

Computing, Dynamics, and The Third Way

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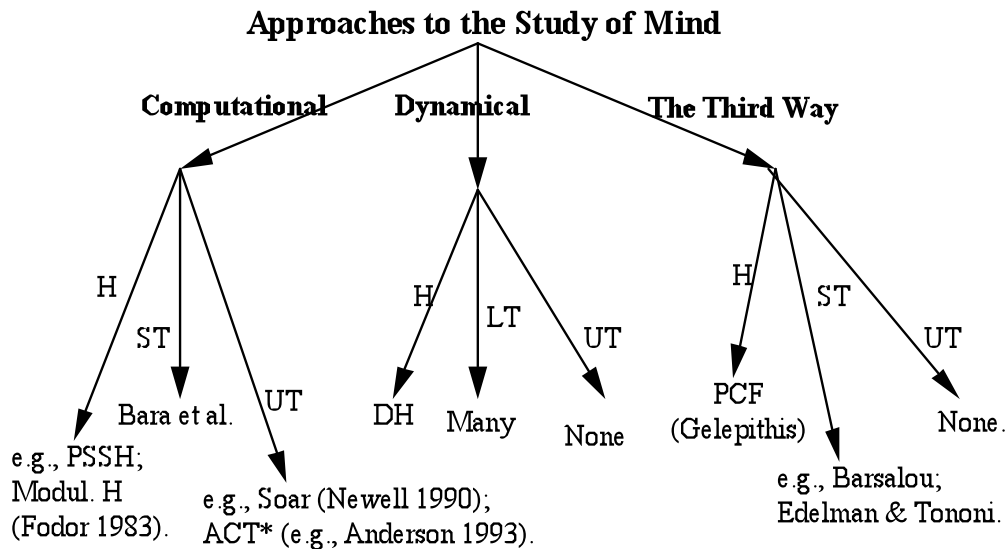
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ABSTRACT

The aim of this paper is to review our fundamental assumptions and theories with respect to the study of Mind (e.g., human, artificial, animal). Specifically, section one codifies the present state of affairs. Section two summarises the key characteristics of the computational and dynamical approaches. Section three outlines my position with respect to one of the fundamental questions of the Cognitive Sciences: What kind of system can display intelligence? Finally, section four lists a few of the major implications of our viewpoint and a couple of preliminary comparisons among the three approaches.

1. INTRODUCTION

What kind of system can display intelligence? The following tree diagram codifies the major positions:



Legend:

H = Hypotheses	PSSH = Physical Symbol Systems Hypothesis.
LT = Local Theories	Modul H = Modularity Hypothesis.
ST = Subject Theories	DH = Dynamical Hypothesis.
UT = Unified Theories	PCF = Preliminary Conceptual Framework.

See text for explanations and additional references.

It should be noticed that the above diagram is representative rather than exhaustive. An exhaustive classification would be both beyond the scope of this paper and it would not modify the number or types of approaches to the study of mind. The next section summarises the key characteristics of the computational and dynamical approaches.

2. THE COMPUTATIONAL AND DYNAMICAL APPROACHES

The dominant computational approach, based on Newell and Simon's (1976) Physical Symbol Systems Hypothesis (PSSH), has been elaborated in Unified Theories of Cognition (Newell 1990) and extensively debated (e.g., Newell 1992). The emerging dynamical approach has its early proponents in work in artificial neural networks and, has recently put forward by Van Gelder (1998).

The following table summarises the key characteristics of each approach some of which will be juxtaposed to those of our position in the final section.

Characteristics	The PSSH	The DH
Ontological criteria	Newell's classification of systems (1990).	Van Gelder's definition of dynamical system.
Epistemological criteria	Detailed theoretical framework whose key notions are: knowledge, representation, computation, symbols, and architecture.	Two major components: (i) the nature hypothesis; and (ii) the knowledge hypothesis.
Types of representation	Amodal.	Not addressed.
Necessary and sufficient conditions	Necessary yes. Sufficient no, but further organisation of a PSS can exhibit general intelligence.	Neither.

A clarification point: both hypotheses have been proposed as laws of qualitative structure, i.e., characterisations which "set the terms within which more detailed knowledge can be developed." (Newel and Simon 1976).

3. A CENTRAL CONSTITUENT OF THE THIRD WAY

The Third Way is the attempt to propose alternative foundations for the Cognitive Sciences. Already, a few people work, at least partially, outside the boundaries of Computing and Dynamics. For instance, Barsalou (1999) has developed a theory of knowledge attempting "to integrate representation, statistical processing, and embodiment." Edelman and Tononi (2000) have proposed a full-scale theory of consciousness based on Darwinian principles and neuroscientific findings. The aim of this invited talk is to outline, axiomatically, an answer to one of the fundamental questions of the Cognitive Sciences: What kind of system can display intelligence? This will draw upon the alternative foundational framework we developed so far (Gelepithis 1986, 1988, 1989, 1991, 1995, 1997, 1999, 2001; Gelepithis and Goodfellow 1992; Gelepithis and Parillon 2002).

Our task is the delineation of the class of intelligent systems. The following definition specifies necessary and sufficient conditions for membership to the space of intelligent systems.

A system, S , is intelligent if and only if it:

- a) possesses sensors.
- b) is able to act on its environment.
- c) possesses its *own* representational system R_s , i.e., R_s is independent of the language of another kind of system S^* .
- d) is able to connect sensory, representational, and motor information.
- e) is able to communicate with other systems within its *own* class.

It follows that the space of intelligent systems is extremely varied with nearly impenetrable regions of intelligence. For instance, a system, S , is human –level intelligent if and only if it is intelligent and it is able to communicate in a human-equivalent language.

Our next move then is to define the notions of ‘communication’ and ‘representational system’. We start with the latter. Let R_e be the symbol for the representational system of entity E . We define:

$R_e =_{df}$ is a thought system of E able to create representations. Where: a representation of a situation, say, S_1 , is another situation, say, S_2 , characterised by the properties:

S_2 simplifies S_1 ; and

S_2 preserves the essential characteristics of S_1 .

Thought system of $E =_{df}$ a system of thoughts of entity E .

Thought = $_{df}$ An ordered n -tuple of meanings.

Finally: The meaning, M , of something s , in the context C_s , for the entity E , at time t -symbol $M(s, C_s, E, t)$ - is the *prevailed* formations of R_e^m , at t . (R_e^m the representational material of E).

A few clarificatory remarks are in order. First, our definition assumes the existence of a whole class of R_e^m formations out of which a particular formation eventually prevails. The term prevailed is used to indicate the potential complexity involved in the struggle for selection. Such complexity depends on the complexity of the R_e . In the case of humans $R_e =$ the human brain whose complexity is known to be hyper-astronomical. Second, it can be shown that meanings can be represented topologically in terms of neighbourhood systems where tokens (i.e., instances of concepts) are represented by neighbourhoods and concepts by neighbourhood families. Specifically, neighbourhoods are members of the power set $P(R_e^m)$, and neighbourhood families members of the $P(P(R_e^m))$. Finally, it should be noticed that the cardinality of R_e^m , $P(R_e^m)$, and $P(P(R_e^m))$ changes over time through processes like development, learning, growth and understanding.

We turn now to our definition of communication: An entity E_1 communicates with E_2 on a topic T if, and only if: (i) E_1 understands T {Symbol: $U(E_1 T)$ }; (ii) E_2 understands T {Symbol: $U(E_2 T)$ }; (iii) $U(E_1 T)$ is describable to and understood by E_2 ; and (iv) $U(E_2 T)$ is describable to and understood by E_1 . This brings us to our last definition: An entity E has understood something, S , if and only if, E can describe S in terms of a system of *own* primitives (p is a primitive if and only if p 's understanding is immediate). In other words, understanding is a thought process characterised by reducibility to a system of primitives. Our task is now completed. Significant, related questions remain and will be introduced in my talk.

In the next section we list a few of the major implications of this conception and a couple of preliminary comparisons. Because of paper length limitations, full supporting arguments that may be required are omitted in this written outline.

4. SOME IMPLICATIONS AND PRELIMINARY COMPARISONS

There are two kinds of representational systems. All current computational systems exemplify only one of them.

Communication between two different kind of entities is delimited by the extent of overlap between their respective representational systems.

Machines can both think and become conscious, they are still not there. Therefore, the Turing test is no more required.

The mathematical basis of the three approaches differ: logic, dynamical modelling and dynamical systems theory, topology.

The Third Way provides necessary and sufficient conditions for membership of the class of intelligent systems.

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