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From da Vinci to CAD and beyond

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Abstract Here what I would like to accomplish is to set something of the stage from which the growing recognition of what I shall now term *technoscience's visualism*—a term which can accommodate both sciences and engineering, and both imaging and design practices—takes its recognition. I shall very briefly look at the 'godfathers and peers' who help set this stage, and then proceed to an examination of a few moments in the development of visualism from da Vinci to computer assisted design (CAD) and beyond.

Keywords Computer assisted design · Imaging technologies · Postphenomenology · Visualism · Whole body experience

"Visualization" is today a totally common term in a variety of practices, including those practices in the sciences and engineering to be examined here. I do not know how recently "visualization" began to be used, but I suspect it is of mid-20th century origin. Note that to 'visualize' is both more specific and narrower than, say, the older use of *Gedankenexperimenten,* or 'imaginative variations' or other less sensory-specific modes of illustration. Although it is not often noted, Albert Einstein often used human bodily experiences to illustrate his physical theories—for example, the equivalence of acceleration and gravity was related to how kinesthetic experience would respond to these phenomena—although he often also used simple visual observation examples as well.

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On my part, I long ago claimed that the sciences tended toward a dominantly 'visualist' practice of interpretation and illustration which today is so well exemplified in the proliferation of *imaging technologies* which are used in all the natural sciences. In *Listening and Voice* (1976), I claimed that this trajectory towards a dominant 'visualism,' which although already prominent from early Greek philosophy, accelerated in early modernity in a form of a 'double reduction.' There was a tendency to 'reduce' all sensory experience to a privileged position for vision, but, secondly, a 'reduction' of vision to a certain type and style of vision, 'objectifying' vision. Looking back today at this claim, I can see how "heideggerian" I remained in the 70's! Then, more recently, in *Expanding Hermeneutics: Visualism in Science* (1998), while still retaining the claim that science practice remains 'visualist' in its dominant modes of interpretation, I realized that by honing and refining, the sciences had developed a very sophisticated *visual hermeneutics,* precisely through these visualist practices. Permit a couple of quotations:

1. Hermeneuticallly, in the perceptualist style of interpretation emphasized here—the progress of "hermeneutic sensory translation devices" as they might be called—*imaging technologies* have become dominantly visualist. These devices make non-visual sources into visual ones. This, through new visual probes of interiors, from X-rays, to MRI scans, to ultrasound (in visual form) and PET processes, has allowed medical science to deal with bodies become transparent.[1]
2. While all this instrumentation designed to turn all phenomena into visualizable form for a "reading" illustrates what I take to be one of science's deeply entrenched "hermeneutic practices…."[2]

In short, *visual hermeneutics* is simply a certain style of hermeneutics favored by the sciences. This was again confirmed in the 23 September 2005 issue of *Science* which announced its annual contest for visualizations.

Here what I would like to accomplish is to set something of the stage from which the growing recognition of what I shall now term *technoscience's visualism*—a term which can accommodate both sciences and engineering, and both imaging and design practices—takes its recognition. I shall very briefly look at the 'godfathers and peers' who help set this stage, and then proceed to an examination of a few moments in the development of visualism from da Vinci to computer assisted design (CAD) and beyond.

1 Godfathers and peers

I begin with Martin Heidegger—as early as his 1938 essay on "The Age of the World Picture," he begins to discern that not only are the sciences 'visualist' in a special sense, but that a certain framing of vision has taken place—in Heidegger's typically high altitude metaphysical sense. He claims that with modernity there is a certain inversion of how World is seen: "Hence world picture, when understood essentially,

[1] Ihde (1998).

[2] ibid., p. 160.

does not mean a picture of the world *but the world conceived and grasped as picture.*[3]

The inversion of world-as-picture [or image!] carries a lot of freight since, for Heidegger, it is the invention of modernity itself—here are some of the implications according to Heidegger:

1. World-as-picture invents humanism: "It is no wonder that humanism first arises where the world becomes picture."[4] And, this in turn is the invention of both subject-object or 'objectivism' and 'subjectivism.' A picture is something which can be set before someone, out there, set at a distance. "This objectifying of whatever is, is accomplished in a setting-before, a representing, that aims at bringing each particular being before it in such a way that man who calculates can be sure, and that means be certain, of that being."[5] Then, on the human side, humanism-subjectivism, is where, "What is decisive is that man himself expressly takes up this position as one constituted by himself, that he intentionally maintains it as that taken up by himself, and that he makes it secure as the solid footing for a possible development of humanity."[6]
2. World-as-picture is, of course for Heidegger, a *representational* style of metaphysics (in contrast to what he thinks of as both Greek and medieval thought): "In distinction from Greek apprehending, modern representing …brings to its earliest expression, intends something quite different. Here to represent means to bring what is present at hand before oneself as something standing over against, to relate it to oneself, to the one representing it, and to force it back into this relationship to oneself as the normative realm."[7]
3. All this, then, leads to what Heidegger takes as the conquest of nature, or being, through what eventually becomes "Technology": "The fundamental event of the modern age is the conquest of the world as picture. The world "picture" now means the structured image that is the creature of man's producing which represents and sets before."[8]

All this is typical Heidegger, critical of modernity, nostalgic of Greek and medieval lifeworlds, but also insightful insofar as the 'visualism' of modernity is recognized. It is to be remembered that "The Age of the World Picture" was originally a lecture to an arts group, but that also in this lecture most of what Heidegger addresses is the transformation of 'science' into '*research,*' another prescient notion.

I now move from the early to the mid-20th century: Thomas Kuhn's *The Structure of Scientific Revolutions* (1962) remains even today a landmark book interpreting science. And, he, too, recognizes in another way, the *visualism* inherent in science. Kuhn, of course, introduced the now virtually popular term, *paradigm,* into the language

[3] Heidegger (1977).

[4] ibid., p. 133.

[5] ibid., p. 127.

[6] ibid., p. 132.

[7] ibid., p. 131.

[8] ibid., p. 134.

about science. One can find it used with high frequency in such magazines as *Science* and *Nature,* and even in speeches by Dubya Bush! As you all know, Kuhn contrasts what he calls "normal science" from "revolutionary science" and the occasional shift from the former to the latter occurs thought a *paradigm shift.* A paradigm shift, however, is, as *Structure* describes it as *Revolutions as Changes of World View* [Chapter X]: "Examining the record of past research from the vantage of contemporary historiography, the historian of science may be tempted to exclaim that when paradigms change, the world itself changes with them. Led by a new paradigm, scientists adopt new instruments and look in new places. Even more important, during revolutions scientists see new and different things….*paradigm changes do cause scientists to see the world of their research-engagement differently* (italics added).[9]

Kuhn goes on to draw upon Wittgenstein and gestalt psychology with a perceptual example, the famous duck-rabbit shift, to model a paradigm shift. And in his text there are many, many examples of seeing things differently: "Looking at a bubble-chamber photograph, the student sees confused and broken lines, the physicist a record of familiar subnuclear events. Only after a number of such transformations of vision does the student become an inhabitant of the scientist's world."[10] These gestalt shifts include Kuhn's most famous example: …"when Aristotle and Galileo looked at swinging stones, the first saw constrained fall, the second a pendulum."[11]

From my perspective, Kuhn notes, but does not capitalize upon, the many instances in which such visual shifts are related to new or improved instruments. In the history of electricity, early effluvium-theory scientists, …"repeatedly saw chaff particles rebound from, or fall off, the electrified bodies that had attracted them….Placed before the same apparatus, a modern observer would see electrostatic repulsion (rather than mechanical or gravitational rebounding) *but historically…electrostatic repulsion was not seen as such until Hauksbee's large scale apparatus had greatly magnified its effects* (italics added)."[12]

So, Kuhn, too, interprets science as a dominantly visualistic practice, indeed, he seems to take visualism pretty much for granted: "The scientist can have no recourse above or beyond what he sees with his eyes and instruments."[13]

Also, mid-century, Michel Foucault's *The Order of Things* (1966 in French) appears. And, he, too, notes the role of visualism in early modernity—the "Classical" *episteme* as he calls it. Foucault notes that prior to early modernity, there are 'histories' and the grand model of the 'book' with all the similitudes and systems of meanings of the earlier *episteme.* But with early modernity 'perception' and 'observation' are invented. In science these are reductions to the visible, a certain sort of visible:

[9] Kuhn (1962).

[10] ibid., p. 111.

[11] ibid., p. 121.

[12] ibid., p. 117.

[13] ibid., p. 114.

1. "Natural history is nothing more than the nomination of the visible…a new field of visibility being constituted in all its density.[14]
2. This style of visualization is characterized by Foucault as a sort of reduction by way of negative conditions, "Observation, from the seventeenth century onward, is a perceptible knowledge furnished with a set of systematically negative conditions. Hearsay is excluded, that goes without saying, but so are taste and smell…touch is very narrowly limited to …a few fairly evident distinctions…which leaves sight with an almost exclusive privilege, being the sense by which we perceive extent and establish proof…"[15]

Foucault, like Kuhn, also recognizes the role of instruments in early modern science, but he inverts Kuhn and, in effect, argues that instruments are demanded by the visualism of the Classical *episteme.* [Interestingly, Foucault seems to favor microscopy as his primary example, rather than the telescope as used by Galileo.]

1. "In fact, it was the same complex of negative conditions that limited the realm of experience and made the use of optical instruments possible. To attempt to improve one's power of observation by looking through a lens, one must renounce the attempt to achieve knowledge by means of the other senses or from hearsay."[16]
2. "Though indefinite confinement of the visible within its own extent is made more easily perceptible to the eye by a microscope, it is nevertheless not freed from it….The microscope was called upon not to go beyond the frontiers of the fundamental domain of visibility, but to resolve…the problems it posed."[17]

Thus, both Kuhn and Foucault, at mid-century provide complimentary support for an intepretation of science's, and given the role of instruments, technoscience's visualism. Allow two interjections: One could take the high altitude of Heidegger, with his disjunction between Greek plus medieval views and modernity as both a very large shift, which clearly occurs rarely in human history, These are *epochs of Being.* But while both Kuhn and Foucault, mimic such shifts, both take them to be of shorter and more common occurrence : paradigm shifts and epistemes are mini versions of *epochs of being. Secondly*, from my perspective, while both Kuhn and Foucault recognize the role of instruments in the changes of paradigms and epistemes, the possible relations between vision and its instrumental embodiments remains unclear. I have and continue to hold, for example, that optics and the modes of vision which they make possible, well precede early modern science, as Lynn White Jr. and Daniel Boorstin have well shown, and one could as easily say that early modern science simply takes advantage of the new phenomena visibly available through lenses.

Finally, now, we reach the end of the 20th century, and I will comment upon only one peer who takes visualization *and instrumentation* in yet a different direction.

[14] Foucault (1973)

[15] ibid., pp. 132–133.

[16] ibid., p. 133.

[17] ibid., p. 133.

I refer to Bruno Latour, particularly the Latour of *Science in Action* (1987). Science does produce *texts,* but these are, in Latour's view, tertiary. Science reports itself in published articles, but one cannot question, undo, or defeat any scientific claim simply by criticizing such texts. Instead, one must go to the site where the evidence for texts is produced: the laboratory. And, in the laboratory, there is machinery for such productions: *instruments.* And it is exactly at this juncture that Latour gives an interesting twist to technoscience visualism:

1. "I will can an instrument (or **inscription device)** any set-up, no matter what its size, nature and cost, that provides a visual display of any sort in a scientific text….. For instance an optical telescope is an instrument, but so is an array of several radio-telescopes even if its constituents are separated by thousands of kilometers…The guinea pig ileum assay is an instrument even if it is small and cheap compared to…the Stanford linear accelerator."[18]
2. "What is behind a scientific text? Inscriptions. How are these inscriptions obtained? By setting up instruments. This other world just beneath the text is invisible as long as there is no controversy. A picture of moon valleys and mountains is presented to us as if we could see them directly. The telescope that makes them visible is invisible and so are the fierce controversies that Galileo had to wage centuries ago to produce an image of the Moon."[19]

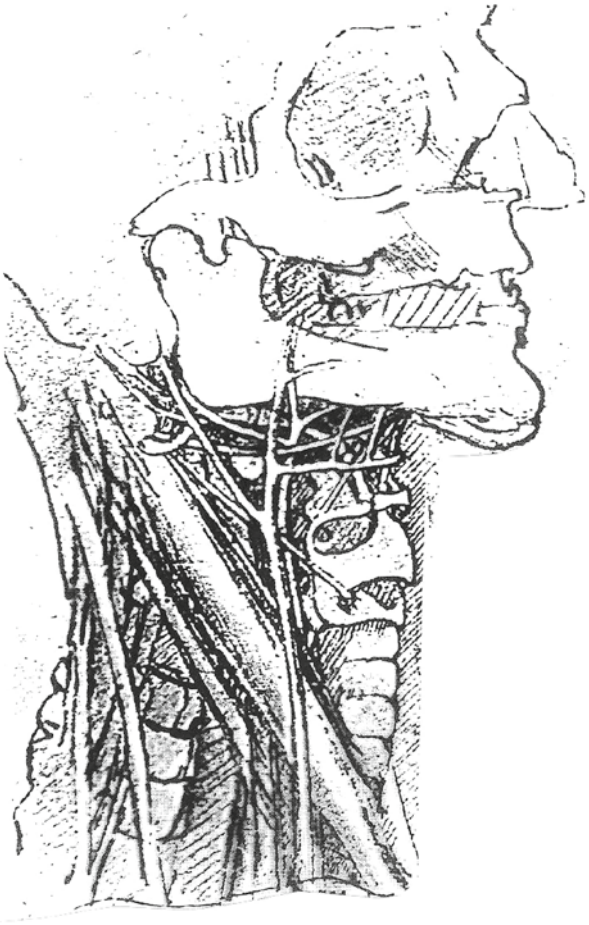
With Latour, technoscience's visualism close-links vision and instruments in a much tighter way. Latour, however, tends to blend together that which is invisible in the production of the visualization and the differences now prominent in late and postmodern instrumentation. The invisibility of that which is beyond the optical, in astronomy for example, is quite different from its earlier optical only history. Contemporary instruments *translate* into visual images that which is beyond human perceptual capacity. But throughout my brief survey of godfathers and peers, there remain different recognitions of visualism. We are now, however, ready to turn some historical examples of visualization.

2 A Postphenomenology of vision

I begin with Leonardo da Vinci (1452–1519). Our standard art histories are unanimous in recognizing Leonardo as a master artist of his time. His output was prodigious with even those with the barest literacy in art history able to name "The Last Supper" and "Mona Lisa" as da Vincian masterpieces. Here, however, I will concentrate upon his drawings, primarily those concerning anatomy and his technical drawings concerning machines. I shall argue that Leonardo, in the drawings, "invents" a style of seeing, a visualization, which pretty much sets the style for early modern science onward. I begin with his anatomical drawing:

[18] Latour (1987)

[19] ibid., p. 69.

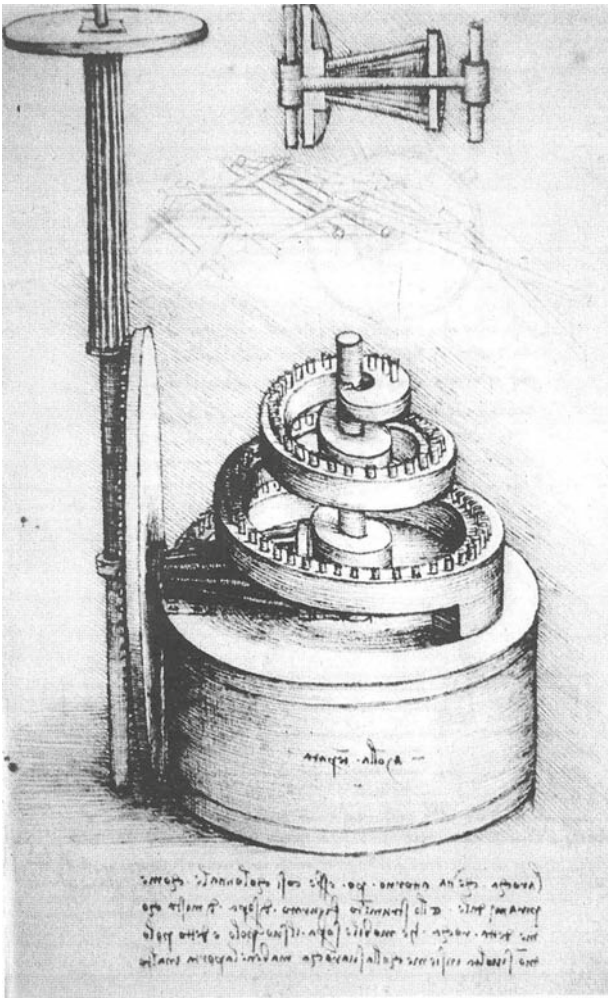


Note several features of this drawing: first, it exemplifies the 'realistic style' of the Renaissance, suggesting three-dimensionality, perspective, and a visual isomorphism with the object being depicted. Second, it penetrates surfaces and depicts interiors, almost as if the object was quasi-transparent. In art this is sometimes called x-ray vision. Third, it exemplifies the move to vision as privileged since bodies are visually drawn and the other senses are absent from concern. What would be easy to miss, without the histories of a science-studies style of analysis (and which could be adumbrated by art histories), is how this style of vision *contrasts* with the previous paradigm/episteme.

Pre-Renaissance depictions, so familiar in our master narratives, tend to lack perspective [it is claimed], be 'flat', and non-three-dimensional. Second, while there are plenty of gory examples of chopped up bodies in such battle depictions, the quasi-transparency of Leonardo's x-ray style is missing. Of course, depicting interiors, or a pre-anatomy version of x-ray depiction is actually cross culturally common, as in an example from my own collection of indigineous art .

But one can easily see that Leonardo's isomorphism is in stark contrast to my Australian example. And, finally, one should also note that the written anatomies of Leonardo's time actually favored descriptions of sensory reports other than vision: smells, tactile textures and degrees of softness, lumps and the like were part of the diagnostic style in anatomy. In other words, 'hands on' anatomy was not dominantly visualist. But, following da Vinci, Vesaliaus's anatomy accelerated the visualist tendency for this science practice.

My other examples come from Leonardo's technical drawings and his fascination with machines. One can perhaps forgive all but the most art history literate, if one did not know that the technical drawings were lost and only rediscovered and publicized by the Italian Futurists in the 1920's. They revived Leonardo as 'engineer' antecedent for their imaginations of a totally technocratic society. But should they have been forgiven for not noting that many of these drawings were, in turn, Leonardo's attempt to draw—visualize—merely imagined machines? Leonardo was fascinated by Roger Bacon's 13th century imaginings of flying machines, under-water vessels, and self-propelled war machines. Here is an example of one of da Vinci's machines.

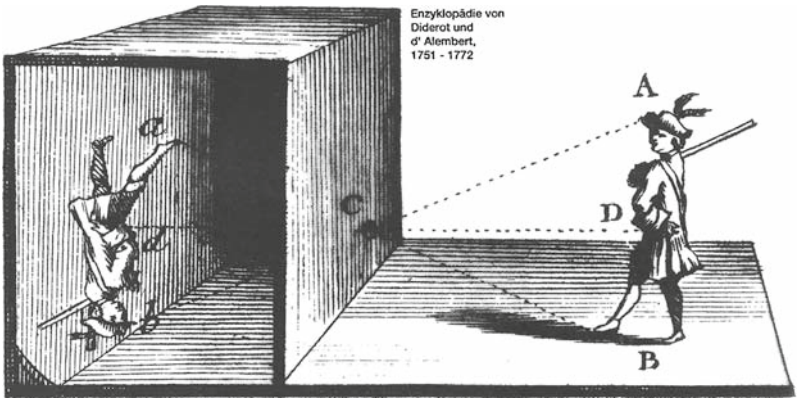


There is, of course, a lot of romantic nonsense about these drawings, embedded in claims about how prescient Leonardo was about the future of technology. Never mind that many, indeed most of Leonardo's machines were never built and for that matter either would have been entirely impractical or unworkable! Rather, here I am interested in the style of depiction, since it is the same as that of the anatomical drawings**.** In short, the realism or isomorphism, the transparent three-dimensionality, and the visualization is identical for both subject matters. It is what today we would call an 'exploded diagram' style of depiction.

To this point I have been using Leonardo to take account of a shift in the way things can be depicted, visualized. And I have been doing my analysis in a way which reverberates and reciprocates with the analyses of the godfathers and peers cited. Now, however, I want to take a different tack and look a bit more closely at the *technological lifeworld* —the instruments—which Leonardo lived in and used. As noted above,

late medieval times were times of a first, pre-modern technological revolution. Vast, large and complicated technologies spread into Europe, sometimes were invented in Europe, to do things such as pump out the North Sea over the seafloor which became the Netherlands (windmills); to later construct the high gothic cathedrals (cranes and lifting devices); unload and count cargo from the ships of the voyages of discovery (precisely Leonardo's times!). But I am particularly interested in the technologies which relate quite immediately to vision, to both art and other practices including military and scientific.

Eyeglasses were so common that they were listed in wills by the 13th century; and while the optics so necessary to early modern science—telescopes and microscopes-were not ready by Leonardo's time, other optical toys were. There were many non-lensed devices, frames and grids, which were which were well known to Leonardo and peers **.** These devices, technologies, were employed in the practices of drawing. And, insofar as they were familiar they become part of a taken-for-granted *lifeworld.* Among such optical devices, there was one which we *know* Leonardo experimented with: *the camera obscura.*



Leonardo reports:

1. "When the images of illuminated bodies pass through a small round hole into a very dark room, if you receive them on a piece of white paper placed vertically in the room at some distance from the aperture, you will see on the paper all those bodies in their natural shapes and colors, but they will appear upside down and smaller…"[20]

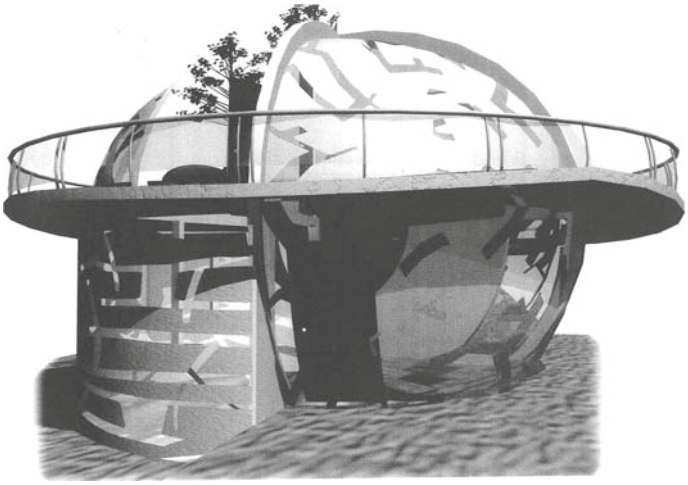
He later produced a sketch of the *camera obscura* and reports on his own use of it to draw a crucifix imaged in the dark room. It may be noted in passing that a number of contemporary artists also used the *camera,* but I resist extrapolating its use

[20] Quoted by Bailey (1989).

as far as has David Hockney in his book, S*ecret Knowledge,* which claimed most artists of the time used such optical devices. What is much more important is what the *camera* does in its imaging: it, in effect, produces *virtually,* the main features of what we call 'Renaissance perspective.' That is, it reduces from three-dimensions to two-dimensions in an isomorphic fashion, a 'realism.' It preserves shape and color features, although inverted, but also reduces these to proportionate sizes. It does not, of course, produce the x-ray effect which Leonardo introduced to his drawings. My point, however, is that insofar as the *camera* allows things to be seen in its imaging style, and insofar as this was a common experience for many of Leonardo's time, this is a factor in an instrumentally mediated world—and, in a rather strange sense, one could characterize its result as a world-as-picture.

I now take a large, historical leap—to the practice of computer-assisted-design. This practice is now wide-spread, from automobile design to architecture, and I have witnessed certain advanced virtual-reality CAD projects regarding Danish windmills while doing an imaging technologies seminar in Aarhus. But I shall use as my example here a simpler, amateur and personal example. I, myself, used a CAD to design my kitchen remodeling in 1992. One simply goes to a supplier and a computer with a large screen is there for use. The project is to design my kitchen and chose the various cabinets, appliances and the like: I feed in the dimensions of the floor space, accounting for cut-outs for a stair well and the like, add height dimensions, etc. Then, following a menu, one can chose which cabinetry, dishwasher, sink, etc. and the CAD will project them on a screen, using standard three-dimensional drawings. I can, as in a video game, chose different perspectives from which to view the virtual kitchen, switch at will the positions of cabinetry and appliances, until I am satisfied with a layout. The print-out and purchase orders are accomplished and I, as amateur architect, can go on to the next steps. Here is design, computer assisted, and for those who are today's academics, one can easily recognize the analog between CAD and *word processing.* The differences between Leonardo's sketches, done by hand, and CAD kitchen design, precisely parallel differences between hand penned and word processed composition.

Hand penned drawing or composing, is relatively slow, and, once drawn, is there before one. But if one wants a change, one has to redraw, and if complex, this entails a certain labor. And, one could, literally, cut-and-paste. What computer assistance does, is to make the changes, the editing fast and easy. This counter fits there, or now, in a different position as does this sentence or paragraph. Within the virtual space of the display, the kitchen or the essay gets shaped and reshaped. It gets fixed only when one 'saves' the design or page. But, on the other hand, there are constraints as well. My CAD kitchen can only appear within a standard, three-dimensional projection, and while I may chose different colors or woods, all the components are off-the-shelf 'bricolage' variations. Unlike the imaginative hand, I have to stick to my stocked variations. CAD is a sort of video-game design. Of course, if I am a programmer, I could re-set the program. The moral of the story, at this amateur level, is that I am quite unlikely to produce any imaginative design, such as those which are now appearing from Frank Gehry or Arakawa such as these:



So, it might appear at this level and in this example, that our godfather, Leonardo, set the trajectory for 'realistic' three-dimensional perspective designs, now made easy and 'democratic' through CAD. Lest you think that the constraints I am pointing to relate only to a low-level design program, I have found that the same characteristics belong to, for example, the virtual CAD for Danish windmills which I have witnessed but not operated. One can shift perspectives, walk around, replace components and the like, but one remains within the familiarity of da Vincian perspective. So, what has happened to paradigm shifts and epistemes with regard to this sedimented perspectival mode of depiction? That is, I am claiming that much, probably most, CAD while automating, making dynamic, and easy to use, simply sediments a long tradition of

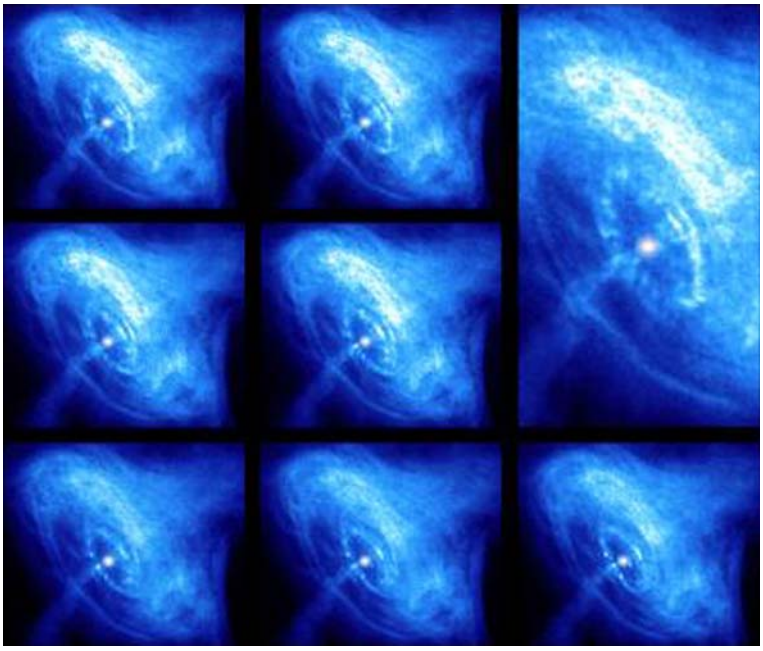
three-dimensional, mostly also Euclidian projection. Could we, can we get beyond this?

3 Visualist futures

In my analysis of da Vincian compared to CAD visualization, I did suggest that the isomorphic optical transformation of three-dimensions to two, via the technology of the *camera obscura,* did suggest a new way of visualization. But what could be seen in the *tabula rasa* of the white screen was not something automatic—it required the imaginative embodiment of a Leonardo. Now, if the new technologies of computer processes and imaging are the 21st century equivalents of the ancient *camera,* what might we expect?

What makes technologies valuable for human practices, I claim, are the non-neutral transformational capacities of these technologies. And for at least the last decade, I have written much about this. Here I can condense much of that work by claiming that computer processes linked to imaging technologies give us a style of instrumentation in which, *by virtue of inversions and transpositions,* give us tools for producing radically new visualizations.

- The first and most widely familiar such process is the convertibility of data and image. Remote imaging, such as a space probe may undertake, with photographic, radar, or infrared imaging, takes its "pictures" of a distant planet, say Venus, and these images are first converted into data which can be transmitted electronically back to our earth station. Then, the data is re-converted into an image and the crew of observers immediately rhetorically hype and publicize the results on the evening news.
- Variations on data-image inversions sometimes also reveal new and unsuspected analogies, such as the algorithmic projection of imagery which we know as chaos and fractal patterns. Here, no original image is converted to data, but the data itself is tweaked to produce patterns which suggest natural processes, such as erosion or land formation.
- In the sciences, others, for example both Peter Galison in his *Image and Logic,* and Bettyann Kevles in *Naked to the Bone,* have shown how such imaging revolutionized microphysics and medical imaging.
- The second process of the new imaging is the ability—for the first time in the 20th century—to image beyond all human sensory capacity and beyond the confines of optical light. I refer, in astronomy, to the new astronomical imaging which took place with long wave radio astronomy early, then into infrared, ultraviolet, and down to x-ray and gamma wave phenomena. This style of imaging necessarily entails a *translation* convertibility to bring results into human range. Associated with all these imaging processes are those of computer processes, such as tomography which can combine and make composites, or which can deal only with slices or narrow ranges of the spectrum being imaged.



- And, recently, I have become aware of a third process which computerization makes possible, the inversion of sensory modalities. I began this paper with the wide-spread recognition of science's preference for visualization. Science imaging practice has learned how to turn virtually any signal into a visual display. Sonar, originally auditory, soon became visual on a screen; similarly, the use of infrasound, as in sonograms, is also visualizable. Even speech can be transformed into an oscillagraphic process and used to help people detect accent and speech defects—visually. Some can even learn to 'read' the wave patterns and know what is being said. But, this process of transforming acoustic phenomena into visualizations, can itself also be inverted.
- The infamous "bugging" process by which lasers can be used to 'read' the vibrations of a window pane, which serves as a sound sending diaphragm, can be turned into audible, if somewhat poor speech. I will conclude with two examples of this capacity imaginatively developed by a Dutch physicist-turned-artist. The first example comes from his acoustical recording of what could be called life-rhythms. In this case, he placed sensors aimed at a series of apartment windows, the acoustic results were then computer condensed and recorded on a CD. Thus the buzz of early morning activity, followed by the lull of empty apartments, followed by the return to evening activity, produced a sort of 'song' of human actions. The second example was more surprising and accidental; he detected in some of his acoustical, environmental sensing, a repeated rhythm which at first was unrecognizable, but correlated with barometric patterns—to make the story short, he discovered that these were the sounds of periodic storms off Iceland which still reverberated over Holland, a sort of 'earth-song.'

I end with the suggestion that if today's imaging, combined with computer processing, serves as a postmodern *camera obscura analog,* that we may expect some radically different visualizations due to the complexity, convertibility, and invertability of these technologies, but also that more than visualization may lie before us. Here, I have only taken us to a threshold which retains far too much from a now outstripped *episteme,* an *episteme* which still discourses in terms of sensory dimensions—sight, hearing, possibly kinesthesia—whereas in phenomenology as I know it, *whole body experience* is primary. Yet our instruments, including the most advanced virtual reality simulations, do not give us this. Instead, our traditional instrumentation exaggerates precisely a kind of magnification/reduction distortion into monosensory dimensions. And while contemporary instrumentation exceeds the limits of earlier instrumentation, it still tends to follow 'slices' of visual and sometimes audio dimensions. Indeed, this is what makes visualization possible. But, *no instrument can eliminate whole body, primary experience!* Instead, it simply rearranges, produces an amplified dimension while the other multiple dimensions are backgrounded—but they do not disappear. Yet, this magnification/reduction is not 'bad,' in fact it is what makes much scientific knowledge possible. Only insofar as our instruments transform experience are they of use or interest. This, however, with the qualification that a critical awareness and a critical interpretation is thus called for across all instrumental use, and, by implication, for all forms of visualization.

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