

### **Abstract**

This is where the abstract will go. I guess I'll mention a thing or two about the contents, what I plan to discuss and what my analysis shows.

Cognitive Science and Artificial Intelligence: An  
Interwoven Approach  
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June 15, 2021

# 1 Introduction

This is Paolo Marzolo's bachelor thesis, written as part of the three-year program in computer science at University of Bologna. The stated objective of this document is to analyze the history of Cognitive Science and Artificial Intelligence and identify how influences among the two disciplines and others led to a partially shared evolution in the overarching research topics throughout their lifespans. Other similarities will be pointed out, and some of the algorithms and concepts contained throughout the sections will be explained in detail, in order to give the reader a more complete understanding.

The structure of the document will be as follows: after this introduction, a brief glossary will introduce some of the terms that will be used in this document with a short definition; this has been included to avoid having "foundational" terms be constrained by a specific philosophy or line of research. Then, the rest of the document will develop parallel to the history of the disciplines. In the final section, a bird's-eye-view will provide additional insight, and **MAYBE** a brief discussion of the roles of symbols will conclude the contents.

# 2 Terms and Definitions

Before defining our glossary, it is important to understand the reasoning behind why we chose to include it: when discussing researchers' understanding of human thought, it is nearly impossible to avoid using terms that have a strong past history. As an example, "thought" could already be considered too far from a behaviorist point of view. A further example is a recent discussion that took place after a somewhat controversial paper by Nunez was published [5], questioning the multidisciplinary nature of Cognitive Science as a discipline (and journal) and declaring "The prospect launched by the cognitive revolution of a unified and coherent interdisciplinary seamless cognitive science did not materialize".

**Cognitive Science.** As we will see in following sections, saying "definitions of Cognitive Science have evolved throughout the years" would be a massive understatement. ("Thinking can best be understood in terms of representational structures in the mind and computational procedures that operate on those structures"). Its multidisciplinary nature is uncontested from what the International Encyclopedia of Social & Behavioral Sciences [3] reports ' may have been the first published use of the term cognitive science':

'The concerted efforts of a number of people from ... linguistics, artificial intelligence, and psychology may be creating a new field: cognitive science'

. Even the "essential original features" identified by Gardner in 1987 [2] (summarized here as (1) necessity to speak about mental representation as a separate layer of analysis from the biological, (2) faith that the computer is central to the understanding of the human mind and (3) de-emphasizing factors such as

emotions or cultural factors) would be completely or partially thrown out by contemporary scholars.

In a more recent publication[1], Cognitive Science is characterized as

The field would be better defined as the study of ‘mind as machine’  
... More precisely, cognitive science is the interdisciplinary study of  
mind, informed by theoretical concepts drawn from computer science  
and control theory.

Not only was its definition cloudy and unstable (“cognitive science is ... a perspective, rather than a discipline in any conventional sense” [6]), but as Nunez points out its disciplines have varied wildly in which ones they are and how represented they are in the Cognitive Science enterprise. Because of the reasons outlined here, far removed from the subject of this document, we will avoid using the term “Cognitive Science”, and prefer the acronym “DCS”.

**Descriptive Cognitive Sciences (DCS).** As we mentioned, the disciplines which make up Cognitive Science are not only multiple, but subject to interpretation as well. Since the nature of this work is to compare it to the history of Artificial Intelligence, we will from this point on use the acronym “DCS”, for Descriptive Cognitive Sciences, as an alternate approach to the Constructive one taken by Artificial Intelligence researchers. This is not to say that a psychologist cannot take a constructive approach to the explanation of consciousness: the only reason we chose this is because we found it to be an intuitive use of the term.

**Mind.** Once again, although we take notice of the history of the term, we have to select a few terms to use in our language. Hereafter, we consider the mind as the non-physical correlate of human brains: “the complex of faculties involved in perceiving, remembering, considering, evaluating, and deciding. Mind is in some sense reflected in such occurrences as sensations, perceptions, emotions, memory, desires, various types of reasoning, motives, choices, traits of personality, and the unconscious.” [4].

**whatever else will come up**

### 3 A History of Influences

As mentioned in the introduction, our approach will follow the historical sequence of events, although some references or explanations may be anachronistic for clarity. In order to give a general view, we split the histories of these disciplines into broad periods: one for (more or less) every substantial shift in approach and views. Generally, every time period will mention two sides of the story: one of them will focus on DCS, and the other on AI and Computer Science.

### 3.1 Landscape before 1950

Although the official birth of the "Cognitive Science" institutions is in the late 1970s, reasoning about thought has been a staple in philosophical research for centuries. Because of the scope of this document, we will focus on a few important concepts, and use them to set the stage for the first large shift of ideas.

#### 3.1.1 Mathematics and Computer Science

Some of the most relevant contributions to the "reasoning as a process" come from Mathematics and what would later become Theoretical Computer Science. We will outline some of them here.

**Boole's Laws of Thought and Boolean Algebra.** To avoid going too deep in mathematical concepts for our purposes, we can think of Boolean algebra as the branch of algebra where the variables can be either true or false (1 and 0), and the main operations on its variables are conjunction (and,  $\wedge$ ), disjunction (or,  $\vee$ ), negation (not,  $\neg$ ). Through these, logical operations can be described. In "An Investigation of the Laws of Thought on Which are Founded the Mathematical Theories of Logic and Probabilities", one of the author's two monographs on algebraic logic, George Boole, then mathematics professor in Ireland, introduces Boole's algebra as an extension to Aristotle's logic. In it, Boole provides Aristotle's algebra with mathematical foundations, and expands it from two-term to any-term. Boole's algebra differs from modern Boolean algebra (in Boole's algebra *uninterpretable* terms exist) and cannot be interpreted as set operations; still, its introduction marks a step towards the formalization of laws of thought and a possible bridge between mathematical research and thinking processes. Boolean algebra would instead be developed by Boole's successors (Jevons, Peirce, Schroder and Huntington in particular); this work allows boolean algebra to now be defined by the Stanford Encyclopedia as

the algebra of two-valued logic with only sentential connectives, or equivalently of algebras of sets under union and complementation.

#### **Cybernetics.**

- Boole "Laws of Thought" - automata theory - cybernetics - information theory

topics: - behaviorism - gestalt? - Vygotsky-Luria? - Several psychologists who later pioneered a more cognitive approach, including Miller, Ulric Neisser, and Donald Norman, received their training in S. S. Stevens's Psycho-acoustic Laboratory at Harvard - simplest McCulloch-Pitts neuron is 1943!

- 3.2 1956: A Pivotal Year
- 3.3 1960-1970: Great Promise
- 3.4 1975-1985: Ashes and Embers
- 3.5 1987-1993: Bodies as the Key to Minds
- 3.6 1993-2000: Agents and Cooperation
- 3.7 2000-now: Hybrid Systems: New Perspectives
- 3.7.1 gianandrea

## 4 Perception shifts

Should I merge these two?

- 4.1 Symbolism and Connectionism
- 4.2 Symbols and Subsymbols: Collect or Extract

## 5 Conclusion

## References

- [1] Margaret A. Boden. *Mind as Machine: A History of Cognitive Science*. en. Google-Books-ID: yRyETy43AdQC. Clarendon Press, June 2008. ISBN: 978-0-19-954316-8.
- [2] Howard E. Gardner. *The Mind's New Science: A History of the Cognitive Revolution*. June 1987.
- [3] *International Encyclopedia of Social & Behavioral Sciences - 1st Edition*. URL: <https://www.elsevier.com/books/international-encyclopedia-of-social-and-behavioral-sciences/smelser/978-0-08-043076-8> (visited on 06/14/2021).
- [4] *Mind*. en. URL: <https://www.britannica.com/topic/mind> (visited on 06/14/2021).
- [5] Rafael Núñez et al. “What happened to cognitive science?” en. In: *Nature Human Behaviour* 3.8 (Aug. 2019). Number: 8 Publisher: Nature Publishing Group, pp. 782–791. ISSN: 2397-3374. DOI: 10.1038/s41562-019-0626-2. URL: <https://www.nature.com/articles/s41562-019-0626-2> (visited on 06/13/2021).
- [6] Noel Sheehy and Antony J. Chapman. *Cognitive Science*. Sept. 1995.