Man-Computer Symbiosis (J.C.R. Licklider, 1960)

Ron Baecker, 7 August 2006

I am a knowledge media designer. I conceive of novel tools incorporating computational and communications technology that help people think, learn, create, communicate, and collaborate. The work proceeds best when based on deep understandings of how people work and learn.

How did I choose this career? I became inspired to think about interactive computing by a seminal JCR Licklider (1960) article entitled "Man-Computer Symbiosis", an Anthony Oettinger 1965 course at Harvard entitled "Technological Aids to Human Thought", and good fortune — joining in 1966 a group at MIT Lincoln Laboratory[1] that was the birthplace of the new field of interactive computer graphics.

The central idea was Licklider's (everyone called him Lick) vision of interactive computing as a synergistic coupling of human and machine capabilities. In a now famous passage, Lick (1960, p. 4) draws an analogy between the symbiotic relationship of the fig tree and the Blastophaga grossorum, the insect which pollinates it, and man-machine systems: "The hope is that, in not too many years, human brains and computing machines will be coupled together very tightly and that the resulting partnership will think as no human brain has ever thought ..." Noting that the then-current generation of machines fails to facilitate this symbiosis, and he goes on to postulate requirements for achieving his vision:

> One of the main aims of man-computer symbiosis is to bring the computing machine effectively into the formulative parts of technical problems. … To think in interaction with a computer in the same way that you think with a colleague whose competence supplements your own will require much tighter coupling between man and machine … than is possible today.

He then suggests how computers could facilitate thinking and problem-solving, concluding (p. 6):

> If those problems can be solved in such a way as to create a symbiotic relation between a man and a fast information-retrieval and data-processing machine … it seems evident that the cooperative interaction would greatly improve the thinking process.

The remarkably prescient second half of the paper catalogues problems whose solutions are prerequisites for realizing human-computer symbiosis. These includes bridging the speed mismatch between humans and computers — his solution is time-sharing, since conceiving of ubiquitous and inexpensive personal computers in 1960 was too big a stretch even for Lick; memory hardware improvements by many orders of magnitude; innovations in the way memory is organized and accessed; more powerful languages for communicating with machines; and input and output equipment, including desktop displays and controls, computer-based wall displays, and automatic speech generation and recognition.

Where did these brilliant insights arise? Licklider's history[2] suggests the influence of six interacting sources: Trained in psychology, math, and physics, Lick became an accomplished scientist and psycho-acoustician. He interacted with and was in turn influenced by pioneering cognitive psychologists. He came under the influence of radical new ideas in cybernetics, information theory, and neuroscience being developed by amazing MIT mathematicians, scientists, and engineers. At Bolt Beranek and Newman Corporation he consulted on military, scientific, and engineering challenges such as command and control. In doing science, he was both experimenter and model builder, using analog computers and, by the 50s, digital computers to analyze data and build models. Today he would be described as a hacker[3],

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[1] For an introduction to the work and culture of interactive computer graphics at Lincoln Lab, see http://www.billbuxton.com/Lincoln.html and http://epresence.tv/mediaContent/website_archived.aspx.

[2] For more detailed accounts, see Fano (1998), Waldrop (2001).

[3] Like good interactive system builders, Lick used and learned from his own tools. I once heard him speak about how some ARPA contractors, finding it difficult to reach him to discuss their projects, began sending him reports with an early email system to enable some measure of communication. Soon Lick would be greeted each morning with teletype paper cascading all over the office.

as he spent long hours working directly at early machines. Finally, he had the good fortune to experience and use extraordinary early interactive computers such as Whirlwind, TX-0, TX-2, and the first PDP-1s.

Licklider's influence on the development of computers and ultimately on the field of human-computer interaction was profound. This was not simply due to "Man-Computer Symbiosis", but to a remarkable range of other activities. Important publications include Licklider and Clark (1962), which expanded his list of five research challenges to the achievement of man-computer symbiosis to a longer list of ten prerequisites; a seminal book on Libraries of the Future (Licklider, 1965); and other writings on human-computer communication (Licklider, 1968; Licklider and Taylor, 1968).

Yet in 1962 he found himself in a quite different role than that of scientist and scholar. He was asked to lead the new Information Processing Techniques Office (IPTO) of the Advaned Research Projects Agency (ARPA) of the U.S. Department of Defence. In his two years in this position, with a budget of roughly $10 million per year, he initiated a significant expansion and deepening of computer science research and education in the United States. This included funding pioneering work on time-sharing, knowledge augmentation environments, interactive computer graphics, artificial intelligence, cognitive information processing, and the theory of computing. Lick funded the work of visionary computer scientists such as Doug Engelbart, Dave Evans, Ed Feigenbaum, John McCarthy, Marvin Minsky, Allen Newell, Alan Perlis, and Herb Simon at universities including Berkeley, CMU, MIT, and Stanford.

He termed his growing ARPA community the Intergalactic Computer Network, by which he meant ARPA researchers and graduate students, and also the emerging concept of a self-evolving "information utility" (Licklider, 1970) that was prototyped by the Arpanet and that later evolved into the Internet. Lick stayed at ARPA only two years, but he and successors Ivan Sutherland, Bob Taylor, and Larry Roberts, along with talented scientists and engineers such as Paul Baran, Vinton Cerf, Bob Kahn, and Leonard Kleinrock invented the technology of the Internet. Lick's leadership and vision got it all started.

More generally, work in these labs and at Xerox PARC — the intellectual byproduct of Lick's ARPA community — did pioneering work on areas of critical importance to modern HCI such as information processing models of user interfaces; tools for document processing, artistic expression, and scientific modeling; search engines; and systems to support real-time collaboration and virtual communities.

I am a living embodiment of Lick's vision. In aiding users of computers "to think as no human brain has ever thought", we needed to develop and to document in teaching materials a craft of user-centred interactive system design (Baecker and Buxton, 1987; Baecker, Grudin, Buxton, and Greenberg, 1995). We also needed to create centers such as Toronto's Knowledge Media Design Institute (KMDI, 2006) dedicated to using computing to help people think, learn, create, communicate, and collaborate.

My early work on picture-driven animation (Baecker, 1969) allowed animators to deal with motions as effectively as they could deal with still images, and to see their creations come to life instantly on a CRT screen, which had never previously been possible. I then worked on creating software visualization systems (Price, Baecker, and Small, 1993) and exemplars (Baecker, 1981; Baecker and Marcus, 1990), seeking to empower programming students and software engineers to see for the first time their programs come to life in vivid computer animations and other graphical representations.

My research on collaboration technologies (Baecker, 1993) and collaborative writing tools was animated by a vision of distributed student writers thinking and working together synchronously. Research on multimedia authoring and web publishing systems (Baecker et al, 1996) empowered filmmakers to create video documents with structure as rich as in text documents, and to webcast and publish multimedia presentations on the Internet so they could be viewed any place, any time (Baecker, 2003). Finally, I have begun a new effort to envision, design, create, and evaluate electronic prostheses to combat the ravages of cognitive decline and to preserve as well as possible our abilities to think as we age (Baecker, 2006).

In summary, I have tried to achieve effective human-computer symbiosis through the design of novel knowledge media. Hopefully what I have accomplished is worthy of Lick's vision.

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Biographical Sketch

Ronald Baecker is Professor of Computer Science, Bell University Laboratories Chair in Human-Computer Interaction, and founder and Chief Scientist of the Knowledge Media Design Institute at the University of Toronto. He is also Affiliate Scientist with the Kunin-Lunenfeld Applied Research Unit of the Baycrest Centre for Geriatric Care, and has previously been a visiting Scientist at Xerox PARC and Apple's Advanced Technology Group, and a Visiting Professor at the MIT Media Lab and at the Cognitive Neuroscience Division of the Columbia University College of Physicians & Surgeons. Baecker is Principal Investigator of the CDN$5.5M Canada-wide NSERC Network for Effective Collaboration Technologies through Advanced Research (NECTAR), has been named one of the 60 Pioneers of Computer Graphics by ACM SIGGRAPH, has been elected to the CHI Academy by ACM SIGCHI, and has been awarded the Canadian Human Computer Communications Society Achievement Award. He has published over 125 papers and articles, is author or co-author of four books and co-holder of 2 patents, was the Co-Chair of CHI+GI'87, and has founded and run two software companies. His current entrepreneurial venture is a virtual non-profit foundation within the University of Toronto to distribute and support the open source ePresence Interactive Media system (http://epresence.tv). His B.Sc., M.Sc., and Ph.D. are from M.I.T.