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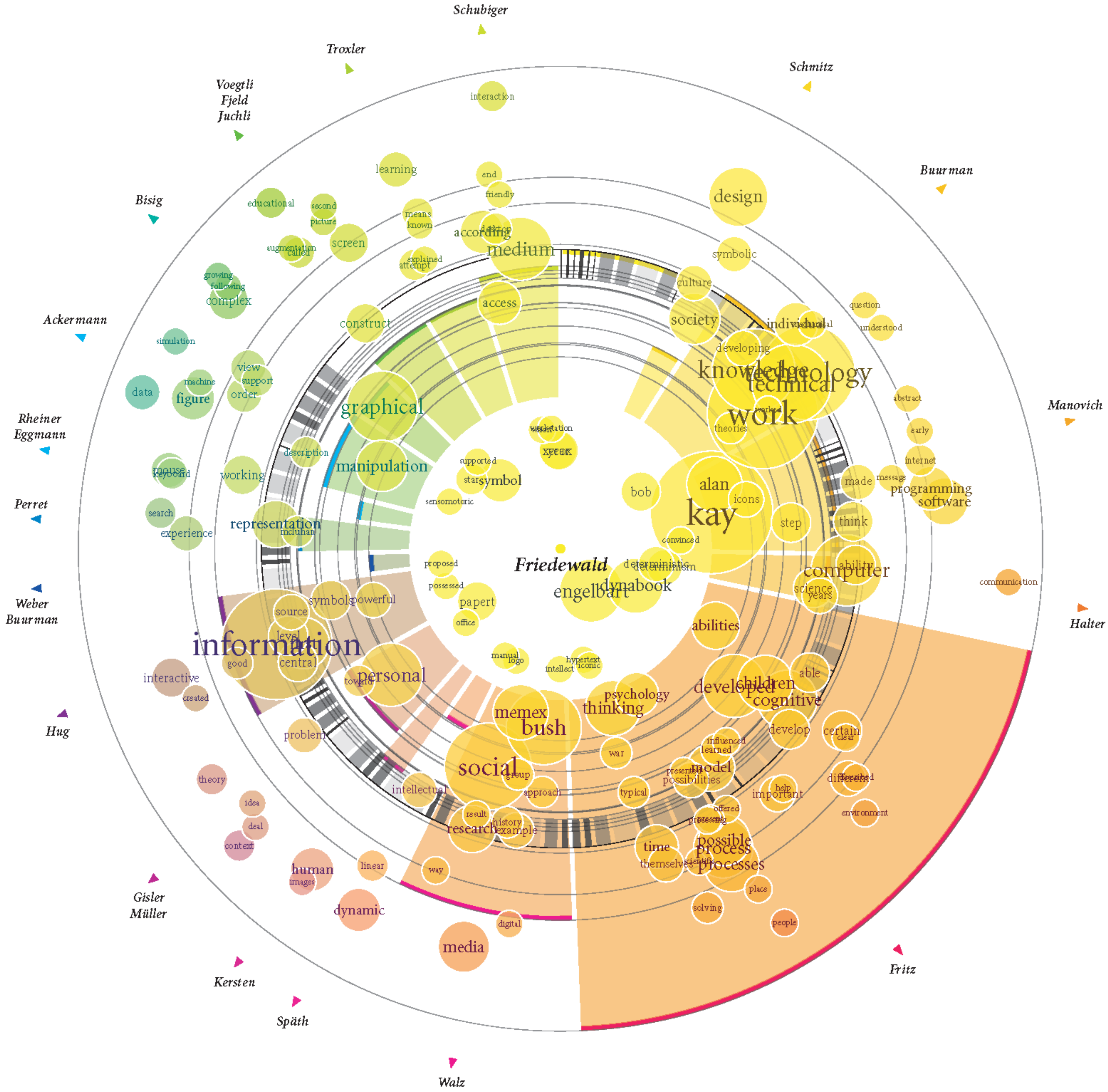

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THE CONTINUOUS CONSTRUCTION OF THE COMPUTER USER: VISIONS AND USER MODELS IN THE HISTORY OF HUMAN-COMPUTER INTERACTION

Michael Friedewald

Abstract

The design of interactive computer systems since the end of World War II has been influenced by a series of scientific theories and ideas about the typical computer user. The principal actors involved in this development were all convinced that the answer to the question of how to represent and impart knowledge would be the key to good system design. This article pursues the question of which interaction has taken place between these ideas about information system users and the technical systems developed in the past few decades.

A whole series of theories has been suggested in an attempt to explain the relationship between technical and social change. Technical determinism and social determinism are the two main theories. Those who believe in technical determinism argue that the characteristics of new technologies predetermine the direction of changes and set the conditions for social change. Those who represent the social deterministic direction formulate the idea that the influence of technology can only be understood in terms of the importance or meaning that humans attribute to it.

Technical determinism is principally criticized for reducing the complex social system to the interaction of its individual parts and for typically overlooking the social context in which the technology is embedded. Accordingly, its description of the relationship between technical development and social change is insufficient. Social determinism also reduces technology and society to a linear system within a fixed context of cause and effect. In this context, science and technological development are not understood as a culture with its own rationale of individual development.[> 01] Although both technical and social determinism are coming under attack with increasing frequency, they continue to remain the most popular and influential theories for describing the relationship between technology and society.

In order to describe the interaction between technology and society better, the social constructionistic approach was developed in the mid-1980s.[> 02] This placed the human actor in the center of the process being examined, and observed technology and its development as an extremely dynamic system with a multitude of feedback. As Berg and Lie stated, "Several of our studies concluded that changing technologies initiate a period of instability and provide possibilities for social change, but we also saw that desirable changes had to be initiated by human action."[> 03]

01 > Compare, for example, Merrit Roe Smith, Leo Marx, eds., *Does Technology Drive History? The Dilemma of Technological Determinism* (Cambridge, Mass., 1994) Daniel Chandler, *Shaping and Being Shaped*, Computer-Mediated Communication Magazine 3, no. 2 (199).

02 > For the program of the approach, compare Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch, eds., *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, Mass., 1987).

03 > Anne-Jorunn Berg and Merte Lie, "Feminism and Constructivism: Do Artifacts have Gender?" *Science, Technology & Human Values* 20 (199): 337.

Modern Myths

The computer and the Internet are often understood as a kind of global library in which the total knowledge of mankind is stored, continually growing and becoming more complete – even though this was recently exposed as a legend by Hans Dieter Hellige.[> 04] And Peter Burke pointed out in his fundamental work on the birth of the knowledge society that wisdom cannot be accumulated.[> 05] The Internet is presented as a media tidal wave, abruptly washing over us and offering no escape. Only, there are no abrupt innovations in the field of the media, there is no *deus ex machina* which can open the gates to the paradise of knowledge. Media technologies are and will remain tools which require manipulation and control they provide answers to concrete questions and offer solutions to concrete human problems.

Critical discussions of the new media are often dismissed, accused of being reactionary reflexes or hostile toward technology, sometimes even of being anti-modernist. The communication scientist Norbert Bolz, for example, is of the opinion that this is absolutely anachronistic, that perhaps we are on the way back to a mythical age and that our present should be the age of description, not of critique. The only issues today are of appropriate description and of “opportunism and eclecticism.” The truth is that which corresponds to the spirit of the times, and good theory is what allows us to see more than before, not what defends knowledge and teaches us to make critical decisions, writes Bolz.[> 06]

This way of dealing with the history and current events of media neglects to mention that the description of “new media” formulated today, and the knowledge or information society itself, are the result of a historical process in which certain images possessed an important discourse-leading function. Thus today’s computer and Internet myths do not reflect an eternal and monolithic truth rather, they arose in the course of more than 0 years of history and during that time were undergoing constant transformation. The development of the graphical user interface is a revealing example of the power and influence of models which are themselves tied to a certain idea about the interplay of social and technical development. The following will trace the influence that deterministic and constructivistic ideas have possessed and the lessons which can be learned for the design of future technical systems.

Vannevar Bush, the Information Problem and the Memex

The idea of the personal computer, the graphical user interface, and the concept of hypertext, which is most obviously embodied in the World Wide Web, can be traced back to Vannevar Bush’s visionary article “As We May Think,” written at the end of 1939 and published in August 194 .[> 07]

Bush (1890 – 1974) was a typical representative of an age of uninterrupted belief in the beneficial power of science and technology. As advisor to President Franklin D. Roosevelt and director of the influential Office of Scientific Development and Research during the World War II, Bush recognized that access to exponentially increasing knowledge was developing into the central problem of science and technology. Bush summarized this “information problem” in the following way:

> “There is a growing mountain of research. But there is increased evidence that we are being bogged down today as specialization extends. The investigator is staggered by the findings and conclusions of thousands of other workers – conclusions which he cannot find time to grasp, much less to remember, as they appear.”[> 08]

04 > Hans Dieter Hellige, *Weltbibliothek, Universal-enzyklopädie, Worldbrain: Zur Säkulardebatte über die Organisation des Wissens,* Technikgeschichte 7 (2000): 303 – 329.
05 > Peter Burke, *Papier und Marktgeschrei: Die Geburt der Wissensgesellschaft* (Berlin, 2001), 21. Originally published in English as *A Social History of Knowledge: From Gutenberg to Diderot.*
06 > Norbert Bolz, *Konformisten des Andersseins. Ende der Kritik* (Munich, 1999).
07 > Vannevar Bush, “As We May Think,” *Atlantic Monthly* 17 (194): 101 – 108.
08 > Ibid.

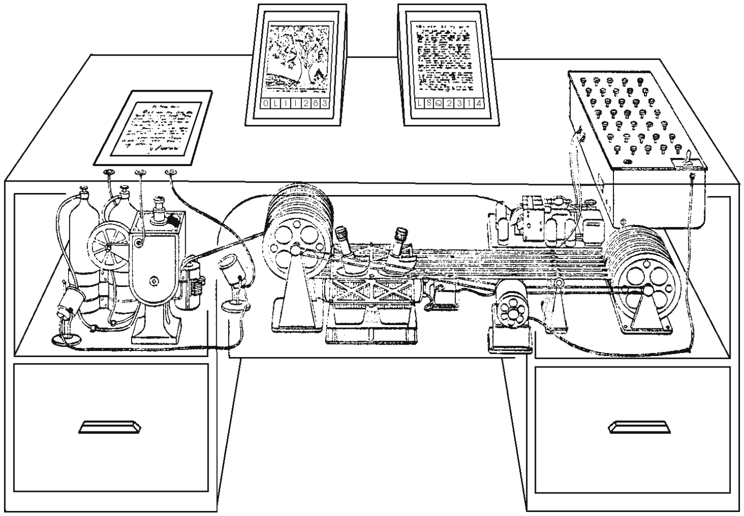
09 > Compare also Stefan Willeke, *Die Technokratiebewegung in Nordamerika und Deutschland zwischen den Weltkriegen* (Frankfurt a. M., 199).
10 > Bush.
11 > James M. Nyce and Paul ahn, *A Machine for the Mind: Vannevar Bush's Memex,* in *From Memex to Hypertext: Vannevar Bush and the Mind's Machine,* ed. James M. Nyce and Paul ahn (Boston, 1991), 8 Michael Friedewald, "Blick zurück auf den Memex: Anmerkungen zu Vannevar Bushs Aufsatz As We May Think," *Informatik Forum* 12 (1998): 177 – 18 .
12 > Ibid., 39. Jakob Nielsen, *Hypertext & Hypermedia* (Boston, 1993), 31ff.
13 > R. A. Fairthorne, "Automatic Retrieval of Recorded Information," *The Computer Journal* 1 (19 8): 3 .
01 Drawing of the fictious Memex. Source: LIFE Magazin 11 (194), 123.

He further recognized that this problem required new methods of organizing the growing amount of information. Bush attempted to solve the problem in the technocratic tradition by proposing to mechanize access to the technical and scientific knowledge saved in libraries with the help of progressive technology, thus making it more effective. This approach was based on the conviction that all economic and political decisions in post-war society should be made by experts, who thus would need effective access to as much relevant information as possible. A technocrat, Bush wanted to apply technology to solving the social problems he observed.[> 09] He called the device proposed for this task "Memex," memory extender (see Figure 01):

> "A Memex is a device in which an individual stores all his books, records and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory."[> 10]

Bush's essay presented a typical social deterministic approach toward the explanation of technical progress which identified a defect in society and described the technology necessary to correct it.

Bush envisioned Memex as a tool to support intellectual activity and did not plan to imitate cognitive processes, later the goal of artificial intelligence (AI). In contrast to AI researchers, who tried to make the computer "think" like a human being, Bush saw Memex as an aid supporting humans' mental activity by the use of an automatic procedure for indexing, saving and recalling information. Individual pieces of information would be grouped into "associative trails" according to the individual concepts of the user (in today's terminology, one would speak of "links"). This direct orientation of a technical system on biological procedures differentiated Bush from other scientists of his age and shows his propinquity to cybernetic thinking.[> 11]



01

Computer specialists and information scientists today happily refer to Bush's article, with its concept of associative linking of information, as the first description of a machine which makes it possible to save information in a form suited to the way people think. They consider Memex to be the prototype for hypertext, multimedia, information retrieval and the Internet.[> 12] Memex itself was never built however, it influenced the ideas and goals of the scientists and engineers who later developed hypertext systems, the graphical user interface, and the World Wide Web. Although Memex remained a "paper machine," because of Bush's reputation and rhetoric "As We May Think" unleashed a far-reaching, stimulating response. The essay came out at the right time to open the eyes of scientists and the wallets of politicians, as R. A. Fairthorne pointed out as early as 19 8.[> 13]

01

14 > Compare Douglas C. Engelbart, "Possibilities for Teaching Machine Activity at SRI," *Stanford Research Institute Memorandum,* Menlo Park, 19 0. Stanford University Library, Special Collections, Douglas C. Engelbart Collection, Box 1 , Folder 4 Douglas C. Engelbart, "The Augmented nowledge Workshop," in *A History of Personal Workstations,* ed. Adele Goldberg (Reading, Mass., 1988), 187–23 .

15 > Michael Friedewald, *Der Computer als Werkzeug und Medium: Die geistigen und technischen Wurzeln des Personal Computers* (Berlin und Diepholz, 1999), 191–99 Thierry Bardini, *Bootstrapping: Douglas Engelbart, Coevolution, and the Origins of Personal Computing* (Stanford, 2000), chapter .

16 > Ibid., 1 9ff.

17 > Douglas C. Engelbart, "Augmenting Human Intellect: A Conceptual Framework," *Summary Report to Air Force Office of Scientific Research* (Menlo Park, 19 2), 20f.

18 > Ibid., 21.

19 > Ibid., 22.

20 > Ibid., 23.

Douglas Engelbart and the Augmentation of Human Intellect

If one considers Vannevar Bush to be an intellectual, then Douglas C. Engelbart (*192) is the visionary developer who set out to give Bush's concepts form and shape. At the beginning of the 19 0s, some years after he first read "As We May Think," Engelbart became convinced that building a tool for better mastering the intellectual problems of an increasingly complex world would be a worthy goal.[> 14]

Over the next few years, Engelbart developed the concept of a computer-based system for the augmentation of human intellect. He worked on the realization of his vision between 19 7 and 1977 at the Stanford Research Institute in Menlo Park, California. At the beginning of the 19 0s, he became director of a research group assigned the task of developing aids for efficient communication between humans and the computer.[> 15]

Engelbart recognized early on that the transition from manual tools like paper and pencil to computer-based tools would also bring organizational changes to ways of working and work flow. For this reason he made a case for the continuous technological education of workers. Thus, the design and realization of new software tools were not Engelbart's only goals he also aspired to the development of new methods of working with these tools.[> 16]

The work with a complex technical system like the computer always consists of a complex combination of human and mechanical work processes at the human-machine interface. In 19 2, Engelbart wrote:

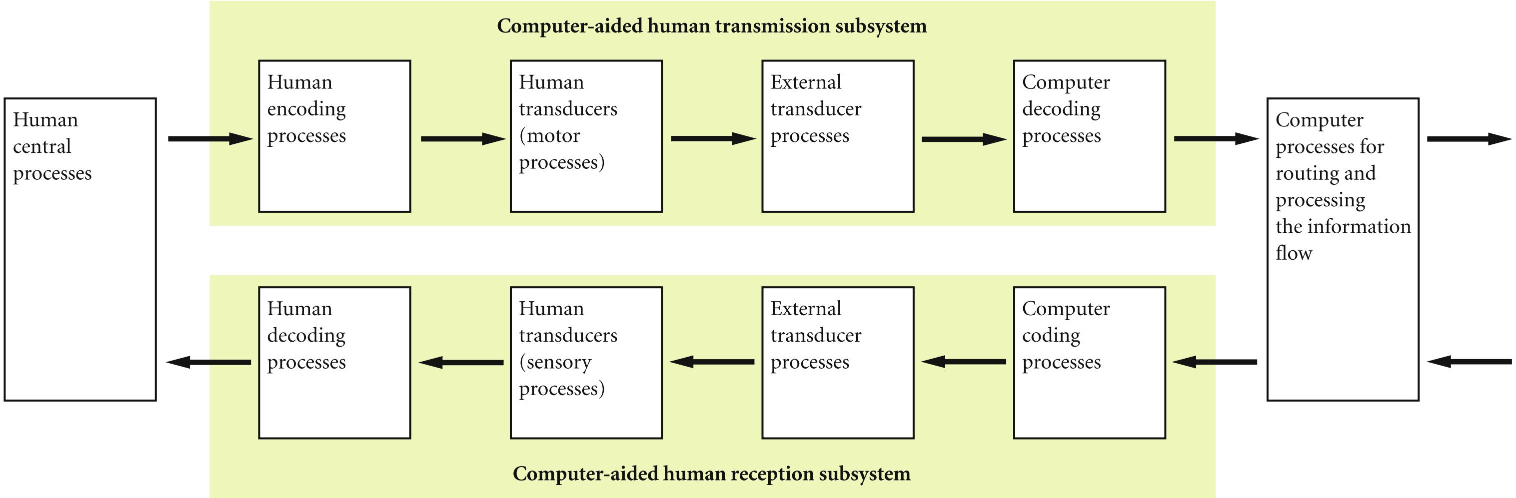
"The term "man-machine interface" has been used for some years to represent the boundary across which energy is exchanged between the two domains. Exchange across this "interface" occurs when an explicit-human process is coupled to an explicit-artifact process."[> 17]

Thus the movement of the finger while typing on a keyboard (an explicitly human process) activates the appropriate program flow of the computer (its explicitly mechanical process). In this way, the human-computer interface is the place at which the interaction between the mechanical process of the computer and the activity of the human takes place. Because of this, the interface must be designed with great consciousness and care.

02

According to Engelbart, an appropriate interface (see Figure 02) for enabling a smooth combination of human and mechanical processes could contribute to the augmentation of the cognitive abilities of humans. To describe this step forward, Engelbart assumed a hierarchical segmentation of the user's cognitive abilities. The lowest level is the manipulation of concepts: "Humans [have] the biological capability for developing abstractions and concepts. They could manipulate these concepts within their minds to a certain extent, and think about situations in the abstract."[> 18]

The next level was the manipulation of symbols: "Humans made another great step forward when they learned to represent particular concepts in their minds with specific symbols."[> 19] On the highest level (until now) the manual manipulation of external symbols enhanced the human ability to perceive and imagine. The manual manipulation of external symbols includes transformation into graphic forms of representation by applying aids such as paper and pencil, ruler and compass. Engelbart argued that today's forms of thinking are fundamentally shaped by the way in which humans have learned to deal with symbolic forms of representation – in both written and spoken form.[> 20]



02

In his further argumentation, Engelbart called upon the work of the ethno-linguist Benjamin Lee Whorf, who was very popular with scientists working on the boundary between psychology, cybernetics and computer science around 19 0. Whorf supported the thesis that the central concepts of a culture are shaped by and embedded in its language, and that all members of a culture internalize these concepts when they learn to speak.[> 21] In other words, the acquisition of language determines the acquisition of a certain way of thinking and view of the world.

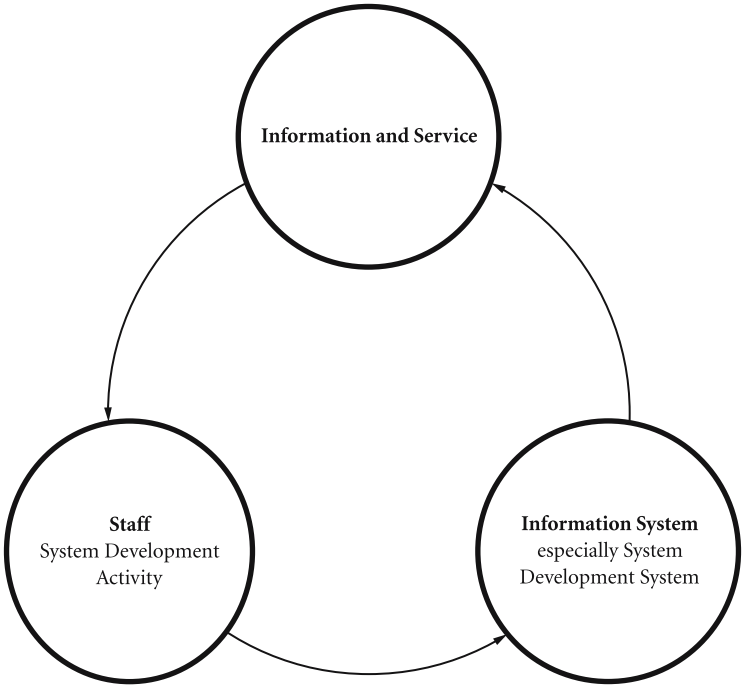
Engelbart seized upon Whorf's theory and expanded it so that it could be applied not only to language, but also to technical artifacts like the computer as an instrument for the representation and manipulation of symbols. While Whorf was of the opinion that thinking obtained its structure through language only, Engelbart proposed the hypothesis that technical artifacts have a similar effect. However, because the symbolic representation of a thought influences the world view it explains, the computer representation must also produce a new, independent view of the world. If this hypothesis proves correct, it would be possible to construct "thinking tools" which do not imitate cognitive processes but instead can strengthen the natural intelligence of humans in the same way that tools strengthen their manual abilities.[> 22] The human and technical components of the socio-technical system were thus equally important, whereby the functionality of the computer tool and the human ability to use this tool come together at the human-computer interface.[> 23]

21 > Benjamin Lee Whorf, *Sprache, Denken, Wirklichkeit: Beiträge zur Metalinguistik und Sprachphilosophie* (Reinbek bei Hamburg, 1997), 7 – 18. Originally published in English as *Language, Thought, and Reality: Selected Writings of Benjamin Lee Whorf.*
22 > Engelbart, "Augmenting Human Intellect: A Conceptual Framework," 24.
23 > Ibid., 217.

02 Engelbart's concept of the human-computer interface. Source: Douglas C. Engelbart, "Augmenting Human Intellect: Experiments, Concepts, and Possibilities," *Summary Report to the Air Force Office of Scientific Research* (Menlo Park, 19), 7.

03 ▭ Engelbart's concept of system development by bootstrapping

24 > Ibid., 24.
25 > Ibid., 2 .
26 > Ibid.



▭ **03**

Engelbart recommended systematic examination of different computer tools with respect to their effect on the work of the user. Through this, not only could the initial hypothesis on the character of computer-based tools be verified, but a step-by-step improvement to systems consisting of humans and computers could follow. Engelbart proposed a method for this co-evolution known as "bootstrapping." He understood this as an adaptive and recursive method of learning and developing, whose goal was to develop tools and methods which in turn would be used to develop better tools and methods for problem solving. > **24**

▭ **03**

At first, Engelbart wanted to examine how people deal with new tools and how these change their workflow. In the next step, he would analyze which positive effects application of the tool had on thinking. He arrived at the hopeful supposition that the use of a computer offered the possibility of automatically manipulating symbols and through this, humans would be able to reach a fourth level in the development of their intellectual abilities. > **25**

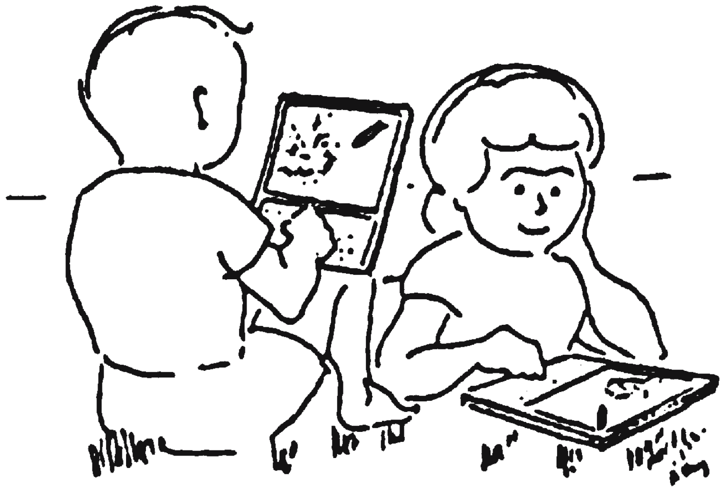
Engelbart also described what his system for augmenting human intellect might look like:

"Symbols with which the human represents the concepts he is manipulating can be arranged before his eyes, moved, stored, recalled, operated upon according to extremely complex rules … In the limit of what we might now imagine, this could be a computer, with which we could communicate rapidly and easily, coupled to a three-dimensional color display within which it could construct extremely sophisticated images with the computer being able to execute a wide variety of processes upon parts or all of these images in automatic response to human direction." > **26**

Through the use of interactive computer tools, Engelbart attempted to solve a problem considered to be important by postwar society, namely, quick and reliable decision-making in a confusing world influenced by a multiplicity of uncertain and mutually dependent factors. At the same time, he was quite aware that the implementation of the tools he developed would have an effect on science, society and culture. Instead of adopting a linear and monocausal perspective, Engelbart kept in mind that humans and technology always mutually influence each other. The co-evolutionary aspects of Engelbart's vision of interactive computer use were based on the assumption that language is not just a symbol for the things it describes, but is itself socially constructed. This implies that – despite his orientation toward Bush's Memex and his hierarchical segmentation of human abilities – Engelbart did not follow a social deterministic approach. For him, the development of technology and the development of the individual or society are symbiotic processes, not linear and monocausal, but rather complex and dynamic.[27]

The system developed in Engelbart's laboratory, known as the "oN-Line System" (NLS), consisted of a whole range of new communication tools which supported the cooperative work of a software development group. These included a word processing system with segmentation tools, a document administration system, a teleconferencing system that allowed different people to work on the same document at the same time, hypertext, and the use of simple screen graphics. In addition, Engelbart and his colleagues tested a number of devices for supporting human-computer communication, including the typewriter keyboard, light pen, video monitor, the chord keyboard developed by Engelbart himself, and today's omnipresent mouse. More exotic input devices were tested, such as a data glove, and knee and eye controls.[28]

In December 19 8, Engelbart and his team were finally ready to present their system at the fall conference of the American Federation of Information Processing Societies (AFIPS) in San Francisco. In a 90-minute tour de force, Engelbart presented all the important functions of NLS. He showed the audience the mouse and the chord keyboard and explained how they worked and how to use them, how data are set up on the monitor, how text is edited, how crossreferences are generated, and how one can search in a document. Finally, he demonstrated how the NLS could be used to work together with another user who is not in the same room. For most of those present who had never worked on an interactive computer terminal, it was a short and fascinating glimpse into a completely foreign world.[29] Among the audience was Alan ay, who was to give new impetus to the field of human-computer interaction through his development of a graphical user interface in the following years.



04

Alan Kay, Cognitive Psychology and Graphical User Interfaces

Alan C. ay (*1941) is occasionally called the "Father of the PC" because at the end of the 19 0s he described a fictive computer which he named the "Dynabook." The Dynabook was to be a powerful central unit and would have a flat graphical screen. So that it could be carried everywhere, it wouldn't be bigger or heavier than a spiral-bound notebook. The Dynabook would be a personal, dynamic medium for the masses, on which users should be able to save all their personal documents, texts, sounds, pictures and animations. Through an interface to a data network, one would be able to use the Dynabook to access the accumulated knowledge of mankind.[30] Alan ay came to the newly-founded Xerox Palo Alto Research Center (Parc) with this vision in 1971.

04

27 > Compare here with Michael Friedewald, *Konzepte der Mensch-Computer-Kommunikation in den 1960er Jahren: J. C. R. Licklider, Douglas Engelbart und der Computer als Intelligenzverstärker,* Technikgeschichte 7 (2000), 1–24.

28 > William . English et al., "Display-Selection Techniques for Text Manipulation," *IEEE Transactions on Human Factors in Electronics HFE*-8 (19 7), –1 Douglas C. Engelbart and William . English, *A Research Center for Augmenting Human Intellect,* 19 8 AFIPS Fall Joint Computer Conference, (Washington, 19 8), 9–21 Friedewald, *Der Computer als Werkzeug und Medium.*

29 > Stan Augarten, *The Invention of Personal Computing: The Origin of the Most Important Technology of our Time,* unpublished manuscript, circa 199 .

30 > Alan C. ay, "A Dynamic Medium for Creative Thought," *Proceedings of the 1972 Minnesota NCTE Seminars on Research in English Education,* (Minneapolis, 1972) Alan C. ay, *A Personal Computer for Children of All Ages,* Proceedings of the ACM National Conference (Boston, 1972).

04 Children play *Spacewar!* on the Dynabook. Drawing by Alan ay. Source: ay, Personal Computer (as in Footnote 30).

31 > Alan C. ay, "The Early History of Smalltalk," in *History of Programming Languages* II, ed. Thomas J. Bergin, Jr. and Richard G. Gibson, Jr. (Reading, Mass., 199), 11– 79.
32 > Alan C. ay, "User Interface: A Personal View," in *The Art of Human-Computer Interface Design*, ed. Brenda Laurel (Reading, Mass., 1990), 192.
33 > Alan C. ay, "Microelectronics and the Personal Computer," *Scientific American* 237 (1977), 243.
34 > Ibid., 193.
35 > Ibid., 234.

Despite enormous advances in microelectronics, at this point in history the technology necessary for building a Dynabook (large-scale integrated circuits, flat displays) was not available. Because of this, ay decided first to develop an "Interim Dynabook" at Parc. The result of this work was the first personal workstation, the Xerox Alto, and the Smalltalk programming language with its graphical user interface, developed between 1972 and 197 .> 31

ay was influenced by the theories of Marshall McLuhan, which inspired him to consider the computer as a medium rather than a tool. A further inspiration was the work of Seymour Papert, who convinced him that computer languages can be thinking tools and that graphical communication is a powerful means for human-computer interaction. After reading McLuhan's book *Understanding Media* (19 4), ay explained that "the most important thing about any communications medium is that the message receipt is really message recovery anyone who wishes to receive a message embedded in a medium must first have internalized the medim so it can be 'contracted' out to leave the message behind."> 32

For this reason, ay began to understand the use of a computer as a communicative act and the computer as its medium. It also became clear to him that his real goal was to shape an entirely new medium, fundamentally different from all other media which had preceeded it. The computer would become a dynamic medium – an aid toward presenting, explaining, and animating thoughts, dreams and fantasies as well as texts, pictures and sounds. Alan ay had admired Engelbart's oN-Line-System because of its ingenious possibilities for supporting intellectual activities. But that wasn't enough for him. He wanted an even more powerful, more universal, and more user-friendly computer system that was fun to use.> 33

While working with McLuhan's theory, ay also became persuaded that the computer with its possibility of interaction offered a way of avoiding the passivity and boredom associated with all other previous media. Finally, it became clear to him that the computer, like every other medium, would trigger changes on an individual as well as a social level. He wrote:

> "What McLuhan was saying is that if the personal computer is a truly new medium then the very use of it would actually change the thought patterns of an entire civilization. He had certainly been right about the effects of the electronic stained-glass window that was television – a remedievalizing tribal influence at best. The intensely interactive and involving nature of the personal computer seemed an antiparticle that could annihilate the passive boredom invoked by television. But it also promised to surpass the book to bring about a new kind of renaissance by going beyond static representations to dynamic simulation. What kind of a thinker would you become if you grew up with an active simulator connected, not just to one point of view, but to all points of view of the ages represented so they could be dynamically tried out and compared."> 34

The term "dynamic simulation" refers to the possibility of processing, comparing and superimposing text and pictures quickly with the help of the computer, and thus interacting with the information. Thus, in ay's concept, dynamic simulation was the central element on the path toward realizing the Dynabook.> 35 He spoke only of the Dynabook and no longer of the computer, but he was not only trying to capture the spirit of McLuhan's theory. ay also implied that the Dynabook would have a similar effect on culture as the "Gutenberg technology" did.

36 > The concept of self-controlled and practical learning that developed within the framework of nineteenth-century education reform has been anchored in conventional educational institutions much longer in the U.S. than in Europe. Compare Ludwig Marcuse, *Amerikanisches Philosophieren: Pragmatisten, Polytheisten, Tragiker* (Zürich, 1994), 137f.

37 > Seymour Papert, *The Connected Family: Bridging the Digital Generation Gap* (Atlanta, 199), 4 .

38 > Seymour Papert, *Mindstorms: Kinder, Computer und neues Lernen* (Basel, 198), 1 ff. Originally published in English as *Mindstorms: Children, Computers, and Powerful Ideas.*

39 > Ibid., 43.

40 > Ibid., 0.

41 > Howard Rheingold, *Tools for Thought: The People and Ideas Behind the Next Computer Revolution* (New York, 198), 24 .

42 > Papert, 3 f. For the ideas effective in the development of programing languages, compare Heike Stach, *Zwischen Organismus und Notation: Zur kulturellen Konstruktion des Computer-Programms* (Wiesbaden, 2001).

43 > ay, “User Interface,” 193.

Alan ay’s methodology of interface design was based on cognitive, constructivistic educational psychology. This assumes that pupils best acquire their knowledge in self-controlled interaction with their environment: > 36

“[Cognitive psychology] complains that much traditional teaching is based on a model of a pipeline through which knowledge passes from teacher to student. The name constructivism derives from an alternative model, according to which the learner has to construct knowledge afresh every time.” > 37

Cognitive educational psychology replaces the linear model with a dynamic, feedback-intensive model of the acquisition of knowledge in which humans with their physical and cognitive abilities occupy the focal point.

ay came into contact with these ideas in 19 8, when he got to know MIT Professor Seymour Papert (*1928) and his work on the use of educational psychology principles in computer-supported education of children. Papert was one of the most highly-profiled representatives of cognitive educational psychology in the United States. He had worked with Jean Piaget, the influential and highly respected founder of this field, in Geneva for five years before beginning his work at MIT.

Papert held the position that the presentation and interaction possibilities of the computer could be used to construct artificial “microworlds.” One possible microworld was an interactive learning environment which pupils could explore actively – similar to their real environment. In a playful manner they could acquire knowledge about the fundamental laws of mathematics, for example. > 38 Papert and his colleagues developed the programming language LOGO for realizing his idea. With this language, children could create computer programs effortlessly. In the process of “teaching the computer how to think,” > 39 the children themselves developed an idea of how mathematical problems are structured and found ways of solving them. Papert found that a programming language is like a natural language, and therefore has a strong influence on computer culture. According to his view, one should be able to conclude that educators who are interested in the use of computers and sensitive to cultural influences might pay particular attention to the programming language. However, educators may often be too frightened of technology or too ignorant to attempt to influence the languages offered by manufacturers, and have accepted the programming languages offered by industry and science in spite of their inadequacy. > 40

Before the development of LOGO, programming languages were often compared to a recipe which explained step by step and in detail the operations to be carried out by a soulless mechanism in order to achieve a certain result. > 41 This type of linear picture is typical for a technological deterministic design and not adapted to human problem-solving strategies. LOGO on the other hand, would support the communication process between the computer and its user. > 42

During his visits to Boston, ay met with children who could write programs for drawing, generating concrete poetry, or translating English texts into simple Latin. ay was deeply impressed by how effortlessly the children learned to work with the computer, and by how creative they were in the development and use of programs. Looking back, he explained: “It was as if I were possessed by the analogy between conventional literacy and LOGO.” > 43

44 > Ibid.
45 > Ibid., 193f.
46 > Jerome S. Bruner, *Entwurf einer Unterrichtstheorie* (Berlin, 1974). Originally published in English *Toward a theory of instruction*.
47 > Ibid., 1 .
48 > Ibid., 1 ff.
49 > ay, "User Interface," 19 .
50 > Ibid., 19 .

One year earlier, as he was working on the concept for his doctorate, he had assumed that computer users had to be good programmers before they could use the computer effectively. Papert's work seemed to prove the opposite, because the children also happily and creatively used programs which they hadn't written themselves. They were just as inspired by using programs as by developing them.[> 44] ay concluded that every good programming language must be conceived so that children (and computer laymen in general) could work with computers even without having undergone extensive training. Each development from ay's "Learning Research Group" (LRG) was thus evaluated for how well it could be learned by children and the extent to which it supported the solution of complex problems:

"The ability to 'read' a medium means you can access materials and tools created by others. The ability to 'write' in a medium means you can generate materials and tools for others. You must have both to be literate. In print writing, the tools you generate are rhetorical they demonstrate and convince. In computer writing, the tools you generate are processes they simulate and decide.

"If the computer is only a vehicle, perhaps you can wait until high school to give 'driver's ed' on it – but if it's a medium, then it must be extended all the way into the world of the child."[> 45]

But how should a computer system be constructed so that operating it is child's play? Answers to this question were also given by cognitive educational psychology, especially the work of Jerome Bruner, another student of Piaget.[> 46] From his observation of children's development, Bruner elaborated a model in stages from which different forms of learning could be derived. The study focused on the issue of the representation of knowledge: "How can children free themselves of the influence of stimuli in the present and store early experiences in a model, and which rules apply to storing experience and retrieving information from this model?" He proposed the thesis "that humans probably do this in three ways."[> 47]

According to this, ability and knowledge are acquired in the first, sensomotoric stage primarily through actions or the imitation of actions. In the second, iconic development stage, there arises the ability to absorb information represented by pictures (visually) or by some other sensual perception. With this, pictures develop the important function of summarizing actions. In the third, symbolic stage of development, the ability to deal with abstract terms which can be created or transformed by using formal rules evolves.[> 48] There are also basic differences between the three forms of knowledge representation. In symbolic representation, the words which stand for the things are arbitrary. Only syntax and grammar bring order to the process of perception and thus are the means by which reality is constructed.

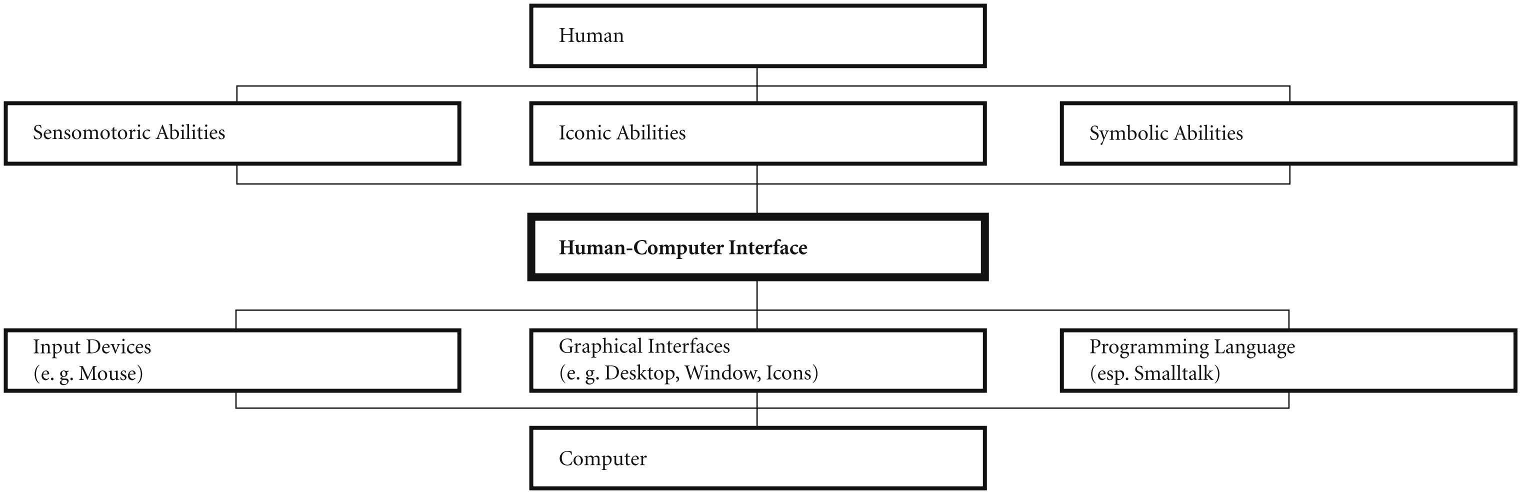
ay's conclusion based on his study of Bruner's theory was that even a computer medium like the Dynabook not only should be operated or programmed on the symbolic level, but also had to support the sensomotoric and iconic abilities of the human user. In ay's own words, "Doing with images makes symbols." The maxim for the design of a human-computer interface derived from this:

"Now, we agree with the evidence that the human cognitive facilities are made up of a doing mentality, an image mentality and a symbolic mentality, then any user interface we construct should at least cater to the mechanisms that seem to be there."[> 49]

ay was further convinced that thinking and problem-solving processes increasingly use forms of representation in a parallel manner. He argued that creative processes always include the use of sensomotoric and iconic forms of representation, especially in art and science. Indeed, creative work in these fields is seldom an abstract manipulation of symbols. Thinking in visual or iconic representation is also less susceptible to blockages which can occur whenever new, interesting impressions divert from the core of the problem.[> 50]

51 > Ibid.
52 > Charles H. Ferguson and Charles R. Morris, *Computer Battles: Computerschlachten: Überlebensstrategien in der weltweit wichtigsten Industrie* (Frankfurt a. M. and New York, 1994), 12 . Originally published in English *Computer Wars: How the West Can Win in a Post-IBM World.*
53 > David Canfield Smith and Charles Irby, “Xerox Star Live Demonstration,” in *Summary Proceedings of the CHI’98 Conference,* ed. Clare-Marie arat and Arnold Lund (New York, 1998), 17.

05 Alan ay’s concept of the human-computer interface.



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In other words, because one form of representation is not superior to another, “the best strategy for the design of a user interface would be to gently force a synergy between them.”> [51] To achieve this, ay began to consider the different forms of representation in the design of the human-computer interface as having equal rights. With the help of the mouse, the user could interact with data in a sensomotoric manner, manipulate text and pictures, and navigate within the “information space” created by the computer. Screen windows and icons as well as the metaphor of the desktop called upon the visual abilities of the user, and the Smalltalk programming language was a powerful tool for the manipulation of symbols. However, “visual communication” became the central element in the design of the human-computer interface.

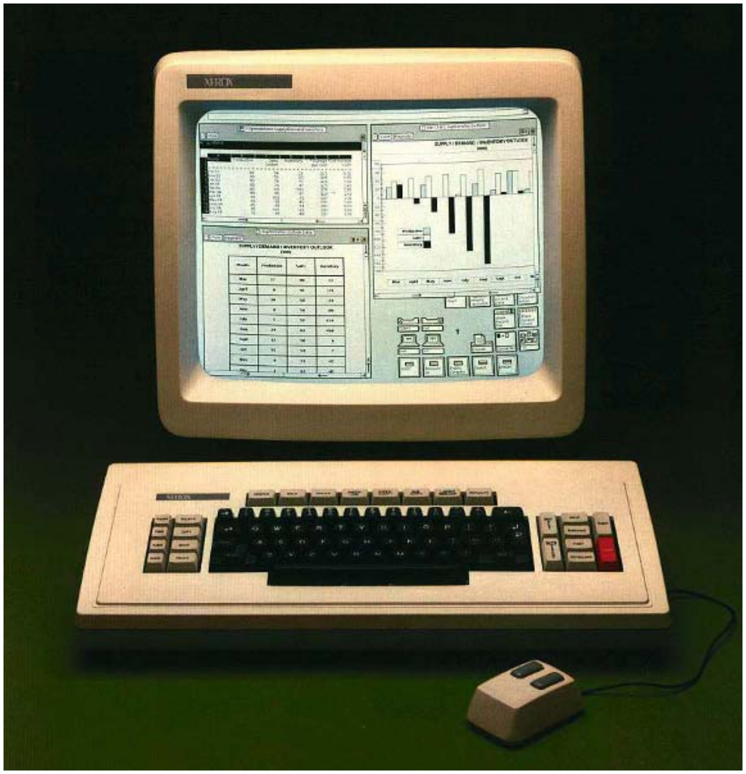
05

The principles and procedure for the development of user interfaces developed by ay’s working group were applied consequently in the development of Xerox’s first commercial workstation, the Xerox Star, introduced in 1981(see Figure 0). It possessed a sophisticated gra-phical user interface which could be used so intuitively that “most people … could deal with a Star workstation in about an hour.”> [52] Looking back, the Star had:

> “… a profound effect on the personal computer industry … [It introduced] many of the elements of successful graphical user interfaces (GUI’s), including icons, direct manipulation, the desktop metaphor, dialog boxes, universal commands and pointing and clicking. [It] popularized other GUI techniques, such as bitmapped display, overlapping windows, the mouse, noun-verb commands and object orientation.”> [53]

06

06 Xerox 8010 “Star” workstation with graphical user interface and mouse (1981). Source: Xerox Corporation



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54 > Compare Werner Rammert, “Computer Use at Home – A Cultural Challenge to Technology Development,” in *The Information Superhighway and Private Households, Case Studies of Business Impacts,* ed. Walter Brenner and Lutz olbe, (Berlin, New York, Tokyo, 199), 399–408. Jef Raskin, “Intuitive Equals Familiar,” *Communications of the ACM* 37, no. 9 (1994), 17 Michael L. Dertouzos, “Creating the People’s Computer,” *Technology Review* 100 (1997), 20–31.

55 > Alan C. ay, “Computer Software,” *Scientific American* 2 1 (1984), 41–47.

56 > Brenda Laurel, *Computers as Theater* (Reading, Mass., 1993) Byron Reeves and Clifford Ivar Nass, *The Media Equation: How People Treat Computers, Televisions, and New Media Like Real People and Places* (Stanford, 199).

57 > Reeves and Nass.

The Star became a business flop for Xerox, and it wasn’t until the detour via the Apple Macintosh and Microsoft Windows that the graphical user interface experienced its breakthrough in the second half of the 1980s.

According to Alan ay, modern user interfaces, with their focus on the direct manipulation of objects on the screen, have only just begun to scratch the surface of the computer’s possibilities. A user interface that uses metaphors will always be an abstraction which cannot be followed by all users in the same way. However, by now most computer users have become so accustomed to graphical user interfaces and their weaknesses that they confuse this familiarity with the user-friendliness of the computer. In this context, Rammert speaks of a reduction to the everyday level in dealing with the inadequacies of technology. >[54]

Because of this, the claim is justified that the metaphor of the desktop has become an impediment to the development of even more user-friendly computers today, as Alan ay pointed out as early as 1984:

> “A powerful genre can serve as wings or chains. The most treacherous metaphors are the ones that seem to work for a time, because they can keep more powerful insights from bubbling up. As a result, progress is slow …” >[55]

The desktop metaphor is also obstructive for another reason: the group of users originally targeted by the manufacturers of user-friendly computers were classical information workers such as scientists and managers. Normally, they didn’t have experience in dealing with computers, but felt comfortable in the classical office environment. Since then, however, the use of computers has radically changed office work, and many younger computer users from the Nintendo Generation were able to gather experience with computers in their childhood. Just as the car had to liberate itself from the model of the horse-drawn carriage in order to gain its own profile, the human-computer interface must free itself of the initially helpful, but now rather constrictive model of the desktop.

Beyond the Graphical Interface

At the same time that the graphical user interface became accepted, a young generation of scientists like Brenda Laurel, Byron Reeves and Clifford Nass began to develop new concepts of human-computer interaction which apply a theater or agent metaphor. >[56] An interface concept called “Bob,” introduced by Microsoft in the mid-90s (see Figure 07) was based, for example, on the work of Reeves and Nass at Stanford University. Their work sprang from the premise that humans have a tendency to equate the (virtual) worlds created by the media with real life. >[57] Consequently, the interaction of the individual with the computer as a process of reality construction actually has a social nature.

Bob was an attempt to develop an interface which built upon the experience of the user in everyday situations. In addition, it was the first large-scale commercial attempt to overcome the WIMP-Paradigm (Windows, Icons, Menus, Pointing) in favor of an alternative user interface. Instead of processing icons on the screen with the mouse, the user now interacts with “Bob’s Friends.” These included 14 “personal guides,” each of which possesses his/her own personality. This personality is expressed through pithy one-liners and short animations. For example, “Rover” the dog gives moody comments and wiggles his ears to express surprise. The guides offer a series of navigation possibilities to choose from, but there is no handbook for Bob. Users are forced to rely only on their personal guide (although there is also an impersonal guide in the form of a simple loudspeaker mounted on the wall – for those users who are absolutely unable to get used to animated animals as navigational aids).

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07 ▭ User interface of Microsoft's Bob with "Rover" in the lower right corner. Source: http://www.digibarn.com (accessed on August 20, 2003).

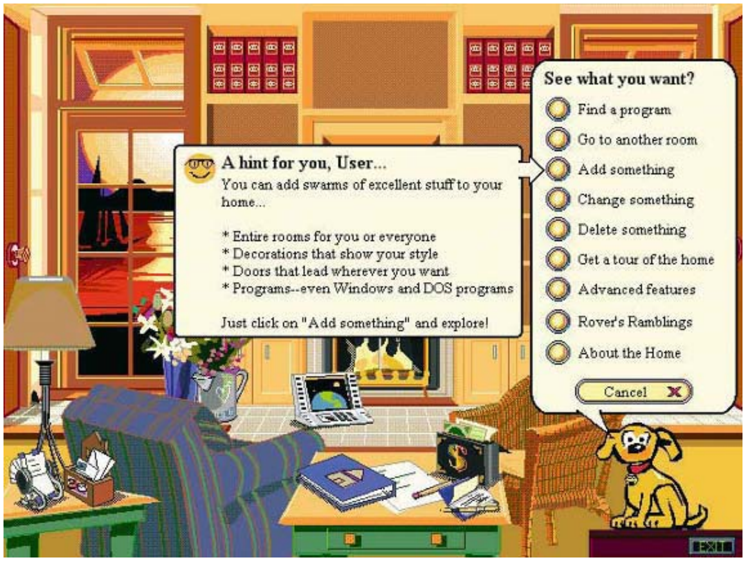
58 > Steven Johnson, *Interface Culture: Wie neue Technologien Kreativität und Kommunikation verändern* (Stuttgart, 1999), 73. Originally published in English as *Interface Culture: How New Technology Transforms the Way We Create and Communicate.*

59 > Mark Weiser, "The Computer for the 21st Century," *Scientific American* 2 , no. 3, (1991), 94–104 Mark Weiser and John Seely Brown, *The Coming Age of Calm Technology, Beyond Calculation: The Next Fifty Years of Computing,* ed. Peter J. Denning and Robert M. Metcalfe, (New York, 1997), 7 –8 .

60 > Jeffrey M. Bradshaw, *Software Agents,* (Cambridge, Mass., 1997).

61 > ay, *Computer Software,* 41–47.

62 > Pattie Maes, "Agents that Reduce Work and Information Overload," *Communications of the ACM* 37, no. 7, (1994), 40.



▭ **07**

The program was a commercial failure, primarily because the user (especially in Europe) did not react positively to the "personalities" of the different characters and because "somewhere along the way the good faith of user-friendly metaphors had been replaced by the hysteria of total simulation."> 58

Bob was probably the last serious attempt to develop a new type of human-computer interface for a personal computer in the traditional sense, because in the meantime, hardware development has been making another effort to revolutionize our understanding of the computer. Through the ongoing improvement of the integration density and performance, it will soon be possible to equip even everyday objects with "intelligence." Discussion of the "disappearing computer" or the ubiquitous computer abounds.> 59 But how can one communicate with coffee cups, refrigerators, or with a "personal digital assistant" which is smaller than a Walkman, thus lacking either a monitor or a keyboard?

Within this context, the idea of the social human-computer interface will be developed further. Intelligent help programs, known as "software agents," will be integrated into the interface.> 60 The idea of using such programs in the design of human-computer interaction can also be traced back to Alan ay, who described them as "an active extension of one's purposes and goals."> 61 Instead of directly manipulating objects on the screen, the user of a computer system would delegate tasks via spoken input to personalized software agents, who carry them out on the basis of their information on the interests and goals of the user. The metaphor of the personal assistant, who communicates with the human user in the most natural way possible, is popularly applied to such software agents. They try to support a smooth interaction between humans and computers because they work so intuitively.> 62

Despite certain similarities, there are fundamental differences between icons and software agents: icons must remain visible in order to be moved from one place to another on the screen. In addition, they are passive and thus must be moved by the user. In contrast to this, agents can register events and changes, and react to them actively. They are set up to continuously record and analyze the users' interactions in order to collect information about their preferences, goals and strategies. This information is then used to adapt the user interface to the need of the user, to automate certain tasks, completely or in part. Ultimately it should become possible for agents to learn by

63 > Bradshaw, 82.

example and to construct processes themselves.

Agents are thus programs which are able to formulate and define goals, to initiate processes, and to interact with other software agents and the user in the sense of reacting to events appropriately.[> 63] The idea of learning through cooperative work and experience, interactive learning, has thus become a central element in the design of human-computer interfaces and plays a role in the development of software agents. The development of new forms of human-computer interaction has thus now turned deterministic ideas upside down: the use of technology is obviously not formed by the characteristics of technology, but instead is shaped according to requirements resulting from social interaction.

Summary and Conclusion

The starting point of the development of human-computer interfaces was the diagnosis of an "information problem" during and directly after the World War II, which made it increasingly difficult to gain access to the body of exponentially growing worldwide knowledge. In the following years, this problem was intensified by the introduction of the electronic digital computer, because it not only made the fast access to inventories of data possible, but it also became the source of more and more information itself. Appropriately, the first developments in the 1940s and ' 0s were characterized by the search for procedures which would make efficient access to information possible and relieve the user of routine work.

With the introduction of computer systems which had the potential to support the users's intellectual activities, it became clear that the computer was by no means merely another incarnation of well-known "tools for thinking," but rather presented an opportunity to construct completely new (thinking and working) worlds.

As a reaction to this realization, in the 19 0s and even more intensely in the 1970s, the communicative aspect of the human-computer interaction stepped into the spotlight of research and development. In retrospect, it is clear that in this phase the search to try and understand the user became the central question. With developing clarity about the qualities of the user also came the search for a lingua franca for human-computer communication, which should make an intuitive and frictionless understanding possible.

The leitmotif of this decade-long development process has been the question of how the computer can represent knowledge adequately so that it is no longer oriented to the characteristics and limits of the computer technology, but rather to the user's needs and abilities as he or she absorbs information. The search for an answer has still not come to an end, and the nearly 0-year history of human-computer interaction appears to be an ongoing approach to this goal.

The digital revolution posited for the last 1 years has thus revealed itself to be a never-ending story. An abyss is yawning between the feverish promises of cybergurus and the experience of typical computer users, who again and again find themselves forced to buy improved hardware to meet the latest software standard, who wonder where their data disappears when the computer crashes, who have no idea why they can't get into the Internet. It seems that up to now, the digital revolution has swept along only the computer – and left the human behind.