

From the Externalization of the Psyche to the Implantation of Technology

Lev Manovich

1.

In 1877 Sir Francis Galton, a statistician and a cousin of Charles Darwin, a founder of eugenics (a project of social betterment through planned breeding), and the author of highly influential psychological texts, pioneered a procedure of making composite photographs which proliferated widely in the next three decades.^[1] Fabricated by a process of successive registration and exposure of portraits onto a single plate, Galton's composites were thought to constitute true statistic averages, representing human types -- a criminal, a prostitute, an Englishman, a Jew, and others. Galton wrote about his composite pictures that they are "much more than averages; they are rather the equivalents of those large statistical tables whose totals, divided by the number of classes and entered on the bottom line, are the averages. They are real generalizations, because they include the whole of the material under consideration."^[2]

Galton not only claimed that "the ideal faces obtained by the method of composite portraiture appear to have a great deal in common with...so-called abstract ideas" but in fact he proposed to rename abstract ideas "cumulative ideas." In contrast to the human mind, "a most imperfect apparatus for the elaboration of general ideas," Galton championed his composite photographs, which, being mechanical and precise, were much more reliable for arriving at abstract representations.^[3]

With his photographs, Galton not only proposed that universals may be represented through generic images; he actually objectified and materialized them. Plato's ideas were given concrete form: they could now be touched, copied, fabricated, multiplied, distributed, etc.

Galton's belief that his composite photographs gave abstract ideas material tangible form is just one example of a more general modern phenomenon. This phenomenon can be called externalization of the mind. It shows itself in two ways. On the one hand, we witness recurrent claims by the users of new visual technologies, from Galton to Jaron Lanier, that these technologies externalize and objectify the mind. On the other hand, modern psychological theories of the mind, from Freud to cognitive psychology, also equate mental processes with external, technologically generated visual forms.

What to make of this desire to externalize the mind? In this essay, I will relate it to the demand of modern mass society for standardization. The subjects have to be standardized, and the means by which they are standardized need to be standardized as well. Hence the objectification of internal, private mental processes, and their equation with external visual forms which can be easily manipulated, mass produced, and standardized on its own. The private and individual is translated into the public and becomes regulated.

What before was a mental process, a uniquely individual state, now became part of a public sphere. Unobservable and interior processes and representations were taken out of individual heads and put outside -- as drawings, photographs and other visual forms. Now they could be discussed in public, employed in teaching and propaganda, standardized, and mass-distributed. What was private became public. What was unique became mass-produced. What was hidden in an individual's mind became shared.

2.

Galton saw photography as a machine for externalization of ideas. Even stronger claims were made about the next visual technology -- film.

Indeed, the revolutionary new medium, the medium of mass society par excellence -- film -- was immediately proclaimed to be the machine for the externalization of private mental functions and states. In 1916 Hugo Münsterberg, a Professor of Psychology at Harvard University and one of the founders of the fields of industrial and applied psychology, published The Film: A Psychological Study, today canonized as one of the earliest theoretical treatments of cinema.^[4] According to Münsterberg, the essence of the new medium lies in its ability to reproduce, or "objectify" various mental functions on the screen: "The photoplay obeys the laws of the mind rather than those of the outer world."^[5] In contrast to the theater, where the action is constrained by the limitations of physical reality, film is free to shape arbitrarily its material, closely approximating flashes of memory, the flights of imagination, and other mental acts. For instance, while in theater events have to follow each other corresponding to the progression of time, in film the action can suddenly jump back and forth, just as in an act of imagination.

Münsterberg was not content to point out the analogy between film and mental life; in an astounding analysis, he correlated the main cinematic techniques to different mental functions such as attention and memory, one-to-one. For example, in the close-up, "everything which our mind wants to disregard has been suddenly banished from our sight and has disappeared," analogous to how our attention selects a particular object from the environment. Similarly, the "cut-back" technique objectifies the mental function of memory.

"In both cases," Münsterberg wrote, "the act which in the ordinary theater would go on in our mind alone is here in the photography projected into the pictures themselves."^[6] The psychological laboratory became indistinguishable from the movie house; the textbook of experimental psychology -- from the cinematographer's manual. The mind was projected on the screen; the inside became the outside.

Münsterberg admired the power of film to externalize the functions of consciousness. The next logical step was taken by a German psychologist Kurt Levin who, in 1924-25, was the first to use film in his experiments. He wrote that "fiction film attempts to objectify certain psychological processes for the viewer. Psychological (scientific) film

studies to what extent these psychological processes can be objectified."^[7] Soviet psychologist A.P. Luria, who planned to establish a psychological laboratory in Moscow in cooperation with the State Film Academy, acquainted Levin with Eisenstein, who attended the shooting of one of Levin's films and advised him.^[8]

The figure of Eisenstein is particularly important because it reveals the historical connection between the desire to externalize the mind and the rise of mass communication, of which film was a major vehicle. The emergence of new mass societies in the earlier part of this century dictated the necessity to communicate ideological concepts to mass populations which were often illiterate.^[9] In the 1920s Eisenstein boldly conceived a screen adaptation of Marx's Capital as a way to efficiently bring about the political enlightenment of Russian audiences, especially the peasants who would not sit through a political lecture but, attracted by the "novelty" of a movie projector, would come to see movies, regardless of what was shown.^[10]

Unprecedented as his project was, its radicalism lay not only in the decision to visualize the abstract notions and logic of Capital but in the method employed, which, according to Eisenstein, would directly provoke dialectical thinking in audiences.^[11] Jacques Aumont concludes that for Eisenstein, "the object privileged in Marx's work is not a theoretical one, like any of the key concepts from Capital. It is at another level entirely that Eisenstein selects his true object -- the Marxist method itself."^[12] Thus it was not simply a matter of the modern redeployment of the directions of the 1492 sermon: "...Images of the Virgin and the Saints were introduced...on account of the ignorance of simple people, so that those who are not able to read the scriptures can yet learn by seeing the sacraments of our salvation and faith in pictures."^[13] The viewers of Capital were not only to learn the scriptures of the new atheistic religion; they were to learn the process of reasoning.

It is significant that the most categorical statement by Eisenstein on the possibility of "filmic reasoning," reasoning through images, appears in the context of his discussion of the sequence known as For God and Country from October (1929):

Maintaining the denotation of "God," the images increasingly disagree with our concept of God, inevitably leading to individual conclusions about the nature of all deities...a chain of images attempted to achieve a purely intellectual resolution, resulting from a conflict between a preconception and a gradual discrediting of its purposeful steps.

Step by step...power is accumulated behind a process that can be formally identified with that of a logical deduction...The conventional descriptive form for film leads to the formal possibility of a kind of filmic reasoning. While conventional film directs emotions, this suggests an opportunity to encourage and direct the whole thought process as well.[\[14\]](#)

Far from simply representing God or deities, as they did for centuries, here images serve a totally new function -- to provoke and direct reasoning, reasoning of a particular kind -- "Marxist dialectics." In accordance with its principles, as canonized by the official Soviet philosophy, Eisenstein wants to present the viewer with the visual equivalents of thesis and anti-thesis so that the viewer can then proceed to arrive at synthesis, i.e. the correct conclusion, pre-programmed by Eisenstein.

"The content of CAPITAL (its aim) is now formulated: to teach the worker to think dialectically," Eisenstein writes enthusiastically in April of 1928.[\[15\]](#) Schooled by the film, viewers would become self-sufficient thinkers, learning the skill of "Communist decoding of the world," each a walking camera, snapping pictures of visual thesis and anti-thesis, the brain automatically executing cognitive operations of montage, thinking through images, efficiently and effectively.

Eisenstein claims the radical novelty of his concept of "filmic reasoning":

The proclamation that I'm going to make a movie of Marx's Das Kapital is not a publicity stunt. I believe that the films of the future will be found going in this direction (or else they'll be filming things like The Idea of Christianity from the bourgeois point of view!) In any case, they will have to do with philosophy...the field is absolutely untouched. Tabula rasa.¹⁶

Yet, Einstein's theory was not an isolated development. Many in the artistic left of the 1920s shared a similar belief in the cognitive power of new visual forms such as montage. In the late 1920s Alexander Rodchenko promoted the use of montage sequences in graphic design and, like Eisenstein, he saw montage as being equivalent to "dialectical" reasoning. In this formulation, an individual image corresponded to a single concept, and thinking was thought to be provoked when a number of images were juxtaposed in a series.[\[17\]](#)

Galton, Münsterberg, Eisenstein. Composite photographs, cinematic devices of close-up, cut-back, and montage. These developments are symptoms of a single social imaginary at work: to make the mind more controllable by externalizing it and rendering it visible.

What before was a mental process, a uniquely individual state, now became part of a public sphere. Unobservable and interior processes and representations were taken out of individual heads and put outside -- as photographs, films and other visual forms. Now they could be discussed in public, employed in teaching and propaganda, standardized, and mass-distributed. What was private became public. What was unique became mass-produced. What was hidden in an individual's mind became shared.

3.

The recurrent claims that new visual technologies externalize and objectify reasoning, and that they can be used to augment or control it, are based on the assumption of the isomorphism of mental representations and operations with external visual effects such as dissolves, composite images, and edited sequences. This assumption, which I so far have not questioned, on a closer examination appears to be highly problematic.

Whatever mental representations and operations really are, the mind surely does not contain pictures, photographs or film clips which some mental homunculus looks at. The external images presented to the mind are not magically transplanted inside it as ready-made ideas and arguments. Regardless of what visual forms can be presented before the eye -- diagrams, photographs, film images -- as any other visual input, they are

subjected to the complicated processing by the nervous system which constructs its own internal representations.

Yet, the assumption of such an isomorphism continues to persist in modern thinking about vision, ignited by every new round of visualization technology: photography, film, computer animation, and virtual reality. Consider the claims which surround the new field of scientific visualization -- visualization of data sets, their relationships and their dynamic behavior using computer graphics. Richard Mark Friedhoff and William Benson proclaim that computer visualization techniques constitute the second computer revolution because they act as the direct "extension of preconscious visual processes."[\[18\]](#) They assume that the images on a computer screen do not simply function as an aid for reasoning but that they are equivalent to the mental representations the mind may construct while thinking -- and this is the source of their power.

Or consider the technology, which, even more so than scientific visualization, is seen as capable of completely objectifying, better yet, transparently merging with mental processes -- virtual reality (VR). Again, the descriptions of its capabilities do not distinguish between internal mental functions, events and processes, and externally presented images. This is how, according to Jaron Lanier, VR can take over human memory: "You can play back your memory through time and classify your memories in various ways. You'd be able to run back through the experiential places you've been in order to be able to find people, tools."[\[19\]](#) Lanier also claims that VR will lead to the age of "post-symbolic communication," communication without language or any other symbols. Indeed, why should there be any need for linguistic symbols, if everybody, rather than being locked into a "prison-house of language" (Jameson), will happily live in the ultimate nightmare of democracy -- the single mental space which is shared by everybody, and where every communicative act is always ideal (Habermas). This is Lanier's example of how post-symbolic communication will function: "you can make a cup that someone else can pick when there wasn't a cup before, without having to use a picture of the word "cup."[\[20\]](#) Here, as with the earlier technology of film, the fantasy of objectifying and augmenting consciousness, extending the powers of reason, goes

hand in hand with the desire to see in technology a return to the primitive happy age of pre-language, pre-misunderstanding. Locked in virtual reality caves, with language taken away, we will communicate through gestures, body movements, and grimaces, like our primitive ancestors...[\[21\]](#)

What can one make of this apparently unsound, yet irresistible, assumption of isomorphism between the mental process of reasoning and external, technologically generated visual forms, haunting us at least since the end of the nineteenth century? The conflation of outside and inside is, of course, symptomatic of the desire to project the inside onto the outside, to make it objective and public. But is this all? To really understand the persistence of this assumption, we should turn to the history of ideas about the nature of mental processes.

It is well known that technologies have historically provided and continue to provide the models according to which people imagine the mind. In the seventeenth century it was the clock, in the nineteenth -- the motor, in the second half of the twentieth -- digital computers. More precisely, the paradigms were provided not by the technologies themselves, but by theories which made them possible. To take the last paradigm as an example, cognitive psychology, born in the 1950s and gaining prominence ever since, approaches the mind as an information-processing system, as software which runs on the hardware of the brain. But what gave cognitive psychology its epistemological basis was not the new technology itself (computers), but the information theory accompanying it. It was this paradigm which substituted the discussions of mind and brain by the notion of "human information processing." And before information theory, theories of the mind were influenced by thermodynamics (as in Freud) and mechanics (Hobbes).[\[22\]](#)

It can be also claimed, however, that human imagination about the mind's operations is limited by the current visual technologies. Consider the current views about the nature of mental processes. The linguist George Lakoff asserted that "natural reasoning makes use of at least some unconscious and automatic image-based processes such as superimposing images, scanning them, focusing on part of them"[\[23\]](#) while the psychologist Philip Johnson-Laird proposed that logical reasoning is a matter of

scanning visual models.^[24] Such notions would have been impossible before the emergence of television and computer graphics. These visual technologies made operations on images such as scanning, focusing, and superimposition seem natural. Even more telling are the models of cognitive psychologists who, in the last two decades, have systematically scrutinized the role played by mental images in reasoning. These models, which define mental images in terms of such characteristics as spatial resolution, speed of access, basic graphic operations (rotation, translation, copy), seem to be describing first of all computer imaging systems. Psychologists argue among themselves which imaging systems better resemble mental processes, but they do not doubt the basic metaphor. As Paul Virilio notes, "now the virtual images of the computer screen seem to confirm not only the existence of certain forms of representation but, more immediately, the objective presence of mental images."^[25]

Similarly, in the earlier period, when Freud, in The Interpretation of Dreams, described the mechanisms by which dream-thoughts and the logical relations between them are represented in dreams, he and his fellow psychologists relied on available visual technology for their understanding of the mind. Not surprisingly, Galton's composites, the earliest form of image processing before digital computers, provided a particularly attractive model. Freud compared the process of condensation with one of Francis Galton's procedures which became especially famous: making family portraits by overlaying a different negative image for each member of the family and then making a single print.^[26] Writing in the same decade, the American psychologist Edward Titchener opened the discussion of the nature of abstract ideas in his textbook of psychology by noting that "the suggestion has been made that an abstract idea is a sort of composite photograph, a mental picture which results from the superimposition of many particular perceptions or ideas, and which therefore shows the common elements distinct and the individual elements blurred."^[27] He then proceeds to consider the pros and cons of this view. We should not wonder why Titchener, Freud and other psychologists take the comparison for granted rather than presenting it as a simple metaphor -- contemporary cognitive psychologists also do not question why their

models of the mind are so similar to the computer workstations on which they are constructed.

4.

As psychologists begin to furiously take on the questions philosophers only wondered about, subjecting mental processes to controlled, scientific, laboratory study, their models begin to reflect, more and more, the external visual forms made possible by whatever visual technology dominates the period.

Given the reliance of psychological theories of the mind on contemporary visual technologies, is there any "progress" between the turn of the century and today, except that the imagination of contemporary psychologists depends on the more sophisticated visual technologies of computer graphics? In fact, during this century, the assumption of an isomorphism between the mental and the objective became even more prominent; and externalization of reasoning has been taken much further, both technologically and theoretically.

On the one hand, the refinement of various medical imaging techniques in the 1980s made possible an increasingly precise imaging of brain activity, including the visualization of reasoning -- in a literal sense. It is now possible to ask the experimental subject to concentrate on solving a problem and to see which parts of the cerebral cortex are active. The question of whether reasoning in fact depends on the operations normally involved in perception becomes more and more the question which, according to a number of researchers, can be answered through experimentation -- it is enough to show that the part of a cortex normally dedicated to the processing of visual information is activated in the process of reasoning.[\[28\]](#)

More importantly, in their theories, many cognitive psychologists have accepted as given the equivalence between internal mental processes and the operations which can be done with external, objectively existing visual representations and objects. Consider the debates about the nature and role of mental imagery, which have constituted one of the most active areas of research in cognitive psychology in the last two decades.[\[29\]](#)

On the one hand, there are those (such as Zenon Pylyshyn) who argue that mental imagery simply consists of the use of general thought processes to simulate physical perceptual events. In this view, if the subjects report the presence of mental imagery during reasoning and problem solving, this is simply a side effect, a by-product of real mental computations which do not involve visual representations. On the other hand, there are those psychologists and neurophysiologists who, through experiments and direct imaging of brain activity, want to prove that reasoning takes place through the construction and manipulation of mental images (Alan Pavio, Roger Shepard, Stephen Kosslyn, Martha Farah).

One of the most well-known experiments in defense of the latter view has been done by Roger Shepard and Jacqueline Metzler of Harvard University.^[30] They presented subjects with pairs of perspective line drawings of three-dimensional forms constructed from small cubes. The subjects' task was to determine whether or not the forms were identical in shape, despite the difference in orientation. Shepard and Metzler have found that the reaction time was proportional to the degree of rotation which is required to bring the two objects into a similar position. These results were taken as proof that in solving the problem, the subjects mentally rotated representations of three-dimensional objects, and that imagined rotations corresponded to actual physical rotations of objects: "Imagined rotations and physical transformations exhibit corresponding dynamic characteristics and are governed by the same laws of motion."^[31] Thus, a mental process was equated with an operation one would perform with real, objectively existing objects.

Other experiments in defense of the position that many kinds of reasoning involve manipulation of mental imagery entail the comparison of abstract qualities. When subjects were asked to recall two animals and to judge which one was larger, the reaction time decreased proportionally to the difference in estimated size. In another experiment, one group of subjects was asked to rate animals in intelligence on a scale from one to ten, while another group had to compare the intelligence of pairs of animals. Again, the reaction time decreased as the distance in rated intelligence increased. It was concluded that when the subjects tried to discriminate between two objects,

reaction time was shorter the greater the difference between two objects, regardless of whether the objects were really presented (for instance, two lines of different length), or were imagined (size of animals), or whether the qualities to be compared were abstract (intelligence of animals).[\[32\]](#)

We shall leave to psychologists the debates whether these and numerous related experiments indeed prove that internal mental processes involve the manipulation of pictures similar in their qualities to real images. But for my purpose it is significant in itself that in imagining what mental processes are like, contemporary psychologists have assumed, without any reservations, an equivalence between the internal and the external, between the mental objects and the real ones.

Modernization, visualization, externalization. In order to externalize the internal, the invisible, it was first equated with the visual. Once this was accomplished, it was simple and only logical to equate the visual inside with the visual outside, the objectivity and standardization of images drawn on a classroom blackboard, on the screen of a movie theater, or, most recently, on the computer terminal.

5.

I have traced different ways in which the mind was externalized in the last century and a half. Abstract ideas and the process of condensation were equated with composite photographs (Galton and Freud respectively); mental functions such as attention and memory -- with cinematic devices of close-up and cut-back (Münsterberg); the process of thinking -- with montage (Eisenstein). More recently, Lanier and Friedhoff similarly have linked mental processes with VR and scientific visualization techniques (and Benson). And finally, cognitive scientists have described mental processes and functions in terms of operations only possible with computer imaging systems.

The overall trajectory which I followed is from the inside to the outside, from the private and inaccessible mental states to the public, external, technologically generated visual forms or the latest imaging technologies themselves. One can even say that to a large extent it is this very desire to objectify the psyche which gave birth to modern imaging

technologies such as photography, cinema and VR. Indeed, is not the whole idea of photography to objectify private memories and private mental images?

This trajectory still continues. In fact, the advances in electronics, computers and neuroscience now allow us to externalize mental process in real-time. One example of this which I mentioned is medical imagining of brain activity. Another is the recent work to control computers by thinking commands. The 1993 issue of a computer journal reports:

NTT Researchers in Japan have created methods to use brainwaves to determine which direction a person will move a joystick; University of Illinois psychologists developed a system that types when words are spelled out mentally; and the New York State Health Dept. devised a system that lets users take a cursor up-and-down or side-to-side by visualizing the moves.[\[33\]](#)

However, the same technological advances (as well as work in nanotechnology and neural networks) also make it possible to take the next step: to go from the outside to inside, to internalize external technologies by putting the machines back into the brain. We are now witnessing the birth of neurotechnology: complete computers the size of neurons which can be implanted under the skull or tiny neural network circuits which can be merged with real neural networks.

We may only guess how far such research has already advanced in military labs (is it possible that much science fiction in this century is not about the future but simply an accurate description of contemporary military research?). For now, futuristic movies provide us with the best examples of how such implants could function. Two such movies are Hollywood's Terminator 2 and Robocop. In both films the main character's vision is enhanced by a sophisticated computer imaging circuitry. The circuitry functions as combination of a video camera and a robotic vision system. It allows both heroes to zoom on the objects, to see in the dark, to record and to play back what they see, to bring up stored images which can be compared with what they presently see and so on.

We used to dream of flying carpets and magic castles; now we dream of tiny video recorders implanted in our retinas and computer RAM inside our skulls supplementing our own short-term memory. In short, we dream of becoming neuro-cyborgs.

We used to flock to movie houses where our mental mechanisms were projected on a huge screen. Soon each of us will be able to put back this screen inside her or his head.

Carriage return. End of file.

[1] Allan Sekula, "The Body and the Archive," October 39 (1987): 40.

[2] Qtd. in *Ibid.*, 47.

[3] Qtd. in *Ibid.*, 51.

[4] Hugo Münsterberg, The Photoplay: A Psychological Study (New York: D. Appleton & Co., 1916).

[5] *Ibid.*, 41.

[6] *Ibid.*, 41.

[7] Qtd. in Olga Bulgakova, "Sergei Eisenshtein i ego 'psikhologicheskiy Berlin' -- mezhdru psikhoanalizom i strukturnoy psikhologiyey" (Sergei Eisenstein and his 'psychological Berlin': between psychoanalysis and structural psychology), Kinovedcheskie Zapiski 2 (1988): 187.

[8] *Ibid.*, 177.

[9] For instance, according to the 1926 census, out of every 1,000 citizens of the U.S.S.R., only 445 were literate. Peter Kenez, The Birth of the Propaganda State. Soviet Methods of Mass Mobilization, 1917-1929 (Cambridge: Cambridge University Press, 1985), 157.

[10] Kenez, The Birth of the Propaganda State, 220.

[11] The pioneering work of Annette Michelson was important in bringing my attention to Eisenstein's Capital project. Annette Michelson, "Reading Eisenstein Reading 'Capital'," October 2 (1976): 27-38; October 3 (1977): 82-88.

[12] Jacques Aumont, Montage Eisenstein (London and Bloomington: BFI Publishing and Indiana University Press, 1987), 163.

[13] Qtd. in Michael Baxandall, Painting and Experience in Fifteenth Century Italy (Oxford: Oxford University Press, 1972), 41.

[14] Sergei Eisenstein, "A Dialectical Approach to Film Form," in Film Form: Essays in Film Theory, ed. Jay Leyda (New York: Harcourt Brace and World, 1949), 62. Emphasis mine -- L.M.

[15] Sergei Eisenstein, "Notes for a Film of 'Capital,'" trans. Maciej Sliwowski, Jay Leuda, and Annette Michelson, October 2 (1976): 10.

¹⁶ Qtd. in Michelson, "Reading Eisenstein," October 2: 28.

[17] While at first Rodchenko practiced juxtaposition of many separate photographs and fragments within the space of a single image, at the end of the 1920s his photomontages became multi-page layouts composed of a number of more "traditional" photographs, more like a film montage sequence.

[18] Richard Mark Friedhoff and William Benson, The Second Computer Revolution: Visualization (W.H. Freeman and Company, 1991), 13.

[19] Timothy Druckrey, "Revenge of the Nerds. An Interview with Jaron Lanier," Afterimage (May 1991), 9.

[20] *Ibid.*, 6.

[21] At SIGGRAPH 1992, the premier annual conference on Computer Graphics and Interactive Techniques in the U.S., attended by nearly 30,000 people, about a dozen VR exhibits always had long lines of visitors. However, the lines to two of these exhibits were much longer than any of the others. One was called Dome, the other -- Virtual Reality Cave; in both cases, to see the show, the visitors had to go inside some cave-line structures. It did not matter that one of the exhibits featured a scientific visualization display, of interest only to specialists. Clearly, the fact

that in order to see the spectacle one had to go inside a dark, cave-like space, different from normal space, provided enough attraction at the end of this century, just as it did at its beginning, when millions flocked into the dark caves of movie theaters.

[22] While this theory is well known and widely accepted, other facts suggest that, at least, sometimes, the influence runs in the opposite direction -- biological and psychological theories of body and mind providing paradigms for theories of mechanisms. For instance, it appears that Norbert Wiener's cybernetics was inspired by the concept of homeostasis developed in biology: "Physiologist Walter B. Cannon viewed the animal body as a self-regulating machine. Building on the work done by Claude Bernard in the nineteenth century, Cannon developed the concept of 'homeostasis' -- the process by which the body maintains itself in a state of internal equilibrium. Cannon's ideas were well known to Norbert Wiener. In fact, Cannon's Wisdom of the Body (1932) may be read as sort of an introduction to Wiener's Cybernetics (1948)." Charles Eames and Ray Eames, A Computer Perspective: Background to the Computer Age (Cambridge: Harvard University Press, 1990), 99. Another example is provided by the turn of Artificial Intelligence (AI) in the 1980s from trying to simulate the disembodied mind to the simulation of a collective of primitive organisms, having the functionality of insects. Drawing directly on research in biology, the researchers in AI hope that intelligence will emerge as a product of the collective behavior of machines simulating simple biological organisms.

[23] George Lakoff, "Cognitive Linguistics," Versus 44/45 (1986): 149.

[24] Philip Johnson-Laird, Mental Models: Towards a Cognitive Science of Language, Inference, and Consciousness (Cambridge: Cambridge University Press, 1983).

[25] Paul Virilio, Lost Dimension (New York: Semiotext(e), 1991), 114.

[26] Sigmund Freud, Standard Edition of the Complete Psychological Works (London: Hogarth Press, 1953), 4: 293.

[27] Edward Bradford Titchener, A Beginner's Psychology (New York: The Macmillan Company, 1915), 114.

[28] Martha Farah, "Is Visual Imagery Really Visual? Overlooked Evidence from Neuropsychology," Psychological Review 95, no. 3 (1988): 307-317.

[29] For a summary of different positions, see Ronald A. Finke, Principles of Mental Imagery (Cambridge: The MIT Press, 1989).

[30] S. Shepard and J. Metzler, "Mental Rotations of Three-dimensional Objects," Science 171 (1971): 701-703.

[31] Finke, Principles of Mental Imagery, 93.

[32] John Robert Anderson, "Mental Imagery," in Cognitive Psychology and Its Implications, (W.H. Freeman and Company, 1980).

[33] Communications of the ACM 36, no. 5 (May 1993): 11.