Agents of Risk
embedding resistance in architectural production

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Abstract

In its most common usage, the term *fabrication* calls to mind industry and production. For architecture, *fabrication* and industry have been defining aspects of modern practice. While dependant on the dimensional and temporal standards of industry, modernists were preoccupied with the limitations imposed by the generic restrictions of mass production.

When we make, instead of predetermining action, we discover a map of engagement. We play by challenging and resisting material. It in turn, reveals an intentional resistance that provokes yet another challenge, and on and on and on. In fact, craft excels in the less-than-ideal situations. When challenged by aberrant materials, geometry and craft are forced into innovative discovery: a knot of reaction wood within an otherwise homogeneous surface would force a novel adaptation of geometry generated by the imperfection.

How, then, do we integrate the indeterminate cycle of craft and invention into a design process transformed by tools entirely reliant on prediction and the (virtual and real) homogeneity of materials? Is it reasonable to introduce an element of risk into the realm of digital fabrication equivalent to the auto-generative sabotage of Signwave's *Auto Illustrator*? This paper reflects on the nature of material craft in the realm of digital fabrication. It will look both at the history and the contemporary opportunity of generative art and automata and their subversive (yet essential) relationship to the making of architecture.

Resistance and Risk

1. Material Craft and New Technology

Today we seem to be at an interesting threshold. Industrial production tools, which once restricted building materials to a set of pre-defined generic components, have transformed into powerful CNC tools. This has allowed the individual designer to manufacture unique *'one-offs'* without the debilitating overhead posed by the expensive retooling of machinery, molds, and dyes. Moreover, this new ability to control and actively participate in what we make has introduced new formal possibilities of rich tectonic complexity not seen since the industrial revolution.

It seems that the formal possibilities enabled by these tools are now endless and point to a new freedom for architectural design. Beyond our imagination, new modeling techniques using software such as *Catia, Rhino, Pro-engineer,* and *MasterCAM* allow us to overcome the pragmatic hurdle of making *'difficult'* form. The new CNC technologies seem to offer a better quality of workmanship than one would expect from traditional craft. This is achieved by having total control of the outcome by predicting the shaping and assemblage of material in a virtual environment rather than the daunting risk of a construction site. Visualization techniques and software eliminate the disappointing conflict of quality expectations. As part of this, new production paradigms rely entirely on the strategy of homogenizing material. This approach contradicts the original, i.e. premodern, meaning of fabrication, i.e. production as dictated by *skilled workmanship*, or, *craft*.

David Pye, who has written extensively on traditional artisanry, suggests that difficulty and invention are inextricably linked. Pye explains that there is an important distinction to be made between the *workmanship of certainty* (as found in modern industrial production) and the *workmanship of risk* (as found in traditional craft) (Pye, 1968). Risk is an essential part of the evolution of form and ideas. In order for a body of work to evolve, at some point an artisan must risk the collapse of their work by challenging the material limits of their art.

One has to remember that there are periods in architectural history that developed remarkably complex form and space long before the invention of these new tools (whether industrial or digital) for manipulating materials and shapes. Yet if one were to compare the material command of any period other than our own, one would see not just a knowledge of material but one of action within the horizon of *logos* (language) and *dike* (fate). This is the meaning of *metis* (trope); i.e., fate can turn at any moment in the process.

Pye's description of craft suggests that there is an intentionality embedded in the resistance of the material world to action. When we make something, we engage in a playful challenge to the limits of the material. The reality is that the true generator of form was, in fact, the risk and difficulty in a material process. It is this faith in the material evolution through the consequence of craft that we lost with the advent of what we might call modern techniques.

The notion of resistance as essential to making may be taken even further. For Richard Sennett, resistance is a necessity that even the body of the craftsperson cannot do without: "*Resistance is a fundamental and necessary experience for the human body: through feeling resistance, the body is roused to take note of the world in which it lives. This is the secular version of the lesson from the garden. The body comes to life when coping with difficulty*" (Sennett 1994).

Figure 1. Intricate Difficulty: Grinling Gibbons: Lace Cravat carved out of Limewood. London, Victoria and Albert Museum

Sennett points out that the heart of our contemporary, modern ideology, the idea of freedom and resistance, has its roots in the French revolution. In the years that followed this important event, the streets of Paris were widened and cleared of all obstacles, such as trees and buildings to make way for the physical space of freedom (Sennett 1994). Paris would be driven by this agenda for years to come, as Hausmann would demonstrate. Yet liberty as defined by eliminating resistance is really only a perversion of its experience. Liberty is formed by the experience of struggle. Hence, its very existence depends on impurity, obstruction and difficulty (Sennett 1994). An artist or artisan would know this liberation as the moment of epiphany when she finally begins to command a difficult medium. As design educators, we patiently apprentice our students to reach that point through drawing and making.

Liberty, once divorced from the experience of resistance, becomes nothing but an abstract demand. While the experience of resistance is crucial to our aspirations, a culture of liberation – one bent on eliminating resistance once and for all – has a profound implication on our cultural future. In our modern cities, the body has become a passive organism that simply occupies space in the city. Our bodies are intentionally disconnected from space and time. Our cultural and civil industries are charged with the duty of providing an environment free of *'encumbrance, engagement or even effort.'* In other words, they emancipate us with the last freedom: *'freedom from resistance'* (Sennett 1994).

Even Adorno blames the current cultural crisis on the steady disintegration of materials, in this case, the syntactic materials of language and music. Materials have lost their *a priori* self-evidence (Adorno 1970). Much like the narcissism of the virtual world, our dwindling familiarity with the limits and embedded resistance of material, such a as harmonic scales and even linguistic structure, has signaled the triumph of being for other (Adorno 1970).

The current trend of *'designed'* objects presents us the product of this disintegration. Our objects have lost their edge – literally. We are being surrounded by the baby-smoothness of new consumer items like the *iMac*, that are more reminiscent of a nursery toy than utilitarian function (Kingswell 2000). Automobiles, for instance, are designed to warmly cocoon our bodies as we reach narcotic levels of speed and convenience. It is important that we remain unaware of the automobile's inherent resistance, that is, the pulverized concoction of materials they were made with and what poor souls made them at a barely sustainable wage (or, for that matter, the poor souls – who can no longer wage resist – who were displaced by robots).

Craft and Play

There is another, phenomenological, argument that challenges the equivalency of machined products with traditional craft. A skilled craft necessarily implies that body and world are co-dependant in action. That being said, it is only possible to act, and for that matter even think, when we engage the material presence that we depend on. Our being in the world is a fusion of both subject and object. Beyond this fusion,

the world predestines our actions with an embedded intentionally: "*something begins with me before I begin.*" Instead of predetermining action, we must discover a map of engagement. We must *"play by challenging and resisting"* (Becker 1999).

Play mediates the resistance of a medium whether it is language or matter. Even though one may begin an engagement with a subjective intention, it will only succeed if it provokes a reciprocal response from an *intentionality* embedded in the material. Craft depends on the extended actions that this relationship entails. When we play, we challenge the material, and it in turn reveals an intentional resistance that provokes yet another challenge, and on and on. Craft is the state of play embodied between the challenge and the resistance (Becker 1999). This state has is own material incarnation in the tool. What profoundly determines the nature of the craft is the intermediate materiality with which we use our instruments, our motor skills, or even our voices.

1. Historic use of 'auto-generative sabotage'

The phenomenological cycle of process, play, and material mediation, although generative, is hardly automatic. Invention emerges from an evolutionary cycle of mutation and resolution. Mediating this process is both tenuous and *risky.* It is perhaps here that skill goes further than just the precision of craft, rather it is dependant on the inspired intuition of the *Metis.* There is no better figure representing this mutated and chaotic strategy than the figure of *Daedalus*, the original *'technician'.*

2. The Daidalon

The story of Daedalus tells us a lot about how our culture views craft and invention. Daedalus was indeed an inventor and craftsperson, yet he was evil, scheming, manipulative, vain, and obsessively vindictive.

Classical interpretations of the myth of Daedalus clearly identify his work as architectural craft. In the dramas of Aristophanes he is identified with the verb *architectonein* (Morris 1992). By all accounts Daedalus's craft transcended the mere fashioning of materials into a form of life-giving magic (Perez-Gomez 1985). Daedalus was born with *metis*, a talent often associated with *metalsmithing*, carpentry, and weaving, that fused dexterity and magic together (Frontisi-Ducroux 1975). The scope of Daedalus's work was entirely consistent with the current interpretation of *techne* – the practice of manipulating materials through ritual and magic – as well as the origin of the words *'technology'* and *'technique'* (Frontisi-Ducroux 1975). These techniques would transform inanimate matter into something magically alive. *Daedalus' techne* would always introduce some form of *anima* (soul) into the object created. This was not simple *mimesis* or imitation of what seemed alive; rather, it is stressed in most classical sources that life itself was being made.

Daedalus was most renowned for his animated statues (Perex-Gomez 1985). Although these stone figures were similar in form to any sculpture of the day, they were imbued with the senses and kinetic abilities of humans. Prior to Daedalus, sculptures were condemned to having closed eyes or voiceless speech. Among the powers of literate speech, these statues were also gifted with *autokinesis*, the ability to move using their own means (Morris 1992). Aristotle even mentions Daedalus's automatons in Politics. His interpretation of these creations is that they were, for lack of a better word, robots and were made for completing our daily chores. His description also explains the mechanism of this service; each of these devices was able to accomplish its own task "*either in obedience or anticipation*" of others (Morris 1992).

Curiously, most references to the Daidalian automatons seem to mention their lack of control more often than their utilitarian abilities. Aristophanes frequently mentions that once a statue has been bestowed with animation, it cannot be controlled. In fact, it must be bound in order for it not to run away (Morris 1992). The *Illiad* confirms this warning, with a twist. Any figure or even image of a figure with the abilities of an automaton is destined to a perpetual cycle of uncontrollable events. The animated images of a fawn and a dog in Penelope's golden broach, for instance, are locked within a perpetual cycle of conflict outside any possibility of resolution. Not only does the craft induce life, it holds it in a balanced state of conflict. It is perhaps for this reason that the inevitable conflict of automatons frequently serves as the catalyst for farcical and comic scenarios in a theatrical context.

The sober study of this important figure in Greek mythology could be misleading. The personification of Daedalus as the comic catalyst appears quite often in comedies, Satyr plays, and even humorous interludes in philosophy. The illusion and deception of his kinetic statues often causes the typical farcical conditions of surprise, deception, mistaken identity, and illusion (Morris 1992). In one particular scene from Apollodorus, our childhood hero Herkules is portrayed as a bewildered buffoon, fooled by an animate statue of his own likeness (Morris 1992).

It must be stressed that regardless of this comic emphasis, at no point is Daedalus referred to as other than a craftsman and architect. The comic implications of the *Daidalon* offer us an important insight into the idea of play and making. Beyond the belly laughs, this farcical mechanism reveals an unfolding of the design process. It is clear that all the inventions of Daedalus begin by subverting a given natural order. In each case this invention leads to an unforeseen consequence demanding further invention. Take for example the story of the Labyrinth. It begins with the invention of a mechanical seduction costume for Queen Pasiphae to bed a royal bull. The consequence of subverting the genealogy of royalty, as well as the natural order of the species, results in the birth of a monstrosity. To reconcile that particular consequence, a further invention is required. Hence, the labyrinth (Perez-Gomez 1985). The point here is that the structure of creativity and invention has to do with disruption of a natural chain of events. The cycle of subversion and reconciliation is the engine of creativity. In the *Daidalon*, things are made that cross boundaries and somehow have difficulty reconciling themselves. Each of these steps ultimately opens an infinite sequence of subversions and their necessary reconciliation.

These cycles begin with the most innocent of intentions. Yet as catalysts, they unfold layers and layers of reconciliatory machinations. We are all familiar with the comic figures at the center of these scenarios. They range from Daedalus, to Falstaff to Puck and the more tragic Golem. The plot, like *autokinesis* itself, unfolds with the often mistaken belief that the progenitor can control the outcome of their machinations. One must not mistake this with irony, as in the work of Marcel Duchamp or Oscar Wilde, where the catalyst is above the crowd and has the benefit of both insight and superior wit. In the *Daidalon*, the catalyst is pathetic and in trying to take control, evokes chaos.

Experimental processes such as those developed later by the surrealists as art methods are all about generating an unexpected sequence of events. The consequence of this forces us to elaborate work beyond the common enemy of preconception. Work cannot evolve through a preconception. It will only progress as and when it comes into being. A creative act of subversion not only liberates the imagination, it forces an artist to mediate the subject with material and hone technique.

Erosion of Materiality

The roots of these demands could help to explain the difference between craft and skill. Traditionally, craft was understood as a cultural covenant embodying this liberation in the face of resistance. Craft was the saga of the liberation of form within material. It generated its own parallel community among others, and its own genealogy. This was not merely to form an elite society (e.g. guild); it was a *sedimentation* of the entire history of that very craft, manifested in a liberated form (Sennett 1994). In liberating the *secrets* of this world, Diderot transformed the knowledge of the guilds into commodities. Skill could be acquired, learned, and even exchanged through the medium of the printed book. The identity so often associated with one's family of craft, was now interchangeable at will. As inheritors of this cultural shift, we have become accustomed to the idea of choosing our guild, even after several lifetimes. *Skill* of course, would translate into the idea of *labor* during the industrial revolution, a measurable commodity similar to bushels of wheat (Sennett 1994). One could suggest that as the identity of the laborer associated with craft deteriorates, so does the resistance of the material with modularization.

For philosopher Barbara Becker, the gradual erosion of materiality is at the core of the postmodern condition (Becker 1999). The new digital interfaces that we are toying with now in digital *space* are conditional on the complete subjugation of materiality. In other words, the eventual result of a digital materiality would be the absence of intentionality. For Becker, this is precisely the problem with virtuality. Even

if we were capable of reducing the material world to a subjective consciousness, that discourse would be grounded within the lexicon of the phenomenal world (Becker 1999). Ultimately this would create a world even worse than we have now. For if we deny our embedded intentionally we are only existing in the world for ourselves without the *other*, an almost textbook definition of narcissism (Adorno 1970).

Although the new *'digital'* tools are remarkably good at visualizing and planning the logic of assembly, they are only compliant with material realism at a representational level. CNC processes assume, and work best with, only the purest of materials. These machines are not capable of contending with the varying densities, imperfections and aberrations that we would find in natural materials. Both chipping and fusion deposition technologies, such as prototyping and stereolithography, entail the use of homogeneous material. It is difficult to even identify what materials are being used or generated.

Materials manufactured by accretion technologies are homogeneous, as well, it is important that they are treated as homogeneous in CNC chipping technology. Indeed the very purpose of digital tools and technologies is to eradicate unpredictability and anomaly ('quality control'), both in the process and the product toward an enterprise of utter predictability. In contrast, Pye defines craftsmanship as a practice whereby, regardless of the apparatus and the technique , the end result is undetermined. Rather than a predetermination, the result depends on a dexterity, knowledge and above all active judgement to determine the outcome (Pye 1968). Similarly, there is a link to the design process as the *Daidalon* describes it. Daedalus' work is dependant on risk as a generator of ideas. His ideas are extremely risky.

In exploring the difference between modern automation and traditional craftsmanship, Pye creates a scenario of oscillation between the *'workmanship of risk'* and the *'workmanship of certainty'*. Certainty is the basis for our industrialized culture: if we can predict the exact outcome, we can produce in large volumes. Risk and certainty have a built-in economy. In any process of design, risk and certainty have a balance: what may have begun with a strong investment into the workmanship of risk, may end with a certainty (such as a run from a printing press). Like all evolutions, craft can only follow a course of mutation. Risk provokes change through accident or unintended discovery. The world needs variants (Pye 1968).

What is particularly relevant about Pye's thinking is his assertation that it isn't the hardware – i.e., *'the machine'* – that distinguishes the workmanship of certainty from the workmanship of risk, but the need for predictability. In truth, the first machines (lathes, levers, gears, and jigs) predate the middle ages. Pye assumes that craft is determined by the jig or hand guided by instrument. By this definition then, the moment that a tool enters a material (even a hand-guided material) the initial cut acts as a mechanism (Pye 1968). This implies that the craft of risk is recoverable in a digital world of robots and machines as long as predictability is not the first aim.

Contemporary Subversives

It is at this point that we may be able to turn to the dilemma that we are currently in. The resistance of the material and its cycle of engagement is what generates craft (Becker 1999). If making is dependant on the embedded resistance of the material, how does one make when the material itself is isolated as pure subjectivity? In this case it is not enough to merely resist for the sake of resistance itself, the danger being that somehow we would devalue the work to something ephemeral. In Adorno's words, it would focus only on a *'bogus promissory note on the future'* (Adorno 1970).

We might assume that we simply need to reintroduce any form of material resistance into the configuration of the computer itself. Though the actions of a computer are the pinnacle of subjectivity, it is still, for the time being, a barely physical device. To actually design the circuitry of such a device, one must see the physicality at the molecular scale. We must bring ourselves to a temporal state where, within a billionth of a second, light will travel one foot. The resistance only appears with an intentional shift, or rather a delay, in scale and time. We are, for the time being, barely within the realm of physical materiality. At this point, this material is evaporating and will soon disappear. It could be that the only material we have to work with is time and scale itself.

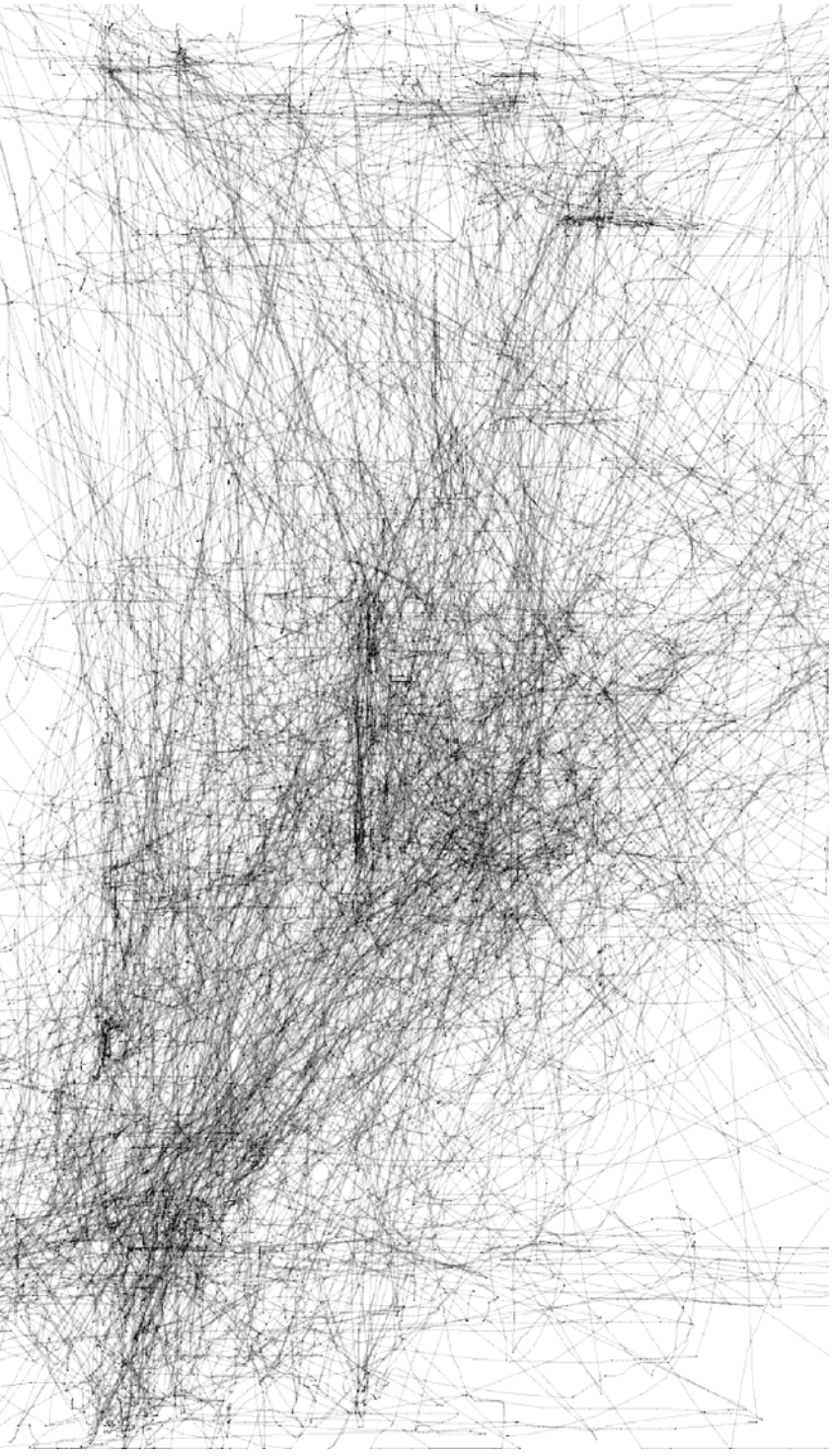

Figure 2. Example output of Signwave's "tracing paper" mouse tracking software. 2003

We need to seek problems. There is, however, a fine distinction to be made between the tradition of *problem solving* that is used to eliminate resistance, and that of *'making problems'* to introduce resistance. For most of the world, seeking problems sounds too much like *'looking for trouble'*. Boat rocker, rabble rouser, and mischief maker are contemporary labels that clearly place the creative mind on the wrong side of good social norms. Like resistance, we need to be free of anything that is counter-productive. It is with the act of reconciling the subverted that form can take shape. For the *'maker'*, subversion and reconciliation are at the heart of any creative strategy. This cycle of activity, as we have seen in the Daidalon, are the embedded narratives that are part of a completed work.

It is in this realm of the narrative, or script, that code such as *Signwave Auto Illustrator* seems to point the way. In a manner similar to various surrealist strategies, a kind of digital *corps esquisse*, *Signwave* is *'a map of engagement'* programmed to subvert the intentions

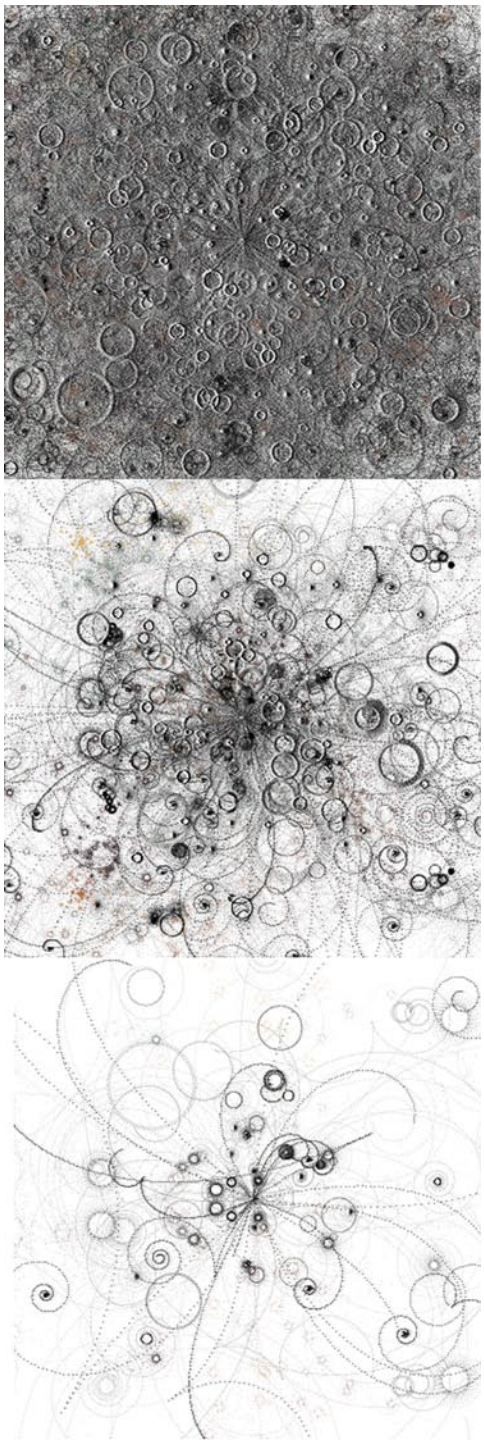

Figure 3. 3 states of Jared Tarbnell's generative art piece: "bubble chamber" written in Processing. 1 minute, 5 minutes and 30 minutes

of the artist. Described by its authors as a *parody* of professional graphic software, Signwave is costly to purchase (upgrades are free on April 1). Artists intentionally use Signwave to subvert and uncontrollably distort their own work. Lines are scripted to go out of control, images to be broken up. As proof of its usefulness to the creative process, Signwave has a cult following. Signwave retraces the tragicomic script of the ancient Greeks.

It is easy to see how Signwave could be useful to a designer, since it operates on a graphical, or representational level. The next question: is there an equivalent possibility for the processes of fabrication? Is there a digitally-inspired strategy or plot that makes use of the aberrations and inherent *'intentionality'* of materials? The thinking of Johnathan Frazer is interesting here. In his desire to understand complexity as generated in complex biological systems, Frazer suggests that creative morphology and intentionality are a science that merits development on its own (Frazer 1995). Frazer

contends that cellular automata (a multitude of *'tiny'* simple machines that comprise a large *'machine'*, as opposed to a singular monolithic machine) will, according to basic and rudimentary decisions over a complex lineage, generate a unique topography, a complex web of form. These automata form the parameters of the system, but the expression or the variable as an external activator is what propels the gradual complex evolution of the project. Frazer's belief is that complexity is generated through the most minimal and innocuous of environmental generators.

Conclusions

Frazer's description of the environmental conditions as the affected factor in all evolutionary functions has the possibility of responding to Pye's understanding of the *design* process. Pye makes a strong distinction between what is designed and not. In order for something to be designed, it must be the result of an evolutionary process, one that results from aberration, mutation, and adaptability. In this sense, a work is *NOT* designed if it is necessarily free of all aberration and potential mutation. In order to provide the opportunity of mutation, one *MUST* not only adapt to risk, but even encourage it.

Our approach to new technology has been one of adapting ourselves to fabrication and manufacturing tools built on promises of prediction and certainty. There is an obvious contradiction here where the tools are at odds with the environmental conditions meant to trigger form. In order to re-introduce these elements into our work, we will need to develop tools at a fundamental (mechanical and software) level that are meant to respond to conditions of external environments, material heterogeneity, time, shape, and aberration. But most importantly they need to able to respond to their own consequences.

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