Morphogenesis: Masonry, Social Justice, and Evolutionary Thinking

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Abstract: This paper is the product of work generated in an undergraduate design studio, looking at masonry as a way to tackle the question of culture and the environment. Might masonry be so assembled as to address changes in human and non-human dynamics? The material has been largely used as a veneer to turn an otherwise colorless building into a spectacle of artistic and economic worth. Might we be able to change that, and see in it the capacity for adaptation, accommodating shifts in climate but also taste and seasonal function? To answer these questions, the studio relied, among other methods, on computational design, digital tools whose virtue lies precisely in their capacity to recognize and respond to change. Pedagogically, this meant a different approach to design, a nonlinear back and forth between the physical and the digital, including the use of body installation as an examination of the site.

Keywords: Computational Design, Algorithmic and Parametric Design, Material Computation, Masonry, Environment and Culture, Social Design, Adaptive Thinking

1 Introduction

It was Prometheus who endured Zeus’s punishment and was rewarded for it. Now freed, he could free both the rock to which he was shackled and the people for whom he cared from years of inaction and lack of creativity. This paper reports on a similar campaign, in this case freeing masonry from years of attachment to structure and tradition using emergent processes. As a material composed of simple and readily available earthly ingredients, masonry has always been part of us, our physical world, transcending place and culture across time and geography. Standardized in units of manageable dimensions, it has appealed to the weak and the strong alike, contributing to vernacular constructs just as much to monuments of great heights. So ubiquitous is masonry we had come to accept it for a certain method and expression. Steel did shift its purpose in the 19th century, relegating it to the role of veneer, but, by and large, it stayed the course. Architects like Louis Kahn liked it for its timeless qualities, while those like Frank Lloyd Wright for its earthly morality. But then something happened in the late 20th C, namely two revolutions that converged on the scene with a particular force.

Between the invention of the internet and the realization that the earth is fragile and needs sustained attention, there arose a global mission to restructure the way we construct values. If the market had for a long time dictated the way we evaluate worth, subjecting values to the dynamics of supply and demand, might it have been time that we looked to a different and more sustainable model by which we can carry on? This is when we began to return to a more Darwinian view of the world, and one that is set on the belief that to sustain is to think incrementally, to evolve rather than break lineage with the past.

If the market had demanded that we relate to things as commodities, evolution asked that we take a closer look at the way those commodities are processed. Biological principles began to supplant economic, leading to a thinking in which even the most material was examined through the lens of the species, as flow carrying messages from past to future. Cities benefited. Now pried open to explorations beyond the picturesque or even the organizational, they became subject to metabolic analysis, treated as open systems in constant communication with the world around. The process involved breaking elements down, in pockets of independent living, each capable of change by the degree to which it can interface with the next pocket over. For the authors of Architectural Theories of the Environment, this required rethinking of the environment in “posthuman” terms, as a condition whose resolution demanded that we step aside as humans and let a
preprogrammed script, a blend of digital and natural, take its own evolutionary course. In this sense, they postulate at one point that, “the environmental production process is conceived in the broadest possible sense...referring to the metabolic process that is energized through the fusion of humans with those of non-humans.” [1]

Technology and biology here proceed blindly. As an embodiment of preprogrammed commands, they both get ahead by naturally selecting what is best for the propagation of the species, or in the case of digital design, the function for whose end the program is scripted. Lifeforms select not based on ulterior motives, malign or benign, but on what will give them the best chances to survive. Eye lenses, for instance, Richard Dawkins tells us in *Climbing Mount Improbable*, evolved just as much to admit light as to edit it, narrowing visual data down to information the brain can process. [2]

It seems that we as humans may have maligned the environment by engaging in competing agendas. It is best to let a system independent of us run its course to a better end, naturally selecting based on what is best for the environment and not on what is best for, say, the market. Might we let algorithmic thinking direct us to a less destructive world and one in which existence is not a zero-sum game but one based on a mutually beneficial performer between us and the environment? Might we indeed be able to embed environmental parameters into emerging computational processes so that the resultant union between material and form is indistinguishable from the very problem that gave rise to it? The following paper explores those issues. Based on a studio whose primary challenge was masonry, it asked two key interrelated questions: can masonry be used to study the tenets of computational design, including evolutionary processes? And if so: can the reverse be true, namely can the premise of computational design foster new expressions in masonry, aesthetic and otherwise?

1.1 Masonry

Masonry earns its virtue not from the unit itself but in the way that unit aggregates and forms wholes. Up to this point in time, this additive process yielded little more than surfaces of picturesque effects, without response or modifications towards outward changes in the environment. Masonry, of course, cannot adapt in a way similar to a chameleon eluding foes. But it can be designed in response to nearby site forces, assuming formations that while static allow for future variations in function and habit. Here is where we will have to veer away from the strictly biological interpretation of evolution to cultural, building on Manuel De Landa’s analysis in “Species and Ecosystems” that the propagation of the human is not only dependent on instinctive reactions to survival hurdles but on careful evaluations of communal membership as well. “Fortunately,” he says, “anthropologists seem to be moving away from dogmatic positions and developing a new interactionist approach, wherein both organic and cultural evolution are considered simultaneously.” [3]

In the spirit of evolutionary linguistics, De Landa speaks of replicators, patterns whose proven record of success compel particular species to repeat them and ensure continuity. He goes on to mention variants, namely that with time and geographic change, the initial pattern will inevitably find a modification to suit new contexts.

What masonry walls our studio was going to generate, they didn’t have to change shape themselves, but simply accommodate designs that could play host to variation in function and shape nearby. Much like interactive art is effective and compelling precisely because it accepts and indeed accommodates a diversity of inputs, so the success of the walls was going to be determined based on the degree to which they allowed parasitic development to grow and develop into new possibilities.

Not unlike Cedric Price’s lifelong mission in the 60s to see in architecture not buildings but the potential between buildings, so was the intention of this studio, to push design to develop in objects the potential for benefit outside themselves. As the author of
Architectural Intelligence says “the iconic architect (Price) argued that the point of architecture should not be to lock people down but to open them up.” She quotes Price as saying that architecture should be seen as an intervention whose purpose is to “to ease up the choice, to free the opportunities of the individual user as to what they would do next.” [4] Similarly in our studio, the challenge was this: to design an object which while fixed and solid must also give rise to worlds yet unknown and by nature remain under intellectual and physical construction.

1.2 Farmer’s market as cause and function

Masonry walls must need a function to be considered architecture and not merely sculpture. Farmer’s markets were deemed a suitable match for both the experimental approach to masonry and the objective of the studio to examine adaptability. They are interesting in that they live a double life, on the one hand, simple and vernacular, and yet, on the other, complex in the way they facilitate social connections. Their power lies in part in the way they come and go, break down and are resurrected at regular intervals, usually once a week, making them particularly suitable for studies in adaptive living and constructability. Other factors of suitability include the fact that they too, like masonry, come in units and wholes, on the one hand, dependent on the singular vendor, but on the other, on many vendors for mutual economic benefits and a sense of belonging to place and culture.

1.3 Studio content and mission

The studio quickly adopted the term “morphogenesis” as its title, a term coined by the team Michael Hensel, Achim Menges and Michael Weinstock, working collaboratively inside the AA, looking at form through the lens of evolutionary biology. How can we understand formless as a product of the mind seeking creative solutions and more as that which stems from internal intelligence already embedded in the material content of the problem. To them, morphogenesis is “the process of evolutionary development and growth, generat[ing] polymorphic systems that obtain their complex organization and shape from the interaction of system-intrinsic material capacities and external environmental influences and forces.”[5]

Through it, they call into question the wisdom of the boundary, as developed and shaped throughout history. They reference Robin Evans and his famous essay on “Figures, Doors and Passages” where he argued that the corridor was invented not without a reason but “originated from the need of the landed gentry to uncouple the space inhabited by their family from that of the servants.”[6] In more biological terms, they mention the work of Tibor Ganti and specifically his book on The Principles of Life. Here they speak of “two categories of life criteria: real or absolute”, on the one hand, and “potential”, on the other. “According to Ganti,” they go on, “the former are necessary for an organism to be in a living state, while the latter are necessary for the organism’s survival in the living world.” [7] If real and absolute criteria require metabolism, unity and inherent stability, “Potential” is about “growth and reproduction, a capacity for hereditary change and evolution.” And so if boundaries are necessary to establish the conditions under which life exists, they must also be open and plastic enough to allow for change and the propagation of future generation.

As we will see later, these question will prove interesting and the difference between computational thinking and evolutionary design. If computational thinking is predicated on binary procedures, the real and the absolute in Ganti’s world, evolutionary processes are much more prone to diversions and change. Might masonry accommodate both? Could we take its binary strength - brick-no brick / solid –void - and vary it to allow for incremental modifications, empowering future variations in function and ideas. More on this later.
Farmers markets are too open and adaptive, capable of operating from any spot in the city, in parking lots, streets, sidewalks and more. That is their virtue but they leave nothing behind when gone, contributing nothing to the afterlife of their wake. Morphogenesis corrects that and insists that adaptive systems must work with traces of the past, evolving as they go but influencing what happens in between. Between one Saturday and the next, farmer’s markets must not completely vanish but leave behind a feature whose use and adaptation by locals can and should inform the potential of their future.

1.4 The pedagogical process

Before any work could take place, the students had to be introduced to the conceptual underpinning of computational thinking. What does it entail and toward what end can it be visualized? The premise is simple enough but it is also new to the field of architecture. Unlike say the study of composition, which does demand from the designer total control and total determination, not to mention a panoptical view of the work underway, computational design asks that we accept that what work is indeed underway it is so, at least in part, under its own tutelage, independent of the designer. Where in composition the work is consumed as a totality, in computation it is understood as parameters, each beholden to the one before and after by a blend of genetic symmetry and incremental change. Where the relationship between elements is used to inform the design and the system, the results are based on defined parameters and principles.

To that end, the studio started with the basics, introducing students to the very conditions under which computational thinking takes place, namely the part and whole, and more importantly the implied and literal movement between the two. A number of images were distributed among the students, each telling its own evolutionary story, including the complex layers of formal systems, some with explicit visual indicators and some less so. The students could choose any one of the images, the only requirement being that it resonates with them visually and intellectually. By critically analyzing a set of 2-dimensional images, the students went on to explore the latent formal system of a chosen image, creating their own formal systems, later deploying them in the creation of the new design.

The first task was merely to identify the critical parts—a fish in a school of fish, a petal in a larger rose and so on. Bold graphics of a limited palette, black and white in most cases, signifying the binary essence of the analysis, were used to cul from the images the essential information about shape, interface, and overlap. In addition to hand drawings, students took up digital software like Illustrator and Photoshop to analyze the images and identify their formal relations. By the end of this phase, a compilation of analytical images was produced that both codified and described essential formal systems.

Among other lessons the first phase made visible, the link between the parts was the most important, revealing the internal dynamics embodied inside the scatter of parts, the glue, if you will, that holds them together, and which ultimately identifies the DNA, so to speak, of their particular species. Where former applications of masonry may have stemmed from our understanding of the unit’s internal properties, with this project we explored external ties to other units and potentially the environment.

But it is one thing to identify the internal vital dynamics of an image and another to actually understand it. To do so, the students had to undergo internalizations of their own, designing and creating a new work of art based on information generated in the first phase. Take the abstractions generated so far and build an image of your own that demonstrates a thorough understanding of not just the shapes and spaces involved but the very forces that drive the lines and the turns of those shapes. Here students were asked to investigate the materials and the extent to which they were complicit in the shape of the part. Consider their impact on the tactile, phenomenological, and spatial experiences. Does the fact that the parts were
made out of sand matter and if so seek an expression that demonstrates that? What about stone or wood? (Fig.1)

![Fig 1. Phase 1 & 2. Students’ analytical drawings identifying the latent formal system in the chosen image and creating their own new formal systems based on those analyses and material investigations.](image)

Of the central characteristics of evolution, the response to the local is the most critical. What species do not sense it does not react to and those happen at the immediate level of the environment, be it cultural, climatic or otherwise. In that, evolution is a matter of incredible practicality, changing when and where change is most needed to protect and preserve the species. “In natural systems, most sensing, decision-making, and reactions are entirely local, and global behaviour is the product of local actions, with a high degree of functionality in the material itself.”[8] But how might one teach the local? Here the body was seen as a good starting point, something we all understand we must accommodate in one way or another. By adapting the design to it, the students would inevitably learn about what is here and now, creating a form based on an intimate understanding of what is closest to us. Lessons in translation between the digital and the material were afoot, but also on the importance of site and culture as well.

And so the students proceeded, taking what they had generated in 2D initially and turning it into a 3D design that accommodated the turn and twists of their bodies. The challenge was not merely to drape the design over one’s body but create a body installation and spatial construct that understood and empowered a particular limb or joint. Interestingly, this killed two birds in one stone, achieving a keen understanding of the local but also of the materials used to produce the designs, not masonry yet but a material of choice perhaps particularly selected to reveal what is best for the body. This way the students learned how to rethink the purpose of materials, as an end in their own right, and not merely a commodity worthwhile only insofar that it can be exchanged and valued in the marketplace. (Fig.2)
At this time, it was necessary to transition into architecture and preparing the stage for the final design of the farmer’s market. But before the students could jump in, the study of masonry had to be backed by meaning, otherwise, the results could run the risk of devolving into a mere look. What heights and flights the masonry walls were going to acquire in support of the market, they had to be informed by a foundational logic. For that, we needed a document through which we could ask critical questions.

It would come in the form of a parable by Franz Kafka titled “Before the Law” which as parables go is short but packs a strong intellectual punch. It tells a story about a man from the country seeking admittance to a sort of kingdom beyond a gate, guarded, as it were, by a gatekeeper. The latter rejects the man’s request verbally but not physically. Nothing prevents the man from going through but he nonetheless honors the gatekeeper’s word who asks him to wait. For how long is anyone’s guess.

Two weeks were devoted to this phase of the semester, the first to read and interpret the parable, the second to design on a site of the students’ choosing a physical gateway that matches in intellect and purpose the one in the text. Among the several lessons that emerged, the one associated with computational thinking was key. Between the man from the country and the gatekeeper, and then again between admittance and non-admittance, critical binary information was at play. The man from the country had two choices and only two it seems, either acceptance or rejection, inside or outside. What waiting he had to do was of no evolutionary purpose, as he was neither challenged nor required to improve or change in any way. Even after many years of waiting nothing really happened other than the man deteriorated and finally died.

This is interesting because it tells us that between computational thinking and morphogenesis there is a difference if not an opposition, that while morphogenesis stems from a certain programming logic, a DNA script if you will, it is not strictly computational. Could the design of the gateway help, specifically in its application as a masonry entity?

Fig 2. Phase 3. In this phase students translated their design from the digital to the physical and generated active installations on their body, engaging the potential of material. Throughout, they examined concepts such as context, survey, measurement, proportion, and scale.
Can this material unfold and stretch in such a way that can give waiting a purpose? Can the brick units follow binary procedures of solid-void, here or there, but do so precisely in a way that accomplishes un-binary things and as such give meaning and purpose to the grey space of the in-between? Ensuing designs grappled with that dichotomy; how a gateway can divide and create two distinct sides and yet at the same time also make room for a meaningful liminal space and through which the human can evolve as a social animal. Here we see walls bifurcate, open up like a peel and allow variations in function to occur, accommodating in one instance, say, a bench and meditation area, while in another a playground for children, and yet another a cultural stand for music and theatrical performances.

Many of the lessons learned with the gateway were directly transferred to the final farmer’s market phase of the semester but this time as further informed by site analysis. Where the gateway in “Before the Law” was largely designed in the abstract, here it would acquire specificity through the site. To that end, the site was treated as an embodiment of forces, each, like an arrow, can be adapted to push, pull or otherwise stretch the architecture of the market. Using computational design, critical issues such as pedestrian and vehicular traffic in and around the site were treated not merely as static findings but as active forces capable of shaping physical results. Even views and solar patterns were analyzed and applied in that same manner. The same with distances and links with nearby farms, given the agricultural nature of the program. Later, these forces would find expression through Grasshopper, mobilized as attractors that can drag and tessellate masonry units.

Between literary analysis and site analysis, the students were now primed to turn their energies toward designing the market. Programatically the challenge was simple: provide a setting that can accommodate up to 23 vendors and one amphitheater-like space for music or other such performances. Intellectually it was more difficult. How could we design a set of walls that could support the market on Saturdays but remain open to other possibilities on other days? Could the very porosity of the walls spell out ideas for a transformative environment?

1.5 Masonry competition

The market assignment was part of a masonry competition sponsored by a regional masonry industry. First prize winners took their clues from three key analytical points. The first has to do with the realization that while farmer’s markets have front and back—the front where people walk and shop, the back where delivery trucks park—the two weave an informal dynamic between them, visual and circulatory. Even scale is siphoned and understood in a similarly casual way, namely that while there is a difference between the size of the truck and that of the human, the two stand in relative peace with each other. Why not morph the two, taking what is inherently predicated on two sides and turning it to do the opposite? Here masonry rises but soon turns and twists and in so doing forms textile patterns shaped by the very motion and direction of the twists. This is where the second point is introduced, namely taken from the shape and direction of the site, a long and rather misspelled property sitting right next to an old railroad track. As if the train had just come and gone, so the masonry wall/shell proposed twists and turns as if in memory of the train having just blown by, creating eddies of wind in its wake. Sun and wind provide the last point, two visibly prevalent sources of energy in the area. Lines and forces generated through wind and solar analysis were imported into Grasshopper and used to influence and inform the design. In its rise and fall, the masonry units tessellate, creating gaps through which wind and light pass, both structurally sustaining the structure by reducing its weight and giving it the ability to create compelling dappled light effects.

So sculptural was the result, it resembled the undulating hills of nature next door, or a smooth silky dress swaying under some duress. So much energy was already embedded in
the design, it was questionable whether it needed additional intervention to make it respond to the temporary demands of the challenge. To that end, it was determined to leave the design as sculpture doing what great sculptures do, inviting the imagination to see in the design a variety of future possibilities.

(Fig.3)

Fig 3. Images showing one of the students’ farmers market proposal. Here, students pushed the boundaries of masonry using computational design, simulating and analyzing systems by which to overcome structural challenges.

Winners of the honorable mention interestingly started where the last winner dropped off, namely to give the intervention a center where none existed. They too had generated diagrams with which to grapple with the site, this time focusing on key relations with neighboring properties. Views, paths and solar patterns were analyzed and turned into forces by which the design of the market could make concrete certain valuable connections with the community. Ultimately, the results proposed a binary effect between a permanent masonry feature, on the one hand, and a temporary (umbrella-shaped) woodsly structures, on the other. The team envisioned that it was between the two that critical cultural and functional adaptations would take place, say by fishing temporary beams between the two and casting a fabric, sail-like, on top. Together they invite the community to acquire say in what happens to their public space, perhaps according to seasonal changes, extending the market’s use across the day, the week and the beyond. (Fig.4)
1.6 Conclusion

As we move into a time in which everything that we do we must do in recognition of the environment, it is important that we rethink the nature of materials, including the language we use to describe them. Where before we had referred to them as “finishes” and “veneers,” today we must see in them the capacity for mutual relations with the world outside. Masonry, traditionally an earth-bound material, is here pushed through emergent technologies to empower possibilities, cultural and otherwise, beyond itself. It is to that end that this paper celebrates the inter-relationship of architecture, materials, culture, and environment. (Fig.5)
Fig 5. Installations featuring full-scale excerpts from the designs of the walls for the farmer’s market. Using computational design and digital fabrication, they served as proof of concept for the final submissions.

References

7- Ibid, P25.