Self-Willed: Flux and Reaction in Systems, Organisms and Materials

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Abstract

Working with a new material inverts the usual design process: the research begins by determining the possibilities inherent in the material, not a preconceived final form. In this reversed strategy function now follows form and form is determined by behavior. As such, the process becomes founded in potentialities. Foregrounding behaviors in reactive materials, systems and organisms is an innovative starting point that can articulate new processes of creative making: design emerges from interactions among force, energy and matter. How do the unique struggles of surrendering authorial control by working with self-willed materials lead to creative advantages and deeper meaning?

Structured as a "Powers of Ten", five creative practices are presented zooming out from the chemical to the cellular, followed by the animal, the human, and the ecosystem. This expanding perspective offers dimensionality in recognizing the creative struggle and transcendence of working with matter that won't sit still. Each project focuses on the non-binary, self-determined moments of life in their chosen materials, when the spark of energies change properties in a messy but meaningful flux. Each member articulates a next scalar relationship to the previous as an example of material potentialities determining outcome within their selected strata. Collectively, they represent how new material behaviors and repercussions create unique opportunities in artistic expression.

Keywords

New Materials, Reactive, Bio Art, Sculpture, Eco Art, Synthetic Biology, Data

Introduction

While much interest in the 'new materialism' is in the forms and applications now possible with emerging resources enhanced through technology, a subset of artists is investigating the moments of transition within them. Material flux, the shift of properties due to natural force, is inherent in our entire physical world and provides rich insight into understanding our environment.

The paper represents five strata in studies of material flux. These creative practitioners are less concerned with the sculpture on the pedestal but instead the hardening of the clay. In each project, it is the behavior of the materials that becomes the core property of the artwork: the behavior of crude chemicals joining, the behavior of wind in Antarctica, the behavior of blood burning.

The energy, change, chance and kinesis in their respective materials are paradoxically both pre-digital and post-digital. Reactions are not binary, they are triggered and result in materials becoming alive, self-determined. This flux-as-life is the artistic impetus in each of these five practices: the chemical mediated, the cellular transformed, the animal augmented, the human hacked, the environment interpreted

Thus, the paper is constructed as the synthesis of an argument ranging from the inorganic to the organic, from the microscopic to the global and from the reaction to the systemic. The dialogue spans across arts education with Tobias Klein showcasing student involvement in the mediation of chemically reactive smart materials as part of the Skunkworks lab and the recording and choreographing of environmental data in the Extreme Environments program presented by Scott Hessels.

Yet, the global scale of the argument surrounding the flux of materials, systems and organisms draws from the mavericks and the most experimental. Dr. Howard Boland's work at the cellular level demonstrates the creation of biological functions not present in nature. Animals as materials will be presented through the use of soft robotics in a colony of mole-rats in the research of Dr. Julie Freeman. The conversation culminates in questioning the relation between all of the panellists topics and their relation to the construct of the human and the human body with its transformational properties, discussed by Jaden J. A. Hastings.

The Chemical: Skunkworks

Skunkworks is a term derived from Lockheed Martin's Advanced Development Program in their revolutionary research environment. The name originally stems from the popular comic strip Li'l Abner in which a moonshine brewery operation was located outside the town of Dogpatch producing malodorous smells by seemingly randomly mixing abstruse ingredients. In Lockheed's case, the infamous smell at the secret laboratories were the result of close proximity to a nearby plastic factory. While anecdotal on the one hand, the project revolutionary research concept of Lockheed's Skunkworks - to give a high degree of autonomy of small groups with the task of working on advanced or secret projects, is the strategy behind the educational experiment in reversing a current trend of designing through simulation and information modelling. Instead, similar to Li'l Abner's seemingly random moonshine distillery, Skunkworks is a project-based approach in designing through material characterized by trial, error, observation, material deduction, resulting in a behaviour design with and through materials. Instead of materials being selected at the moment of fabrication, we are articulating design through iterative material experiments and documentation.

This seeming madness of students working with chemical reactions as the basis of design - an approach of observation and resulting notional control over reactive materiality as environmental and design vector – is juxtaposed by precise and highly controlled digital design workflows such as additive and subtractive manufacturing. Embedded into the design process, Computer Numeric Control (CNC) precision reacts and is adjusted to the flux condition or smart reactive materiality and their highly volatile and non-repeatability. In short, how can working with an uncontrollable – yet influenceable chemical reaction be combined with a highly controlled digital design tools in the form of Computer Aided Design (CAD) and Manufacturing (CAM)? This dialectic pairing between analogue and digital tools, methods and materiality or the lack of, forms new narratives and design processes, leading to innovation of the resulting form, yet as well the design with and through reactivity itself.

In detail, this platform allowed the investigation of materials that react to environmental and shifts in light, temperature, noise, moisture, pollutants. The setup in this material-based design is by nature entropic, unique and resulting changes of color, form or structure, transforming energy from an environmental input into a design language challenges modern fabrication and understanding of standardisation, repetition and optimization. Instead, smart materials and their reactions can become a new form of reactive display design. This emerging media shifts from the independent to the integrated and yield opportunity for a new media art, free from the screen, yet still able to convey information, narrative and aesthetics.

This combination of material based working and digital design emphasizes the dual approach in the workshop as a design methodology situated between testing, exploring documenting and simulating. As such, the work with environmental reactive materials in addition to CAD and CAM acts as a catalyst and testing ground for a design new practice where the uncontrollable reaction is a design process and not result.

The ingredients are 60 highly motivated undergraduate students, two excited educators, over 120 reactive chemical components, innumerable existing and makeshift tools, the proximity to Shenzhen with an incredible affordable additive and subtractive manufacturing industry, 1 computer lab including high resolution 3D scanning devices, 1 makeshift laboratory with only two fire and smoke detectors. The result is a plethora of new concepts and working prototypes where narration, shape, form, behavior, kinesis, surface, patina, tool marks are amalgamated to a reciprocal dialogue between digital precision and conditional reaction.

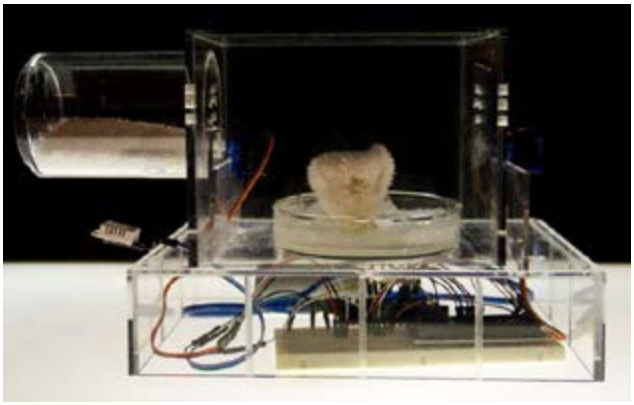

Fig.1 From Skunkworks, student work by Chan, Hin Chung, 2018 a self-regulating crystal growing incubator reacting to humidity to optimize the fragile growth of Urea crystals. © The School of Creative Media, City University of Hong Kong

The Cellular: Synthetic Biology

Synthetic biology aims to design new biological functions and systems not found in nature. While much of these investigation deal with molecular and genetic components, it also involves creating hybrid and pseudo living systems that can made to perform novel biological functions (or unintended by nature). An example of this is shown in Figure 2.

Fig. 2 *Artwork*, 2018, C-LAB, Magnetotactic Bacteria create real-time images, © CLAB

The nature of such materials (e.g. cells, genes and proteins) are intangible in scale, complex in function and sensitive in handling yet their capacity to transform is powerful. Traditionally, it has been difficult to approach material and knowledge needed, but an increasing number of artists are now able to access laboratories and work in this capacity. How then can artists assimilate plastic affordance of the biosciences in art production and what critical issues are at stake? What interfaces can be built to help broker an understanding of 'life' in non-human systems? What physical and biological interfaces can be devised to enable access to this knowledge?

The Animal: Rodent Activity Transmissions

Rodent Activity Transmission (RAT) systems is a collaborative multi-disciplinary project which uses longitudinal real-time data to examine the lives a colony of naked mole-rats *(Heterocephalus glaber).* At the same time as the electronic tracking and data collection system forms the basis for generating deeper understanding about this unique eusocial mammals' behavior, it also forms the core material for development of digital artworks including visualizations, an abstract animated soundscape, and a series of kinetic forms.

The collection and distribution of data in enables the use of animal behaviour as a real-time dynamic art material. 'This is Nature Now' (TINN) draws on empathic reaction to abstract forms (Heider and Simmel, 1944) to produce a `dynamic-passive' (Candy and Edmonds, 2002) `data sculpture' (Vande Moere and Patel, 2009) consisting of set of real-time biological data-informed soft robotic objects. An example of this is shown in Figure 3.

In TINN, real-time transference of animal activity into dynamic motion in the sculptures raises questions of self-will within the work. The artist designs and establishes a system with hardware and software parameters, according to her artistic intention, yet the rhythms and gestural patterns exhibited in the works are 'driven' by the animals. Additional subtlety in the movements are affected by a number of actors 'internal' to the system: the format of the animal data; the algorithms used to map the data to the hardware; the inherent properties of the silicon material; and the tolerances of the custom-designed pneumatic control system. Due to the unpredictability of the animals and these internal actors, the artist cannot predict the final performance. It could be that this compelling unpredictability provides the *challenge* and the *desire* to create work, placing a demand on the artist to relinquish a certain amount of authorship of the final piece. The *challenge* comes from the ultimate lack of control over the end result, and the addition of uncertainty in the work. The *desire* originates from the thrill of the risk, of the possibility of discovery, perhaps of some 'other' aesthetic or meaning emerging from the known unknown.

The artist refers to the soft robotic gesturing in TINN as a 'body language of objects'. The research-led work attempts to simulate liveness and natural motion through electro-mechanical means to create dynamic data-driven forms with zoomorphic qualities - the quality of self-will.

Fig.3 This is Nature Now 2017 by Julie Freeman, © Julie Freeman

The Human: Xenopoietic Forms

Xenopoiesis is the experimentalisation of an iterative process of "strange-making", whereby material that would once have comprised part of one object undergoes a process of transformation into another, and with it a shift from familiarity toward alienation. When framed within the context of artwork that concerns itself with the bioengineered body, and utilises self-experimentation, unpacking self-hood becomes particularly problematic. The act of separation from the body by medical procedure forces the artist's biomaterial into a liminal state of transition from functional tissue into foreign object. This liminal state is revealed not only in how one refers to the tissue that is excised, let alone transformed, but reflected in both the ethical and legal ambiguity surrounding its ownership status (Skene, 2002; Björkman and Hansson, 2006)

Through a series of artistic experiments—generating 'inert' materials such as glass, pigment, and glaze, as well as a biobank of cryogenically stored cell lines generated from tissue extracted from the artists' body—this troubled state of human biomaterial is revealed through its disembodiment, not for the sake of biomedical utility, but rather toward artistic research (see Figure 4). Traditional classification of human tissue insists upon a duality of living or non-living, yet the material produced in this project appears to exist in myriad states of vitality. Catts and Zurr have long been proponents of recognising a state of 'semi-living', or those entities that sit at the "fuzzy border between the

living/nonliving, grown/constructed, born/manufactured, and object/subject" (Catts and Zurr, 2007). This recognition of both the liminal, as well as dependent state, of cultured human tissue is particularly germane to those cell lines kept in a state of either stasis (cryogenically frozen) or expansion (cell culture). Yet, it is also incomplete to describe that material which is in an 'inert' state as non-living, particularly if we accept the challenge of vital materialism. As Bennett asserts, by accepting the premise that all matter is, in some manner, lively, then all bodies are elevated, and "not only is the difference between subjects and objects minimized, but the status of shared materiality of all things is elevated." (Bennett, 2009).

That this transformed material will continue to manifest into new forms, new bodies (artworks), in an unpredictable, generative manner. Moreover, by creating works of art utilizing the artist's biomaterial, not only archiving one's corporeal being, but also capturing a piece of its natural history, the biological trace of this (the artist's) body intra-acting with its environs to construct its form (an assemblage). The outcome, therefore, of this research does not necessarily reside solely within the resultant artwork, but rather the myriad complexities and uncertainties latent within the development of novel techniques, as well as a body of work, that is fixed upon the artists' own (human) tissue as a creative medium.

Fig.4 *Carbon Black (Blood)* 2017 Jaden J. A. Hastings, © Jaden J. A. Hastings

The Ecosystem: Extreme Environments

Field station research locations offer scientists isolation and immersion for more untainted statistical analysis of climate change and environmental damage. Hong Kong's Extreme Environments program provides art and design students access to these difficult, scientific research sites to partner with expert scientific researchers who share their approaches and tools. Exposure to the most current sophisticated sensor and locative technologies allows the students to measure delicate eco-balances and to produce meaningful data that is inextricably linked to the natural features of the sites. To date, the program has worked with leading climate scientists in four distinct ecosystems: the Mojave Desert, Antarctica, a recently-discovered cave network in central Vietnam, and in two sites in the Coral Triangle: underwater in Sipidan, Malaysia and on disappearing atolls in the Solomon Islands.

Each site has been radically destabilized through climate change and yet the message is still muted in public discourse. Students leverage scientific technologies to find new, innovative ways to give meaning to the onsite findings of science. The immaterial is made material through computational and procedural programming, 3D printing possibilities, screen and projection technologies, robotics, interaction design, kinetic sculpture and more.

The program's first rule is that the artwork cannot exist without direct input from nature. This emphasis on natural energy and force often creates dramatic redirection both on-site and later in the artworks' development. In nearly every student project, a moment has occurred in which the site would not reveal its secrets, e.g. wind studies planned but no wind, currents that would shift out of reach, phenomenon that would appear and then disappear. The loss of authorial control became the critical issue in the in design of the artwork, the dialogue with site was complex, muted, unapproachable, shifting, or a host of other *communication* issues. It is precisely this difficulty of engagement that adds depth of meaning to the works. Flux is surprising and dynamic, just like a real conversation.

The capture and presentation of natural forces being dangerously altered in the Anthropocene provides an unprecedented opportunity to expand our understanding of the feedback loop of a natural environment increasingly informed and shaped by human presence. By creating physical models of scientific research, but accepting the expressive and experiential edge provided by direct presence, the projects demonstrate more than just nature but our complex relationship with it. An example of students working in the field is shown in Figure 5.

Fig.5 *Extreme Environments Antarctica,* 2018 Art students collecting pollutant data, © School of Creative Media, City University

Conclusion

In each project, irrespective of the scale, distinct creative advantages were perceived and realized by releasing authorial control to materials that are self-willed. The unique struggles connected with its unpredictability are perceived as the interesting point of entry, the hook that

pulls each artist in. From there, however, no single aesthetic from this type of practice emerges, as evidenced by the wide range of both the student and profession creative work being realized. Instead, the flux inherent in the materials enabled an extra layering of meaning because the non-human animal, human physiology, chemical and biological worlds, and natural environment all have a great deal to give. Each artist recognized the flux as 'The Other', letting it in, creating a dialogue, and valuing it, whether through authorship, physical behaviour or conceptual meaning.

In response to today's changed understanding of media, matter and materials, this panels sets out to articulate a new multi-scalar and multi-dimensional response to the new challenges and opportunities found in the extension of Art to Art and Science.

Each panellist is working within specific reactive environments, from the microscopic inorganic to the global systemic. Each environment possesses specific design impulses, vectors and resulting material behaviours. Each environment sits at a different scale, yet each is a system that can be interfered with, manipulated and ultimately changed.

The role of the artist has ultimately changed from creator/craftsman to conductor in an interplay of environment, orchestrated material behaviours and entropic systemic processes that shape the resulting art and design. Thus, Art and design has ultimately become unbound from the cumbersome anticipation of the artist as genius in a self-fulfilling prophecy of narratives.

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Authors Biographies

Dr. Howard Boland is a multidisciplinary practitioner working across art, science and technology. With a strong technical and innovative creative skills, his experience spans from artistic and scientific research contexts to leading projects and teams in the interactive industry. He is artistic director of the art-science organisation c-lab specialising in biological art. His PhD combined synthetic biology and art to produce novel visual expressions in bacteria culminating in the UK's first art exhibition featuring living genetically modified microorganisms at the Royal Institute of Great Britain. He has an extensive experience in the digital creative industry leading creative and technical teams to award-winning projects.

Dr. Julie Freeman translates complex processes and data from natural sources into kinetic sculptures, physical objects, images, sound compositions and animations. Her work explores the relationship between science and the natural world; questioning the use of technology in how we translate nature. A mix of computer scientist and artist, her focus is the investigation of data as an art material, using it to create work which reflects the human condition through the analysis and representation of live animal data. She often works collaboratively and experimentally with scientists. She is co-founder of Fine Acts which bridges human rights and art to instigate social change. She co-leads the Data as Culture art program at the Open Data Institute, is a TED senior fellow and a Nesta fellow.

Jaden J. A. Hastings' research hybridizes the fields of biology (tissue engineering, genomics), informatics (machine learning), and New Media arts practice. She is an alumna of New York University, Harvard University, and the University of Oxford with advanced degrees in both Biology and Bioinformatics. Presently, she is a PhD candidate at the University of Melbourne in Interdisciplinary Arts Practice on an Endeavour IPRS/APA scholarship. She is also Chief Scientist of the x0.lab research group and Artist-in-Residence within the Biofabrication Lab of St. Vincent's Hospital in Melbourne.

Scott Hessels is an American filmmaker, sculptor and media artist based in Hong Kong. His artworks span different media including film, video, online, music, broadcast, print, kinetic sculpture, and performance. His films have shown internationally and his new media installations have been presented in museum exhibitions focusing on technology as well as those presenting fine arts. His recognitions include patents for developed technologies, references in books and periodicals on new media art, and coverage in cultural media. He is currently an associate professor at The School of Creative Media and executive producer of the Extreme Environments Program which organizes art/science expeditions to environmentally significant sites.

Tobias Klein works in the fields of Architecture, Art, Design and interactive Media Installation. His work generates a syncretism of contemporary CAD/CAM technologies with site and culturally specific design narratives, intuitive non-linear design processes, and historical cultural references. Before joining City University Hong Kong in the role as interdisciplinary Assistant Professor in the School of Creative Media and the architectural department, he was employed at the Architectural Association and the Royal College of Art. The resulting works of his studio are exhibited international with examples being in the permanent collection of the Antwerp Fashion Museum, the London Science Museum, the V&A, the Bellevue Arts Museum, Museum of Moscow and Vancouver.