Discrete representation, random access, multimedia—cinema already contained these principles. So they cannot help us to separate new media from old media. Let us continue interrogating the remaining principles. If many principles of new media turn out to be not so new, what about the idea of digital representation? Surely, this is the one idea that radically redefines media? The answer is not so straightforward, however, because this idea acts as an umbrella for three unrelated concepts—analog-to-digital conversion (digitization), a common representational code, and numerical representation. Whenever we claim that some quality of new media is due to its digital status, we need to specify which of these three concepts is at work. For example, the fact that different media can be combined into a single digital file is due to the use of a common representational code, whereas the ability to copy media without introducing degradation is an effect of numerical representation.

Because of this ambiguity, I try to avoid using the word *digital* in this book. In "Principles of New Media" I showed that numerical representation is the one really crucial concept of the three. Numerical representation turns media into computer data, thus making it programmable. And this indeed radically changes the nature of media.

In contrast, as I will show below, the alleged principles of new media that are often deduced from the concept of digitization—that analog-to-digital conversion inevitably results in a loss of information and that digital copies are identical to the original—do not hold up under closer examination; that is, although these principles are indeed logical consequences of digitization, they do not apply to concrete computer technologies in the way in which they are currently used.

> (4) Digitization inevitably involves loss of information. In contrast to an analog representation, a digitally encoded representation contains a fixed amount of information.

In his important study of digital photography *The Reconfigured Eye,* William Mitchell explains this principle as follows: "There is an indefinite amount of information in a continuous-tone photograph, so enlargement usually reveals more detail but yields a fuzzier and grainier picture. . . . A digital image, on the other hand, has precisely limited spatial and tonal resolution and contains a fixed amount of information."[29] From a logical point of view, this principle is a correct deduction from the idea of digital representation. A digital image consists of a finite number of pixels, each having a distinct color or tonal value, and this number determines the amount of detail an image can represent. Yet in reality this difference does not matter. By the end of the 1990s, even cheap consumer scanners were capable of scanning images at resolutions of 1,200 or 2,400 pixels per inch. So while a digitally stored image is still comprised of a finite number of pixels, at such resolution it can contain much finer detail than was ever possible with traditional photography. This nullifies the whole distinction between an "indefinite amount of information in a continuous-tone photograph" and a fixed amount of detail in a digital image. The more relevant question is how much information in an image can be useful to the viewer. By the end of new media's first decade, technology had already reached the point where a digital image could easily contain much more information than anyone would ever want.

But even the pixel-based representation, which appears to be the very essence of digital imaging, cannot be taken for granted. Some computer graphics software has bypassed the main limitation of the traditional pixel grid—fixed resolution. *Live Picture,* an image-editing program, converts a pixel-based image into a set of mathematical equations. This allows the user to work with an image of virtually unlimited resolution. Another paint program, *Matador,* makes possible painting on a tiny image, which may consist of just a few pixels, as though it were a high-resolution image. (It achieves this by breaking each pixel into a number of smaller sub-pixels.) In both programs, the pixel is no longer a "final frontier"; as far as the user is concerned, it simply does not exist. Texture-mapping algorithms make the notion of a fixed resolution meaningless in a different way. They often store the same image at a number of different resolutions. During rendering, the texture map of arbitrary resolution is produced by interpolating two images that are closest to this resolution. (A similar technique is used by VR software, which stores the number of versions of a singular object at different degrees of detail.) Finally, certain compression techniques eliminate pixel-based

29. William J. Mitchell, *The Reconfigured Eye* (Cambridge, Mass: MIT Press, 1982), 6.

representation altogether, instead representing an image via different mathematical constructs (such as transforms).

(5) In contrast to analog media where each successive copy loses quality, digitally encoded media can be copied endlessly without degradation.

Mitchell summarizes this as follows: "The continuous spatial and tonal variation of analog pictures is not exactly replicable, so such images cannot be transmitted or copied without degradation. . . . But discrete states can be replicated precisely, so a digital image that is a thousand generations away from the original is indistinguishable in quality from any one of its progenitors."[30] Therefore in digital culture, "an image file can be copied endlessly, and the copy is distinguishable from the original by its date since there is no loss of quality."[31] This is all true—in principle. In reality, however, there is actually much more degradation and loss of information between copies of digital images than between copies of traditional photographs. A single digital image consists of millions of pixels. All of this data requires considerable storage space in a computer; it also takes a long time (in contrast to a text file) to transmit over a network. Because of this, the software and hardware used to acquire, store, manipulate, and transmit digital images rely uniformly on *lossy compression*—the technique of making image files smaller by deleting some information. Examples of the technique include the JPEG format, which is used to store still images, and MPEG, which is used to store digital video on DVD. The technique involves a compromise between image quality and file size—the smaller the size of a compressed file, the more visible the visual artifacts introduced in deleting information become. Depending on the level of compression, these artifacts range from barely noticeable to quite pronounced.

One may argue that this situation is temporary, that once cheaper computer storage and faster networks become commonplace, lossy compression will disappear. Presently, however, the trend is quite the opposite, with lossy

30. Ibid., 6.

31. Ibid., 49.

compression becoming more and more the norm for representing visual information. If a single digital image already contains a lot of data, this amount increases dramatically if we want to produce and distribute moving images in a digital form. (One second of video, for instance, consists of thirty still images.) Digital television with its hundreds of channels and video on-demand services, the distribution of full-length films on DVD or over the Internet, fully digital post-production of feature films—all of these developments are made possible by lossy compression. It will be a number of years before advances in storage media and communication bandwidth will eliminate the need to compress audio-visual data. So rather than being an aberration, a flaw in the otherwise pure and perfect world of the digital, where not even a single bit of information is ever lost, lossy compression is the very foundation of computer culture, at least for now. Therefore, while in theory, computer technology entails the flawless replication of data, its actual use in contemporary society is characterized by loss of data, degradation, and noise.

The Myth of Interactivity

We have only one principle still remaining from the original list: interactivity.

(6) New media is interactive. In contrast to old media where the order of presentation is fixed, the user can now interact with a media object. In the process of interaction the user can choose which elements to display or which paths to follow, thus generating a unique work. In this way the user becomes the co-author of the work.

As with *digital* I avoid using the word *interactive* in this book without qualifying it, for the same reason—I find the concept to be too broad to be truly useful.

In relation to computer-based media, the concept of interactivity is a tautology. Modern HCI is by definition interactive. In contrast to earlier interfaces such as batch processing, modern HCI allows the user to control the computer in real-time by manipulating information displayed on the screen. Once an object is represented in a computer, it automatically becomes interactive. Therefore, to call computer media "interactive" is meaningless—it simply means stating the most basic fact about computers.

Rather than evoking this concept by itself, I use a number of other concepts, such as menu-based interactivity, scalability, simulation, image-interface, and image-instrument, to describe different kinds of interactive structures and operations. The distinction between "closed" and "open" interactivity is just one example of this approach.

Although it is relatively easy to specify different interactive structures used in new media objects, it is much more difficult to deal theoretically with users' experiences of these structures. This aspect of interactivity remains one of the most difficult theoretical questions raised by new media. Without pretending to have a complete answer, I would like to address some aspects of the question here.

All classical, and even moreso modern, art is "interactive" in a number of ways. Ellipses in literary narration, missing details of objects in visual art, and other representational "shortcuts" require the user to fill in missing information.[32] Theater and painting also rely on techniques of staging and composition to orchestrate the viewer's attention over time, requiring her to focus on different parts of the display. With sculpture and architecture, the viewer has to move her whole body to experience the spatial structure.

Modern media and art pushed each of these techniques further, placing new cognitive and physical demands on the viewer. Beginning in the 1920s, new narrative techniques such as film montage forced audiences to bridge quickly the mental gaps between unrelated images. Film cinematography actively guided the viewer to switch from one part of a frame to another. The new representational style of semi-abstraction, which along with photography became the "international style" of modern visual culture, required the viewer to reconstruct represented objects from a bare minimum—a contour, a few patches of color, shadows cast by the objects not represented directly. Finally, in the 1960s, continuing where Futurism and Dada left off, new forms of art such as happenings, performance, and installation turned art explicitly participational—a transformation that, according to some new media theorists, prepared the ground for the interactive computer installations that appeared in the 1980s.[33]

When we use the concept of "interactive media" exclusively in relation to computer-based media, there is the danger that we will interpret "interaction" literally, equating it with physical interaction between a user and a media object (pressing a button, choosing a link, moving the body), at the expense of psychological interaction. The psychological processes of filling-in, hypothesis formation, recall, and identification, which are required for us to comprehend any text or image at all, are mistakenly identified with an objectively existing structure of interactive links.[34]

This mistake is not new; on the contrary, it is a structural feature of the history of modern media. The literal interpretation of interactivity is just the latest example of a larger modern trend to externalize mental life, a process in which media technologies—photography, film, VR—have played a key role.[35] Beginning in the nineteenth century, we witness recurrent claims by the users and theorists of new media technologies, from Francis Galton (the inventor of composite photography in the 1870s) to Hugo Munsterberg, Sergei Eisenstein and, recently, Jaron Lanier, that these technologies externalize and objectify the mind. Galton not only claimed that "the ideal faces obtained by the method of composite portraiture appear to have a great deal

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32. Ernst Gombrich analyzes "the beholder's share" in decoding the missing information in visual images in his classic *Art and Illusion: A Study in the Psychology of Pictorial Representation* (Princeton, N.J.: Princeton University Press, 1960).

33. The notion that computer interactive art has its origins in new art forms of the 1960s is explored in Söke Dinkla, "The History of the Interface in Interactive Art," ISEA (International Symposium on Electronic Art) 1994 Proceedings (http://www.uiah.fi/bookshop/isea_proc/nextgen/08.html; "From Participation to Interaction: Toward the Origins of Interactive Art," in Lynn Hershman Leeson, ed., *Clicking In: Hot Links to a Digital Culture* (Seattle: Bay Press, 1996), 279–290. See also Simon Penny, "Consumer Culture and the Technological Imperative: The Artist in Dataspace," in Simon Penny, ed., *Critical Issues in Electronic Media* (Albany: State University of New York Press, 1993), 47–74.

34. This argument relies on a cognitivist perspective that stresses the active mental processes involved in comprehension of any cultural text. For examples of a cognitivist approach in film studies, see Bordwell and Thompson, *Film Art*, and David Bordwell, *Narration in the Fiction Film* (Madison: University of Wisconsin Press, 1989).

35. For a more detailed analysis of this trend, see my article "From the Externalization of the Psyche to the Implantation of Technology," in *Mind Revolution: Interface Brain/Computer*, ed. Florian Rötzer (Münich: Akademie Zum Dritten Jahrtausend, 1995), 90–100.

in common with . . . so-called abstract ideas" but in fact he proposed to rename abstract ideas "cumulative ideas."[36] According to Münsterberg, who was a Professor of Psychology at Harvard University and an author of one of the earliest theoretical treatments of cinema entitled *The Film: A Psychological Study* (1916), the essence of film 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."[37] In the 1920s Eisenstein speculated that film could be used to externalize—and control—thinking. As an experiment in this direction, he boldly conceived a screen adaptation of Marx's *Capital*. "The content of CAPITAL (its aim) is now formulated: to teach the worker to think dialectically," Eisenstein writes enthusiastically in April of 1928.[38] In accordance with the principles of "Marxist dialectics" as canonized by the official Soviet philosophy, Eisenstein planned to present the viewer with the visual equivalents of thesis and anti-thesis so that the viewer could then proceed to arrive at synthesis, that is, the correct conclusion, as pre-programmed by Eisenstein.

In the 1980s, VR pioneer Jaron Lanier similarly saw VR technology as capable of completely objectifying—better yet, transparently merging with—mental processes. His descriptions of its capabilities did not distinguish between internal mental functions, events, and processes and externally presented images. This is how, according to 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."[39] Lanier also claimed 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 everyone

36. Quoted in Allan Sekula, "The Body and the Archive," *October* 39 (1987): 51.

37. Hugo Münsterberg, *The Photoplay: A Psychological Study* (New York: D. Appleton and Company, 1916), 41.

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

39. Timothy Druckrey, "Revenge of the Nerds: An Interview with Jaron Lanier," *Afterimage* (May 1991), 9.

rather than being locked into a "prison-house of language" (Fredric Jameson),[40] will happily live in the ultimate nightmare of democracy—the single mental space that is shared by everyone, and where every communicative act is always ideal (Jürgen Habermas).[41] 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.'"[42] 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 . . .

The recurrent claims that new media 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 is shared not only by modern media inventors, artists, and critics but also by modern psychologists. Modern psychological theories of the mind, from Freud to cognitive psychology, repeatedly equate mental processes with external, technologically generated visual forms. Thus Freud in *The Interpretation of Dreams* (1900) compared the process of condensation with one of Francis Galton's procedures that became especially famous: making family portraits by overlaying a different negative image for each member of the family and then making a single print.[43] Writing in the same decade, the American psychologist Edward Titchener

40. Fredric Jameson, *The Prison-house of Language: A Critical Account of Structuralism and Russian Formalism* (Princeton, N.J.: Princeton University Press, 1972).

41. Jürgen Habermas, *The Theory of Communicative Action: Reason and Rationalization of Society* (The Theory of Communicative Action, Vol. 1), trans. Thomas McCarthy (Boston: Beacon Press, 1985).

42. Druckrey, "Revenge of the Nerds," 6.

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

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."[44] 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. 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,"[45] and the psychologist Philip Johnson-Laird proposed that logical reasoning is a matter of scanning visual models.[46] 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.

What to make of this modern desire to externalize the mind? It can be related 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 that can easily be manipulated, mass produced, and standardized on their own. The private and individual are translated into the public and become regulated.

What before had been a mental process, a uniquely individual state, now became part of the public sphere. Unobservable and interior processes and representations were taken out of individual heads and placed outside—as drawings, photographs, and other visual forms. Now they could be discussed in public, employed in teaching and propaganda, standardized, and mass-

44. Edward Bradford Titchener, *A Beginner's Psychology* (New York: Macmillan, 1915), 114.

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

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

distributed. What was private became public. What was unique became mass-produced. What was hidden in an individual's mind became shared.

Interactive computer media perfectly fits this trend to externalize and objectify the mind's operations. The very principle of hyperlinking, which forms the basis of interactive media, objectifies the process of association, often taken to be central to human thinking. Mental processes of reflection, problem solving, recall, and association are externalized, equated with following a link, moving to a new page, choosing a new image, or a new scene. Before we would look at an image and mentally follow our own private associations to other images. Now interactive computer media asks us instead to click on an image in order to go to another image. Before, we would read a sentence of a story or a line of a poem and think of other lines, images, memories. Now interactive media asks us to click on a highlighted sentence to go to another sentence. In short, we are asked to follow pre-programmed, objectively existing associations. Put differently, in what can be read as an updated version of French philosopher Louis Althusser's concept of "interpellation," we are asked to mistake the structure of somebody's else mind for our own.[47]

This is a new kind of identification appropriate for the information age of cognitive labor. The cultural technologies of an industrial society—cinema and fashion—asked us to identify with someone else's bodily image. Interactive media ask us to identify with someone else's mental structure. If the cinema viewer, male and female, lusted after and tried to emulate the body of the movie star, the computer user is asked to follow the mental trajectory of the new media designer.

47. Louis Althusser introduced his influential notion of ideological interpellation in "Ideology and Ideological State Apparatuses (Notes towards an Investigation)," in *Lenin and Philosophy*, trans. Ben Brewster (New York: Monthly Review Press, 1971).