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Combinatoric Micro-Strategies for Emergent Transdisciplinary Education

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.

Micro-strategies

There are many *micro-strategies* (see glossary) that can be drawn upon in the service of enabling new forms of transdisciplinary research.[5] A

micro-strategy is a focused algorithmic process that is employed to facilitate a chosen goal-directed activity. The computer is an open system, and code can be authored to enable work on many different kinds of tasks. The *potential* (see glossary) is to design systems that bring multiple micro-strategies together in authored media environments to facilitate tasks that have many different interoperative components, thus facilitating many different kinds of computational functionality through various *combinatoric means* (see glossary). 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* (see glossary), and ongoing human commitment to understanding 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 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

generative approach to new forms of education and research relevant to many different projects and areas of inquiry.

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.[6] 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 of many varieties. In transdisciplinary research there are often many highly complex areas of data *relationality* (see glossary) 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[7], 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* (see glossary). 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.

Meta-meaning systems

Meta-meaning systems (see glossary) 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* (see glossary) produced through interaction, *neighbouring* (see glossary)* 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.

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.[8]

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 .[9]

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.

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.

2) The examination of visual material within complex digital media—contexts that are inhabited by multiple digital media forms, such as sounds, still and time-based imagery; 3-D images; virtual space; text-as-image; 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* (see glossary); 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.

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. [10]

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 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.[11]

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."[12] 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. [13]

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 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."[14]

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."[15] 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.[16]

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."[17] [18]

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. [19]

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; the creation of new forms of human/computer — human/human interface through new "sensing" paradigms; the entertainment of complex sonifications of data; as well as the dynamic exploration of physical representations of information in a focused and interactive manner—haptic feedback systems.

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.

Systems informed and/or inspired by biomimetics

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 education.

Interfaciology

Otto Rössler, biochemist and theoretical physicist, coined the term "interfaciology." In May of 2000 a symposium took place at the ZKM (Center for Art and Media, Karlsruhe, Germany) in honour of Rössler's sixtieth birthday. Hans Diebner and Timothy Druckrey made 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.[20]

In discussing Rössler's approach to interface, a lab [au] (the collaborative laboratory for architecture and urbanism) state:

> According to Otto Rössler, the world "is not the world in which we live" but the interface through which we perceive and act, and the electronic realm induced by computation and communication technologies are not "the world of data and information" in which we are brought to life because the real

> world "doesn't function anymore," but [becomes (emphasis added by Seaman)] the interface to a set of symbolic and expressive "processes."[21]

We seek to extend such an approach to interfaciology in an emergent manner under the rubric of the Visual Studies Initiative, exploring interface potentials from a transdisciplinary and, in part, biologically inspired perspective.

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—images, sound, text, 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. 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.[22] I am interested in how multi-modal machinic sensing can inform a dynamic new interface paradigm.[23] 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 give. 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 means
• 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 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* (see glossary).

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.[24]

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 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 an individual's authorship
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 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 dynamic, interactive on-line interface.[25]

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. 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.[26]

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," "centre 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* (see glossary), 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. [27]

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. 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. We are currently on the cusp of funding the above project, although the original *World Generator* artwork is alive and well, pointing to future potentials.

Other tool building

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.[28]
>
> 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.[29]

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

Additional tool kits and potentials

I have been working with 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,[30] 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 [31]). 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,[32] 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.[33]

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 education, not to mention education in general. It is obvious that computer and authored programs 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* (see glossary) manner, becomes central. These flexible environments will enable micro-strategies to be focused toward solving particular transdisciplinary tasks. The open-source nature of the software means that additional code can be authored for more specialized functionalities. I imagine such hybrid tools to be of great benefit to contemporary arts education as well as for the interdisciplinary and transdisciplinary research of the future.

Glossary of Terms

abductive logic

"[abductive logic] makes its observations without reference to any previously propounded question, but, on the contrary, itself starts a question, or problematically propounded hypothesis, to explain a surprising observation."[34]

non-two value logic

"There are three-valued systems that operate with true, false and possible/indeterminate. There are systems that use more than three values. And there is a large branch of logic (modal logic) that deals not with simple propositional assertions, but with concepts like possible, impossible, contingent, necessary and absurd."[35]

combinatorics

Our generative methodology explores *combinatorics*. A system can be designed to combine and recombine media materials in differing ways and in different combinations as an ongoing generative process. This generation of differing "configurations" might be brought about within differing kinds of environments including virtual environments, augmented reality environments, interactive video environments, interactive text environments, interactive sound environments, and/or some form of mixed digital space, enabling the generation of configurations of many different kids of media elements and processes.

computational processes

Computational processes are computer-based processes that are enabled via specifically authored computer code.

fields of meaning

One way of coming to understand combinatoric systems that bring different media elements into juxtaposition and/or superimposition is to explore the metaphor of *fields of meaning* as borrowed from physics. This new approach to meaning production bears relation to notions of gestalt. That is, a 3-D object might have one meaning, and an image another, and the sonic background that the work is being created in forms another dynamic relation that feeds into the reception of the work. Each media element brings a different meaning force to the equation. Each participant brings the field of his/her own historical relations to different patterns of media experience, and there is an ongoing relational "meaning-summing" that takes into account the different meaning vectors that each media element brings to evocation in a given work.

focus on process instead of final result

Generative works focus on *process-oriented* activities, requiring attention to the potentials of interface, programming, media variables, and mode of output to enable specific kinds of variable processes to bring about new fields of media configurations.

interface design: input + functionality = output

A tight structural coupling exists between the behavior of the participant who is generating particular input into the system (through one form or another of *interface* device), the functionality of the system, and the output of that system. I have used a formula in the past consisting of the following: input + functionality = output. Each variable is comprised of two different levels: a conceptual one and a physical one. It is difficult to say where one

boundary or another occurs once the system is made operational and human interaction takes place. It is better to think of this as a holistic system, functioning in a continuum, where an ongoing process of change is being explored.

Thus, a central characteristic of generative works is change over time. New media spaces (like virtual worlds) are generated in an ongoing manner as a result of the micro-processes that are set in motion. This promotes a shift in terms of traditional art historical concerns away from the static work of art to one that explores what I call active meaning-becoming. In a generative interactive work, the meaning-becoming is potentially a more overtly participatory process and is heightened as an operative consequence of interaction.

interauthorship: layers of authorship potential

I coined the term *interauthorship* to point at the potentials of some forms of generative work. The artist/programmer "authors" a particular environment that merges interface, software, hardware, input, functionality, and output within a system that produces limitless unique outcomes. The user of the system adds an individual layer of his/her own "authorship," exploring the operative potentiality of the system. A unique emergent outcome arises through their particular interaction.

locationality

New media, especially after the advent of GPS (Global Positioning Systems), can be tied to determining exact locations; thus one can tie digital information to geographical specificity (like the maps in cars). LPS (Local

Positioning Systems) enable very precise digital/physical relationality to be explored at the scale of an individual room.

meta-meaning potentials

In certain of my works, I have been interested in how a generative work can enable one to observe meaning as it arises and changes via participant interaction with the system. Since one can operate on these generative works, bringing in different media elements and processes over time and distributed in space, one can also mindfully witness meaning production as it takes place.

meta-tags

Meta-tags are key-word designators that enable the computer to sort particular media elements.

media object

Any form of media file (or data), be it text, video, image, animation, output of a scientific imaging system, sound, or other digital form.

micro-strategies / micro-processes

A *micro-strategy* is a focused algorithmic process that is being employed to facilitate a chosen goal-directed activity. 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 functionalities through focused interaction.

operative Space — Media and More

Ada Lovelace [England 1815-1852], the first computer programmer, wrote in the 19th century about the *"operative" potentials* related to differing media that the computer might bring about, in her *Notes to The Analytical Engine*. Generative systems can enable the operative manipulation of all forms of digital media in the service of emergent production.

potentiality/potentials

A generative system enables a "probability" of certain kinds of outcome based on differing combinations of micro-strategies that are employed. These *potentials* are based on the programmer's selection of algorithms (or micro-processes) that become operative in a media environment, and the choices of the participant who is interacting with the code-authored constrains intrinsic to that environment. Each combinatorial strategy or set of strategies may have a different outcome. Instead of talking about a fixed outcome, one talks about an outcome potential derived through interactivity with the system.

recombinant poetics

I have written at length in the past about the potentials of *recombinant poetics*, exploring the biological metaphor of recombinant DNA. This points to the "living" nature of media, as it pertains to new properties of meaning production brought about through digital combinatoric processes.

relationality and neighbouring

In *Semiotics of Visual Language*, Saint-Martin speaks about the relevance of *neighbouring*, which is central to the production of meaning in a virtual environment. Neighbouring brings about media *relationality* between differing media elements:

> 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[36] 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."[37]

Thus, Bachelard also points toward neighbouring as being central to an enlarged understanding of topological space. Relational media presents the potential to explore specific "intelligent" juxtapositions that the system can facilitate, potentially leading to new insights.

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[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] 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.

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

[7] Conversation with geneticist Philip Benfey, Duke University

[*] See *relationality and neighbouring*

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

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

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

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

[12] 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.

[*] Defined below. See "Contemporary memory theatres"

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

[14] 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>

[15] Licklider page 5

[16] 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).

[17] 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 .

[18] I will be team teaching with Hayles at Duke beginning in the fall of 2009.

[19] 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).

[20] From Diebner and Druckrey's introduction to the symposium at the Sciences of the Interface Web site. See *Sciences of the Interface*, 15 Mar. 2001, Web, <http://193.197.168.165/symposium/>.

[21] *Otto* Rössler quoted in Hans Diebner and Timothy Druckrey, "connective inter.face—archite[x]tures,"*spark-online* 31.0 April 2002: n.p., Web. 3 Feb. 2009, < http://www.spark-online.com/issue31/lab.html>.

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

[23] *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>.

[24] 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/>.

[25] 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.
[26] Citation for Huhtamo from conversation with Seaman
[27] 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.
[28] See the Cobalt open-source browser at *Cobalt*, n.d., Web, 3 Feb. 2009, < http://www.duke.edu/~julian/Cobalt/Home.html>.
[29] For more information about Croquet, see *The Croquet Consortium*, n.d., Web, 3 Feb. 2009, <http://opencroquet.org/index.php/Main_Page>.
[30] I was formerly chair of this program at RISD and partial funding midwife to this class, which became highly articulated by Howe)
[31] See Christiane Fellbaum, ed., *WordNet. An Electronic Lexical Database (*Cambridge,: MIT Press, 1998).
[32] Casey Reas and Ben Fry, *Processing: A Programming Handbook for Visual Designers and Artists*, (Cambridge, MA: MIT Press, 2007). See also http://processing.org/
[33] 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)
[34] Charles Sanders Peirce (1902) Application for support for his logic (1902)
from Memoir 19, Draft E: *On Arguments as presented at* <http://carbon.cudenver.edu/~mryder/mem19.html>, Feb. 19, 2009
[35]< http://www.textetc.com/theory/truth-in-logic.html>,
C. John Holcombe 2007, Feb. 19, 2009
[36] See Bachelard, G. 1951, *L'Activité Rationaliste de la Physique Contemporaine*. Paris: Presses Universitaires de France, P.6.

[37] Saint-Martin, F. 1990. *Semiotics of Visual Language*. Bloomington/London: Indiana University Press. P.69.