# Abstracting Craft

## The Practiced Digital Hand

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*In memory of Dorothy Humason, my grandmother, a painter*

# Contents

# 7 Medium

To give work substance, we require a medium. The actions of our hands, eyes, and tools must be mediated. Our personal knowledge and skills must be given a habitual setting for practice.

The word "medium" has many meanings: a medium may be a material, such as plaster, or a means, an agency, or an instrumentality, such as the press. It may be an intervening person or thing, such as a messenger, or some other kind of carrier, like the liquid mixed with pigments to make paint flow. It may be a pervasive environment, in which bodies exist, like the air in which birds fly.

Quite often the word signifies a class of tools and raw materials. For example, metalworking is a medium, which includes welders, torches, hammers, and clamps, as well as aluminum, iron, and bronze. Because a type of material distinguishes a particular class of tools, the ensemble may be referred to on the whole as a medium. When the tools are complex, when the artifacts produced are abstract, or when tools provide the only means of access to the medium (all common conditions in high technology), it can be difficult to say where a tool ends and a medium begins. But

we can say that under skilled practice even these tools become transparent, and that a sense of a medium eventually emerges.

Normally this is a more simple relation: a medium receives the work of tools. Where a tool is an effector or a probe, a medium is a substance that may be sensed or altered somehow by tools. If a tool is kinetic, and under active human guidance, a medium is static, and passively presents limits to human control. The meeting of tool and medium provides a locus for skills. As we push material around, we encounter structure. We find that we may work only in certain ways, and only at certain rates. We say that the medium has a feel, and we sense this quality only in action. Substance mediates action.

To mediate is not only to shape but also to communicate. Because a medium shapes the way a tool conducts an author's intent, it provides a locus for expression, and becomes subject to interpretation. In this way, a medium communicates between author and audience. The more tacit expression, subtle interpretation, or latent content a medium is capable of communicating, the richer it seems.

A richer medium invites interpretation. Its subtleties become subject to connoisseurship. The contexts and purposes under which it is used and interpreted create genres. In the case of craft, interpretations focus specifically on the way in which content takes form. With art, however, the relation of form and content varies constantly. Computing transforms this relation too: the same content (bits) may take many different forms quite easily, and it may do so after the fact. Of course there is considerable debate as to whether content must take material form, or whether the articulation of a more abstractly mediating substance, such as generative algorithms, may be subject to appreciation. But rather than entering a discussion on the merits of computer art, let us focus on the basis of an abstract medium.

Engagement, Affordance, Constraint

If it is to be anything at all, a medium must have sufficient effect on the senses in order to command our attention. It must stir our imagination.

7.1 A medium defines a practice

This quality of engagement is personal. If you are like most people, you probably work well only when your attention is focused on the task at hand. Something must draw your interest. This might be the pleasure of handling a material. It could be the concentration required not to ruin a piece of work. At a more abstract level, it could be the intricacies of solving a problem, whether technical or conceptual. It could be the anticipation of a finished product. It might be the ambition to succeed, or the fear of failure. Or it could simply be the calming effect of routine, based on soothing motions, habitual expertise, and a sustaining commitment to practice. If enough of these engaging qualities are sufficiently strong, nothing will distract you from your workthe hours will fly by, and you might not even hear the phone ringing. But if they are weak, the techniques of which they are a part may not make much of an impression on you, and your mind will drift.1

Many of these psychological factors depend directly on the properties of a medium. When we speak of richness, difficulty, or versatility, we are not only referring to the discipline of our practices, or the quality of our tools, but also to the very medium in which we work. In the sense of the word that means a pervasive context, these are the properties of a medium that surrounds us.

Thus the best way to begin understanding any medium is as a range of possibilities. Within traditional material craft, this is often articulated in terms of structure. Wood has a grain, paper has tooth, metal has temper. Understanding of structure is implicit; it is learned through experience. Although this becomes everyday knowledge, it does not become formalized. For example, although there are lumber grades based on the number of clear faces on a cut piece, we still have no formal scale or gradation for describing the texture and grain of wood. Moreover, the understanding is in terms of workability and practices, rather than according to any theoretical constitution. Thus people worked metals for centuries without any notion of lattices and free electrons. Acute knowledge of a medium's structure comes not by theory but through involvement.

For a medium to be engaging, it must be dense. This means that it must surround us in possibilities. Such immersion is more than sensory, for

| Medium | Continuous process |
|---|---|
| Image processing | Tonal correction, layered composition |
| Paint | Finely controllable brushstrokes |
| Illustration | Drawing curves and shapes |
| Page layout | Placing elements |
| 2d animation | Placing elements and transitions |
| Mapping | (rapidly iterative queries) |
| Geometric modeling | Position, scale, alignment |
| Sketch modeling | Geometric transformations |
| Parametric modeling | Parametric variation |
| Rapid prototyping | (iterative fabrications) |
| CNC machining | Programming by demonstration |
| 3D object language | Navigating generative form |
| Rendering | Adjusting lights and cameras |
| 3D animation | Path and transition control |
| Digital video | Cueing elements, editing orchestrations |
| Hypermedia | (following associative trail) |

7.2 Continuous operations in digital media

it also serves the imagination with opportunities to coax the medium from one state to another. Ideally there should be enough states of the medium to create a sense of a *continuum* of possibilities. Continuity depends on the condition that between any two states there exists still another. It also means sensations of states cannot be disjoint: a neighboring state must appear, and feel, nearly like the present state. Only such density will produce continuous behavior that can be worked with continuous hand-guided processes, like coaxing a material. Although this is difficult to document, the importance of continuity to reflective, masterful processes cannot be underestimated. Work must flow.

Density supports engagement not only through continuity but also through variety. Only countless subtle differentiations of conditions will yield a heightened, satisfactory practice. A rich medium offers such an extent of possibilities that no one author or piece can incorporate them all, and only this is enough to sustain continued exploration.

Thus the attuned craftsman asks, "What can this medium do?" as much as "What do I wish to do with this medium?" It matters that one works in a medium whose properties suit one's purposes: sometimes a more forgiving medium; sometimes a more rewarding medium; occasionally rigor for rigor's sake; but always a medium whose intrinsic advantages are appropriate to the task at hand. An experienced craftsman knows how to choose the right medium and to push it as far as it will goand no further.

Psychologists (and software experts) often employ the term "affordances" to describe the workable capacities of a medium.[2] This reflects the truism that opportunities shape outlook: "how we see the world depends on what we can do with it."[3] Or we sometimes speak of "what a medium can do." For example, every physical material has tolerances, within which it is workable and outside of which it breaks down. Wood can be cut across the grain more readily than along the grain, and it can be cut only so thin and still remain rigid. Each type of wood has distinct qualities. Harder woods afford more detailed forming processes, such as carving and sanding. Any wood can be carved more easily than stone. More resilient wood can be
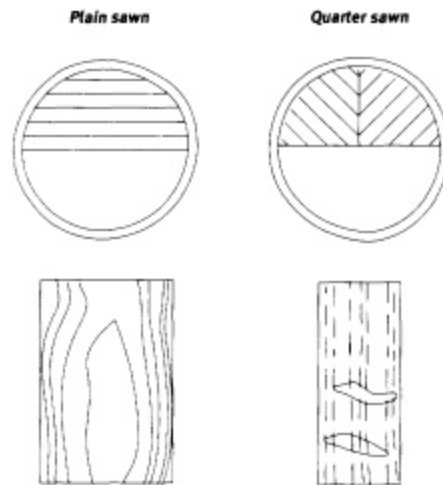
7.3 An example of material properties:
quartersawn lumber looks better because
of continuous ring lines, and is less
likely to warp, but wastes more wood

worked further than less resilient wood of equal hardness. Of course, no two pieces of one wood are alike. Clear wood is stronger than knotty wood. Aged or dried wood is less likely to deform, but wood dried too rapidly will crack. Untreated wood is relatively cheap, and there tend to be leftover pieces of it lying around, which can be worked with relatively unspecialized tools, such as a penknife. Thus we might say that wood affords whittling.4

There is no guarantee that the affordances of a medium will be obvious. Unlike objects of industrial design, for which the term affordances is also used in describing the potential purpose and self-evident uses of things, a medium is not necessarily established for a particular intent. Rather, it is found. Its affordances are discovered. They may not be subject to identity or measure, but knowledge of their presence may be embodied implicitly in tradition.

Affordances seem to be meted out more or less equally among various desirable media. In this sense the word affordance implies a finite budget of opportunities, and so it is complemented with the idea of

"constraint." For a medium must also have limits. It is not too difficult to imagine that an unconstrained medium would have little identity. Presumably it would be unpleasant. Being able to do whatever one wants does not induce creativity so much as paralysis. But in reality, there is no ultimate medium. Constraints define specific formal possibilities and guide creativity into specific channels, much like banks define a river.5

In other words, constraint is a source of strength. This is especially the case with respect to the nature of a material and the giving of *form*. Effective constraints are not explicit methods for the use of tools so much as implicit limitations learned from the behavior of a medium. Such limitations focus the scope of process without obstructing engagement the way explicit rules do. Thus, another way to think of constraint is as the rigor of substance. Note that this is not necessarily material so much as structural. As we continue to note, structure is a particularly constructive source of constraint. Only through the possibilities and limitations of structured substance does expression come into beingotherwise it remains only inspiration.

Together, affordances and constraints shape expression, and they do so in the process of giving form. Form establishes boundaries. A medium shapes the structure of expression. Its unique capabilities give rise to idioms. Some expressive forms, like a sonnet or sonata, may be more clearly constrained than others, like action painting. Gombrich wrote, "It is because art operates with a structured style governed by technique and the schemata of tradition that representation could become the instrument not only of information but also of expression."6

Understanding affordances and constraints is exactly what engineers, designers, artists, and craftspeople do well. Each of these expertises involves deep familiarity with possibilities and *practicalities* of particular media. Consider their respective approaches.

An engineermost pertinently a manufacturing engineeris concerned with measurable qualities that yield reproducible results. Armed with such certainties he or she can automate processes in a way that goes far beyond human strength, precision, patience, or endurance. Though

experience and studybut also through predictive modelingthe engineer can become familiar with the practical possibilities of a technological configuration. Similarly, an industrial designer can master the aesthetic possibilities of a standardized production process, albeit without giving much personal charm to the individual products.

Almost any other kind of artist, by contrast, is released from practicality. This condition is especially pronounced in the freedom from having to put material to work economically. The artist, devoted to seeking pure expression, has little concern for optimal use of raw material. In this case, getting the most out of limited affordances matters less. Rather a coded intellectual context (aesthetic theory) serves as a guide, and individual vision assumes dominance over any practice of traditional skills.

But between these modes there remains some realm where scientific production cannot go, where mechanized industry finds too little demand to go, and where artistic discourse cares not to go. Where personal knowledge still combines with practical intent, where the expression is as much functional economy as aesthetic stance, where the products are individual and idiomatic, where the medium is the basis for mastery: there we find craft.

One better articulation of well-understood affordances dominates craft, and that is *workmanship*. Clearly this is a reflection of engagement: it is the quality with which a design vision takes form in a specific medium. It is also a matter of appropriate expression, in recognition that idioms seldom translate well from one medium to another, particularly from a finer to a cheaper material. For example you cannot replicate in Formica what you can accomplish in mahogany, and the results tend to be ugly if you tryalthough of course Formica has its own distinct possibilities. Good workmanship is sympathetic to such potentials of a medium and uses any idiosyncrasies to its advantage. In this regard, workmanship ultimately seems more a property of the process, or of the worker, than of the very medium.

Many people believe that workmanship is a fundamental human disposition. For example, in *The Instinct of Workmanship and the State of the*

*Industrial Arts* (1914), Thorstein Veblen affirmed how "The instinct of workmanship is effective in such consistent, ubiquitous, and resilient fashion that students of human culture will have to count it as one of the integral hereditary traits of mankind."7 Veblen felt that this trait was being obstructed by mechanization, which distanced the worker from the medium, but he recognized that workmanship is largely a matter of functional economy. "Workmanship is not less the object of attention and sentiment in its own right. Efficient use of the means at hand, and adequate management of the resources available for the purposes of life, is itself an end of endeavor, and accomplishment of this kind is a source of gratification."8 Moreover, Veblen took the view that "All instinctive action is intelligent and teleological." This supported his main thesis that if the craftsman could retain control of the process, even within an industrial setting, technological excellence would result. To put it simply, workmanship will find a way. In this sense, a new medium could be made, even within a more abstract and technologized context.9

Aesthetic historian David Pye has studied workmanship at length and asserted its primacy over material. "In speaking of good material we are paying an unconscious tribute to the enormous strength of the traditions of workmanship," he says. "We talk as though good material were found and not made."10 Pye's central argument is very much along the lines of personal knowledge and commitment:

> Workmanship of the better sort is called, in an honorific way, craftsmanship. Nobody is prepared to say where craftsmanship ends and ordinary manufacture begins . . . [But] if I must ascribe a meaning to the word 'craftsmanship,' I shall say as a first approximation that it means simply workmanship using any kind of technique or apparatus, in which the quality of the result is not predetermined, but depends on the judgment, dexterity, and care which the maker exercises as he works. The essential idea is that the quality of the result is continually at risk during the process of making; and so I shall call this kind of workmanship "The Workmanship of Risk": an uncouth phrase, but at least descriptive.11

This kind of workmanship Pye contrasts with a "workmanship of certainty," which he presents as the basis of ordinary manufacturing. Certainty, particularly in the form of standardization, yields incontestable economies. But uncertainty, or diversity, can yield a wider range of practical endeavors and a more natural expression of material microstructure. By the latter is meant conditions where, like the wrinkles in finely tanned leather, diverse irregularities in the medium, which might be eliminated in standardizing processes, instead become a source of beauty.

Workmanship engages us with both functional and aesthetic qualities. It conveys a specific relation between form and content, such that the form realizes the content, in a manner that is enriched by the idiosyncrasies of the medium. In this sense it is an act of appreciation.

Appreciation

Usefulness and beauty are in the eye of the beholder: just as a medium must provide a context for skilled action, so it must provide a context for developed interpretation. Here the word "medium" is used in the sense of an intervening carrier. It allows authors to give form, whose users and audiences may interpret. It implies the necessity of intermediate objects, that is, artifacts. This was the essence of Focillon's phenomenological argument: "A work of art exists only in so far as it is form. In other words, a work of art is not the outline or the graph of art as an activity; it is art itself. It does not design art; it creates it. Art is made up, not of the artist's intentions, but of works of art."12

An artifact is a phenomenon in itself, and not just an exact representation of an abstract vision. Its expressiveness is shaped by the very properties of the medium. The manner in which an artifact employs known affordances and works within implicit constraints conveys vision indirectly, through the stuff of the medium. Repeated or related executions establish types and genres of form. Affordances for talented execution, and for a vivid record of an impassioned or contemplative state, improve the chances for a widely differentiated body of work, possibly including individual masterpieces. In other words, affordances give rise to expressive

conventions, and they do so through the particularity of the artifacts. Gombrich summarized: "The forms of art, ancient and modern, are not duplications of what the artist has in mind any more than they are duplications of what he sees in the outer world. In both cases they are renderings within an acquired medium, a medium grown up through tradition and skillthat of the artist and that of the beholder."13 Note the emphasis on the fact that a medium must be acquired, both in terms of skill and with respect to interpretation.

Obviously a piece must be received on a higher level than the purely sensory, like turning on the lights, or the purely literal, like retrieving a phone message. At minimum, its reception must somehow engage the subjective framework of its audience. For example, it might be decoded according to a shared body of meaning, such as engineering drawing conventions, or religious iconography. Or it might remain meaningful on an uncoded, sensory level, but appeal to some sort of shared experience"digging it." However, normally, appreciation combines coded structure, shared sensation, and personal reflectivity into a higher level of reception. This was the essence of Gombrich's position in *Art and Illusion* (1960). "The true miracle of the language of art is not that it enables the artist to create an illusion of reality. It is that under the hands of a great master the image becomes translucent. In teaching us to see the visible world afresh, he gives us the illusion of looking into the invisible realms of the mind."14

The notion of artifact as translucent vessel brings forth the possibility of latent content, which can be defined as expression neither intended by the author nor read in by the recipient, but conveyed by the cultural context under which the artifact has been produced and received. Thus an author's intent is not the sole arbiter of meaning. Latent content dominates especially in craft artifacts that are not overtly artistic but simply the product of traditions.

Appreciation is a participatory practice, culturally positioned, and without explicit rules or grading. Here there are parallels to skill. Polanyi suggested connoisseurship as a dimension of active personal knowledge: "Connoisseurship, like skill, can be communicated only by example, not

by precept. To become an expert wine taster, to acquire a knowledge of innumerable blends of tea or to be trained as a medical diagnostician, you must go through a long course of experience under the guidance of a master."15 We don't just see: we study; we learn. Anything less would be mere apprehension, or mere projection. Appreciation requires exposure to a lot of pieces, for experience assists assimilation. Appreciation also benefits from repeated exposure to the same pieces, so that by reflecting our moods they may also reveal themselves.

Appreciation also incorporates intent. This may be unstudied disposition: as the critics say, "dogs see dogs." However, more usually intent is a matter of willful receptivity. For example, the difference between hearing and listening to a piece of music might be its relation to the last piece listened to, and this is why many people prefer media in which they get to choose the programming. Intent lets us decide the context in which we receive a piece: we might say that is lets us look at a medium or through it. For example, we might return to the theater to see a play a second or third time to study it at different levels, for example, the acting, the direction, or the lighting. Such intentional appreciation has a close relationship to craft. It doesn't hurt to have first-hand experience with the making.

More specifically, the interpretive process centers on familiar categories of forms within an acquired medium. We might say that appreciation can be *within* a genre or *of* agenre. The Parthenon is great primarily in relation to so many other Greek temples. Greek temples are great because they gave us so many related artifacts, including the Parthenon. We appreciate a genre in proportion to how many pleasing artifacts it has given us.

Octavio Paz evokes the simplicity of the craft artifact, the appreciation of which is based on the simplest relation of form and content:

> A glass jug, a wicker basket, a coarse muslin *huipul,* a wooden serving dish: beautiful objects, not despite their usefulness, but because of it. Their beauty is simply an inherent part of them, like the perfume and the color of flowers. It is inseparable from their function: they are beautiful things because they are useful things. Handcrafts belong to a world antedating the separation of the useful and the

beautiful. Such a separation is more recent than is generally supposed.16

The separation of art and craft is a modern historical development. Increasing differentiation of skills, newly discovered respect for originals in an autographic medium, and growing freedom to explore personal visions combined to introduce a new kind of artifact: the work of art. If the history of art may be regarded a study of the ever-changing relation between form and content, then we may say that this kind of artifact established a new condition in which beauty was freed from necessity. This freedom has advanced in stages: first from necessity for utilitarian function, later from any necessity of literal representation, and finally from necessity of technique.

We cannot ask of the work of art what it is "for." Utility became the province of the industrial object, which especially in its early stages was crudely formed, banal in intent, its design unbalanced by infatuation with newly convenient processes, its ornament imitating traditional expression but in cheaper materialsin a word, ugly. Art appreciation generally ran away from the machine, at least until industrialism had a century to mature. The emergence of a "machine age" aesthetic in the 1920s was an exception to this divorce of function and beauty, and this had passing influence on earlier, therefore presumably higher arts. In architecture, for example, Le Corbusier celebrated grain elevators and ocean liners.

Herbert Read drew distinction between fine and applied arts, or cabinet arts and useful arts, as he called them. The problem of artistry in earlier industrial objects was that it was appliedliterally. Ornament was derived from traditional materials, methods, and expressions, "distinct from the processes of machine production, and applied to the manufactured object."17 Classical ("cabinet") taste had been the measure of nineteenth-century industrial art, with dreadful results, and forcing modernism to rise independently. "Meanwhile, by use of [modern streamlining] the man in the street is betraying his instinctive aesthetic judgementsaesthetic judgements which owe nothing to the standards of

traditional taste and academic artsjudgements which are, in fact, evidence of a new aesthetic sensibility."18 In other words, industrial design emerged because popular tastes became ready to recognize the possibility of an abstract art in the pervasive industrial vernacularin products. The systematic modularity of production and product lines, and the disposable interchangeability of individual pieces, however beautiful, were a great departure from the previous understanding of art as individual works.

In opposition, the autonomy of academic Art deepened. Then, as today, any dominance by or widespread commercial use of a powerful new technique tended to taint its acceptance in the artistic academy. This happened with modern architecture, with photography, and above all with the early cinema. Industrial design, despite its initial achievements, eventually came to be seen as a form of marketing corporate identitymere packaging. Altogether, industrial artifacts continued to be considered ugly. They had to lose their usefulness, like Pittsburgh blast furnaces, before they could be valued for their beauty. Utility was not only ignored in higher aesthetics; it was also denied. Oppenheim made fur-lined teacups (1936). "Ceci n'est pas un Pipe" (1950), painted Magritte, without need for adding: "only a referent."

But like the industrial object, the art object also broke away from codified representation. One might overgeneralize that if traditional appreciation was *within* a medium, then modern appreciation became more likely to be *of* amedium. Traditionally, functional objects created within aesthetic traditions had used the embellishments of necessary components as a means of expression. This was not limited to physical wares, which were displaced by the products of industry, but also included representative imagery. For example, interpreting religious iconography uses traditional conventions to reformulate content. Only certain elements and themes were expected to be subjected to artistry.

By contrast, more recent artistic expression defies such direct interpretation. Although traditional art was mimetic, the arrival of the camera, and more importantly the loss of shared mythology, undermined its representative function. Modern art, from Motherwell to Monk, is not *about;* it

simply *is*. As is a matter of phenomenology it finds epiphanies in the simple. Under these conditions, conventional, codified interpretation was reduced to a means for bourgeois apologetics and academic pedantry, so the artists just got rid of it. In the case of painting, as Susan Sontag identified, modernism easily shook off the yoke of interpretation by using the twin tactics of abandoning representation, as in abstract expressionism, or resorting to literal representation of banal, nonsymbolic objects, as in pop.19

This same freedom enabled latent content to be engineered or even eliminated from intellectually richer artifacts. That is, works played more self-consciously with their cultural contexts. Because people who have acquired a sensibility naturally share an intellectual frame of reference, the possibility exists for an exclusive art that endeavors to confound all but a few insiders. As the shared frame goes beyond the sensory and improves communication independent of execution, there is a tendency toward works devoid of technique. Anyone who demands technique, or who otherwise fails to buy in to these subterfuges, can simply be dismissed as a philistine.

This is not to say that appreciation has stopped. On the contrary, art, however confounding, has been allowed to fill some of the void left by religion. Recall how with *In Praise of Hands,* Paz laid out this accusation of art in defense of the merits of craft.

> Art inherited from religion the power of consecrating things and imparting a sort of eternity to them. The museums are its temples; the critics, its theologians . . .

> [However] the modern religion of art continually circles back upon itself without ever finding the path to salvation: it keeps shifting back and forth from the negation of meaning for the sake of the object to the negation of the object for the sake of meaning.20

Perhaps this is one reason for a renewal of interest in craft: in Art, it would seem, the snake has long since swallowed its tail.

The Electronic Medium

Meanwhile, any fissures between art, craft, and industry have by now been completely overshadowed by the popular culture of electronic communications. Not only does an electronic medium such as film, television, or recorded music allow an easier emphasis on form, with cheaply produced and reproduced content, but also it comes comparatively free from cultural baggage. In the 1960s, Sontag asserted that film had become the most important medium, because there "It is possible to elude the interpreters in another way, by making works of art whose surface is so unified and clean, whose momentum is so rapid, whose address is so direct that the work can be . .. just what it is."21

"The Medium is the Message" became Marshall McLuhan's famous slogan of this incipient electronic era. Factors such as instant total awareness, unity of form and function, and the lack of need to ask what a functional medium such as electric light was "about" all contributed to this emphasis on the medium in itself. Moreover, any direct effect of the content the media conveyed was felt to be secondary to the indirect social consequences of increasingly technological media. It did not matter what was on television, so much as that everyone was watching. McLuhan's creed was that "The message of any medium or technology is the change of scale or pace or pattern that it introduces into human affairs."22

The change of pattern that followed from the permeation of society by television has been the onset of postmodern consumerism. Postmodernity does restore a use value to aesthetic production, but the use is political and economic rather than simply functional. As noted in the earlier discussion of images and media culture, this condition is marked by dematerialization, simulation, and commodification of aesthetic artifacts, most of which are pure image. This state has been well charted by the academic left. To cite but one example, Fredric Jameson suggests that any formerly elite cultural appreciation has not so much vanished as exploded. "A prodigious expansion of culture throughout the social realm, to the point where everything in our social lifefrom economic value and state power

to practices and to the very structure of the psyche itselfcan be said to have become 'cultural' in some original and as yet untheorized sense."23

Twenty years into postmodernity, we have arrived at a condition where the ubiquitous fusion of economics and culture has transformed aesthetic production from the work of a fairly cloistered few into the play of the increasingly networked many. One of the consequences is that artifacts must be electronically transmissible if they are to be noticed. As was explored in the chapter on visuality, the necessities of information delivery both demand and invite new developments in abstract, electronic media.

The rise of digital media once again overturns the relation between form and content. We have begun to depart from the era of passive television, of information segregation by delivery media, rather than by content, and of primacy of form over content. Earlier media theories such as those of Sontag and McLuhan do not necessarily translate to this era, where both medium and message are streams of bits that demand (and often provide) interpretation. Negroponte observes that the two most important properties of bits are, one, that they commingle, intrinsically producing the condition known as multimedia, and two, that some bits exist specifically to tell you how to use other bits.24 Notably, as an outgrowth of these conditions, particular content can be given many forms, according to the wishes of whomever receives it. "The medium is not the message in a digital world. It is an embodiment of it. A message might have several embodiments automatically deliverable from the same data."25

As evidence of a reemphasis on content, note that as the internet has begun to achieve critical mass, a new electronic profession, often a cottage industry, has emerged under the rubric of "content producers." Perhaps to the older media mogul this term is indicative of a subsidiary industry addressing the irritating but quickly dispatched need to have some stuff to push over the wires. But what if people pull instead? That is, what if people browse and download content of their own choosing, and "least common denominator" broadcast content simply fades from the scene? If the audience may choose between formats, the owner of the channel has less of a monopoly on their attention. When browsing among content

headers (bits about bits) rather than tuning in at a specified broadcast time determines what will be received, then what will matter is content.

Interestingly, the content producers, working in digital media, are the ones talking about craft.

The Abstract Medium: Engaging Notational Density

It is in appreciation of abstract, notational media where we use the word craft most broadly. Consider the writer's craft, for example. Writing, is very much shaped by its artifacts, which are sentences and paragraphs. Formless thoughts must be executed in the quirky phenomenon of words. Ideas cannot be organized in just any manner, but must be joined from one to the next in such a manner that the sound of the language flows. Because of this need, small, idiosyncratic difficulties of putting one word after another can derail entire trains of thought. Like wood, language has a grain. Within the medium of words, the writer's craft incorporates countless devices to work this grain: specialized vocabulary, idioms of usage, tone, meter, voices, metaphors, allusions, similies, tropes, imagery, apostrophe. The experienced writer bridges ideas by means of these constructionsto varying degrees of success. A beginner who tries to use too many of these will suffer. Consistency without monotony is a very elusive goal to achieve, and elegance is more difficult still.

Note that even within intellectual pursuits, languages of expression may be influenced by production technology. For example, Hugh Kenner evokes the mechanical muses of the poet Ezra Pound:

> Pound uses the indents made easy by the typewriter as poetic device: to indicate change of voice. He uses the reference materials produced by the Victorian era to incorporate so much knowledge not necessarily his, e.g. elements of other languages. He abided by the spirit of accuracy, efficiency, and concentrated power. The aesthetic of a tooland-die maker. Pound's ideal poem would consist solely in mobile parts and the parts required to keep 'em in their orbits or loci.26

Kenner appreciates how Pound used the medium of typewritten text to evoke the century of the machine. He infers: "Once we persuade ourselves that 'machine' need not connote iron nor hardware, that the word applies to any economic self-activating system for organizing resources, we can see mechanisms everywhere." For example, the reference materials used by Pound were a great machine: the *Oxford English Dictionary* was the crowning epic poem built by many thousands of toilers organizing and making accessible all that could be ascertained about the record of human speech.27

However, if the conditions within design computing were no different from this example in literature, the proposition of craft in digital media would be mostly semanticand not very interesting. The word craft applied to a nonmaterial medium, such as poetry, has a distinctly different meaningand not the one we are curious aboutthan the word craft applied to a physical medium, such as stone.

Must a craft medium have a material substance? Historically, physical materials have been the best source of mediating structure. The physical workability of a material is what defines its possibilities as a medium. Traditional arts and craft forms are identified as much by material as by any practices or modes of expression. Examples are everywhere in terms of material: woodblocks, lithographs, watercolors, oils, silver, ironwork, textiles. The working of these materials has been directwithout symbolic notationand this directness has been the source of greater tacit affordances than can be obtained from notational media. In other words, historically there have been limits to mediation, and the ability to somehow execute work directly within the medium and work it in some unstated way has remained essential to expression.

For example, in Pye's conception of workmanship we have a fundamental challenge from tradition to the proposition of electronic craft: must a true medium entail sufficient risk and irreversibility to demand the rigor and devotion that have always been necessary for great works? Can a computer with its *undo* and *save as* functions ever demand sufficient concentration

on our part to enable serious, expressive works to come forth? Can these functions enable us to take greater risks and therefore express ourselves all the better? Or do they render us noncommital and our work superficial?

Materiality is therefore pivotal to the question of craft in the electronic realm. Recall the opening discussion of touch technology. What good is the computer as medium if you can't even touch it? May we suspend the need for physical properties, or the subtlety of touch, or the durability of tangible artifacts, in exchange for a more dynamic manipulation of abstract structures of symbols? Is this question even reasonable? Or may we only ask the question to the degree that electronic media provide for manual dexterity through positional gesture, touch sense, and motion rates? Or is it that we are extending the sense of the word craft to apply to an different, more abstract situation, more like that of Pound, that only bears conceptual similarities to the working of physical materials?
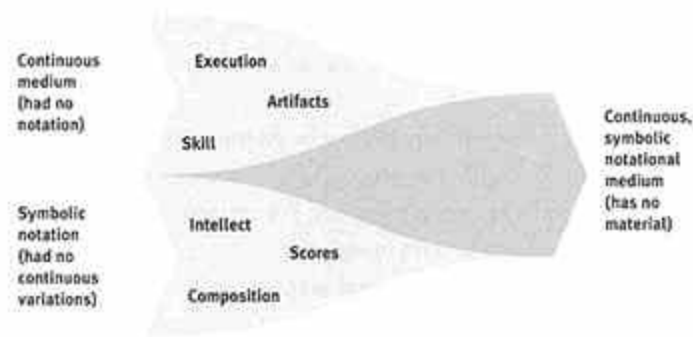
Fortunately there is more to the issue. Today we are faced with conditions that transform age-old relations between material and notational artifacts. This intellectual understanding of craft based on the particularities of notation is merging with the more usual skillful kind of craft, based on the continuously workable medium. We might describe this unification in terms of four basic ideas.

To begin, the fundamental difference between digital and traditional media is rooted in microstructure: bits versus atoms. Processes that move physical atoms around are precisely the irreversible aspect of traditional work. According to very fundamental laws of physics, operations such as cutting, bonding, and mixing are irreversible. Mix black paint into white, and you've got grey for the duration. Crack a fine piece of laboriously refined jade work, and you have lost not only time but also expensive materiala rare configuration of atoms. By contrast, the microstructure of the computer medium is bits: a specified arrangement of symbols. The computer is made out of atoms, to be sure, but its logic employs symbols that quantize the physical charges they representit obtains stable bits. Because any physical deviations caused by atoms get rounded and corrected,

these symbols built on bits do not degrade. In the microstructure of the digital medium, arrangements and values can always be reconstructed; their previous states can be stored and recalled; additional instances and versions can be replicated.

And this is the second principle: In electronic design media, format is often determined after content. Artifacts in many different formats may emerge from a single database. The structure of the abstract database is the content. Moreover, data structures are partially exchangeable. Once in digital format, the media become to some degree translatable into one another. Versions can proliferate as easily as invoking a *save as* operation. To use Goodman's terminology, these are obviously properties of an allographic medium, whereas craft, as it has been understood traditionally (and not in the manner of the recent example of the writer's craft), has depended on a continuous, autographic medium. But now the distinction is waning.

The third idea behind this merger is maybe the most important: *Increased notational density supports quasi-continuous operations formerly only available from physical materials.* The use of abstract data types based on highprecision numerical representations not only increases the density, but also expands the range of allographic media. Increased notational density distinguishes computing from earlier allographic media based on manual notations such as text or musical scores, which however rich were neither possible to manipulate in real time nor able to provide a continuum of potential states. By contrast, the data structures and variations described in the preceding chapter modify notations nearly continuously. Although there are not infinite possibilities, the mathematical resolution, of say, double-precision floating point calculations so exceeds the resolution of any devices by which they may be manipulated that in effect, there seem to be infinite possibilities. The fundamental condition of density is met: between any two practical possibilities, there exists a third. Similarly in images, both the number of pixels and the number of intensities available for them to take on are finite, and easily handled in notation, but are more than enough to provide the sense of continuity before the human eye.

Continuous
medium
(had no
notation)

Execution

Artifacts

Skill

Continuous,
symbolic
notational
medium
(has no
material)

Symbolic
notation
(had no
continuous
variations)

Intellect

Scores

Composition

7.4 Dense, effectively continuous notation

Lastly, then, better human-computer interfaces, based on dense notations, provide increasing engagement in structural manipulations. In particular, they engage the hand in the modification of notation, and this begins to reunite skill and intellect.

Computer as Medium

In light of these various conditions, it is fair to assert that despite the lack of physicality there exists a growing possibility of constructing the experience of a medium in the world of the computer. Furthermore, there exists a growing collection of such rich symbolic contexts: a digital repertoire. Intentional differences in symbolic data structure, forms of interaction, and types of indirect constructions yield distinctions between a growing variety of digital media. One way to understand these is in terms of the dimensionality of the artifacts. One-dimensional media manipulate text or sounds; two-dimensional media are naturally for pixels, lines, and polygons; three-dimensional media place lines, surfaces, or solids in space; n-dimensional media introduce time, as in animation, and may also add links between a variety of items or formats, as in hypertext.28 Each of these media is at least partly related to the others; translations between them are routine. Software is packaged and chosen not for specific tasks so much

as for the kinds of vocabularies and operators provided. Working environments cobble together many such pieces of software into powerful design networks.

Notably, some media formerly lacking in notation now become describable, and therefore subject to generative constructions and compositions. Autographic media become allographic. For example, sculptural geometry now has a notation in solid modeling.

The data structures underlying dense notation become a source of affordance and constraint. We have explored how internal representations in software, such as graphic primitives, represent available actions and implicitly suggest suitable applications. For example, representations of surfaces in space suggest rendition in light and shadow, whereas the additional representation of occupied volume suggests sculpting by union, intersection, and subtraction, and is wasted on rendering. Such affordances are not binding. In theory you could draft with a paint system, if you set out to do so, but the raster data structure would hardly encourage the act; conversely, you could paint with a vector graphics system, but the experience would be clumsy at best. More subtly, you could render a three-dimensional interior scene by means of raytracing or an exterior by means of radiosity, but the respective advantages of the two methods would suggest doing thereverse, because raytracing does highlights and sharp shadows better, whereas radiosity does diffusion across surfaces better. Like understanding the affordances of physical materials, choosing the digital medium that best suits your purposes has emerged as an important component of software expertise.

At the same time the psychological dimensions of human-computer interaction determine the degree of engagement with these symbolic manipulation worlds. As we have seen two chapters ago, engagement depends partly on sensory-motor activity and partly on handling perceptual loads. These processes, too, may be understood in terms of affordance and constraint. Moreover, the experience of them depends very much on the dynamics of interaction, and is best when continuous. Thus the nature of the computer as a medium began with the introduction of direct manipulation,

and continues to depend intensively upon the ever-improving quality and range of continuous interactions.

Establishing both design worlds and psychological engagement depends on building adequate mental models. This is the most essential requirement for the computer to be understood as a medium. The best way to approach these questions is to understand software as a representational context: software designed and used properly creates a world of possibilities within whose assumptions and parameters we operate. Desktops, studios, sequencers, and stages all are representational contexts for specific classes of actions. We base our actions and understandings on these contexts. Often to succeed, we must necessarily subjugate our awareness of outside contexts to participation in the representation. As Brenda Laurel has observed, this is similar to what we experience when attending a good play:

> Engagement, as I use the concept, is similar in many ways to the theatrical notion of the 'willing suspension of disbelief', a concept introduced by early nineteenth century critic and poet Samuel Coleridge. It is the state of mind that we must attain in order to enjoy a representation of an action. Coleridge believed that any idiot could see that the play on the stage was not real life. He noticed that, in order to enjoy a play, we must temporarily suspend (or attenuate) our knowledge that it is 'pretend'. We do this 'willingly' in order to experience other emotional responses as a result of viewing the action.29

Suspending disbelief is an act *of participation.* As participants we are involved with what is going on within the terms of the representation, and we are unconcerned about how the performance itself is working. Note the similarity to the subjugation of sensory-motor response described by Polanyi in the context of tool usage. Here in an intellectual framework it is a matter of appreciating the implicit assumptions that theatrically frame a medium. Thus we suspend our awareness that we are working with a

computer, and we enter the mental model, as though our monitor were a proscenium, or better yet as if we were onstage ourselves. Incidentally, this explains much of the enthusiasm for interfaces that construct, at a lower, sensory-motor level, the perception that we are within the work.

The intellectual ability to appreciate a medium well enough to construct a robust mental model must be acquired and maintained through learning, play, and practice. On the surface, it might seem that such intellectual articulation is at odds with active, participatory, tacit knowing. Polanyi noted this "peculiar contrast," which he reconciled by demonstrating that articulation is never complete.30 But under deeper consideration, it should appear more reasonable that the mental model should couple with several other levels of awareness.

Recall Gelertner's spectrum of intellectual focus, wherein focal symbolic reasoning is complemented by diffuse free association, and where creative work moves back and forth along the spectrum of focus. To support such work, an effective mental model should not tie up so much attention that this oscillation between levels of consciousness cannot occur. This requires that once we suspend our disbelief, we should be able to work with those assumptions in the background, and not suffer being dropped out of the model or its representation by anomalies we encounter. Conversely, it demands that the lower-level operations we conduct within the representation should reinforce the assumptions and contribute to building an understanding at a higher, more symbolic level. This is another embodiment of Alan Kay's summary principle about graphical human-computer interfaces, that "doing with images makes symbols."

There may exist correspondences between tacit skill or appreciation and the structure of the mastered medium. Cognitive psychologists may have much to contribute here: even if the mind is assuredly not a sequential symbolic-processing mechanism, specific structures of cognition may yet reflect particular creative states. If so, these might inform our approach toward engagement and appreciation. Holtzman argues this. "One can conclude that approaching expressive media in terms of abstract structure should not limit their ability to be expressive even of the most profound

and subtle emotions. To the extent that the emotions themselves are built on a system of structures and relationships, expressive media viewed as systems of relationships can represent profound emotions. The challenge in designing abstract systems of expressive capability is not a limitation of the systems themselvesof dealing with abstract structure. Rather, the challenge is to develop abstract descriptions of sufficient richness, capable of capturing profound emotions and subtle expressive nuances."31

Just because a medium is structured does not mean that it has to be confining. The presence of structure does not necessarily reduce the opportunities for improvisation and expression. As we overcome the residual notion that computing is for objective documentation only, we must cultivate expressive sensibilities. These may result in a digital aesthetic or poetics, and they may involve artifacts that convey latent content and reflect active intent. Already we can begin from works that simply involve economy and emphasis. And in the end, chances are that appropriate artifacts and descriptions will engage us through rich and transparent tools, built on newfound densities of symbolic notation and personally experienced as a medium.