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# The Computer and the Brain: Perspectives on Human and Artificial Intelligence

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North-Holland

# THE COMPUTER AND THE BRAIN: PERSPECTIVES ON HUMAN AND ARTIFICIAL INTELLIGENCE

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## INTRODUCTION

While the field of cognitive science is generally understood to have developed in the late 1950s, the questions posed by researchers in this new field respond to the issues raised by Descartes and seventeenth-century rationalist philosophers and echo the epistemological deliberations introduced by Plato in the Socratic dialogues. The historicity of cognitive science, both its framework and assumptions, is a fascinating feature of this developing discipline.

John von Neumann was one of the first to address the highly controversial issue of appropriate models to use in discussing cognitive science. The issue that von Neumann raised most pointedly, one that is still hotly debated, is the language of the brain. In his Silliman Lectures, von Neumann questions the validity of using the computer as an interpretive model for human thought, asserting that the language of the brain is not mathematical. Later in the same lecture series, however, he attributes a statistical pattern to the brain. This paradoxical stance of von Neumann's is representative of the rapidly shifting nature of cognitive science. It is also representative of the study of the nature of language; creating exciting scenarios which lead men to attempt to understand the greatest of all paradoxes, the brain.

*The Computer and the Brain: Perspectives on Human and Artificial Intelligence* is a collection of interdisciplinary analyses addressing the issue of the language of the brain. The contributors include computer scientists, neuroscientists, psychologists, linguists, and historians. The resulting collection suggests the state of knowledge more than a generation after John von Neumann entitled his tantalizing and provocative lectures, *The Computer and the Brain*.

## ACKNOWLEDGMENTS

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The commemoration of John von Neumann began on February 8, 1987, at his birthplace in Budapest, Hungary, thirty years after his death. Dr. Ferenc Nagy, who organized the Hungarian commemoration, kindly assisted in preparing the exhibit for the Arizona symposium. We also gratefully acknowledge Dénes Nagy, professor at the Eötvös Lorand University in Budapest, who conceived of linking the Hungarian and Arizona symposia and who, while a visiting professor at Arizona State University, organized a series of workshops on human and artificial intelligence related to the symposium.

A few of the essays printed here derive from previously published materials. We gratefully acknowledge permission to reprint the following:

"John von Neumann: Formative Years" is adapted from Nicholas Vonneuman's *John von Neumann As Seen By His Brother* and is reprinted here with the kind permission of Nicholas Vonneuman. "The von Neumann - Ortway Connection" is taken from *The Computer, the Brain, and the Missing Link (In Memoriam John von Neumann)*, a summary of the Hungarian book *Neumann János és a "magyar titok" (John von Neumann and the "Hungarian secret")*, OMIKK, 1987, and is reprinted here with the permission of the editors, Dénes Nagy, Ferenc Nagy, and Péter Horváth and of the publisher, the National Technical Information Centre and Library, Budapest.

William Aspray's "John von Neumann's Contributions to Computing and Computer Science" contains material adapted from the author's essay, "The Mathematical Reception of the Modern Computer: John von Neumann and the Institute for Advanced Study Computer," in *Studies in the History of Mathematics*, edited by Esther R. Phillips, and is reprinted here with the permission of The Mathematical Association of America. MIT Press has also granted permission to Ray Jackendoff to reprint material from *Consciousness and the Computational Mind* in his essay on "Languages of the Computational Mind." John Haugeland likewise acknowledges permission from MIT Press to reprint portions of *Artificial*

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## **SECTION 1: HISTORICAL PERSPECTIVE**



## BINARY SYSTEMS, RATIOS, AND ESTHETIC JUDGMENTS IN THE RENAISSANCE

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As you may recall, John von Neumann introduced *The Computer and the Brain* with a modest disclaimer. "Since I am neither a neurologist nor a psychiatrist," he wrote, "but a mathematician, the work that follows requires some explanation and justification." Well, I have to go von Neumann one better. I am certainly not a neurologist or a psychiatrist--and I cannot even claim to be a mathematician. But I am fascinated by what the new sciences can do, and I am enormously pleased to have the opportunity of participating in a conference paying homage to von Neumann and his colleagues.

When Jean Brink asked me to come to the conference, she told me that she would like a paper about modes of perception in the Renaissance and concepts of memory and theories of intelligence and things like that. The challenge, of course, is how to make any of that relevant to what is going on today. As I thought about all this material, though, a teasing comparison came to dominate my thinking. In many fundamental ways, a computer is like a poem, such as Dante's *Divine Comedy*. To begin with, both are man-made constructs, and both use signs, languages of an artificial sort. Moreover, a poem encodes information as though it were a memory bank, while it must allow a reader to retrieve this information. So I began to play with the notion that Renaissance works of art in all media--in painting and music as well as poetry--bore comparison to computers.

Furthermore, it occurred to me that those working in artificial intelligence face a problem similar to the one faced by those in the Renaissance who saw their works of art as representation in small of the great universe, a microsystem encompassing the infinite variety in nature. In Renaissance terms, a system of artificial intelligence is a microcosm representing the limitless potential of the macrocosm. Anyone devising a program of artificial intelligence is necessarily limited to a finite system; and yet, this system should be responsive to as many contingencies as possible. Although the system is finite, ideally it should submit to manipulation in an infinite number of ways. So I decided it might be worthwhile to explore with you this purpose of art: the relating of the man-made and therefore finite to the natural and therefore all-encompassing.

Now, since I profess to be a cultural historian, let me get historical. My instructions were to talk about the Renaissance. But it is extremely difficult to set dates for that event glibly called the Renaissance, so I am going rather arbitrarily to talk about what the scene looked like in the year 1500--by which time the





Figure 1. Charles de Bouelles, "Libellus de nichilo,"  
Liber de intellectu et al. (Paris, 1510) fol. 63.