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Interpreting Aspirational Forms: A Technography of 3D Printing

By

T. L. Hudson

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Faculty Advisor: Michael Fisch

Preceptor: Ella Wilhoit

Abstract: This thesis examines the coinciding of human values and the affordances of technological material as an active form of directed evolution. Considering an entangled person and technology as an assemblage, the investigation responds to the question of technological choice as it refers to discrete moments of change: why is it that the assemblage orients toward a specific future way of being? This research demonstrates the choice is discernible as a chain of dependent moments which circumscribe innovation. Owing to its highly adaptable ontology as a relation between people and technology, the ethnographic fieldwork for this study involved interviewing hobbyists of 3d printing about their relationship with the platform technology. This work finds that the chain of dependent moments which minimally describe evolution for the person-printer assemblage can be organized as three successive coincidences: a predisposition prior to a new entanglement, a turn in which the person and printer are interactive, and an aspirational form which emerges with a discernible future orientation. As this study is reactive to larger discussions of global anxiety around human progress and the reality of the Anthropocene, I argue that theorists of progress should adopt a posthuman perspective which contends with the discursive relation between human values and material affordances as a superior descriptive heuristic than a focus on human choice alone.

Keywords: affordances; assemblage; ontogenesis; Simondon; technicity; technography; transduction; values

Everything functions. That is exactly what is uncanny. Everything functions and the functioning drives us further and further to more functioning, and technology tears people away and uproots them from the Earth more and more.

-Martin Heidegger, *Der Speigel* (1966 interview)

There was a child went forth every day,
And the first object he looked upon and received with wonder or pity or love or dread, that object he became,
And that object became part of him for the day or a certain part of the day…

-Walt Whitman, *There Was a Child Went Forth Every Day*

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Introduction

In this essay I approach the phenomenon of mediation between people and technical objects as a convergent process, a coming together of person and material-machine which is dialogic, super-additive, and evolutionary. Technology which acts upon us as much or more than we act upon it now crowds around the human being, constituting an amorphous boundary between what is human and what is not—a reality which is both accelerating and complexifying. Recognizing such a ubiquitous dynamism as a source of disorienting change that is often rife with negative externalities, it is increasingly important for the ontogenesis of people and the technical to bring forth healthy and beneficial ways of being that orient the future toward further felicity. In other words, innovation must contend with how such relations act upon the very process of becoming in ways which result in the promise of future good, not only minimizing current harm. Nevertheless, deliberate interventions toward the purpose of healthy ontogenesis will remain one-off without first establishing a coherent understanding of how people and technology co-evolve. In addition to contributing to a more comprehensive depiction of overall human progress, this coherent understanding would constitute a science equipped to analyze such change beginning from the most discrete case. The challenge posed by this analytic is twofold: identifying the forces which engage in interaction between people and the material world and isolating the conditions which structure their mediation. Approaching the task in equal measures anthropologically, philosophically, and cognitively, I chose to examine the discursivity between people and things as a coming together of human values and the affordances of the material world around us. Here I am using the concept of 'affordances' as posed by the psychologist James Gibson in which the environment as a surface is said to "offer…, provide, or furnish" the animal (in this case a human)

with utility (Gibson 2014, 119). Studying the entanglement of the mental and the physical in small cases, I looked to answer the question of why specific ways of being emerge through the correspondence between human values and such perceived utility. Furthermore, I sought to explicate from this investigation a logic which transcends the subject case, rather than simply explaining an outcome from my fieldwork.

For this investigation I adopted the methodological philosophy of "technography[1]," described by anthropologist Michael Fisch as "the medium of post-human humanism" (Fisch 2018, x), an approach which decenters the primacy of human agency in analysis, while retaining a normative optimism about our shared future. In exploring this topic on-the-ground I required a human-technological subject which possesses a high degree of flexibility in form and operation. A technological relationship fit for more easily illuminating this ontogeny would ideally be responsive to retrofitting and customization and invite the creativity of the human partner to modify its form, thereby offering many instances of correspondent evolution. As a practice and hobby, the 3d printing movement affords the qualities I was looking for in a subject. The popularity of 3d printing as a mode of design and creation for both novel and practical things has led to a plethora of customized printers capable of creating objects from a diverse set of filament types to include various plastics, clay, and even organic matter. The uniquely ontological relation between hobbyists of 3d printing and the technical object allowed me to identify many discrete instances of technological choice and evolution upon which I could explore specific research questions: how is it that correspondence between human values and the affordances offered by the 3d printer interact? In depicting such an interaction, what minimal ordinal structure circumscribes the

[1] "Technography" may be interpreted as a portmanteau of "technology" and "ethnography", although as a metareference, the term signifies more than the sum of its individual parts. See Michael Fisch's *An Anthropology of the Machine* 2018.

sequence of an evolution? And finally, *why* is it that specific orientations toward future modes of being emerge through the correspondence of person and printer? This research frames the emergent form of the person-printer assemblage in a way that reaches for a prediction of its future manifestation, as reasoned through its current individuation. In so doing I illustrate the core offering of this study: what I call the 'aspirational form,' a way of understanding the yearning of the assemblage toward its future as a bounded space of possibility, a space delimited by the combination of values and material affordances and the result of their mediation.

Background – Theories of Progress and the Present Anxiety

When Hannah Arendt first differentiated man from all else, the distinction lay in mankind's seemingly unique mode; the propensity to impose upon the world 'the Human Condition'. For Arendt, mankind's nature was a reality of making mired in the intricacies of politics and the unnatural products of our creation and existence (Arendt 1958; 2-4). Initially, it may seem that Arendt's framing of humanity would yield us an exceptional status—that what separates man from animal is this capacity for creation—the making of 'our' world. This is not a true exception, however, as many animals also make and use tools to their advantage. One way to demarcate us from other species who also possess these aptitudes is to consider how the very outcomes of our production act upon our evolution as a species, ontologically restructuring our thoughts as well as our bodily forms and ways of being (Ihde and Malafouris 2018).

Throughout history, advances in science, technology, and culture have driven large-scale change in how we live, engage in leisure and labor, give birth, and even die. Even the very structures of our brains have adapted to our changing relationships with the things of our crafting and engagement, a neuroplastic response that renders us more adept at skilled behaviors, such as playing sports or musical instruments (Eagleman 2015). While the 20th century romanticized the

advances in quality of life brought forth by such innovations, recent years have brought about a concern for the world we are creating, and what kind of people we are becoming amidst the outcomes of our production. For many years it has been common knowledge that we are killing the planet, and possibly the promise of a future. As Kath Weston asks, "What does it mean to know but not to grasp, to have realization end in a shrug?" (Weston, 177). Likening the current political discourse around ecology to the post-Fordist anxiety of late-capitalism, Weston argues that we have come to grips with a state of perpetual precarity (ibid, 180). In this mode, governments and their constituents largely acquiesce to incremental changes, stopgap measures that offer the illusion of doing something meaningful devoid of substantial action. Why the inaction, then, if many share such anxiety? In part, it may be that isolating and containing the problem is not as easy as it is to describe, particularly as we each participate inescapably in the march of progress—to whatever end—but we do so as the combination of infinitely many relations to others and other things. In this way, changing the habits of billions of people is a much greater task than the sum of each person changing their individual habits. However, this challenge to resolving the existential threat of climate change is not limited to ecological damage. The problems that stymie its resolution extend to all facets of our existence with the material world; the perpetuity and ubiquity of our engagement with the *things* that dominate our existence and our apparent inability to break with our habits of their engagement. What can be done, then? While the focus of this study is not on the lark of how to bring about a utopia, I do want to contribute to a better understanding of how we can analyze such change, change which is now inextricably bound to the technological as an ever-present and everywhere phenomenon.

While Arendt would focus primarily on the relationships between the individual, material, and society, her work was somewhat more philosophical than practical in that she eschews specific

historical references upon which to ground her theory. In a similar manner, the historical dialecticism and economic theories of Karl Marx come readily to mind as an attempt to understand progress in terms of the relations between man and material conditions, such as machines and institutions. Twentieth-century historians of science such as Lewis Mumford have reiterated Marx' position of the primacy of material over the social and ideological apparatus of the superstructure, suggesting the role of people in the unfolding of history may not be as pronounced as that offered by Hannah Arendt. In concordance with Marx' philosophy, Mumford described society as advanced through technological epochs, each of which was typified and largely structured by the invention of specific technologies that fundamentally altered the way of life of mankind (Mumford 1934, 109). Indeed, inventions such as the mechanical clock are described as fundamental to the formation of capitalism (Giddens 1981, 132), or the steam engine and railway to altering our perception of space and distance (see Schivelbusch 1977). To explain the way ideas precede ideas to arrive at such inventions, Mumford offered the concept of technical syncretism, a kind of mixing between previously isolated cultures which facilitates the emergence of new technological ideas upon their merging as a dialectic (Mumford 1934, 107). A congruent view of the dispersion of technological knowledge gained traction in the 1960's amongst archaeologists who took up the theory of V. Gordon Childe. Childe observed in the records of data an effect of diffusion of craft production techniques between artifacts found from Bronze Age Europe and the Near East (Wailes 1996, 4). While much of Childe's conclusions drawn from the archaeological record have subsequently been challenged and incidentally refuted by later archaeologists working with the benefit of better tools, the ideas he proposed which united the material record with the social ways of being for differing cultures was quite popular throughout the 1970's and 1980's. One such archaeologist who provided evidence against some of Childe's findings during this period was

Colin Renfrew. (ibid, 47). Renfrew's concern with respect to Childe's concept of diffusion was the degree to which Childe neglected the contribution to emergent technological practice arising from the very matter by which ancient craftsmen worked. In Renfrew's view, archaeology needed to consider the cognitive engagement between the craftsperson and the material as a medium (see Renfrew 1994). In a sense taking up the phenomenological disposition of Edmund Husserl and Arendt's teacher Martin Heidegger (see Husserl 1931, see also Heidegger 1967), Renfrew would argue for a turn within archaeology to decenter the primacy of man in mankind's own social evolution. This new perspective would require archaeologists to see potsherds and brooch pins as more than inert, but rather as participants in the making of history. Acknowledging *est modus in rebus*, Renfrew's student Lambros Malafouris would suggest Material Engagement Theory (MET) as a compromise between mind and matter; things in the world "project towards (us) as much as (we) project towards them" (Malafouris 2008; 33).

Many scholars of philosophy, anthropology, and science and technology studies such as Malafouris and those who have explored theories of the extensibility of the mind and externalized intentionality (see Clark, Chalmers 1998; Tollefson 2006)[2] have made significant progress toward philosophy of the discursive interactivity between people and the material world as dialogic. Nevertheless, the question of material-social becoming rather than biological ontogenesis—or perhaps better said in a style recalling Martin Heidegger, *being-in-action*, remains poorly understood from an analytical perspective. As theories of social progress have tried to make sense of the ebb and flow of humanity in the grandest sense across continents and over centuries, there exists a disconnect between such grand narratives and the elemental scale of the individual person

[2] Clark and Chalmers propose the extended-mind hypothesis wherein the mind is not constrained to the human head, while Tollefson suggests a collective (multi-person) mind and group intentionality.

and machine. In a simple way, if we consider small acts of innovation as the componential counterpart to large-scale evolution, the task at hand is to make sense of innovating as the most discrete case of invention. My use of the word invention in this instance should be taken as modestly as possible. Whereas the term is often associated with acts of brilliance, it should be noted that aside from the subjective measure of the excellence of a given innovation, any new form or function is fundamentally indistinguishable. The goal here is to reapportion the credit owed to such development between the human and the material, and to isolate and identify how interaction is generative of such change. Isolating instances of such moments of inspiration is not possible at the scale of cities let alone nations. Instead, observing such phenomenon requires the study of moments and small instances of change. What is called for is a coming together of disciplines which, together, can establish links between the day-to-day lived experiences of people and things and the aggregated change of the Human Condition.

On Technographic Subjects, Methodology, and Method

In 2006, linguistic anthropologist Keith Murphy went to Stockholm, Sweden, to study the design philosophy of Swedish furniture makers. As Murphy argues, the socio-political values of Swedish people act through the designer in the design process to reify the cultural norms they embody, such as minimalism and social-democratic ideals of care and caring (Murphy 2019, 9). Murphy describes the process acted out by the designers as abductive, as "performatively inscrib(ing) indexical links between emergent forms and real-world objects, embedding their unfolding designs within a particular formal framework and ordering the *potential trajectories* the design might take" (Murphy 2013; 164, emphasis mine). Drawing a comparison between his study and those of others who have explored the embodied aspects of craftwork and making such as chocolatiers and woodworkers, Murphy emphasizes the discursivity between multiple designers

in the same studios as contributory to the outcome of their design, an apt observation for a linguistic anthropologist (ibid, 27). Perhaps owing to his focus on the human-human interactions which contribute to the design outcome, in Murphy's study culture takes on a primacy over the specific properties and qualities of the material with which the designers work, albeit by acting *through* the material.

For the individual designer working with material as a limiting or liberating medium, depicting *how* this set of 'potential trajectories' is collapsed to a single state is perhaps best illustrated through the work of French philosopher Gilbert Simondon in his manuscript *On the Mode of Existence of Technical Objects.* In his book, Simondon establishes a foundational lexicon for making sense of the process of 'individuation,' or the condition of becoming else as distinguished from other. Words like 'transduction' describe the continuous motion of differentiation of things in time, while the philosopher reclaims the verb 'to concresce' to signify how two things correspond to synthesize a new material articulation, becoming together more than the sum of their parts prior. For Simondon, the measure by which a thing is not defined toward a specific purpose, and as such its range of possible interactivity, is called the 'margin of indeterminacy' (Simondon 2017; 18). Upon directing technical objects unto a task, the margin of indeterminacy generally becomes reduced, as its functionality is now bound to a specific way of being, thereby occupying what I would call its machinic-intention. This ordering of a purpose creates a condition in which direction toward other tasks may be denied by the maintenance of existing relations. To be clear, this should not be taken as a universal fact, but a generalizing logic. For an exception, consider artificial intelligence which—upon direction to a task—may develop through 'learning' an increased capacity of performance. The sum of the capacity for which a technical thing may be directed to purposes is described by Simondon as the 'technicity,' or the

presentation of more or less of an openness to ways of being. (ibid, 17). In this essay, I would like to think with Simondon along these lines while maintaining a foremost concern in how technicity and the margin of indeterminacy are perceived and engaged with, and how perception fails and succeeds to reveal affordances in material through mediation.

Moving beyond the revealing of potential in the material, Chicago anthropologist Michael Fisch studied the creation of such new 'potential trajectories' in his technographic work *An Anthropology of the Machine*. Taking the Tokyo commuter train network and its commuters as an ethnographic/technographic subject, Fisch reveals how the process of stressing the relation between commuters and the machine opens new possible modes of being for the ensemble (Fisch 2017; 14). As Fisch demonstrates, correspondence between people and things does not just reveal new ways of being together but can even create novel potential trajectories: the instantiation of previously hidden futures and the increase in technicity. These ways of being which share the same technical object can manifest as different modalities for different cultures and subcultures within the same urban setting.

While Murphy and Fisch used ethnographic fieldwork to study the phenomenon of emerging forms at the societal level, each gave significant attention to the contribution of culture as a collective force acting upon change. For Murphy, Swedish culture is presented as often dominant upon the choices of the designer, thereby registering *Svensk design* as what he calls “culturally durable” (Murphy, 210). In other words, Murphy notes that the designers often unconsciously reify the design norm in their creative outcomes. In Fisch’s case, the Tokyo metro takes on a special role as a technical object which is entangled to millions of people, daily. The emergence of its form and operation is thus predicated on the contribution of uncountably many moments of interaction, by contrast to the process of the studio designer and the one-off design

product. In the case of Tokyo, the countless ways of being with the metro system are the result of sedimenting numerous cultural norms alongside one another which themselves entangle and interpolate. For both Murphy and Fisch, the multiplicity of human actors is generative of what Simondon calls "inter-individuation," wherein the reality of the relation between people is one constituted in part by the technical (the train itself, or the geometry or form of the furniture) and acts as an intermediary to communicate change catalyzing information from person to person as much as the force of interaction between people through dialogue (see Simondon 2017, 252).

As a practice or hobby, 3d printing likewise constitutes a culture composed of subcultures and human-machine ensembles. By contrast to Swedish design or the Tokyo train network, however, many practitioners of 3d printing operate in a more one-to-one relationship with the machine. Nevertheless, these hobbyists participate in significant networks of sociality and form bonds based on mutual interests and sharing of specialized knowledge. Although 3d printing is easily accessible for beginners to create simple pre-designed and configured prints, the potential for customization in the machine, as well as the open-ended outcomes of design engender the practice with a wide range of skilled engagement. As a result, most hobbyists participate in some community making to share tips and reviews as well as to show off their craftwork. Although these communities create the opportunity for culture to act upon the design choices of 3d printing hobbyists in a similar fashion as *Svensk design* operates through Swedish design studios, the outcomes of design choices are of somewhat less focus here than the dialogic which acts upon the process of emergent forming. For 3d printers, these choices are primarily concerned with material as medium; the potentials latent in substance as determined by elemental composition and conditions, and the function of mechanical components. In this study, I therefore take up some elements of Simondon's philosophy to think through the process by which my participants undergo

change, while also embracing elements of the substantialism he rejected to explicate engagement of the individual with the machine as a perceptive-cognitive exercise in revealing affordances. An outcome of this approach is taking as given the influence of culture as a force acting upon the values of the individual, focusing instead upon the way those values in turn act upon the perception of affordances. In this way, this study adds to the work done by Murphy and Fisch in studying human-machine ontogenesis by attending more intimately to the singular relationship of one person and technical object.

I should also clarify that due to the constrained nature of thesis research, this study focuses on one specific category of 3d printing, that of the in-home variant, a form of 3d printing called 'fused deposition modeling'. This method of 3d printing is an example of additive manufacturing, a method of producing an object through the aggregation of material. This process produces an object by extruding a filament material into a heating element which then deposits the warmed medium upon a surface. The warmed material aggregates in a pre-determined pattern which then cools and hardens. In the case of most in-home 3d printers, this material is usually one of a variety of plastic filaments which are arranged on a spool. Other print mediums do exist, such as clay (which will be discussed in this study), but also organic material such as sugar and peanut butter. To start the process in the usual manner, a print schematic file is connected to the 3d printer by universal serial bus (USB). The file contains the instructions for the 3d printer to execute in printing the pattern. After warming up the print nozzle and print bed, the running-end of the plastic filament is fed into the extruder which delivers the filament to the heating end (also called hotend) and the deposit nozzle. To facilitate the pre-determined pattern by which the warmed filament is deposited, the heating element is maneuvered over the print surface by a system of motors and pulleys. In addition, some additive 3d printers use a movable print surface, which is also controlled

by a motor. With simultaneous movement of the print head along the x-axis and the print surface along the y-axis, it is possible to trace out two-dimensional curves or straight edges. As the machine elevates the print head for each subsequent layer, vertical z-axis curves and straight edges can also be enunciated in the final product. In this way complex shapes and even movable parts can be created with the 3d printer.

In addition to additive 3d printers, there are other variants which create 3-dimensional objects through processes of stereolithography, selective-laser sintering, and others. I will not go into detail on these or other types, however it is important to consider that 3d printing as a technology constitutes a family of genera. While a more comprehensive inquiry may explore the circumstances that led to the emergence of 3d printing in the home, within academic research, or within factories for industrial purposes, this study focuses solely on the case of the in-home variant, and in particular the additive manufacturing type described above.

To conduct fieldwork for this research, I recruited six participants through online social media networks who have taken up 3d printing as an activity to attend a one-hour Zoom teleconference to share their experiences. Prior to each interview with my subjects, I requested photographs of objects they have printed with their 3d printer as those objects are in situ and as intended to be used. Additionally, I requested photographs of any modifications that the interlocutor may have applied to their 3d printers. These modifications included 'off-the-shelf' upgrades or adaptors purchased by a commercial manufacturer, as well as those custom made by the discussant. In many instances, 3d printing hobbyists or professionals design their own modifications, however there is also an abundance of schematic design material available on the internet which can be downloaded, allowing for the printing of parts which can then be fitted to the machine. These schematics are sometimes sold, but many (if not most) are freely available.

The photographs I requested were primarily used for two purposes. First, to facilitate conversation. Asking for these in advance enabled me to formulate initial hypotheses about the values of the participant and establish a tentative angle of inquiry. Additionally, the photographs afforded richer contextualization of the semi-structured discussion by directing questions to specific prints and modifications. While I used a set of guiding questions to engender some consistency between interviews, I developed the arc of the conversation around trying to depict my subject's experience within three temporal windows: prior to taking up 3d printing, their experience from that instance until the present, and what the future holds for their relationship with the technology.

My interest in these three windows of time derives from an analogous formulation of the research question in terms of mathematical calculus and the physics of bodies in motion. The task at hand was to understand the orientation or directionality of something at a moment in time and explain why it has that orientation, a problem not unlike looking at a photograph and trying to make sense of how the elements in the picture represent movement. In terms of calculus, the process of looking at a line of a graph and asking in what way it is oriented at a specific point is the concept of the tangent. To define the tangent line or vector to a given point on a curve or path representing motion over time, it is necessary to have information about the path as it is traced. In essence, the understanding of the person-printer assemblage as to its form of being-in-action is analogous to understanding the orientation of an object in motion at a given point in time. The requirements for the elucidation of a tangent line of some object in motion then suggest the requirements for the elucidation of some being-in-action. The three moments described in this study are then an initial starting position, a movement along a path, and the entanglement of two

forces which generate a new vector, the directionality of which are thus determined as what I call the *aspirational form*.

From this research I have then identified three pivotal moments which comprise elucidation of such an aspirational form. The first moment I call simply 'predisposition.' In the moment of predisposition, the individual stands apart from the 3d printer and has yet to engage with it discursively, therefore any affect it may have on their being is not yet apparent as a change, but only as suppositions or beliefs. The second moment is 'the turn.' During the turn, the person-printer assembly have begun to correspond in such a way that some change to the form of the assembly is discernible as an outcome of interaction. These events are identified by the coincidence of and correspondence between the values of the person and the affordances offered by the 3d printer which are subsequently transduced toward a concrescence. The third moment is the rendering visible of the 'aspirational form.' The aspirational form pays homage to the emergent aspect and structures the future orientation of the assembly. In essence, it is the acknowledgement that a path has been signaled or indicated; a precursor of a future way of being for the assemblage.

Prior to beginning the interviewing phase of the project, I purchased for myself a 3d printer and took up the practice. In thinking of ways to overcome some of the limitations of Zoom conferencing in lieu of participant observation, I adopted the theory of empathy as posed by Omar McRoberts to work toward "experiential understanding" (McRoberts 2004; 202). This method contributed to my understanding across multiple registers of interaction with my subjects in which I was able to relate personally to details of experience as suggested by their stories. This was most significant in aiding my understanding of the first moment of predisposition as well as the machine operation.

To present the analysis and findings of this fieldwork, I will first illustrate case studies from two interlocutors which offer slightly differing manifestations of the aspirational form before discussion of each of the three moments, in order. I feel that by presenting these case studies chronologically, how the three moments develop into the elucidation of the aspirational form is made most obvious to the reader. The two case studies chosen best express the range by which potential trajectories emerge through correspondence between the individual and the machine. The first conversation demonstrates an aspirational form which accentuates human agency over the material. The second case study presents a stronger material influence on the aspirational form of the subject assemblage. The variance demonstrated with these two cases is illustrative of the range of possibility which emerges through mediation with the printer and illustrates how aspirational forms can be expressive more upon the biological, the artificial, or as emergent in the associated actor-network[3].

Case Study One – Piotr & Printing with Clay

In looking for subjects of the in-home variant on the 3d printing online forum, Reddit, I was immediately drawn by the unusual shape of the modified print-head posted by a gentleman named Piotr. From the looks of the photo in Piotr's post, he had created a print head which could produce three beads of clay filament. This was unusual in that the vast majority of 3d printers use variants of plastic filament, and only print one bead of filament at a time. This unusual configuration led me to wonder for what purpose a three-bead print head might be capable of.

Piotr's photos were remarkable in their artistry, evidenced both in the aesthetic he presented with his style of photography, but also in the uniqueness, visual complexity, and elegance of the

[3] My use of "actor-network" in this situation refers to actor-network theory as proposed by Bruno Latour. See Latour, "Reassembling the Social," 2005.

objects that he had printed. Piotr stood apart from other subjects not only in that he was printing with clay as a medium, but also in that he brought to his creations a high level of artistic skill.

Before our call, I had concluded that Piotr was either a professional sculptor, or at least had some formal background in artistic training. I was correct on the second account. Raised in Krakow, Poland, Piotr had studied fine arts in graduate school, with an emphasis in sculpture with wood. Piotr explained to me that his father was also a sculptor, and his mother a skilled painter. The two of them had worked to repair and restore paintings, frescos, and facades of buildings damaged during the Nazi invasion of Poland during the Second World War. Despite the apparent lineage, Piotr surprised me by explaining that he had only studied fine arts after his parents had both passed. Rather, during college he studied electrical engineering to prove to them that he could do something different from their talents. He told me that his children are the same: "If I ask them to do what I want, they will do the opposite."

Piotr began his passion of sculpting with wood, however after some time he switched to the more yielding medium of clay to ease stress from inflammation in his joints. After discovering 3d printing, he was initially drawn by the idea of being able to create sculptures through design and fabrication by an electromechanical means in lieu of the gestures he was already intimately familiar with. The combination of his artistic curiosity and a perception of 3d printing as offering a way to sculpt that was easier on his body were attractive to him. Nonetheless, he eventually turned to a clay printer out of an affection for the medium. Although his first printer was a Prusa brand using a plastic ABS[4] filament, he stumbled upon a Polish manufacturer of a clay 3d printer

[4] Acrylonitrile Butadiene Styrene (ABS) is noted for its durability and scratch resistance.

at an exhibition. In this excerpt from our conversation, Piotr explains to me the issues he noted with the design of the clay printer.

> They built this printer that was not so sophisticated, but it was the first time I saw someone who printed something (clay). Now they are my friends, so they sold me this printer. I was working with the extruder because the extruder was not so good. There is a motor that through an auger puts clay to the nozzle. Their extruder had a seal leak, so clay and particles of air go to the nozzle. When you have some particles of air inside the clay, so the pieces you print sometimes have holes.

Piotr explains to me that he spent about half a year working on a redesign of the motor and auger. Using the Prusa printer, he printed his modified auger design using PLA[5] filament (a corn-based plastic), as well as a rebuilt housing for the motor. The improved motor and auger design, he told me, performs better by laying a smoother bead of clay with less air bubbles. After telling me about this performance improvement, we discussed the more elaborate invention.

> I have designed my triple color extruder because no one mixed clays together. I wanted to know what would happen if I mixed it. So there are three augers and three motors pushing it, and a third AC motor that turns a small micromixer. So it is possible to mix clays, but also possible not to mix it. (see figure 1)

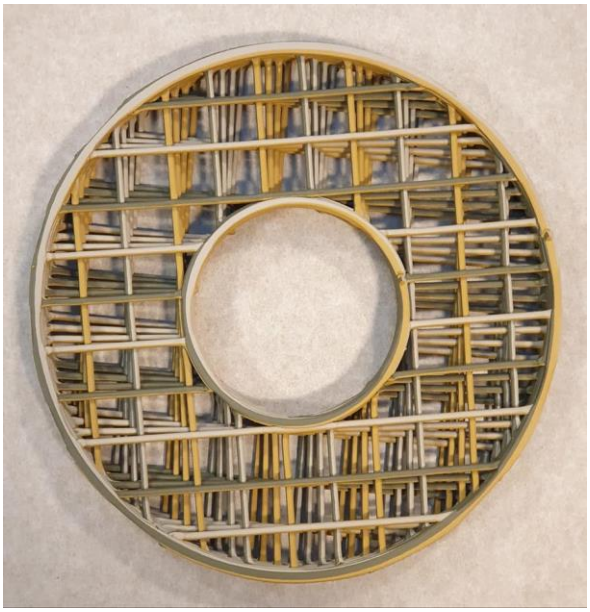
[5] Polylactic acid filament tends to produce smooth surfaces and fine details in prints.

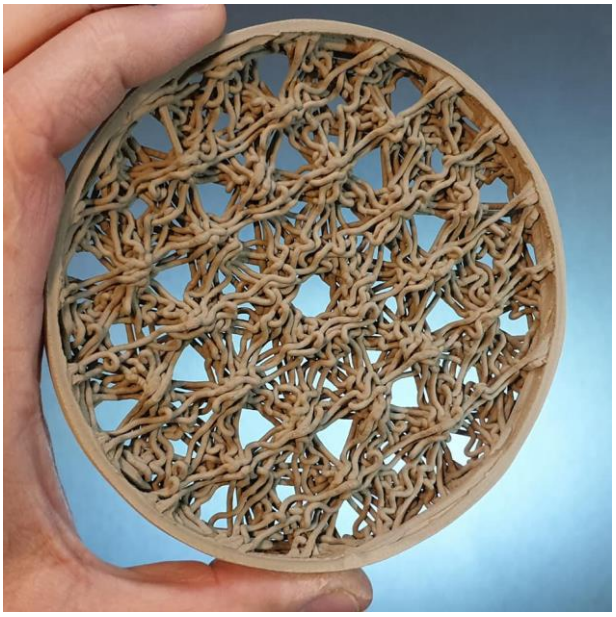
Figure 1. Triple Headed Clay Filament Extruder

Note: Not included in this photograph are tubes which feed the clay filament into the top of the extruder. (Black squares at top of photo). Plastic augers rotate within the extruder assembly to force clay into the nozzle at bottom. Photo provided by subject.

To demonstrate what his invention is capable of, Piotr showed me two identically shaped prints he had made with the triple filament print head. Each print is a circular disc with a lattice of clay material. One print is composed of three colors of clay, the other print by contrast was made by mixing the clay at the hot end. (see figures 2 and 3, next page).

Figures 2 and 3. Clay Prints Produced from Triple Filament Extruder





Note: Photos provided by subject.

Each print is demonstrative of the surprising complexity which the machine is capable of printing, a granularity that would be exceptionally difficult (if not impossible) for the hands of most sculptors. The contrast between the two prints is also demonstrative of the way different colors of clay may be arranged relative to one another; either separate or blended. Piotr explicates on how he perceives the strengths and weaknesses of his invention:

> I think it is impossible with other techniques to do such a thing. 3d printing is very good for making some things, but not for making other things. The pottery made on a pottery wheel is much better than ceramics printed on a 3d printer, because the clay when mixed with hands, it is one structure. This system of the 3d printer is placing layer after layer, and so it is not so strong. But sometimes, 3d printing is opening new horizons to do things in a totally different way. For example, this extruder, cannot be done a normal way. There is a very thin hole with a 2mm diameter that passes through the housing. It is very hard to make

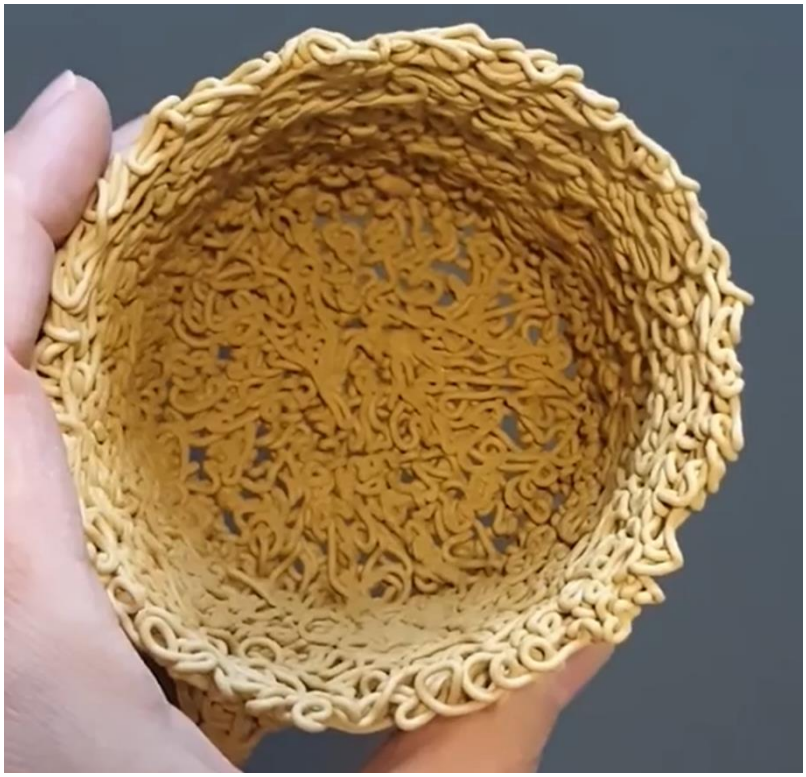
a drill bit with CNC[6] that can make such a thin hole. On the 3d printer, it is only a 30-hour print.

As Piotr explained, the method for making clay on the wheel affords a stronger bond between the molecules of clay, however, the elaborate patterns of his prints would be extremely difficult to construct by hand. By contrast, the 2mm print bead can be produced using the specialized auger made of PLA. The PLA auger is generative of a finer bead than that drilled in steel from a CNC machine. These affordances are considered in Piotr's thought process and orient his exploration of the capabilities of the technology, although they may initially appear trivial aside from the aesthetic beauty.

To demonstrate his next point in our discussion, Piotr retrieved another sculpture he had made. This sculpture looked much like the nest of a bird, a seemingly haphazardly laid tangle of clay which forms the outline of a shallow bowl. (see figure 4, next page). He told me that he can accomplish this by holding the extruder in his hand rather than attached to the gantry system of the 3d printer. In this style, he can control the placement of the clay material himself. This technique appears to suggest a compromise between the formation of a uniform bead offered by the print head, and a departure from the rigidity of the pre-determined print schematic. In this mode of printing, the seeming randomness of the unsteady hand's gesture is embraced in lieu of a detailed plan. With respect to Piotr's experience as a skilled sculptor, this exercise seems to suggest a dialogue, a back-and-forth between his talent and what the machine offers. In this way of use, he regains some control over the outcome of the print.

[6] Computerized numerically controlled (CNC) machines are electromechanical machines used for the cutting, drilling, and shaping of hard metals with the use of metal bits.

Figure 4. Clay "Bird's Nest" Printed Free-hand



Note: Photo provided by subject.

Piotr offers further explication of how he sees his personal style of innovation as part of something larger than himself:

> If you are doing anything in your life, you don't know what might happen tomorrow. You need to learn a lot in different branches so that maybe you will find something interesting. I still do not know what printed ceramics is for. I am doing it, but I don't know why. I don't know its usefulness. But, maybe in the future some people will see this, and discover perhaps they can put it together with something.

To help him make this point, Piotr then held up something which resembled a coat hanger, made of a thick dark grey material. Embossed on the side of the coat-hanger were the words "I am made of skirt." As he described, there is a company in Poland which recycles clothes but does not

know what they should do with the material. The material is broken down and processed before it is pushed through an extruder.

"It's all made of trash."

For Piotr, the experimentation with the 3d printer was not about achieving a superior printed product and it was not about creating novel artworks for him to show off. Rather, he was interested in exploring what potentials are latent in the combination of materials and machine. By testing what could be done with clay and what could be done by changing the engineering, he pushes upon the boundaries in the hopes that what he invents could be taken up by others in a productive way.

I was curious about what might motivate this for Piotr. I asked him if he intends to patent his inventions for potential future productization.

"No. Creative Commons Zero. It is my favorite thing. Do you know about this?"

"Please tell me about this."

"Creative Commons Zero. If you see something on the internet, you can take it. Think. Change. Put it back on the internet. *Nihil est in intellectu quod non prius fuerit in sensu*. There is nothing in your brain, that you haven't seen before."

According to their website, Creative Commons Zero "is a nonprofit organization that helps overcome legal obstacles to the sharing of knowledge and creativity to address the world's pressing challenges" (CC0 2019) For Piotr, there is no desire to commodify his invention, rather he seeks to share it with the world. But why? To understand this, we must consider his philosophy.

Nihil est in intellectu quod non prius feurit in sensu. Known as the Peripatetic axiom, the spirit of the idiom originates in the Lyceum during and after the headship of Aristotle, and Theophrastus of Eresus after him. As noted by Robert Sharples, the school was known to collect and interpret information in every field, knowledge which was then put into dialogue to reveal theoretical challenges which could then be overcome (Sharples 2010; 147).

In Piotr's case, we can interpret the Peripatetic axiom as operative upon his predisposition on two levels. First, it orients his engagement with skills. By waiting until the passing of his parents to study and subsequently demonstrate talent as a sculptor, he implicitly demonstrates his logic that the talent was present in him without having formally learned it from his parents. Rather, he chose to study engineering while they were with him so that he could bring a new set of knowledge into the household, rather than recirculate what was already latent in his family lyceum. Second, the Peripatetic philosophy circulates through Piotr. By (re)placing his knowledge back on the internet for the world, he adds to the collective epistemology with something new, even if that knowledge is not yet taken up in a useful manner. In Piotr's case, the moment of turn occurred when he came to possess 3d printers which printed two different mediums. This affordance coincided with his Peripatetic philosophy to ask how their synthesis could open new possibilities. Using the plastic filament with the Prusa printer to produce new augers and subsequently print a new extruder assembly for the clay printer thus positioned Piotr for further discovery of modes of being. The design and creation of the mixing print head demonstrates the aspirational mode of the Piotr-printer assembly. In this emergent form, Piotr is searching for uses for the blended material, seeking ways to synthesize his contribution of knowledge with others, thereby articulating his Peripatetic values.

Although many others within the community of 3d printing may not be familiar with the history of the Lyceum, the attitude of freely sharing knowledge for the betterment of all is relatively common throughout the culture. Like Mumford's syncretism, 3d printing enthusiasts recognize the potential for broad technological advancement that results from the blending of ideas. For many in the community, this knowledge bears special value in that it can be taken up freely, without commodification by industrialists.

While Piotr's case illustrates an aspirational form that is easily recognizable in its material manifestation, I will now share a case which presents in a slightly different manner with an aspirational form that articulates within the associated milieu aside from the material.

Case Study Two – Sam and Scale

Within the various subcultures of 3d printing lies one which is significant for its controversy, and in some ways is particularly American in its ideals: the printing of plastic guns. These guns are not toys, however—they are the real thing. The potential for fabrication of firearms was one of the earliest capabilities engendered by in-home 3d printing which drew attention to the technology in its nascent emergence as a highly open-ended platform with an unpredictable future.

Sam, a technology consultant in New Jersey, is a self-proclaimed pro 2nd Amendment patriot and is part of this subculture—a detail which he volunteered without provocation. As he clarified, however, it was not the ability to print firearms that drew him to 3d printing, but rather the high degree of customizability afforded by the machine:

> The thing about the (3d printer) was that there were so many add-ons for it. You could make it a completely different printer by changing a lot of the things on there. You could even print some of the modifications. A lot of the firearms I have, I built from the ground

> up. I like that intimacy with the machine itself. You know? Being able to customize it and make it into something of my own.

In Sam's case, he may have become aware of 3d printing through his social circles that included people who saw the technology as an avenue to safeguard their Constitutional right to bear arms, but it was the aspect of making something intimate that drew him in. The moment of predisposition for Sam was a coinciding of his enjoyment of customization in hobbies and a perceived quality of customizability afforded by 3d printers. This is not to understate the importance of his affiliation with the subculture of 2A 3d printers, but rather to highlight that aside from the force of culture, interior values such as an affection for customizing can often dominate the decision-criteria when they coincide with a perceived affordance.

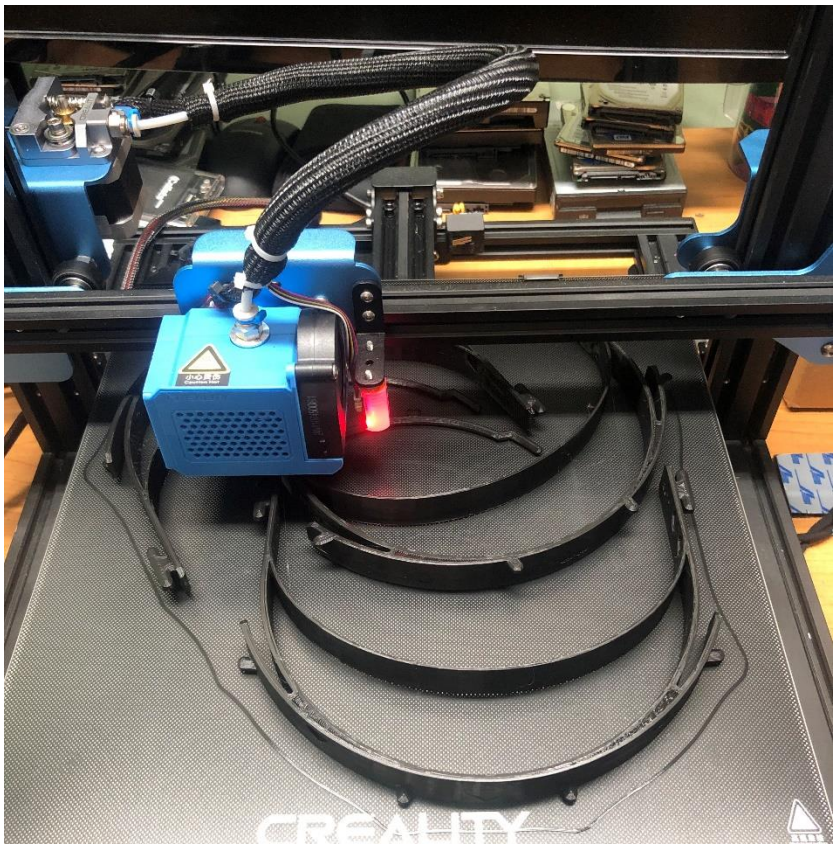
When Sam shared photos of his prints and printers, one that stood out was a photo of his sister-in-law, a nurse, wearing a protective face mask. Here he discusses the photo, taken in the early days of the coronavirus pandemic:

> When the pandemic began, I saw that there were a group of people that were printing personal protective equipment (PPE) for healthcare workers. So I thought to myself—'This is something that I have to do. I absolutely have to get into this.' So I began printing face shields for my sister-in-law's hospital. (see figure 5, next page).

Around the time that Sam began providing the hospital staff with facemasks, shortages of PPE were impacting hospitals across the country. Realizing how important this was to his country, Sam purchased more printers—as well as a model CR-10 printer with a much larger print bed. The staff at his sister-in-law's hospital were thankful for his contribution.

"Everybody in her ward, they all signed a card thanking me for sending the face shields. So I posted that on my timeline on Facebook, and a friend saw it. Her son was going for his Eagle Scout, and for his project he wanted to print these face shields for local first responders."

Figure 5. Printing Face Shields for Healthcare Providers



Note: To complete the face shield, a clear panel of plastic is inserted into the headband.

Photo provided by subject.

As a strong proponent of the Eagle Scouts, and as a father to a Cub Scout, Sam was jubilant at the opportunity to mentor. He helped to advise the project with printer and filament selection, as well as education about how to print. In the end, he and the young Scout worked together to print hundreds of facemasks as well as other pieces of PPE for the hospital staff.

After the supply shortage of protective equipment began to subside, Sam was left with multiple 3d printers to include his large CR-10 model. Rather than sell them, however, Sam began to print more things in bulk.

"I am also a bowler, so I printed these rings, they are ball cups to hold a bowling ball while you clean it. I printed a bunch of charging stations for iPhones and Apple watches and things like that. I also printed these 'COVID keys.'[7] "

Sam was not ready to do-away with his newly formed bulk production capability. Meanwhile, he was also experimenting with new filament types such as carbon fiber PETG[8] and ABS for printing gun parts. Doing this required modifying his printers, however.

> A lot of the people in the (firearms printing) community were talking about different materials they were using, but you needed to have a heavily modified printer to do it, which is where a lot of my mods came in. The first was moving to an all-metal hotend. You need to be able to crank up the temperature to print these materials. Another thing was moving to a steel nozzle because a lot of those materials are abrasive. If you use a typical brass nozzle, it would erode rather quickly.

In this instance we can see how Sam is considering a combination of factors in his decision process. His experimentation with other filaments incurs a requirement to modify the printer because of the higher temperatures necessary to melt the material and minimize abrasion. For Sam,

[7] Covid keys are small objects that resemble a key used for open and closing doors without contacting the door surface. These 'keys' are intended to reduce surface transmission of viruses.
[8] Glycol modified Polyethylene Terephthalate (PETG) is a filament type noted for its ease of use, strength, and flexibility.

learning about the substance of material and the modification requirements is consistent with his motives to take up 3d printing as he was originally predisposed to, as a hobby.

Thinking about my own recent experimentation with different layer heights, I asked him if the carbon fiber is printed as a thinner layer, as it requires more heat.

"No. That is actually something I learned about by accident. You want to print at a higher layer height because the prints are stronger. If you use a smaller layer height, what happens is those layers are more prone to separating."

This reply reminds me of what Piotr had said about shaping clay with the wheel by comparison to that which is printed. It seems with both clay and plastic filament thin layers produce a more brittle print. In either case, this acknowledgement reflects a discursive learning process that contrasts affordances between similar material forms and mechanical techniques.

For other modifications, Sam also replaced his thermistor and heating element for the hotend, as well as upgrading to a direct drive extruder.

In addition to printing firearms components and further customizing his 3d printer, I was curious about what might be next for Sam. His reply clearly suggests a coming-together of his values and the affordances of the technology.

> I have seen that with a lot of the things I am interested in, I can find video courses for them. And I like to teach, so I think the next progression for me will most likely be teaching people about 3d printing and how to troubleshoot some of the issues they're having, to try to make it easier for them to enjoy the hobby. It's just a matter of sitting down and scripting it out. I don't think I would have a big problem marketing it. There are plenty of people on Facebook who would be more than happy to pay for it.

Sam was originally motivated to take up 3d printing by the affordance of the printer to be customizable, something which aligned to his values as a hobbyist. In the moment of the turn, however, we see that Sam recognized the ability of the printer to produce things in bulk, a quality for which he had no prior suppositions. Understanding Sam and printer as an assemblage, we see that after the turn the assemblage was now possessive of 'scale', the ability to repeatedly produce in bulk volume, with volumes adjusted to need. In Sam's case the aspirational form presented is one in which his value of mentorship coincides with the assemblage's newly formed propensity to scale as well as the knowledge gained through the discursive activity of modifying the printer. Creating videos which can pass along his knowledge and experience with the technology contributes to the actor-network of the 3d printing community. Thinking through this sequence in reverse, we can see how the aspirational form of the assemblage as-is requires the experience of the turn, which likewise is dependent on the combination of values and affordances which present themselves following the moment of predisposition.

The narrations of these two case studies demonstrate the process of creating 'potential trajectories' by the coming together and interacting between individual and machine. Each is illustrative of how values and affordances coincide within the assemblage in the margin of indeterminacy, ultimately corresponding in a way that leads to the emergence of a novel potential trajectory. In these examples it is possible to get a better sense of the ways in which specific potential trajectories are then selected and oriented toward *qua* the aspirational form. The three moments (predisposition, the turn, aspirational form) were presented chronologically to demonstrate how each informs the next. I will now discuss each pivotal phase in greater detail.

The First Moment - Predisposition

Most people who take up 3d printing can be understood as coming to the practice in one of two general ways. The most common group are those who are pre-existing hobbyists that become interested in 3d printing as an activity. When speaking of what drew them in, they speak of things in terms of their satisfaction with creating, modifying, and other forms of tinkering.

Consider this excerpt from my discussion with Chazz, a paramedic:

"I like creating, I like making things. When I was in high school, I took engineering and I liked CAD (computer-aided design) and it was neat to design stuff but I never really got to see it come to fruition."

In Chazz's case, he was predisposed to 3d printing as an end unto itself, rather than a means to produce things. When asked about his first prints, he made no clear indication about specific objects he had set out to make, but rather made "trinkets and things" for friends and family.

By contrast, others who take up 3d printing do so from a position of utility toward a specific kind of outcome. For these people, the technology is a means to an end in which an exigent circumstance suggests that 3d printing will afford them some way to create something useful. Consider the example of Riordan, a computer repair technician and inventor. Riordan had invented a consumer product which was manufactured by a factory in China for sales in North America. His product, a device that attaches magnetically to the tank of a motorcycle, is used to clean the visor of a motorcycle helmet. The process of making design changes for his product was costly and took many days between iterations as he would have to rely on injection-mold manufacturers in China to create each prototype. When he discovered 3d printing, he saw an opportunity to easily create prototypes that he could test at home. (see figure 6, next page)

Figure 6. 3d Printed Design Prototype of Visor Cleaning Product

Note: Photo provided by subject.

For each modality of engaging with 3d printing, the types of potential trajectories that are made possible are the same, but the likelihood of choosing some paths over others varies by predisposition. For those who are drawn to 3d printing as a hobby, the activity of tinkering or modifying the printer itself is already established as a recognized affordance. These individuals approach the technology with a readiness for dialogue. For those who are drawn to 3d printing to create a specific item, the out-of-the-box configurations may be more attractive while the affordances offered by the items which are printed may be more likely to be taken up as important.

For the individual first learning about the technology, or learning of some new component upgrade or modification, the set of values which are brought to the interaction are seemingly limitless, establishing a hierarchy of goals that are understood consciously as well as

unconsciously. A person might have values about their family, their politics, their perception of art, health, or culture—beliefs relative to any concept which has any degree of importance to their life is likely influenced by a set of values. The affordances offered by the machine may also be equally numerous, but prior to assemblage those affordances lie in a dormant state as potential—not yet revealed as *affordances*. The moment of predisposition thus constitutes the event of bringing together the individual set of values and the set of properties and qualities of the material in such a way that instigates an automatic reordering of values through the identification of affordances from the material potential that invite interaction. Once knowledge of the potential within the material initiates entanglement with the values of the individual, the moment of predisposition wanes toward the second moment of interactivity, the turn.

The Second Moment - The Turn

Each participant in this study had at least one remarkable experience with their 3d printer, which was for them, fascinating or worthy of talking passionately about (most had multiple). Commonly known as the eureka effect or epiphany, these turns constitute a fundamental shift that alters the relation between the person and their printer. For Piotr in the first case study, his excitement when discussing the design of his plastic augers was palpable. It was not enough to simply point out that they were different, but instead he took a considerable amount of time to explain to me the physical and mathematical logic he had applied in creating the new design. In telling me how fluid dynamics and the differing properties of friction between PLA filament and aluminum contributed to why his invention was superior, he was revealing to me that he was very much in his element with this part of the conversation. The realization of using the PLA printer to create a modified component for the clay printer was an expression of what he valued and its concrescence with the affordances of the machines. For Sam, this moment was realizing the printer

he possessed could be used for more than printing things one at a time but could be used to print many things at once—in his case—face masks.

For some, the eureka moment may not be consciously recognizable, yet still operative on their intentionality. Rodric, a train operator in the U.K., has children with special needs who became interested in the role-playing game Dungeons & Dragons. In our conversation, he told me that he took up 3d printing because he found it more cost-effective to print out the various figurines and game tiles used in playing the game than otherwise purchasing them. Given the expensive models of his three printers I was doubtful about his estimation as their cost would greatly exceed that of buying the figures in stores. Only later in our conversation did I learn that he had begun printing cosplay items as a hobby of his own, which might begin to explain the purchase of a second and third printer. We also discussed his printing of useful things to support his father, who had recently suffered a stroke that caused paralysis in one arm, as well as how Rodric had taken to painting figurines with his son, something he thoroughly enjoyed. For Rodric, the turn was realizing that 3d printing afforded him a personal pleasure that was distinct from the utility it offered him as an original investment. In his moment of predisposition, he had not known that 3d printing could be something for him, as much as for his children. While this may not seem remarkable initially, it is important to consider the context of Rodric's experience within his family life. When working as a train operator, he spends much of his time alone. When he is home, the demands of raising children with special needs is something he indicates is foremost to his identity. In this way discovering something which can bring pleasure to him as well as his children takes on a special significance, one which causes him to seek ways of integrating his own happiness into that of his family.

Whereas the first moment establishes for us a kind of benchmark in which entanglement is not yet manifesting of change, the second moment indicates the beginning of a concrescence. This is the starting point of the super-additive nature of becoming for the assemblage. In each moment of turn, the mediation between the person and the material results in something entirely new. While this manifests mentally as an epiphany for the individual, it is the revealing of an affordance for the material that was previously hidden. This is not limited to a single instance, however. As noted previously, the correspondence of values and affordances may be multiple and so there can be multiple ways to characterize a concrescence. What constitutes a meaningful second moment is thus the presence of a third moment; or an aspirational form.

The Third Moment – The Aspirational Form

The challenge presented by this research was to explore how we might approach understanding why particular paths are chosen over others and hence make some measured inference about the future of an assemblage. While I hesitate to explicitly call my conversations with interlocutors an attempt to forecast, it is fair to say I was trying to illustrate a bearing or heading for the assemblage in the same way Malafouris was trying to understand intentionality for the individual and the agency of material. For this reason, the third moment is only an aspiration, or an emerging directionality for the assemblage, one that is contingent on the first and second moments to form a logical orientation. In calling this moment 'aspirational', attention is drawn to the question of intentionality of the assemblage while also recognizing the potential for diversion and the uncertainty of that future. In this moment the values of the of the individual as intention and the affordances of the material have established coherence and concrescence has generated new ways of being for the assemblage. This moment is the moment of greatest importance for the assemblage as it is the moment *in action*. By contrast, the moment of predisposition only exists in

retrospect, as does the moment of the turn. The aspirational form is the form of any assemblage at any present moment. The analysis up to this point is thus only necessary in the elucidation of the aspiration.

For each of my interlocutors, drawing out a clear description of the aspiration required instigating a reflection on the prior moments. For them, this was made salient when discussing what the future held for their relationship with 3d printing, a question that I saved for the end of my interviews. In asking them this nonspecific question, I was offering a locution, the percolution of which was an explicit contemplation necessary to form a response. The timing of this contemplation is important as my discussants processed this reflection after having spent considerable time thinking about and speaking to their values and perceived affordances. Consider the exchange between Sam and I when I asked him about his future with the technology, paying particular attention to the progression in his thinking from one sentence to the next.

> "So, what is next for you with 3d printing?"
>
> Ah, that is a good question. I have been thinking about that quite a bit myself. I have been looking at things that I can print that I could sell to make some money. Maybe turn it into a business. But a lot of what I am seeing now is that there is a huge opportunity for teaching. There are a lot of people that are getting into 3d printing and have no idea what they are getting themselves into.

This comment was followed by Sam describing his plan to create instructional videos to share with others learning the hobby. Taken together, the progression in his thinking is indicative of how his values which were present in his predisposition (value of mentorship) have become entangled with the propensity for scaled production which emerged from the moment of turn. The

assemblage now aspires toward making use of the knowledge produced through his experience learning with the machine, in a manner that is scalable to many students.

In some cases, what my subject said about their aspirations and what I consider to be the actual aspirational form are seemingly in contradiction. The paramedic Chazz, for example, described his next steps with 3d printing in terms of streamlining the set-up of his workshop:

> I want to get things set up in a function printing area that is neat and orderly… (there is) some print farm software out there where I can hook all the printers up (and I can) serve up the files and have everything ready to go with ease. If somebody needs a part printed for something, I can just send it to the printer and go.

I hesitate to buy into Chazz's claim of arranging this setup so that "if somebody needs a part printed for something, I can just send it to the printer and go." In discussion with Chazz, he described printing novelties and what he calls "pretty things" for others, items with more aesthetic value than practical. When talking about the benefits of 3d printing, however, he was proudest of his experiences learning to print things to fix home appliances. As someone who was initially drawn to 3d printing as a hobby during the moment of predisposition, and as a paramedic, Chazz finds satisfaction in finding solutions to puzzles and problems. Serendipitously, the turn for Chazz was learning that others were impressed with his 3d printing and would ask him to print things for them. Judging from his photos and our discussions, however, most of these requests—and most of what he prints—are trinkets and toys rather than practical fixes which enable him to exercise his ingenuity. In essence then, it is his personal value to appease others around him and create things they desire which may underly his motives—as much as solving problems. The recognition of potential modifications to his "set-up" corresponds with this subconscious value of pleasing his friends and family, causing him to concresce with the affordances he has described aspiring to,

that of rapid, on-demand, creation. This is suggestive of how values tend to operate to structure our intentionality at both the conscious and subconscious level and can dominate over our behaviors. In instances such as this when the aspirational form of the assemblage is coherent to subconscious values but seemingly in contradiction to the conscious intentionality of the individual, we might regard the affordances of the material as more expressive upon the aspirational form.

Discussion – Values and Subjective Intent, Revealing Affordances

In this essay I previously defined values as "conscious, or subconscious attitudes that matter to [a person's] life and structure their intentions." It will be useful to explicate this definition somewhat by drawing attention to the variable manifestations of value as a kind of subjective register. Namely, values can be understood both morally as well as economically (although it may be argued that economic decisions are moral decisions). For the former, moral values are themselves closely related to our understanding of the virtuous as classically proposed by Aristotle and later notably revisited by Immanuel Kant, amongst others. Whereas Aristotelian and Kantian perspectives tended to treat values as universal, (see Sherman 1997; cf. Aufderheide 2015) sociologists such as Emile Durkheim and Max Weber[9] advanced a socio-cultural basis and relativity of moral value—a perspective widely accepted today—although not necessarily in opposition to the existence of intrinsically human values (Durkheim 1957). Aside from the question of how values accumulate in the individual, the concept of values as a force that contributes to the guiding of our behavior is consistent with that early philosophy of Aristotle in which we seek achievement of a state of *eudaimonia*, or "flourishing well-being" (Hursthouse,

[9] While some might suggest that Weber was first and foremost a rationalist, Stephen Turner and Regis Factor argue that this is not in contradiction to the social formation of value as Weber maintains a political basis for rationality. See Turner and Factor *Max Weber and the Dispute Over Reason and Value* (Routledge, 2014) 23.

1999, 9-13, see Mckay 2016, 409). Within our social and cultural lives, we seek out that which we understand to be good, as conditioned by and reasoned through our lived experience amongst peers, kin, and our communities.

By contrast to moral values that cut across our subjectivities, we also assess the material world in terms of economic or use value. Referencing Georg Simmel's *The Philosophy of Money*, Arjun Appadurai describes the comprehension of value as a judgement that is never inherent to objects, and only arises on a case by case basis: "that subjectivity is only provisional and actually not very essential" (Appadurai 1988, 3; see Simmel 1978, 73). As Appadurai notes, this understanding of value moves the locus of determination of the value (*qua* evaluation) from the object to the person; "the economic object does not have an absolute value as a result of the demand for it, but the demand, as the basis of a real or imagined exchange, endows the object with value" (ibid, 4). This characterization seemingly relegates the object or material to an impotent state in that the provisional nature of value as subjective is conditioned entirely upon the activity of evaluation, an activity which is ultimately performed under the guise of objectivity and contingent on context. The commodity form of value thus constitutes the potential for disagreement with moral values that must be resolved through deliberation, with perhaps the greatest potential for conflict arising under capitalist systems that impose extrinsic criteria upon valuation.[10] This paradigm offers the illusion of objectivity to evaluation by conditioning the individual to ascribe some metric (usually monetary) to the "worth" of some object. Ultimately, the reality of economic valuation is subjective in the same manner that moral value arises from social contingency, despite its rational veneer. As a culture, 3d printing seems to offer the potential to disrupt this edifice of

[10] For an excellent demonstration of how systems of capitalism instantiate conflict between moral and ethical values, see Zwolinski 2008. Cf. Snyder 2009.

commodification by *almost* eliminating the cost or price basis of valuation of objects and material. Contrary to my expectations, however, I did not observe a significant overt expression of 3d printing affording such benefit from my interlocutors. Instead, the relation between price of filament and cost of print was front-of-mind for many, although the ability to circumvent purchasing through 'traditional' capitalist channels was expressed as a benefit by many of my subjects who recognized its cost-saving potential, such as Rodric.

Central to my discussions with my interlocutors was gaining an understanding of how beliefs about the benefit of the technology—such as its economic benefits—structured their actions. Were they seeking liberation from consumerism, or was the 3d printer merely a toy to bring happiness? Had they encountered some practical challenge which needed a solution offered by 3d printing they couldn't find elsewhere? Did the awareness of 3d printing enter their life in a way that caused them to resolve some larger quandary? While each of these questions points to different related discussions, each shares a fundamental relation toward something much larger, more general, and innately human: our pursuit of well-being.

In his essay *Eudaimonia and Culture: The Anthropology of Virtue*, Francis Mckay argues that two stages in the theorization of eudaimonia have established our present understanding of the concept. He claims that the first stage stretched from the ancient world to the late twentieth-century and was typified by a sustained consensus that eudaimonia relates to "three related terms; 'virtue', 'wisdom', and 'flourishing well-being'" (Mckay 2016, 409). The second stage, according to Mckay, was the formalization of studies of "subjective well-being" within the domain of empirical studies (ibid). In his essay, Mckay proposes that the movement toward this empiricism of eudaimonia primarily concentrated within economics, quantitative social sciences, and psychology have largely lost attentiveness toward the role of culture, the study of which was relatively more

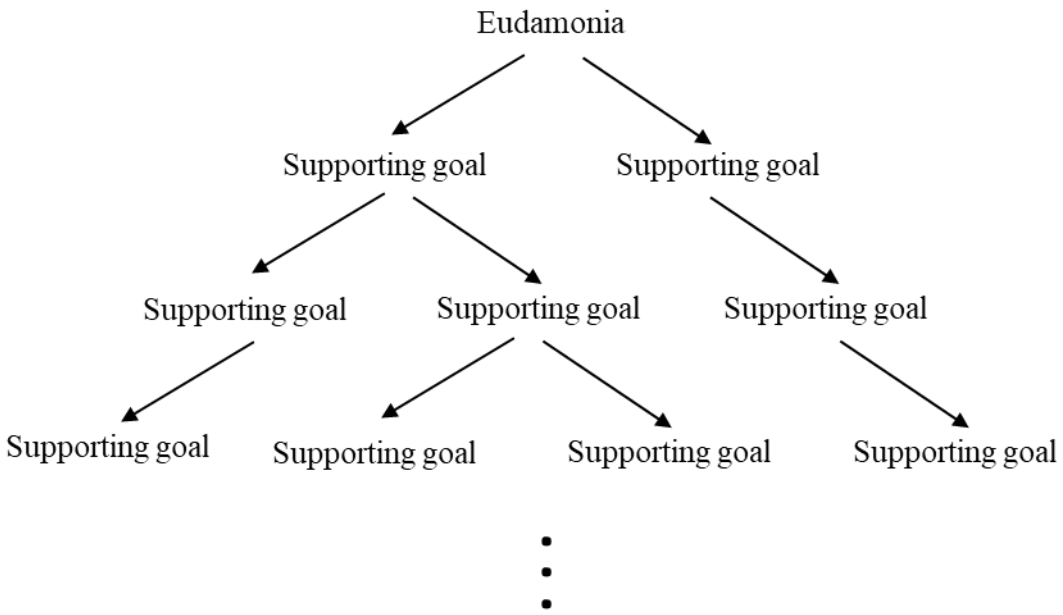
pronounced during the first era. The author argues for the instantiation of a third phase in the study of eudaimonia which they call a

> Critical eudaimonics" [which] reintroduces culturally situated understandings of eudaimonia through thick historical and ethnographic descriptions of virtue, wisdom, and flourishing well-being to highlight the conditions in which people actually cultivate eudaimonia in everyday life (ibid, 410).

While I will not weigh in on the merits or demerits of such a study, I would offer to Mckay a suggestion that the third phase he proposes may also reclaim an understanding of virtue as inclusive of subjective assessments of material. Recalling the Nicomachean Ethics, Mckay quotes Aristotle as such: "every virtue causes that of which it is a virtue to be in a good state, and to perform its characteristic activity well" (Mckay 2016, 410-411; see also NE ii.6 1106a15; trans Crisp 2014). Mckay clarifies Aristotle's perspective on doing an activity well: "at the right time, about the right things, towards the right people, for the right end, and in the right way" (ibid, see also NE ii.6 1106b20). While this perspective known as virtue ethics has come to be well-understood today and extensively explored by scholars such as Alistair MacIntyre (see MacIntyre 2007), a less discussed detail is to what extent the ancient Greeks limited the agency attributed to such activity to people, or even the living. The word virtue, or ἀρετή (arete) in Greek, is mentioned frequently in ancient texts which discuss the topic of ideal life. A canonized example of such works is Plato's *Politeia*, or *The Republic of Plato* as it is more commonly known. In a discussion with Thrasymachus, the protagonist Socrates in his method of elenchus argues that horses, eyes, and ears all have *arete*; virtue to accomplishing a kind of work—the work specific to them (Plato Book I 352d – 354c; trans. Bloom and Kirsch 1968). He also discusses the virtue of the soul and its action on the body (ibid, 403d), and the virtue of a city to its citizens (ibid 433-442). What is clear

from these examples is that the ancient Greek understanding of virtue—at least for Socrates and his interlocutors—was not limited to the activity of humans, the living, or even the corporeal. Furthermore, the understanding of virtue as put forward in Politeia is one of direct correspondence to two aspects: an intrinsic purpose and a superior aptitude toward the activity of that purpose. How then might a third phase in the study of eudaimonia reclaim this expansive definition of virtue? The answer is by acknowledging the influence of the material on our subjective decision making by its action on our goal setting and our ability to perceive attainment of those goals. As Mckay acknowledges, the concept of practical wisdom is a kind of "teleo-logic" (Mckay 411, see MacIntyre 2007 pp 161-162). Mckay describes this as "the form of a practical syllogism, in which the action (the conclusion) is entailed by the premises and the reasoning about those premises" (ibid). Aristotle summarizes this process in three stages: desire, deliberation, and rational choice (ibid). Thomas Hobbes offers a similar framework in speaking of human nature but expands upon the first element to be inclusive of embodied states which can manifest in response to internal or external stimulus, such as hunger or attraction (Hobbes, book I, chapter 6, pp. 127). From these definitions and discussion of virtue we may draw out an understanding of the pursuit of eudaimonia which is inclusive of the effect of non-human material on the rational-choice model through inclusion of external stimuli in the act of deliberation. The introduction of new information about material properties and qualities enters the awareness of the individual and immediately incurs a comparison to all prior knowledge; a comparison which registers across our desires, fears, hopes, and tastes,…,each facet of life that bears upon a sense of purpose. Schematically, this can be portrayed as a set of nested priorities which support the pursuit of euidamonia and are subject to recalibration with the introduction of new information from our material surroundings (see figure 7, next page).

Figure 7. Schematic Representation of Hierarchy of Goals



In addition to recalibrating with new information, the set of nested priorities we work toward would also change in response to mood and other factors. Additionally, goals may overlap, or even conflict. I can have a goal of maintaining good health which has supporting goals such as diet and exercise, and this can conflict with my goal of tasting good food. Importantly, mood helps us to stabilize this structuring by directing our attention and mediating tension between goals. The discursivity implied here cannot be overstated—intentionality for the individual is moderated both internally through our moods and beliefs about our goals, but also through external stimuli.

In his book *Perception: Seeing Things as they Are*, philosopher John Searle offers this definition for intentionality: "Intentionality is that feature of the mind by which it is directed *at*, or *about*, or *of* objects and states of affairs in the world" (Searle 39, emphasis Searle's). In agreement with Aristotle and Hobbes, Searle goes on to propose types of intentionality such as the physiological (hunger, thirst), emotional (lust, fear), or what he calls "derivative forms" such as

belief and hope (ibid). In Searle's framing, these forms of intentionality operate within a "Network" of intentional states and upon a "Background" of aptitudes or capabilities which are preconditioned upon knowledge (Searle 2015, 49). Viewed in this way, the set of conditions for action are a desire to act as deliberated against one's other desires, fears, physiological motives, etc., and the aptitude to do so. In Searle's framework, action arises when intentionality perceives in the environment the conditions to satisfy the intent. Specifically, when in the active sense, Searle refers to *intention-in-action*, which, rather than being purely deterministic is a kind of "trying" (ibid, 102).

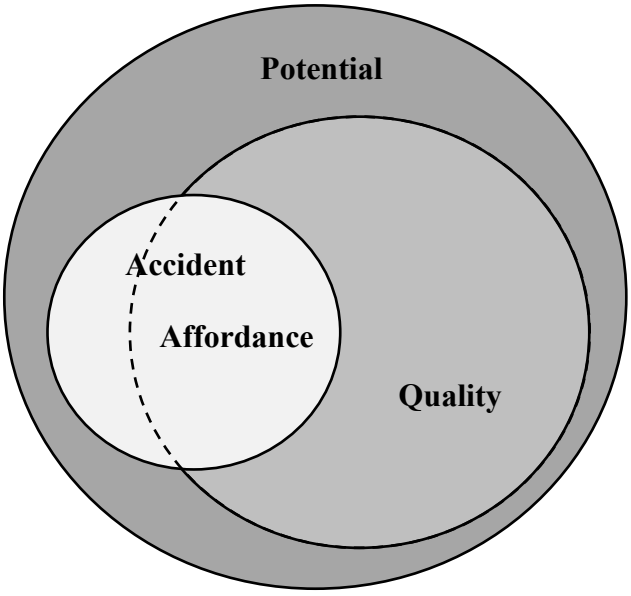
While Searle's 'Network' and 'Background' may be taken as very broad and generalized concepts which align to the logic of the moment of predisposition, they do not quite capture why this action or that action are chosen amongst the various opportunities which are presented—they don't explain the moment of turn as a *choice*. Our intention structures our action, but how are our intentions structured, or ranked? The answer goes beyond Searle's Network and Background and concerns the alignment of affordances as perceived in our environment with respect to our hierarchy of goals. Gibson describes affordances as qualities of the environment which can take on various potentials—a fire affords warmth, but it can also burn, for example (Gibson 2014, 94). In the hypothetical scenario of a singular instance of a desire and a perceived affordance in the environment, it is clear how action then follows as a basic calculus in Searle's framework. With a 3d printer, for example, a person can theoretically print an object of any shape and color, so long as it is small enough for their printer and the filament can support the shape. Hidden in this calculation is a multitude of eschewed potentials, however, as what filament works best, or is most worth the cost, or prints fastest are all part of the consideration, amongst others. Any object or matter as composed within its existing milieu presents the totality of its potential predicated upon

circumstance, and alongside alternatives. A technological choice, then, implies understanding what affordances are offered by the available set of material properties and circumstances, and choosing amongst the options that satisfy such conditions.

The first question is thus concerned with how affordances come to be revealed. Prior to the moment of predisposition, the substance of material constitutes a space of potential as determined by its properties. It is here in the first act of evaluation that the difference between the *properties* and *qualities* of material becomes realized. As David Pye says, what we want to do with material is "express their qualities,…the qualities are…in our heads" (Pye 1978, 47). As Pye delineates between objective properties and subjective qualities, we see a related analog in Thomas Aquinas delineation between *substantial form* and *accidental form*. For Aquinas, the substantial form lends itself to categorization of an object by its kind, allowing for the grouping together of things which are possessive of a consistent property of form. This is known as the object's *quiddity*. By contrast, Aquinas' specifies 'what is not of the essence' as accident of circumstance (Hause 2018, 17). This use of the term 'accident' should not be confused with the concept of that which arises despite human intentions, but rather simply as circumstance that is imposed upon the matter to arrive at the outcome of a specific representation, as determined by the unique combination of the properties and the circumstance. In this sense the matter seemingly has no intention, and as such the term 'accident' is rather fitting when considered from the point-of-view of the matter itself. To make clear the difference between substantial form and accidental form, consider for example the various types of objects made by a 3d printer which are comprised of plastic filaments. Each of these objects is expected to have a kind of hardness which favors them for sustaining the intended printed shape. This hardness is accompanied by an expected texture, density, weight, and other properties. Collectively, the various plastic filaments such as PLA or ABS share these properties

which establishes them within a common genus. Taken individually, these properties are the *quiddity* by which they may be grouped. Comparatively, the specific pattern of the print gives a potential form to the plastic filament—which is circumstantial—and hence the imposing upon the filament of heat and printing into a pattern is an accidental form, or a representation of that which is contained in the instructions provided to the printer with the design software. The properties of the filament both *define* the filament and *delimit* a realm of possible ways of being for the filament. Bringing together the thinking of Pye with that of Thomas Aquinas, the set of perceived and understood possible forms would then constitute the subspace of qualities for the filament, whereas the accident space would be comprised of the set of futures for the material through entanglement with its circumstance, such as its adherence to the print bed with hotter or cooler temperatures at the hotend, or its resistance to crushing under heavy weight given a specific print geometry. Finally, this arrangement allows for the placement of the space of affordances introduced by Gibson. we may characterize the set of affordances as the intersection of the space of accidental forms with the set of perceived qualities. (see figure 8)

Figure 8. Diagram of Potential Space and Associated Subspaces



The set of potential forms as latent in properties would thus constitute the greatest breadth of possibility for the material, where the set of qualities would be strictly contained within this space as limited by perception. Affordances thus come to reveal themselves to the individual by recognizing the coinciding of qualities with the imposition of circumstances, described here as 'accidental' in the language of Aquinas. Importantly, note that there exists a space of accidental forms predicated upon circumstance which are not perceived by the individual, and as such do not register as qualities, and therefore also not affordances. These ways of being for the material or object remain hidden to the individual despite existing as possibility. Furthermore, upon the imposition of circumstance they will necessarily present the accidental form, although unintended by the individual as the form was not perceived as an affordance.

To this point what I have developed is a way of analytically characterizing the spaces of possibility wherein the totality of potential is delimited by the properties of the material, and technical choice is predicated upon circumstance, values, knowledge, and belief. This perspective which I have constructed following the substantialist tradition stands apart from that posed by Simondon and taken up by Fisch and others. Here my emphasis is on identification of the domain in which affordance is revealed or not revealed to the observer, which is necessary to pursue the question of *why* (rather than how) specific potential trajectories are opened up and chosen. By contrast, Simondon's processional view of emergent technicity offers a well formalized view of how potential trajectories emerge through the mediation of man and machine, with less attention to *choice*. This distinction is important in that technical choice for the individual is the result of deliberation, whereas individuation for the assemblage is not concerned with conventional uses of the term "intention", but rather describes totalizing transmission of all information without regard to beliefs, motives, and values.

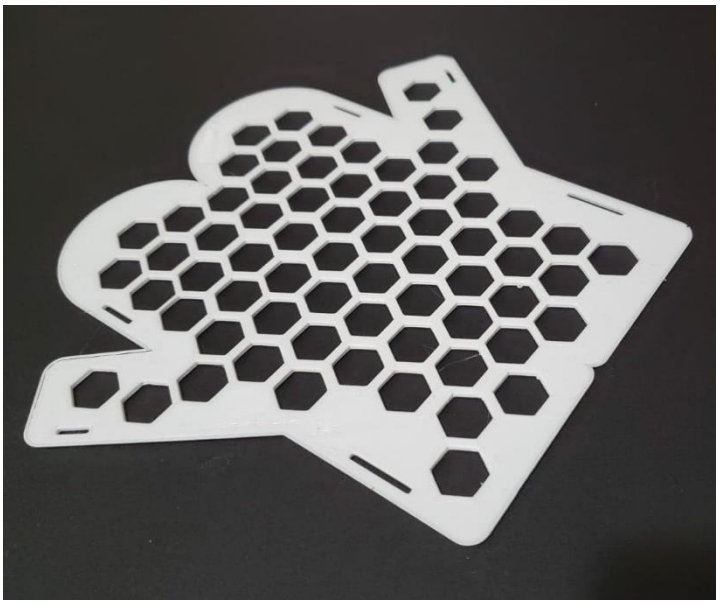
While this formulation thus far is sufficient to describe how the individual may perceive the potential of a given material or object under circumstance to reveal affordances, choices are often a conflict between competing options. In a discussion with one of my subjects I asked about the specific differences between some kinds of plastic filaments. He described PET filament (polyethylene terephthalate) as "rugged", PLA as "artsy", and commented that he had wanted to try nylon and polycarbonate but they "smell pretty noxious and you need good ventilation for them." While it might suffice to say that these subjective attitudes toward the types of filaments are sufficient to differentiate them from one another in a practical sense, the actual fundamental differences are not made explicit by this opinion. While PLA and ABS may be grouped by specific properties which place them within a shared genus, each is also possessive of properties that specify it as itself; its 'thisness' by contrast to its 'whatness.' This is known as the *haecceity* of a given object or material. Simondon contends with haecceity for a given object in a holistic manner:

> In the hylomorphic schema, individuation through matter corresponds to this characteristic of an obstacle or a limit, which is matter in its technical operation; what makes one object different from another is the *set of particular limits*—varying from one case to another—that guarantees that the object possesses its *haecceity*…(Simondon Individuation in light..,43; emphasis mine).

Simondon's processional view of individuation stands against the substantialist tradition, and thereby the hylomorphic schema which is central to it. However, the statement here about *a set of particular limits* as heuristic for differentiating between two options is a crucial component for understanding the nature by which we make choices. I do not reference this quote to suggest that Simondon takes up this position to describe the process of change, but rather to make the point that subjective choice between two near options requires a holistic analysis of the entire set of

property spaces, quality spaces, and circumstances. In this way the identification of haecceity is a logical second step following the identification of what genus possesses a quiddity that is functional toward some goal. In example, one of my subjects shared a story about how his friend's daughter suffers an affliction that often causes her to clench her hand into a tight fist. To aid her in keeping her hand in a straight position, the girl's physician prescribes a cast for her to wear. The cast, however, must be routinely replaced to maintain safe hygiene, as sweat and dirt are apt to accumulate inside the cast. To overcome this challenge, my subject designed and printed a brace using a filament type[11] with a particular set of potential limits: a low melting point, but also rigid and hard at room temperature. The 3d printed brace he created is easy to clean and can be molded into the proper shape by first warming in hot water, before cooling to a rigid state. (see figure 9)

Figure 9. 3d Printed Hygienic Rigid Hand-Brace



Note: The brace is warmed in hot water prior to molding around the hand. Photo provided by subject.

[11] The filament type with this set of properties is polycaprolactone.

As both the physiologist's cast and the 3d printed brace can be grouped by the set of properties which lend them to a rigid form, the differentiating factor that makes the 3d printed brace superior is its ability to be removed and cleaned, as well as its far simpler production. Similarly, all filaments which are extruded through a hotend prior to layering possess the same quality of melting under high heat. In making this filament ideal to its purpose, and thus defines its haecceity, is the combination of its properties to include a low melting point. In other words, the set of potential limits in their entirety constitute the definition of difference between the materials.

This process of revealing affordances and deliberation amongst goals thus precedes the activity of the second moment, the turn, when new ways of being emerge by assembling the values of the individual with the affordances of the material. Revealing affordances should be understood as a kind of searching in which the hierarchy of goals for the individual must correspond with and recognize qualities within the world that can work to support the pursuit of eudamonia. This hierarchy is never static, but instead undergoes constant recalibration in response to interior and exterior forces.

Discussion – Concrescence, The Turn Toward the Aspirational Form and Beyond

In the first case study I discussed how Piotr came to learn of the technology of printing with clay while attending an exhibition. Until that time, his experience with 3d printing was with plastic filament only. When Piotr purchased his clay printer, it was primarily because of his affection for the material as a medium, but his interaction with the affordances offered by the clay print head revealed new ways of being which he ultimately took up. We can frame Piotr's progression toward the aspirational form in terms of the three moments:

1. The moment of disposition:
    - In this moment, Piotr has no 3d printers, but has become aware of the technology.
    - Piotr's set of values are in place, such as his Peripatetic beliefs, his perspectives toward ecology, etc., as well as his set of knowledge of electronics and engineering.
2. The moment of the turn:
    - Piotr has two printers which print different mediums: plastic and clay.
3. Aspirational form:
    - Piotr has invented a special print head which is capable of printing multiple beads of clay filament simultaneously.
    - Piotr is actively searching for applications for his invented technology.

In this example, I have identified the moment of the turn *post facto* by the elucidation of the aspirational form. This seemingly paradoxical approach recognizes the crucial circumstance/accident of the turn which instantiates the aspirational form as the new way of being for the assemblage. Whereas the second moment recognizes the activity of assembly and the creation of potential trajectories, the third moment specifies which trajectory the assemblage is oriented to amongst the set of possibilities. The heuristic implied is tantamount to answering a question which seems to look simultaneously into the past and the future: "how did we get to where we are going?"

Using Piotr's case, we can see that no complete telling of his history prior to the moment of predisposition can answer this question completely, although they contribute. The specific

details required for such an explanation must have occurred between the moment of predisposition and the present. The justification for such logic is that the assemblage that occurs in the second moment is necessarily *super-additive*. This is to say that change does not occur solely to the individual or to the machine in isolation, such that the totality of their changes as distinct is equal to the totality of their change when assembled. Instead, the process of this emergence is evolutionary in three ways: for the individual, for the machine—and crucially—for the ensemble of individual and machine wherein the super-additive elements of change cannot be divided from the assemblage. For the technical object, the change may be highly visible and appear to be as simple as a new physical shape; a hylomorphic modification alone. However, other aspects of change are more subtle and relate to the degree to which the object's technicity undergoes a redefinition. As action occurs between the individual and the material, the force imposed upon the material closes off potential ways of being and concentrates the form of the material toward the outcome of the affordance. It is thus through the activity of the physical mediation that futures are denied, and (at least) one new set of potential futures emerges. For the living being, the activity is outcome of choice; an active denial of the mental and physical states refused in the action, and an embracing of those which are taken up necessarily in response to the entanglement.

For my discussant Sam, the possibility of creating instructional videos was both a modality and a form which was contingent upon the experience of the moment of turn. The activity of using his printers to produce large batches acted upon his psyche in a way that reified the concept of scaled production. If I were to engage with him as an extended-case, I might look for ways in which other aspects of his life have adopted the modality of scaled production. Likewise, the circumstance/accident of each iteration of printing exposed new methods in his print technique, qualities which he revealed as affordances. For his printers, while the properties remained

unchanged, the method of programming patterns which yielded the most efficient prints revealed themselves through interaction. In describing his first prints, he discussed more simple arrangements which were less efficient for the total space offered by the print surface. Through his iterations, he discovered patterns which could allow for a greater density of prints within the confined limitation of the space allowable for one print run. As a collective ensemble in the present, the articulation of the assemblage of Sam-printer reveals a modality which can only be understood by reflecting upon their mediation in the moment of turn.

When speaking of such an emergence for the assemblage at all levels simultaneously (physical, psychical, emotional etc.) together in their *active* mode— that of the mode of progressing—what is described is called 'transduction' by Simondon (Simondon 2020 trans. Adkins; cf. Mackenzie 2002, 16). Within the construct of the three-moment model, transduction describes the present-tense of the aspirational form of the assemblage in its processional nature. While Simondon's theory of transduction forms a comprehensive description of this emergent becoming of the ensembles of living beings and technical things, the important distinction offered by the aspirational form is the focus on the dynamic of values and affordances as the components of mediation. This perspective moves toward an understanding of such phenomena as the point of confluence between the cultural and social forces that drive human search for eudamonia, and the perceptive material reality. Seen through the lens of utility, the aspirational form as an analytic constitutes a point of investigation upon which social and physical scientists may examine the same phenomena in shared language. In the context of such technographies as those done by Murphy or Fisch, the aspirational form is the current articulation of *Svensk design* or the emergent form of the Tokyo Metro station as they are today when viewed as an assemblage of both the material that constitutes them, and the people who participate in their design and use.

Conclusion

The central concept posed in this study, the aspirational form, asks us to look upon technology in two novel ways. First, we must move from a static point of view to an understanding of technology as perpetually in action. The aspirational form is not a snapshot of now but is instead both retrospective and future oriented. The aspirational form asks us to inquire about the turn in that we acknowledge that the current articulation is contingent on a preceding and active concrescence, a coming together of material and individual in a way that is manifesting metaphysical change that is super-additive.

The aspirational form also implies we regard technology as an assemblage of values and affordances. The technology in isolation is inert, without meaning aside from the potential of its inherent properties. The aspirational form is a representation of the values that selected from the margin of indeterminacy some qualities (as special cases of properties) while denying others; it is the active form of the assemblage in the mode of transduction.

While the theory proposed here is operative at the smallest scale—that of a single entanglement over the shortest time horizon sufficient to render the aspirational form visible—the idea as suggested is amenable to aggregation. In this study I chose to examine the phenomenon of mediation between people and the platform technology of 3d printing. While I elected to bound this study between a sole individual and their in-home printer(s), a more comprehensive application of the theory as proposed could examine the emergence of new innovations in the science of 3d printing as an outcome of collective ensembles constitutive of multiple people and technical objects, beyond the singular person-printer assemblage. This more expansive investigation would retain focus on the mediation between the values of those collective groups and the affordances revealed through their mediation with all technological objects within the

network. In this expanded deployment, the analysis of values at the group level would invite incorporating how cultural and social forces work upon the interaction of values and affordances.

The choice of 3d printing as technographic subject for this study was motivated by its high degree of openness and adaptability as an ontological form. While this technology was ideal for the conditions of fieldwork during the coronavirus pandemic, my goal was to explicate a logic which would be extensive to other technographic fieldwork. This extensibility was motivated by the desire to contribute to a much larger multi-disciplinary response to present-day anxieties around human progress which necessitates the collaboration of anthropology with scientists of other guilds.

With accelerating advances in cybernetics and the growing ubiquity of human-technological mediation, the lines between what constitutes human and what constitutes a machine become less and less obvious. In some cases, the ontologies of such assemblies are already indiscernible as a static form. Consider the Amazon Alexa or the Google Home devices. What is the form of these technologies, right now? As a result of billions of individual coinciding interactions between person and machine, the system is only ever fleetingly what it seems. A snapshot in any given moment is a failed depiction of what the technology is becoming, as a snapshot fails to capture the motion of its transduction. Each interaction with the technology produces ever more information. Likewise, the software in computers and smartphones are constantly undergoing development, with updates pushed on a regular basis. These updates are more than subjective deliberation amongst a team of software engineers; they are also an aggregate of large swaths of data consumed pertaining to user entanglement. As such, they are perpetual moments of turn, a beginning of a concrescence of the values of engineers and users with the affordances, the smartphone, and the telecommunications network. Upon entanglement with the

update, an aspirational form emerges; a new articulation of being for the assemblage that is person-computer, or person-smartphone, or person-computer-smartphone, etc. The question should not be, then, what the form of these technologies are, but to what direction do they aspire?

As suggested here, theories of human progress should adapt to reflect the co-evolution of mankind and technology as ontologically inseparable. It is not enough to frame our active becoming as merely the result of politics and culture, alone. Instead, accurate depictions of progress are contingent upon a clear understanding of our coexistence with the technical and material. The research presented in this thesis is a contribution toward an improved understanding of such an ontogenesis.

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