textual flows; define new media storage and retrieval paradigms; develop tools that can enable the creation of relevant media configurations and re-configurations; as well as articulate flexible means of categorization. Can we define new technological processes that form a means to help define the focused relationality of text from one research domain to another? How can we apply knowledge from our transdisciplinary study of human sentience and all that it entails in the service of creating

intelligent machines to function in a resonant and perhaps one day autonomous manner with their human counterparts? Is it a valuable transdisciplinary research domain to attempt to approach the creation of a machinic Neosentience?

New Functionalities

The computer and all of it's deeply material infrastructures of functionality, as it works in tandem with the vast connectivity of the internet (miles of cable, satellites, servers, routers, switches, etc. etc.), becomes an emergent medium for new textual forms and text-based, and/or text-related processes. Code authorship, input and output strategies, and advanced interface design, enable entirely new ways of approaching the malleability of electronically mediated texts. Computational processes open up new worlds of potential for text generation, retrieval, mining, perusal, editing, annotating, sharing, linking, transmitting, storing, intermingling, and comparing texts. *Reading*, in the light of these computational processes, has shifted in meaning. The traditional qualities of the static printed text have been radically altered via the functionality of computer code, although the printed text still stands adjacent to the time-based micro-contexts that are engendered via computational processes. The salient features of computational text includes the following: text becomes infinitely malleable; potentially non-stable as a singular linear experience; "navigable" and emergent through dynamic interaction by an interactant; spatially distributed as in virtual worlds, as well as in mixed and augmented reality environments; experiential through non-linear networks of linkages; and operated upon via algorithmic processes to form new texts and text/media configurations.

We are experiencing first hand the birth of a new linguistics consisting of fields of meaning. This has been discussed in the past by a number of media theorists including Ascott, Hayles, Massumi, Seaman and Ushenko. The computer enables one to explore each different media element as a potential field of meaning – text, image, sound, music, movies, 3D objects, etc. Thus we explore configurations of media-elements, each embodying a unique communication potential and set of characteristics that are unique. Each media-element is "of itself" in terms of

these communication potentials. The ability to position, operate on, recontextualize, categorize and re-categorize, annotate, define text-based meta-tags, navigate, as well as attribute behaviors to media-elements including digital texts, provides us with rich, operative, meaning generation environments. This operative nature shifts simple signification to a realm of mutable “neighboring” meaning potentials. Thus each field has a form of “meaning force” that falls in relation to the other fields that it becomes adjacent to as an ongoing process engendered via the functionality of code, human/computer interface and interaction potentials. In *Semiotics of Visual Language*, Saint-Martin speaks about the relevance of "neighboring," which is central to the production of meaning in a virtual environment, as well as central to many differing computational environments:

> The relationship of neighboring is the most important topological notion by which the function of continuity is constructed in any spatial field, whether physical or perceptual. Its importance to physical sciences was underlined by Bachelard[1] when he stated that any force in the continuity of the field "presents itself as determined by the condition of neighboring. The term, vague in everyday language, acquires all of the desirable conciseness in mathematical expressions." (Saint-Martin, 1990, p.69)

Thus, Bachelard also points toward "neighboring" as being central to an enlarged understanding of topological space. It is in part the set of underlying "mathematical expressions," that characterizes both virtual space and other new forms of computational interaction, which in turn enables the operative exploration of text in relation to juxtaposed media-elements and processes.

Accretive Meaning

We bring our history of meaning production as both an embodied living being and as a computational and media interactant; and experience an ongoing “meaning-summing.” Here we experience text in relation to other texts, in relations to other media-objects and processes, in relation to embodied accretive experience, and in relation to our attention to micro-contexts, both brought before us through navigation as well as “experienced before.” I have described this approach to meaning-becoming in a paper entitled *Pattern Flows / Hybrid Identity Processes*. We encounter a series of multi-modal sense perturbations over time. Each similar but different

context calls up a relationality to past experience, hybridizing the associated identity of a particular segment of lived experience – in particular its textual field of categorical associations. Thus the 'textual' associative field that is attributed to a particular person, process, place or thing is always in a life-long expansion process of ongoing hybridization and becoming. Text is always tied back via memory and association to embodied multi-modal experience. Thus the subjectivity of the human is always called into play and becomes enfolded in the reading and understanding of current contextual relations – through both reading and conceptual projection, a bi-directional process, the individual informs the evocative nature of adjacent media elements and processes as they are entertained in relation to "neighboring" text and previous experience. Thus, we are enmeshed in a life of meaning-becoming. Of course we have not lost printed matter as a media with material qualities. Thus traditional "printed matter" provides an additional set of contexts of relationality. The spoken text, rhetoric, vocal processes of all kinds, and the oral tradition also play into this ever-expanding field of fields. We must continue to find ways to nuture the nature of dialogical processes and build on the knowledge that can emergently arise from all of the processes that feed into and inform textual formation.

Computational Materiality

We might think of a computer in the following way as exemplified by a black box model.

Input + Functionality = Output

We could say this formula happens on two differing intermingled levels – within a material substrate of matter and energy processes (the physics of the system), and on the human conceptual level that both "authors" the potentials of the matter/energy physicality of the system through the development of hardware and software, and entertains the fruits of the output that is enabled by this same hardware/software paradigm.

It was perhaps Einstein who is best known for articulating the dynamic nature of relations between matter and energy although I like the following philosophical and poetic quote related to Heraclitus' universal flux as a relevant early example. The following observations are attributed to Heraclitus from the 6th century B.C., with commentary by Philip Wheelwright.

> Everything flows and nothing abides; everything gives way and nothing stays fixed.
>
> You cannot step twice into the same river, for other waters are continually flowing on.
>
> It is in changing that things find repose. (Wheelwright, 1968, p.29)[5]

Wheelwright muses:

> Permanence is but a relative term, his [Heraclitus', emphasis Seaman] philosophy declares; and what we call permanent is simply an example of change in slow motion. All structures, if you observe them patiently enough and project your imagination far enough, are dissolving slowly; everything, as the Greeks put it, is in a process of coming-to-be and passing-away. (Wheelwright, 1968, p.29)
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> WHEELWRIGHT, P. 1968. *Heraclitus.* 2nd edn. New York: Atheneum.

We can focus on the potentials of the particular matter/energy set of processes or what might be considered to be the potential "material qualities" of digital text, as made manifest through the authorship flows of computer code, new interface potentials and new output potentials, as exemplified within the hardware/software paradigm.

Thus, We must not forget to include *people* in the cybernetic loop to provide the conceptual level, as well as to author the machinic potentials of the system, although in the future intelligent

machines may also contribute enormously to this arena in terms of new forms of “conceptual” human/machine relations. Given the centrality of human sentience, we must change our formula — human input (multi-modal human sensing), functionality (thought), and output (behavior) intermingles with computational input, functionality and output as a continuum of flow – an ongoing loop of meaning-becoming. Text is navigated as an integral part of this process, and a specific variety of text is employed as code to enable the experience. As we add the connectivity of the Internet and the World Wide Web, all of its participants, as well as it’s technological infrastructure into the formula, this continuum loop becomes vast. Thus, a material and energy substrate enables the bridging between computer code and the potentials of human knowledge production — human/machine, and human/human interaction.

What is the material nature of the digital?

Where some would call the digital domain disembodied, I would suggest that it exists only though specific forms of human embodiment – that texts are accessed through a phenomenology that is enabled by the multi-modality of the body’s senses, memory, language acquisition and use. One of the most common ways we perceive computationally mediated text is via LCD screens. LCDs are discussed on the website – *How Stuff Works*.

LCDs – Liquid Crystal Displays

But just what are these things called liquid crystals? The name "liquid crystal" sounds like a contradiction. We think of a crystal as a solid material like quartz, usually as hard as rock, and a liquid is obviously different. How could any material combine the two?[6]

We learned in school that there are three common states of matter: solid, liquid or gaseous. Solids act the way they do because their molecules always maintain their

orientation and stay in the same position with respect to one another. The molecules in liquids are just the opposite: They can change their orientation and move anywhere in the liquid. But there are some substances that can exist in an odd state that is sort of like a liquid and sort of like a solid. When they are in this state, their molecules tend to maintain their orientation, like the molecules in a solid, but also move around to different positions, like the molecules in a liquid. This means that liquid crystals are neither a solid nor a liquid. That's how they ended up with their seemingly contradictory name.

So, do liquid crystals act like solids or liquids or something else? It turns out that liquid crystals are closer to a liquid state than a solid. It takes a fair amount of heat to change a suitable substance from a solid into a liquid crystal, and it only takes a little more heat to turn that same liquid crystal into a real liquid.[7]

There's more to building an LCD than simply creating a sheet of liquid crystals. The combination of four facts makes LCDs possible:

- Light can be polarized.
- Liquid crystals can transmit and change polarized light.
- The structure of liquid crystals can be changed by electric current.
- There are transparent substances that can conduct electricity.

An LCD is a device that uses these four facts in a surprising way. To create an LCD, you take two pieces of polarized glass. A special polymer that creates microscopic grooves in the surface is rubbed on the side of the glass that does not have the polarizing film on it. The grooves must be in the same direction as the polarizing film. You then add a coating of nematic liquid crystals to one of the filters. The grooves will cause the first layer of molecules to align with the filter's orientation. Then add the second piece of glass with the polarizing film at a right angle to the first piece. Each successive layer of TN

molecules will gradually twist until the uppermost layer is at a 90-degree angle to the bottom, matching the polarized glass filters.

As light strikes the first filter, it is polarized. The molecules in each layer then guide the light they receive to the next layer. As the light passes through the liquid crystal layers, the molecules also change the light's plane of vibration to match their own angle. When the light reaches the far side of the liquid crystal substance, it vibrates at the same angle as the final layer of molecules. If the final layer is matched up with the second polarized glass filter, then the light will pass through.

If we apply an electric charge to liquid crystal molecules, they untwist. When they straighten out, they change the angle of the light passing through them so that it no longer matches the angle of the top polarizing filter. Consequently, no light can pass through that area of the LCD, which makes that area darker than the surrounding areas.

Our human bio-functionality also becomes involved. The 'distortions' of our human nature become enfolded in our cybernetic human/machine loop, enabling us to perceive text on LCD screens as configurations of pixels (picture elements) are turned on and off in differing configurations over time.

The Encyclopaedia Britannica provides a series of historical references related to the discovery and articulation of the *Persistence of Vision*:

- animated films...working to create conversation pieces for Victorian parlours …, discovered the principle of persistence of vision. If drawings of the stages of an action were shown in fast succession, the human eye would perceive them as a continuous movement.
- motion pictures … series of still photographs on film, projected in rapid succession onto a screen by means of light. Because of the optical phenomenon known

> as persistence of vision, this gives the illusion of actual, smooth, and continuous movement.
>
> The illusion of motion pictures is based on the optical phenomena known as persistence of vision and the phi phenomenon. The first of these causes the brain to retain images cast upon the retina of the eye for a fraction of a second beyond their disappearance from the field of sight, while the latter creates apparent movement between images when they succeed one another rapidly.[8]

So electronic texts appear to us in part because of persistence of vision. Text "behaviors" are enabled through the intermingling of the human sensory system and computational potentials of text — code authorship that drives a series of sequential changes that are passed on to us via the physics of the operative properties of the LCD screen intermingling with the physics of perception. Code driven sonic texts are also transmitted via a physics of instantiation and embodied reception.

For code to function as a vehicle of text, it depends on the flow of energy; changes in this flow over time that change physical states of the machine that are materially registered; and the functionality of hardware; these all become interfunctional to enable the delivery of code's potentiality, and are registered via human interaction and observation. Thus, the quixotic materiality of the contemporary text is enabled via ongoing changes in matter and energy processes. This is highly different from the strategy of presenting text as printed matter on paper which light bounces off of, entering our eye through embodied interaction!

In *My Mother Was a Computer* N. Katherine Hayles states:

> There are data files, programs that call and process the files, hardware functionalities that interpret or compile the programs, and so on. It takes all of these together to produce the

> electronic text. Omit any one of them, and the text literally cannot be produced. For this reason it would be more accurate to call an electronic text a process rather than an object. Certainly it cannot be identified with, say, a diskette or a CD-ROM, for these alone can never produce a text unless they are performed by the appropriate software running on the appropriate hardware.[9]

Interfaceology

Otto Rössler, Biochemist and Theoretical Physicist coined the term “Interfaciology,” to more fully scientifically articulate the complexity of the concept of interface. Ology comes from the greek logos, meaning “the study of” something.[10]

In May of 2000 a symposium took place at the ZKM (Center for Art and Media, Karlsruhe, Germany) in honor of Rössler turning 60, entitled Sciences of the Interface. Hans Diebner and Timothy Druckrey presented the following observation in discussing the conference:

> Because the broad implications of interfaciology (in Rössler's term) extend across disciplines, we are proposing a symposium that looks as much at physical, biological, mathematical, and engineering aspects of the interface as it does the historical, philosophical, social, and artistic interpretations that are enveloped in the emerging discourses of techno-culture. This would suggest that areas such as cognitive systems, complex systems theory, and the brain sciences, will be as relevant to the discussion as cinema, television, media art, theories of representation and spectatorship in experiential conditions driven less by singular states and more by transformations.[11]

Thus, text arises in the continuum that intermingles digital hardware and software processes that enable output “transformations” with the phenomenology of human perception, and thought.

There are many potential perspectives of study that can contribute to our understanding of the new potentials of text arising out of the breadth of processes that characterise our current computational milieu.

Nicholas Gessler, a faculty member at Duke in the *Information Science + Information Studies* (ISIS) program, and a member of the Visual Studies initiative at Duke states: “All information must reside on some medium (material or energetic)...And every medium has its own "life," it's own cost to record that information, it's own mean-time-before-failure, it's own cost to store, etc.” He went on to say: “…The fact that all information, and all computational processes, take place in physical media of some sort or another is understood and common knowledge to most hardware folks.” He continues: “…Information, code and processes in an electronic computer do create changes in energy (voltages) and/or materiality (pits in DVDs) and/or physical state (magnetic field), but in a desktop computer there are a variety of these changes going on to support the computation and the interface, processes that are both analog and digital. So any interaction with the computer, at the interface or anywhere else, will cause state changes in the physics (materiality or energetics) in some kind of medium.” [12]

In terms of the arts, new interface experiments enable quite physical relationships to textual creation, interaction, and display. Here the computer mediates “physical” output systems where the code and interaction with interactant and/or system drives overtly physical processes (potentially distinct from LCD screens). This includes the regulation of water as text (See German Artist Julius Popp [on YouToob]); the regulation of physical pixels (balls) in space Andrew Shobin (Greyworld) made a work for the London Stock Exchange called “The Source”; the regulation of robotic output with related voice synthesis (Deb Roy – MIT media lab); the movement of molecules on the Nano level – the writing of IBM (James Gimzewsk); the control of lighting systems at the architectural scale (eg BIX is a matrix of 930 fluorescent lamps integrated into the eastern Plexiglas facade of the Kunsthaus in Graz); the articulation of genetic “writing” and genetic “expression” as part of a human/computational processes; The exploration of liquid

crystalline elastomers (LCE) by Simon Biggs; etc. Also of interest are such works as *Text Rain* by Camille Utterback where a participant interacts with texts which “rains down” on the participant via a closed circuit camera interface.

We have covered the quixotic material nature of text as a panoply of matter and energy processes and output strategies. I now want to switch gears and discuss a series of questions related to new computation potentials that explore text in differing ways as a highly malleable series of processes that can lead to knowledge production. In particular I am interested in a series of new tool-kits as well as the creation of new forms of relational database to explore interdisciplinary and transdisciplinary research projects.

Some Salient Questions

The next section of this paper will cover a series of what I believe to be relevant topics concerning new computational approaches to text and related media. Here are a set of overarching questions which I believe to be of importance to this new realm of research:
How can we approach the media and material qualities of computational text to enable new forms of scholarship? How can we author environments that foster new insights through use?
Can we make tools to enhance textual creativity? What dialogical processes can we set in motion to define the relationality that is salient to the bridging of particular problem domains?
How can we reflect embodiment in text mining programs? Can we devise new forms of search engines that are pre-loaded with relational concepts which are arrived at through cross-disciplinary and transdisciplinary discussion, as a means to help focus queries and enable people to access texts that are relevant to one domain but are published in another? We currently have many tools that harness the illusive nature of the digital yet the computer is an open system. The functionality of the system is authored via code, interface strategies as well as input and output systems. What new functionalities could we imagine to be authored into future tool sets?

For every new tool and the potentials that it enables, there are a set of human processes that must be learned. How can we design new tools that are intuitive and have a fast user learning curve? If code can enable new functionalities, can we design modular systems which can be drawn together, to be combined and recombined to reflect the needs of differing research agendas? Could this modular approach enable new intermingled functions and/or higher-order specificity of function? How can we articulate new technological publishing arenas that enable a transcendence of the hegemony of domain specific journals?

Micro-strategies

There are many *micro-strategies* that can be drawn upon in the service of enabling new forms of transdisciplinary research.[13] A micro-strategy is a focused algorithmic process that is employed to facilitate a chosen goal-directed activity. Most of the people in this audience will have already experienced Wikis and Blogs, both of these embody sets of micro-strategies. Also search engines and database exploration are common in contemporary research. Yet – what are the next set of tools and how would their functionality different from current tool-sets?

The computer is an open system, and code can be authored to enable work on many different kinds of tasks. The *potential* is to design systems that bring multiple micro-strategies together in authored media environments to facilitate tasks that have many different inter-operative components, thus facilitating many different kinds of computational functionality through various *combinatoric means*. This is a pragmatic extension of the concepts I employ in my discussions of Recombinant Poetics in other publications.

The metaphor is that each micro-process is like a part of a machine with a specific function. The machine can run many of these processes simultaneously (as in parallel processing systems) or sequentially. The success of the employment of micro-strategies depends on human code authorship, human consideration in terms of specific contextual employment, intuitive *interface*

design, and ongoing human commitment to understanding and articulately framing the "output" from such systems. Developing new media artifacts in the service of knowledge production is central. This requirement points to the dynamic nature of computationally explored media, as it is focused to enable new forms of knowledge production that function in conjunction with the employment of a set of focused "human" intellectual processes. One must also remember that computational processes are also (at this time) authored "human" processes of a particularly abstract variety. The human ability to write computer code arises out of a history of embodied interactions with the world — lived experience. Because of the qualities of abstraction and logic that computer code can enact, the particular functional processes that code authorship can enable, as well as the specific modular nature of this functionality employed as part of a tool set, one can draw on the strategies presented in this text in a selective manner to create a 'model generative approach' to new forms of education and research relevant to many different projects and areas of inquiry, in particular, one can begin to approach text in new ways to *transverse* this *Transdisciplinary Field of Fields.*

Bridging languages and intersection environments

It is interesting to note that related research may be undertaken by a number of fields that, at the moment, do not "speak" to each other to the depth of their potentiality. Many disciplines have differing vocabularies, hegemonies of research, publishing venues, and working processes. Otto Rössler, in a discussion with the author, suggested that focused conversation can form an initial approach to transdisciplinary collaboration.[14] Rössler speaks of two main approaches to knowledge production: the qualitative, in which conversation and textual language is central; and the quantitative, often driven via mathematics, specific data collection, and equations and formulas of many varieties. In transdisciplinary research there are often many highly complex areas of data *relationality* that can become enfolded in the service of knowledge production. Here we must seek to develop new ways to collaborate, at the highest possible level of communication in each instance, with the knowledge that no single person has the solution to certain complex

realms of inquiry. In this case, we seek to bring differing approaches to the intermingling and enfolding of quantitative and qualitative methodologies.

A bridging language can be created through discussion when researchers from multiple fields work together to articulate relevant jargon translations[15] thereby enabling them to find common ground in communication. Such bridging also encompasses the development of common frames of reference, the articulation of relevant related ideas and concepts, the formation of agreed-upon linguistic definitions, the development of shared overarching conceptual domains, the discovery of relevant formal isomorphisms, and the potential to pose "driving" problems stemming from different disciplinary, historical, critical, and conceptual perspectives. Researchers are here bringing very different skill sets and knowledge parameters to the table. In terms of artists joining such teams, this may mean bringing formal spatial knowledge, such as virtual reality production; specialized programming knowledge germane to the arts; "aesthetic" knowledge that might be applied to new forms of visualization, sonification, and haptic environments; deep metaphorical understanding; a propensity for nonlinear approaches to problem solving; and poetic and narrative reflection. In terms of each of the researchers involved in such transdisciplinary projects, individuals must study the problem domain to a sufficient degree to enable "relevant" communication to flourish. We seek to find how different qualities and "depths" of knowledge can best be negotiated and brought together in a symbiotic manner.

A team of researchers can seek to approach highly complex problems by working to functionally enfold numerous individual approaches to various sub-problems. This can be accomplished through the articulation of functional intersections between relevant sub-domains. Thus, the emergent subject matter that arises out of such research is formed within enabling environments, focusing human communication and knowledge production, in part through technological mediation and *interauthorship*. Such media ecologies that are authored through cooperative interauthorship can empower the articulation of the focused "intersection" of problem domains, enacting the potential for new forms of insight that might only arise through particular

transdisciplinary exchanges. People like Greg Ulmer have been exploring this kind of strategy for some time although new forms of code authorship and data mining can seek to extend the potentials of such research methodologies. One should also see the book *SpecLab: Digital Aesthetics and Projects in Speculative Computing* by Joanna Drucker which is soon to be released by Amazon. Another group of researchers are working on KDD – Knowledge Discovery in Databases, a name coined by Gregory Piatetsky-Shapiro[16]. "Knowledge discovery in databases (KDD) is the non-trivial extraction of implicit, previously unknown, and potentially useful information from databases"[17]. In particular one can see sigkdd.org[18], the ACM special interest group on Knowledge Discovery and Data Mining.

Meta-meaning systems

Meta-meaning systems can become a central focus through specific forms of technological authorship. In this kind of work one can look at the same media "object" in different contexts and observe the work in a mindfully aware manner, noting various qualities of meaning *relationality* produced through interaction, *neighboring* juxtaposition, recontextualization, and informed introspection. In such work, the participant observes how meanings arise and change through their interaction with a particular authored technological system. This has been a central strategy in much of my interactive media work over the past 20 years, in particular in The World Generator mentioned below.

The Visual Studies Initiative

I recently took up a new post as a professor in the Art, Art History and Visual Studies Department at Duke University, chaired by Hans Van Miegroet. The Duke Web site describes this initiative:

> Visual Studies at Duke operates at the interface of science, social sciences and the humanities. Our scope is university-wide. The Visual Studies

> Initiative addresses work produced across a broad spectrum of areas in the humanities as well as the natural sciences, mathematics, engineering, medical imaging, cartography, circuit design, information science, logic, and the many zones of graphic production in commercial and public sectors. The Visual Studies Initiative does not limit its investigation to the study of representation alone. Rather, it investigates the material production, dissemination, semiotics, and remediation of images and imaging systems in all their various forms—artistic, popular, scientific, commercial. Computation and the effects of digitality on knowledge-production are central to the VSI enterprise, both in theory and in practice. Our aim is to activate Visual Studies not only horizontally across disciplines and administrative structures, but also vertically, from introductory coursework to advanced teaching and research collaborations. Our Steering Committee includes leaders from Art, Art History and Visual Studies; the Nasher Museum; the Scientific Visualization Lab; Information Science + Information Studies; the Center for Documentary Studies; Literature; Engineering; English; Computer Science; Film, Video, Digital; Duke's Office of Information Technology, and the University Libraries.[19]

The potentials of the Visual Studies Initiative are immense in terms of expanding the definition of visual studies and, in particular, enabling new forms of transdisciplinary research that seek to enable emergent educational processes. Alternately, the sciences at Duke are seeking to build bridges to the arts and the humanities in an initiative called *The Brain and Society* administered by the Duke Institute for Brain Sciences .[20]

Multi-modal approaches

Historically, vision has often been isolated in its study. Any contemporary study of visual phenomena should potentially integrate knowledge related to the inter-functionality of the entire set of human senses and their relation to memory, association, and meaning production; the more general functionality of embodiment and its relation to “difference” across space and time—the body’s nesting in a given environment—as well as the body's relationships to new technologies, further articulated through social and cultural framing. Thus, we seek to posit an embodied study of meaning production in all of its complexity as it relates to visual studies, bridging the arts, the sciences, and the humanities as an ongoing central focus. Textual description and framing are central to this realm of inquiry.

Association

This multi-modal approach to transdisciplinary education opens out via the employment of different “association” generating mechanisms articulated across research fields. This allows us to explore:

1) The conceptual processes of association that go on when one examines a visual experience, bringing multi-modal sensing and memory into play through textual articulation and other media.

2) The examination of visual material (with related textual references) within complex digital media environments—contexts that are inhabited by multiple digital media forms, such as texts; sounds, still and time-based imagery; 3-D images; virtual space; text-as-image (with behaviors); augmented reality; media behaviors; video and film; holography and visual material intrinsic to advanced technological imaging systems related to the sciences; and new forms of relational databases central to contemporary humanities research.

3) New structures enabled by digital technologies, distributed systems, and complex spatial understandings (the digital potentials of generative virtual environments, interactive authorship,

hyperlinks); non-linear approaches to meaning production; the study of emergent meaning (meaning that arises through generative interactive processes and/or algorithmic processes); interauthorship, where one person (or team) defines a generative system and a participant inter-authors an output; collaborative distributed authorship; ubiquitous media potentials as they relate to qualities of physical space and particular geographic contextual *locationality*; database / physical space interrelations; and process-oriented activities that are enhanced through technological means.

4) The multiple histories, social perspectives, ethical concerns, and critical relationships that are enfolded and inform this multi-modal approach.

5) Accretive processes that enable dialogical approaches to be collected and/or mapped, thereby becoming part of the environment.

6) New approaches to relational re-organisation and search of textual and/or other media materials that is not driven via textual meta-tags and/or works in conjunction with meta-tags.

Vannevar Bush's concept of the Memex was an early step in this multi-faceted direction. In *As We May Think,* their study of Vannevar Bush's work, James Nyce and Paul Kahn comment:

> Bush's writings on the Memex can be viewed as a proposal for an actual machine and as a body of essays that explore the potential utility and application of new kinds of machines for managing information and representing knowledge… Computer and information scientists today recognize Bush's article as containing the earliest description of a machine designed to support the building of trails of association through vast stores of information. [21]

Central to this concept is the notion that dynamic association shared through transdisciplinary, team-based exchanges can potentially lead to new insights related to highly complex problem domains.

Computational precursors

Guilio Camillo's Teatro Del Mundo was designed as a "memory theatre" that worked with associational connections between texts, symbolic images and memory. A spectator would sit at a central location inside a portable wooden structure, which contained seven groupings of information, each accessible from seven different levels. The viewer would engage with an intellectual environment designed to reveal secrets about the structure of the universe, from the microcosmic to the macrocosmic.[22]

Turing's description of the ACE (Automatic Computing Engine), the first digital computer, saw the potential for a machine with programmed, responsive "operative" input and output "organs."[23] He described this system as being analogous to the mind, suggesting the machine would have "a finite set of states of mind," with the possibility of exploring "groups." We can think of this idea as an initial glimpse into the metaphors surrounding "machinic perception"* and active human/machinic categorization potentials. In building out a network of metaphors surrounding perception, the notion of navigation also becomes central—navigating relational concepts in particular. The word "cybernetics" actually stems from aspects of navigation. Cybernetics is a word coined by Norbert Wiener to describe the complex of sciences dealing with communication and control in the living organism and in the machine. Of course, the concept of non-fixity and flexibility of navigation is essential to emergent meaning production systems. [24]

Certainly "steering" is a metaphor for reactive environmental thinking, which is here abstracted in part into a set of computer–based processes. The correlation between thinking and the

* Defined below. See "Contemporary memory theatres"

functioning of computers has been historically linked to a set of metaphors. The notion of “control” can be seen to be operative, defining a form of human/machine symbiotic steering. J.C.R. Licklider, in “Man-Computer Symbiosis” states:

> Man-computer symbiosis is an expected development in cooperative interaction between men and electronic computers. It will involve very close coupling between the human and the electronic members of the partnership. The main aims are, 1) to let computers facilitate formulative thinking as they now facilitate the solution of formulated problems, and 2) to enable men and computers to cooperate in making decisions and controlling complex situations without inflexible dependence on predetermined programs. In the anticipated symbiotic partnership, men will set the goals, formulate the hypotheses, determine the criteria, and perform the evaluations. Computing machines will do the routinizable work that must be done to prepare the way for insights and decisions in technical and scientific thinking. Preliminary analyses indicate that the symbiotic partnership will perform intellectual operations much more effectively than man alone can perform them.”[25]

We have seen this kind of partnership explored to a great degree in the human use of different computational systems. These systems can be designed to augment high-level decision processes. Thus, the production of new machinic tools might extend the role of the computer in terms of knowledge production beyond Licklider’s discussion above and into a more autonomous role, where a computer might “suggest” an area of conceptual importance and/or enable the intelligent bridging of research domains if given the appropriate data related to the development of “boundary objects” and “bridging languages” and other shared core concepts described above. Turing’s approach outlined the potential of imbuing a machine with intelligent behavior by creating machines that would function through the "sensing" of user input and would then "respond" with appropriate output. One can begin to speculate on the potentials of multimodal sensing and

search mechanisms as potentially providing a thought augmentation realm. I will expand on this notion below. Licklider states: “One of the main aims of man-computer symbiosis is to bring the computing machine effectively into the cumulative parts of technical problems.”[26] How can a computer be programmed to become a dynamic contributing force and to work symbiotically with a research team in terms of generating associations and analogies contributing to particular transdisciplinary projects? This will need to be approached on a case-by-case basis, in particular, through informed meta-data, data mining, and data-reduction strategies.[27]

Metaphor

As we become increasingly dependent on cybernetic systems as part of the "posthuman" condition, we often employ assemblages of metaphors, or a layering of metaphorical language, to orient ourselves to new approaches to media, science, technology, and the emergence of new hybrid fields. Multiple metaphors related to human/machine interaction are eloquently discussed by N. Katherine Hayles in *How We Became Posthuman: Virtual Bodies in Cyberspace, Literature and Informatics*. Hayles herself often draws on metaphor as a means to help us better understand human/machine relations. In one instance, she refers to George Lakoff and Mark Johnson’s *Metaphors we Live By*: “As George Lakoff and Mark Johnson have shown in their study of embodied metaphors, our images of our bodies, their limitations and possibilities, openings and self containments, inform how we envision the intellectual territories we stake out and occupy.”[28] [29]

Biomimetics, bio-abstraction, and information relationality

Biomimetics and bio-abstraction contribute to the development of new technological systems that augment human potentials, contributing to the advancement of communication and research across multiple fields. The focused study of the body (as nested within the environment) and its

complex bio-functionality, helps us to better come to undertake new forms of knowledge production and information management. [30]

The study of bio-functionality and its abstraction is particularly relevant to computer science, the computational humanities, and the arts. Advanced knowledge of the body and its complex inner workings contribute, in an ongoing manner, to the authorship of new tools that enable us to articulate a multiplicity of dynamic relationships. This includes the mapping of ongoing social interactions; the exploration of change through dynamic visualizations and sonifications of data; the creation of new forms of human/computer — human/human interface through new "sensing" paradigms; as well as the dynamic exploration of physical representations of information in a focused and interactive manner—haptic feedback systems. Text can be employed relationally with each of these realms.

The focused authoring of such systems, the intentional housing and juxtaposition of information within the system (which may be accessed via distributed searching mechanisms), and the "reading" and understanding of the output issued from these systems of *information relationality* can all be used to augment the development of new insights crossing multiple research domains. Certainly introspection related to thought processes, conceptual categorization, association, and logic can potentially be re-embodied in the authorship of new computational tools.

The study and abstraction of embodied human processes inform, in part, the following network of technological systems:

Associational systems (as described above, employing meta-tags, etc.)
Systems that approach the understanding of context through multi-modal sensing
Learning systems
Knowledge management systems
Collaborative authoring systems

Data collection and data mining systems

Systems that employ different forms of logic (inductive, deductive, abductive, and non-two value logic)

Systems that enable creativity and/or become creative in an algorithmic manner

Systems that enable play and/or playful approaches to knowledge acquisition (for example, chance methodologies)

Pattern matching and pattern generation

Virtual reality and mixed/augmented reality systems

Ubiquitous computing systems exploring specific geographic/data relations

Systems that map and explore human behavior and are suggestive of potential alternate behaviors

Each of these systems can be employed in the service of transdisciplinary research and new approaches to knowledge production.

Contemporary memory theatres and attention-related augmentation systems

Sitting in a conference here at Duke University some years ago, I was in a position to plug key words and names into Google and augment my perception of a live event by looking simultaneously at related data, diagrams, and different forms of digital media that entered my field of vision. In a manner related to our ability to sift through vast sets of different memories to inform our perception of current events, I was beginning to imagine both the didactic and poetic potentials of a “machinic perception” system that might augment ongoing human perception. The vision I had incorporated the ability to call forth all forms of digital information—tests, images, sound, virtual environments, video streams, etc. I imagined a machinic perception that was “paying attention” to my “surrounding environment” by searching for streams of information in a “relevant” manner, enabling me to work in concert with such a system and to foreground any

aspect of this environment of data flows to augment my perception and/or communication about a particular “extended” context.

The deepest intellectual questions concerning this vision deal with our ability to learn, share knowledge, do research, and share expressive media-based experience via technological systems. The goal of developing a form of a multi-modal machinic perception that is linked to a memory-augmenting space has many potentials for enhancing transdisciplinary projects. Our senses present to us a lifelong set of elaborate spatial/temporal patterns— spoken and written text being a subset of these patterns. Often our senses work in tandem to put forward a “multi-dimensional” perception of the world. The role of memory is central in terms of gleaning meaning from the patterns that make up each of our worlds. An interest in augmenting memory and meaning production has historically been embodied in memory techniques and memory theatres.[31] I am interested in how multi-modal machinic sensing can inform a dynamic new interface paradigm.[32] Multi-modal sensing is a form of machine sensing that brings together a number of different sensors to work in conjunction with each other to potentially bring about a machinic perception of the environment. One way to imagine this is to substitute different machine senses that model our own senses, such as video for sight, pressure sensors for touch, heat sensors for skin, etc. Yet machine sensing opens out new kinds of perceptions. We have all seen night vision glasses; this sensing technology extends and augments vision. The idea here is to link a series of different sensing systems and database “memory systems” together to give us a higher-order impression of a chosen environment than any singular sensor could. The salient processes that might be focused for use in transdisciplinary education include the following:

• Multi-modal sensing technologies (including multiple “views” or “machinic perceptions” of a chosen space as visualized or made sonic)
• Wireless communication schemes enabling human/machine—sensor/server/media relations
• Peer-to-peer relations
• Wired and/or wireless communication schemes to enable networked interaction

• Servers functioning both as collectors and facilitators (focusing the machinic perception as well as distributing and sharing it among connected communities)

• The storing of time-coded, multi-modal data streams for cross-referencing

• The ability to search for particular multi-modal “neighbourhoods” or “sets” of relevant multi-modal data

• The storing in databases of particular media elements and/or processes with specific encoding methodologies, compatible formats, and meta-data schemes

• The visual and/or spatial representation of particular sets of data with the potential to cross-reference that data and access it via differing sorting methodologies

• The ability to set in motion focused machinic processes related to data mining

• The ability to display and navigate the augmenting data as well as choose from alternate sets of data representations

• The ability to involve multiple forms of output for general environmental augmentation

Search engines are one means of thought augmentation, enabling us to access vast stores of information distributed across the Internet or in more local databases. Here, human memory and computer capabilities work in tandem in the service of thought and knowledge production. As we move to more complex media environments that include dynamic spatial patterns of image, sound, and text forming computer-based contexts, it becomes important to articulate new multi-modal search techniques and strategies for advanced distributed connectivity. As we begin to collect information related to parallel data streams, defining multimodal search methodologies for such databases becomes a central interest. In the long run, one can imagine joining together a network of different systems employing multiple machinic sensing devices, as well as parsing multiple streams of information in the service of augmenting human perception and cognition. One can also imagine layering together advanced scientific imaging technologies that are mapping a time-based event at differing levels of biological and/or cultural scale. New multi-modal pattern-matching procedures will perhaps become central to such a paradigm.

The categorization of categories: defining more articulate search engines and relational databases

Search engines are one mechanism that enable the bringing together of information from disparate sources to help build new insights. I have been particularly interested in developing new kinds of multi-modal search engines that would enable the dynamic "neighbouring" of associated information as drawn from comparisons between different individual approaches to associational collections of *media objects*.

One approach is to author a generative multi-media writing environment to function as an advanced relational database exploring the topic of *The Body as Electrochemical Computer* (the title of a course I plan to offer in the Fall of 2009 at Duke). Here are the key elements of the current proposal for the system: Users would be able to access multiple texts and related media archives (including scientific, humanities-related, and poetic/artistic data) and to generate navigable textual/multi-media "constellations" by dynamically remixing/juxtaposing their searches via a user-friendly interactive interface. The goal of this database would be to generate "associative" media assemblages of related materials. The initial textual and media materials would be written/curated/edited. Later, the system would be made open for others to upload materials. The system would be self-organizing in terms of content management.[33]

This unique project potentially provides an advanced meaning-production arena to explore a set of art/science/humanities relationships that will be sensitive to both the importance and difficulty of situating conceptual and aesthetic objects within their broader social and conceptual contexts. The work will generate a new form of transdisciplinary writing that does not sidestep/dilute complex ideas but renders them accessible and heightens their relational meaning. The user of the system drives the combinatorial engine and thus individually focuses the realm of search/juxtaposition/assemblage. The system will seek to articulate a multi-media writing and research engine that will challenge creatively the limits of existing writing, document "markup,"

and documentation conventions.

Currently the system is in the planning stages. Once the program is completed, the functionality of the system would include the following:

1) The ability to upload a series of different media files to the multi-modal relational database

a) texts

b) audio

c) video

d) diagrams

e) still images

f) 3-D objects

2) The ability of invited external users to define constellations of neighboring texts/media elements (via differing spatial linking methodologies and drawing from elements in the database) to be viewed in a collaged/assemblaged media environment (this could be in 2-D or in virtual space)

3) The ability to explore a user-friendly, intuitive menu system to give participants and invited guests easy access to multiple search/configuration functionalities.

Functionalities to be programmed in the system include:

a) sort and search

b) generate a particular configuration and navigate through this constellation

c) call up multiple constellations and search for elements that are common via a new form of multi-modal relational search mechanism

d) search a particular individual's authorship / associational configuration

e) search entries, topics, and/or key words

f) search chosen media elements

g) search through lists of different varieties of media files

h) explore generative engines that bring different texts/media files together

i) generate constellations of media relationships in virtual space via focused generative engines

j) use different chance methodologies to search and make assemblages and/or constellations

k) define particular jargon translations that enable the construction of bridging languages

l) apply the potentials of pattern matching

Users will be able to access multiple texts and related media archives and will be able to generate navigable textual/multi-media "constellations" by dynamically remixing/juxtaposing their searches via a user-friendly, interactive on-line interface.[34]

The world-generator tool

In order to develop this project, we have proposed a collaboration between Rachael Brady, (director of the DiVE at Duke), myself, and Gideon May, a freelance programmer who has collaborated with me in the past. The project has been funded and will run over the course of one year. One aspect of the project is the authoring of a new open-source software tool to create virtual worlds. The tool also has potentials for constructing worlds in such settings as Second Life or through open virtual world construction technologies such as Croquet if the appropriate code is written for each environment. Media theorist Erkki Huhtamo coined the term "world processing" in discussing the potential functionality of such a system.[35]

The DiVE is an exciting technology on the Duke campus: a cube, three meters per side, that displays images on all of its walls as well as on the ceiling and floor. Six computers coordinate the images that surround the participant and other researchers who work inside this luminous cube

called Duke's Immersive Virtual Environment, or DiVE. In the past, the space has primarily been used for scientific visualization. The tool can thus function as an interdisciplinary and transdisciplinary catalyst for new forms of media production, collaborative design, and distributed communication.

At the moment, creating new works in the DiVE and/or in Caves (another term for similar virtual environments) for the arts, humanities, and the sciences is very difficult. There is currently no strong "real time" tool to facilitate creative production in the DiVE. I have worked with Gideon May in the past on related software projects for the real-time construction of virtual environments. Our proposal for this new project is based, in particular, on an existing work entitled *The World Generator / The Engine of Desire* (1995-present). *The World Generator* is an example of a generative virtual environment. When I say generative, I am suggesting that each exploration of this techno-poetic mechanism can produce a different outcome based on the choices of the participants as they operate within the authored constraints of the system. The work focuses on the exploration and examination of the experience of meaning as an ongoing process of becoming—meaning-becoming. This particular techno-poetic mechanism seeks to empower the participant to construct poetic virtual worlds in real time as well as to navigate and experience those worlds in different ways.

The *World Generator / The Engine of Desire* becomes operative through an intuitive interface metaphor—a series of spinning virtual container-wheels. These container-wheels hold an elaborate set of authored media–elements and processes: 3-D objects; digital video stills and digital video loops; a litany of lines of poetic text; an elaborate series of sound objects (musical loops); a set of varying computer-based behaviors (one can make an object or image spin, rotate, follow a line, move in a spiral path, etc.); a selection of random functions; a series of system commands ("clear world," "center world," etc.).

A surrounding “aura” is toggled on and off to select a particular media-element to operate upon. When the “aura” is activated, the participant can attach a still as a texture map, attach a digital video to the surface of the virtual object, attach a sound to the object, attach behaviors to the object, and superimpose sound objects with the initial selection. One can easily edit the environment, making selections, changing entries, alternating choices, eliminating selections, and instigating semi-random choices. A participant can potentially engage the construction of an entire “chance-driven” virtual world through a particular menu choice. Stills and movies can also potentially be placed in the environment by the participant as texture maps. The above set of processes can also be explored in relation to digital movies and stills that one can view in the space as autonomous objects. Modular 3-D text selections can also potentially be positioned and affected by choices from the container wheels. The participant inter-authors this environment. Media elements loaded into the system already carry *fields of meaning* (as discussed above), as they will be experienced within the container-wheels before they are used as construction material. Meaning can, in part, be generated and explored though dynamic, interactive processes of contextualization and re-contextualization. Here, the experiential approach to meaning production is central. The work could be considered to be articulating an approach to a new, expanded linguistics that such technology affords. [36]

This technological tool enables a particular set of processes in virtual space: poetic and/or didactic construction processes; navigation processes; processes related to authored media behaviors; editing processes; abstraction processes; automated generative processes; processes related to distributed virtual reality; and chance processes of a semi-random nature. It employs a “rolodex” metaphor, a virtual housing system, and a physical interface to enable the participant to easily construct virtual worlds.

Thus, we recognize the potential of this new system to become a contemporary tool for building virtual worlds that are aesthetic and/or contemplative in nature. The tool will be open source and will be made available to other users of the DiVE and for the generation of multi-screen

environments that are also non-immersive. One also hopes to enable connectivity through the internet. The open-source nature of the project means that others will be able to customize the work to their own individual needs. Given the interest in Second Life and contemporary 3-D construction in general, this is an exciting tool to enhance transdisciplinary learning potentials. Thus, here the user of the tool will articulate the media elements that will be entered into the system for world construction

Other tool building projects

Duke University has some strong computational tool-building initiatives that are underway. Some of these are being undertaken in partnership with the Renaissance Computing Institute of the University of North Carolina (RENCI). The potential to construct exciting, collaborative virtual working environments is, in part, being overseen by Julian Lombardi, assistant vice president, Duke Office of Information Technology, and senior research scholar with ISIS – Information Science + Information Studies, Duke University. Such environments might also be explored by artists as part of a transdisciplinary curriculum. Lombardi articulates the following description on the Cobalt Website:

> "Cobalt" is an open source virtual world browser and construction toolkit application being developed at Duke University. Cobalt will make it possible for people to easily create, publish, access, and participate in a network of linked virtual worlds. Currently in pre-alpha and built using the Croquet open source software platform, Cobalt, uses peer-based messaging to eliminate the need for virtual world servers and makes it very simple to create and share secure virtual worlds that run on all major software operating systems.[37]
>
> It features a peer-based messaging protocol that dramatically reduces the need for server infrastructures to support virtual world deployment and

> makes it easy for software developers to create deeply collaborative applications.[38]

The potentials of such collaborative systems, still under development, are immense.

Additional tool kits and potentials

I have been working with computer scientist, writer and artist Daniel Howe on an artwork/toolkit that also has exciting potentials called the “Bisociation Engine” (still a work in progress).

The “Bisociation Engine” (bEngine) is a collaborative, interdisciplinary project that attempts to computationally model specific aspects of human creativity, in particular human literary creativity as it is explored in emergent, spatial computer-based environments. Rather than employing top-down processes, such as propositional logic, the bEngine takes a generative approach that begins with the recognition of micro-level semantic, linguistic, and structural associations between lexical items; it then recursively assembles these into larger units of meaning. Arthur Koestler first coined the term “bisociation” to distinguish between “routine thinking,” which occurs on a single plane and “the creative act,” which, he states, "always operates on more than one plane." A particular focus of the “Bisociation Engine” project thus far has been the human capacity for association, specifically between disparate areas of experience. bEngine algorithms are employed to “intelligently” recognize the relationships between elements drawn from the Internet as well as specific linguistic databases in real time. These relationships (and their relative strengths) are used to situate media items in virtual space, creating an evolving and recombinant set of literary potentials.

Daniel Howe has developed an extensive toolkit for electronic writing called RiTa at Brown University/ Rhode Island School of Design (RISD). The system was used in a class that bridged

RISD's Digital+Media course,[39] Brown University's Electronic Writing (John Cayley), and Brown's Computer Science.

In their paper called "Lessons from a Digital Writing Workshop" (forthcoming), Howe and colleague Braxton Soderman discuss The RiTa Toolkit:

> The RiTa Toolkit for Generative Language is a suite of open-source components, tutorials, and examples that provide support for a range of tasks related to the practice of creative writing in programmable media. Designed both as a toolkit for practicing writers and as an end-to-end solution for digital writing courses, RiTa provides support for a range of computational tasks related to literary language including text analysis, generation, animation, display, text-to-speech, web-based text-mining, and interfaces to external resources (e.g., WordNet [40]). Students from a wide range of backgrounds (creative writers, digital artists, media theorists, linguists, and programmers, etc.) have been able to rapidly achieve facility with the RiTa components and thus move quickly onto their own creative language projects. As RiTa is designed to support integration with the "processing" environment for arts-oriented programming,[41] students have immediate access to a large community of practicing digital artists and can easily augment RiTa's functionality via the vast collection of libraries available.
>
> RiTa was designed with several practical goals in mind, specifically: a) to implement an end-to-end tools set for use across a variety of digital literature courses and workshops, b) to make available (both to students and practicing writers) new procedural techniques to enhance writerly creativity, c) to enable the development of resources to increase

> productivity across typical writing tasks d) to accommodate users with a wide range of backgrounds and levels of technical expertise, and e) to spur the creation of new literary forms. Further, we hoped that these tools would be applicable for users working in a variety of disciplines, not only within creative writing workshops, our focus here. Other potentially viable areas include general language education (English, ESL, etc.), natural language generation tasks, and even computer-augmented literary criticism. High-level design goals for the software included enabling a) experimentation with generative language systems without the large structural and cognitive overhead typical of such systems, b) simple distribution and sharing of prototypes, projects, and code via the web, c) the creation of new literary and artistic forms augmented by computational practices, and d) new insights into design principles for researchers interested in providing creativity support tools for work in natural language.[42]

It is clear that such a toolkit can become central to new forms of language production from a series of different disciplinary perspectives.

Augmenting transdisciplinary realms: future goals

Currently, "research" is valued and verified via multiple mechanisms and approaches within different disciplines. Many disciplines, instead of branching out, are narrowing in. How can we begin to build new modes of communication across disciplinary boundaries? Can we create new transdisciplinary "peer review" committees? Can such a varied group uphold appropriate standards of quality in terms of research and thus be respected across research domains? Tenure cases that are being judged in relation to research that spans a multiplicity of fields can also prove to be problematic. How can complex dossiers be evaluated and experimental forms of inquiry be nurtured and rewarded instead of "discouraged" within academic hierarchies? At the

University of California, Los Angeles, specific ad hoc committees have been named to help address this situation, yet I do not believe this approach has been universally undertaken.

Can we develop new funding bodies—governmental, institutional, and academic—that reward research that is transdisciplinary in nature. Duke has special “Incubator Awards” for just this reason. Can we return to long-term, humanistic research initiatives as opposed to short-term, economically driven research? Can we support mechanisms that “chip away” at extremely difficult problem sets via the funding of the development of new tools and technologies as well as the development of new approaches to the organization and access of information via these tools.

Conclusion

What are the overarching functions that our micro-processes fall into? These are systems that can facilitate the following: data acquisition; data storage; flexible data categorization; data visualization, sonification and physicalization (haptics); new data search methodologies; data mining; relevant data neighboring methodologies (juxtaposition and comparative analysis); data reduction; physical/digital environment bi-directional relationality; algorithmic construction potentials; the potential to bring multiple systems together in a relevant, layered manner; and linguistic framing (the formation of “bridging language” and “boundary objects,” the development of shared definitions and the articulation of shared concepts). In conjunction with such technological functions, micro-processes extend the ability to associate — to read and make inferences, deductions, and abductions from such environments; to converse in a local and distributed manner about such processes in an ongoing dynamic manner; to embody and posit ongoing articulations; and, finally, to present clear distillations of the knowledge production and “artifacts” that are arising out of such environments.

Many micro-processes, both human and computational, can be used to enable the various potentials of transdisciplinary knowledge production. It is obvious that authored computer

applications with a range of specific functionalities hold great potential in augmenting knowledge development. As we author these tool systems, the potential for generating media spaces that enable teams to explore different computational functionalities, as driven by the specificity of particular problem sets in a modular *combinatoric* manner, becomes central. These flexible environments will enable micro-strategies to be focused toward solving particular transdisciplinary tasks, in part by employing and generating texts in new ways. The open-source nature of the software means that additional code can be authored to explore specialized text-oriented functionalities and meta-functionalities. I imagine such hybrid tools to be of great benefit to contemporary knowledge production as well as for the interdisciplinary and transdisciplinary research of the future.

[1] For some different initial approaches to transdisciplinarity, see: Basarab Nicolescu, *Manifesto of Transdisciplinarity* trans. Karen-Claire Voss (New York: SUNY P, 2002); Christian Pohl and Gertrude Hirsch Hadorn, *Principles for Designing Transdisciplinary Research, Proposed by the Swiss Academies of Arts and*

Sciences (München: oekom Verlag, 2007); Myrtha Welti et al., eds., *Transdisciplinarity: Joint Problem Solving among Science, Technology, and Society. An Effective Way for Managing Complexity* (Basel: Birkhäuser, 2001).

[2] I would like to give special thanks to my collaborator, Daniel C. Howe, in part for the inspiration that led to this paper, arising out of our ongoing discussions, as well as for his feedback on the paper itself, and to my ongoing "transdisciplinary" collaboration with Otto Rössler. I would also like to thank Hans Van Miegroet for his vision and energy in bringing the Visual Studies Initiative to fruition at Duke and for his ongoing support of my research as part of the initiative.

[3] Geoffry C. Bowker and Susan Leigh Star, *Sorting Things Out: Classification and Its Consequences* (Cambridge: MIT Press, 1999) 15.

[4] Joseph Kosuth in his 1969 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." See Joseph Kosuth, *Art after Philosophy and After: Collected Writings* (Cambridge: MIT Press, 1991) page 18

[5] WHEELWRIGHT, P. 1968. *Heraclitus.* 2nd edn. New York: Atheneum.

[6] How Stuff Works website — http://electronics.howstuffworks.com/lcd.htm

[7] http://electronics.howstuffworks.com/lcd2.htm

[8] "persistence of vision." Encyclopædia Britannica. 2009. Encyclopædia Britannica Online. 16 Feb. 2009 <http://www.britannica.com/EBchecked/topic/452891/persistence-of-vision>.

[9] http://www.press.uchicago.edu/Misc/Chicago/321487.html

[10] http://natureniche.tripod.com/ology.html

[11] Sciences of the Interface website - http://193.197.168.165/symposium/

[12] Email conversation with Seaman

[13] I have written at length in the past about the potentials of *recombinant poetics*, exploring the biological metaphor of recombinant DNA via many different kinds of media-element combinatoric strategies**.** A condensed discussion of recombinant poetics can be found in Victoria Vesna, ed. *The Database Aesthetic: Art in the Age of Information Overflow* **(**Minneapolis: U of Minnesota P, 2007). I have also collaborated with Daniel C. Howe in the past on *The Architecture of Association* (2008), and on a work (still in progress) entitled *The Bisociation Engine*. Both works explore the use of particular micro-strategies in the service of generative art production with Daniel functioning as programmer for the works.

[14] Otto Rössler and I are working on a new book together: *Neosentience: The Benevolence Engine*.

[15] Conversation with geneticist Philip Benfey, Duke University

[16] http://www.kdnuggets.com/gps.html

[17] http://www.dbs.informatik.uni-muenchen.de/Forschung/KDD/

[18] http://www.sigkdd.org/

[19] See *Visual Studies Initiative*, Duke University, n.d., Web, 2 Feb. 2009,<http://visualstudies.duke.edu/>.

[20] See *Duke Institute for Brain Sciences*, Duke University, n.d. Web, 2 Feb. 2009, <http://www.dibs.duke.edu/>.

[21] James M. Nyce and Paul Kahn, *From Memex to Hypertext: Vannevar Bush and the Mind's Machine* (Boston: Harcourt, 1991) page 39

[22] Frances Yates, *The Art of Memory* (Chicago: U of Chicago P, 1966).

[23] A. M. Turing, *A.M. Turing's ACE Report of 1946 and Other Papers*, vol. 10, eds. B.E. Carpenter and R. W. Doran (Cambridge/London: MIT Press, 1986) 21-124.

[24] Norbert Wiener, *Norbert Wiener: Collected Works with Commentaries* (Cambridge/London: MIT Press) 215.

[25] J.R.C. Licklider, "Man-Computer Symbiosis," *IRE Transactions on Human Factors in Electronics* HFE-1(March 1960): page 4
See also <http://groups.csail.mit.edu/medg/people/psz/Licklider.html>

[26] Licklider page 5

[27] See W. Frawley, G. Piatetsky-Shapiro and C. Matheus, "Knowledge Discovery in Databases: An Overview" *AI Magazine* Fall 1992: 213-228, print; and D. Hand, *Principles of Data Mining* (Cambridge: MIT Press, 2001).
[28] N.Katherine Hayles, *How We Became Posthuman: Virtual Bodies in Cyberspace, Literature, and Infomatics* (Chicago: U of Chicago P, 1999). See entire chapter entitled "Contesting for a Body of Information: The Macy Conferences on Cybernetics: page 50-58 .
[29] I will be team teaching with Hayles at Duke beginning in the fall of 2009.
[30] The book, *Biologically Inspired Intelligent Robots*, by Bar-Cohen and Breazeal is an interesting example of applied biomimetics across a series of fields. See Yoseph Bar-Cohen and Cynthia L. Breazeal, *Biologically Inspired Intelligent Robots* (Bellingham: SPIE, 2003).
[31] See Frances A.Yates, *The Art of Memory* (Chicago: U of Chicago P, 1966).
[32] *The Polysensing Environment* research I have undertaken with Ingrid Verbauwhede (and later, Mark Hansen) is an example of seeking to explore sensing potentials. See Bill Seaman and Ingrid Verbauwhede, "Poly-Sensing Environment: Toward the Development of an Integrated Distributed Technology Exploring Poetic/Informational Grammars of Attention and Functionality," *La fondation Daniel Langlois*, LfDL, n.d., Web 3 Feb. 2009, <http://www.fondation-langlois.org/html/e/page.php?NumPage=49>.
[33] For an example of a self-organizing associational system, see the artwork by George Legrady entitled *Pockets Full of Memories* at *George Legrady Studio*, University of California Santa Barbara, n.d., Web. 3 Feb. 2009, <http://www.georgelegrady.com/>.
[34] I have collaborated with Otto Rössler for the past seven years and have been collecting research papers and URLs of relevant researchers and other artists working in this domain. I have also been in discussion with Peter Cariani, Jon Bird (University of Sussex), and others.
[35] Citation for Huhtamo from conversation with Seaman
[36] My Ph.D. thesis, entitled "Recombinant Poetics: Emergent Meaning as Examined and Explored within a Specific Generative Virtual Environment," University of Wales, 1999, articulates in depth the potentials of such a work.
[37] See the Cobalt open-source browser at *Cobalt*, n.d., Web, 3 Feb. 2009, < http://www.duke.edu/~julian/Cobalt/Home.html>.
[38] For more information about Croquet, see *The Croquet Consortium*, n.d., Web, 3 Feb. 2009, <http://opencroquet.org/index.php/Main_Page>.
[39] I was formerly chair of this program at RISD and partial funding midwife to this class, which became highly articulated by Howe)
[40] See Christiane Fellbaum, ed., *WordNet. An Electronic Lexical Database (*Cambridge,: MIT Press, 1998).
[41] Casey Reas and Ben Fry, *Processing: A Programming Handbook for Visual Designers and Artists*, (Cambridge, MA: MIT Press, 2007). See also http://processing.org/
[42] Howe, Daniel C. and Soderman, Anton B. (2009). The Aesthetics of Generative Literature: Lessons from a Digital Writing Workshop. Leonardo Journal: Cambridge, MA: MIT Press. (forthcoming)