CHALMERS | UNIVERSITY OF GOTHENBURG

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Representation and Reality –
The Book And The Multiple Perspectives on Knowledge

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MORPHOLOGICAL COMPUTING IN COGNITIVE SYSTEMS

MORCOM@COGS RC PROJECT – supported by Swedish Research Council

MORCOM@COGS develops a conceptual framework in which the computation process is generalized from abstract symbol manipulation of the Turing machine type to the information processes in physical systems. The project studies how information is created and structured on different levels or scales and how it changes through natural processes in cognitive systems.

Consequences of the shift in modeling of computation toward cognitive computing are examined by comparing existing models with the new, morphological computations applied to various classes of cognitive systems in nature. Complex systems in nature have already inspired a number of methods for information processing - including artificial neural networks, genetic algorithms and genetic programming, and development continues.

http://www.idt.mdh.se/%7Egdc/Morcom.Cogs.htm

MY RESEARCH COMMUNITIES

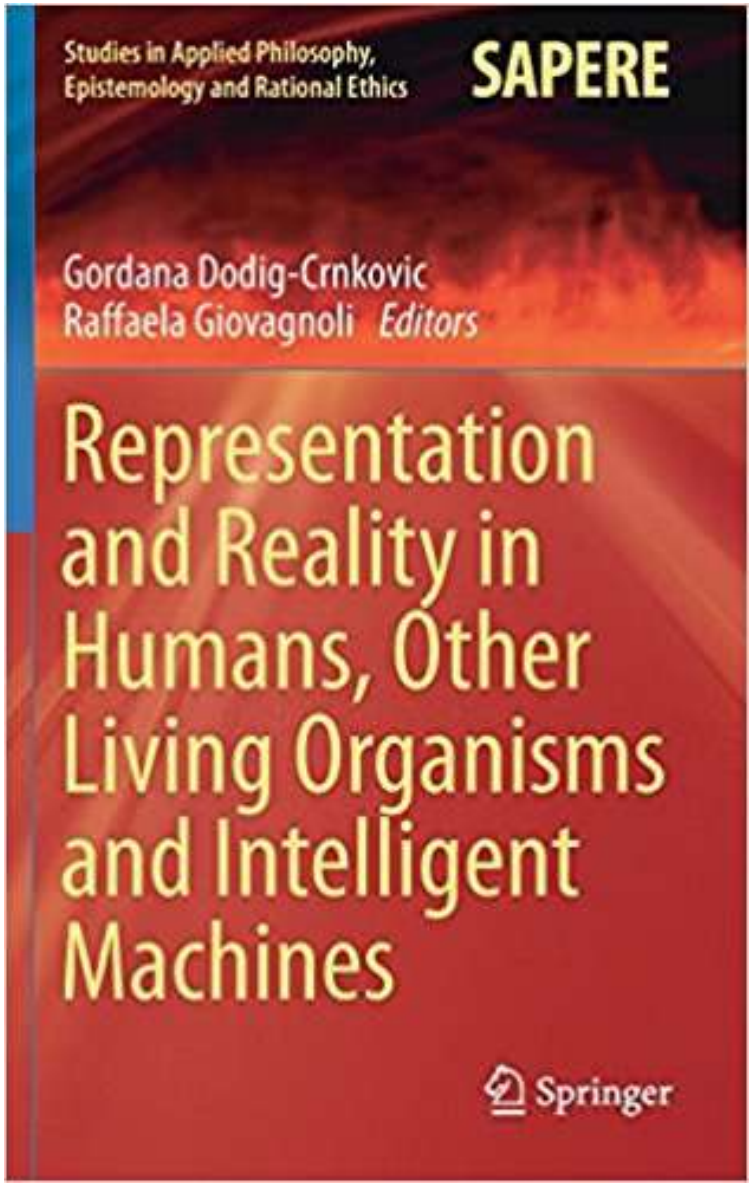
- THEORETICAL PHYSICS
- COMPUTING AND PHILOSOPHY
- THE STUDY OF INFORMATION
- COMPUTATION – INFORMATION – COGNITION
- ARTIFICIAL AND NATURAL INTELLIGENCE
- COMPUTABILITY
- ETHICS – INFORMATION ETHICS & COMPUTER ETHICS
- PHILOSOPHY OF INFORMATION

THE BOOK

Representation and Reality in Humans, Other Living Organisms and Intelligent Machines

Gordana Dodig Crnkovic and Raffaela Giovagnoli, Editors

Springer SAPERE series, 2017



CONTENT

Computational perspectives

Jan van Leeuwen and Jiří Wiedermann: *Knowledge, representation and the dynamics of computation*

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Nicolas Gauvrit, Hector Zenil and Jesper Tegner: *The information-theoretic and algorithmic approach to human, animal and artificial cognition*

Dean Petters, John Hummel, Martin Jüttner, Ellie Wakui, Jules Davidoff: *Using computational models of object recognition to investigate representational change through development*

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Gordana Dodig-Crnkovic and Rickard von Haugwitz*: Reality construction in cognitive agent through process of info-computation*

Philosophical perspectives

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Logical perspectives

Henri Prade and Gilles Richard: *From the structures of opposition between similarity and dissimilarity indicators to logical proportions. A general representation setting for capturing homogeneity and heterogeneity*

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Jean-Yves Béziau: *Being aware of rational animals*

Machine perspectives

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David Zarebski: On the realism of human and machine representational constraints: *a functionalist account on cognitive ontologies*

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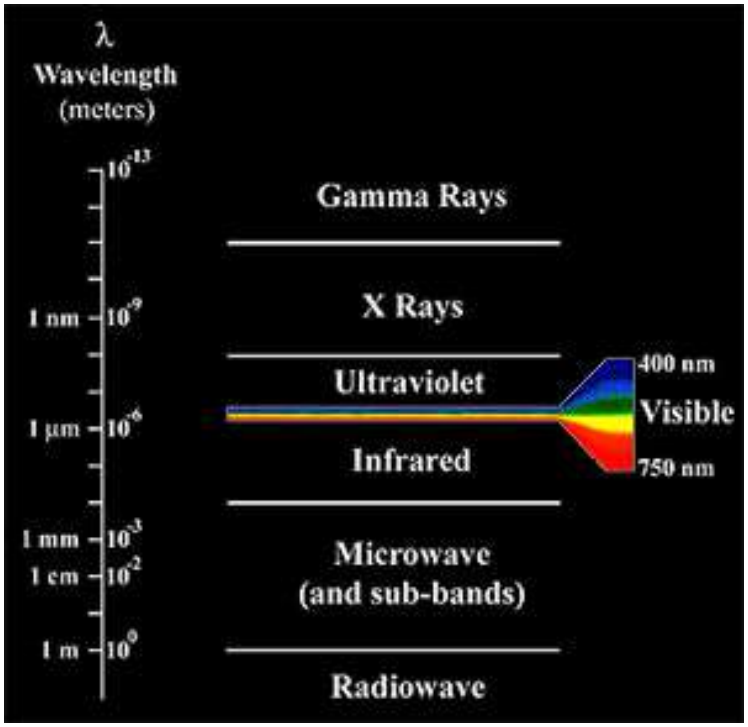
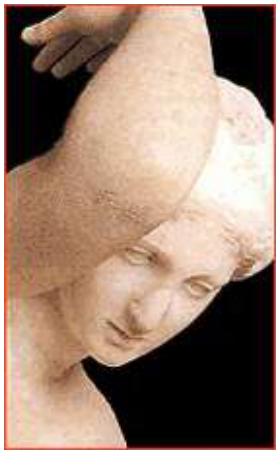
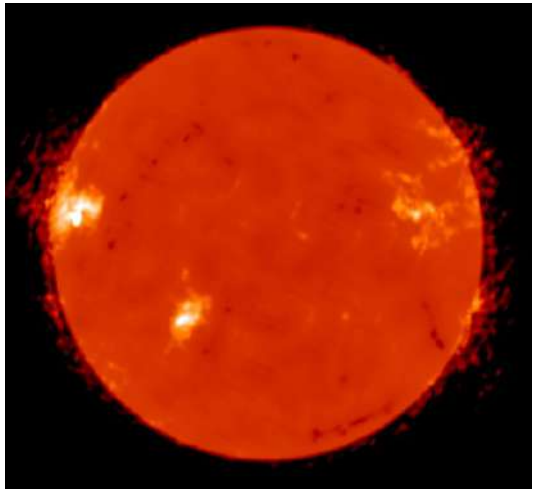
MULTIPLE PERSPECTIVES: World in different light



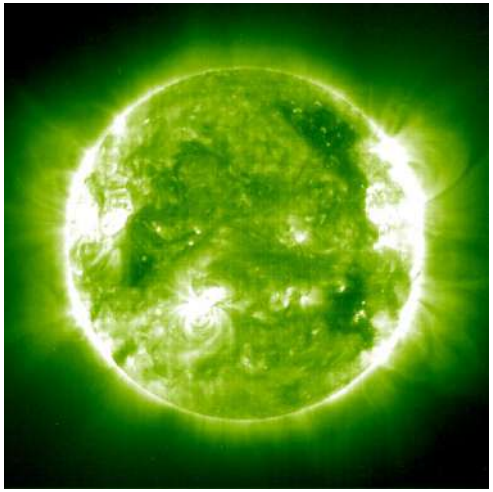


What if we could see in any wavelength of the electromagnetic spectrum, from gamma-rays to radio waves? How would the world appear to us?

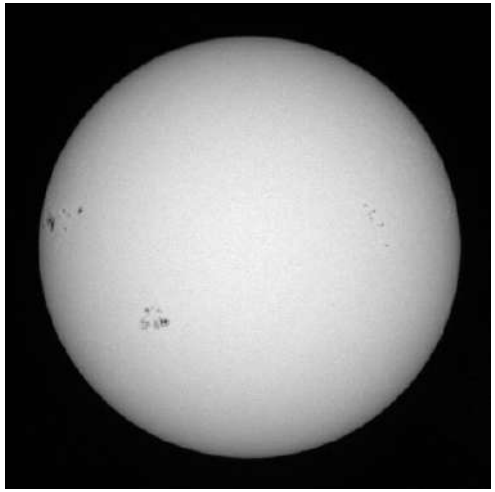
Images of the Sun



RADIO



ULTRAVIOLET



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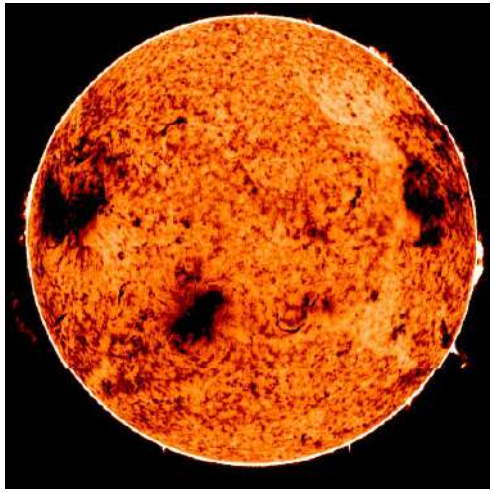

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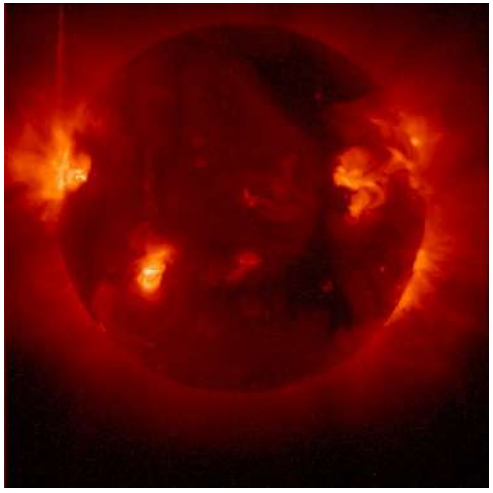
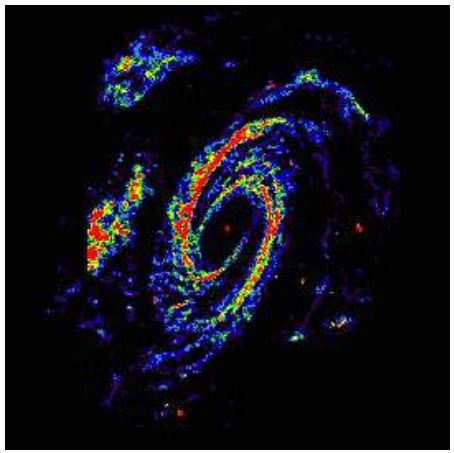


X-RAY

Images of Galaxy M81



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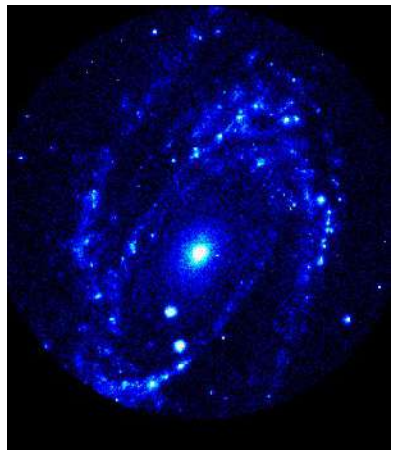

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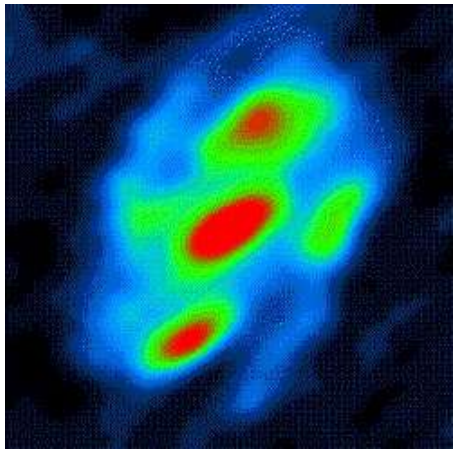

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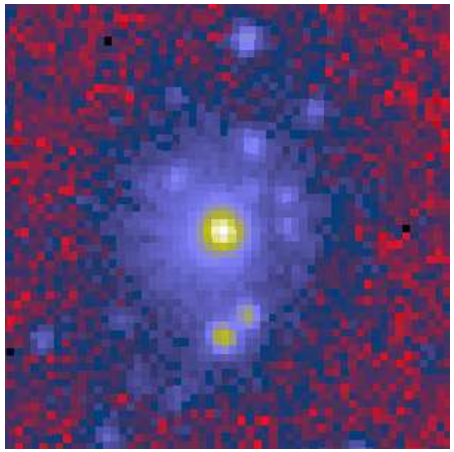


X-RAY

Knowledge and Ways of Knowing

Epistemology Naturalized

Natural sciences can be used to naturalize epistemology

World presents itself as data that cognizing agents structure into information

– from data (atoms of information) to information (data processing)

– from information to knowledge (information processing)

Knowledge and Ways of Knowing

Prisoners of information processing architecture

How shall I talk of the sea to the frog,
if it has never left his pond?

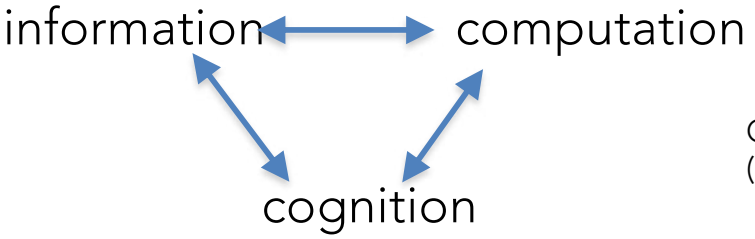
How shall I talk of the frost to the bird of the summerland,
if it has never left the land of its birth?

How shall I talk of life with the sage (learned),
if he is prisoner of his doctrine?

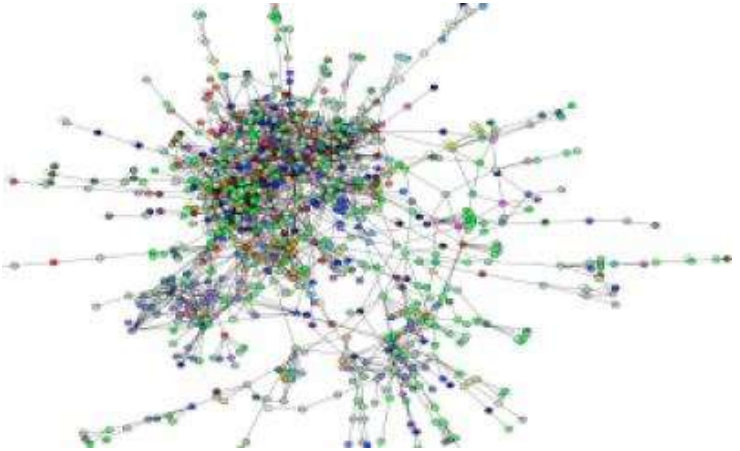
Chung Tsu, 4th Century B.C.

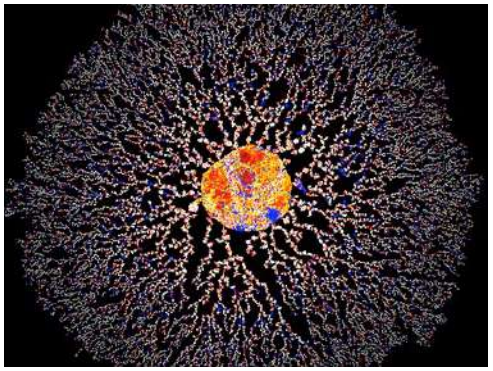
Representation and Reality in Animals

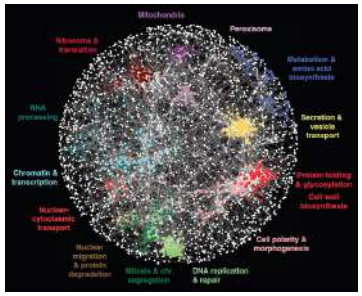
Information, computation, cognition: Agency-based Hierarchies of Levels



Cognition = life
(Maturana)





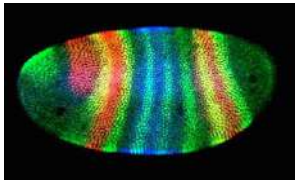


http://www.hhmi.org/research
/global-mapping-genetic-networks

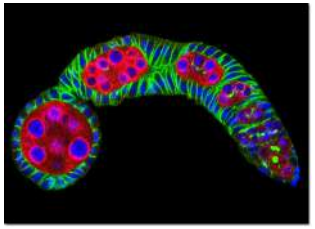
http://phys.org/news/2009-11-conquer-social-network-cells.html

http://www.cellcognition.org/
The cell cognition project

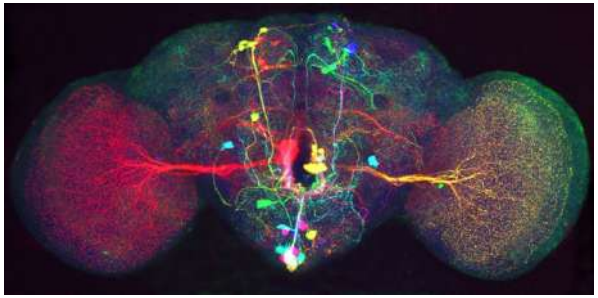
http://www.visualcomplexity.com/vc/images/122_big01.jpg
Protein network



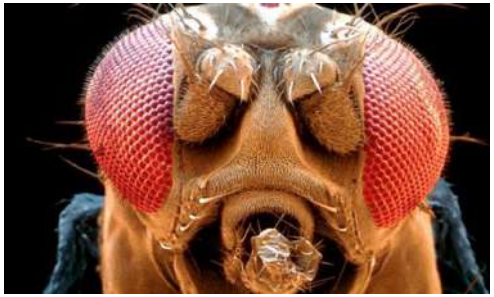
Fruit fly embrio



Fruit fly larva



Fruit fly brain neurons



Fruit fly head

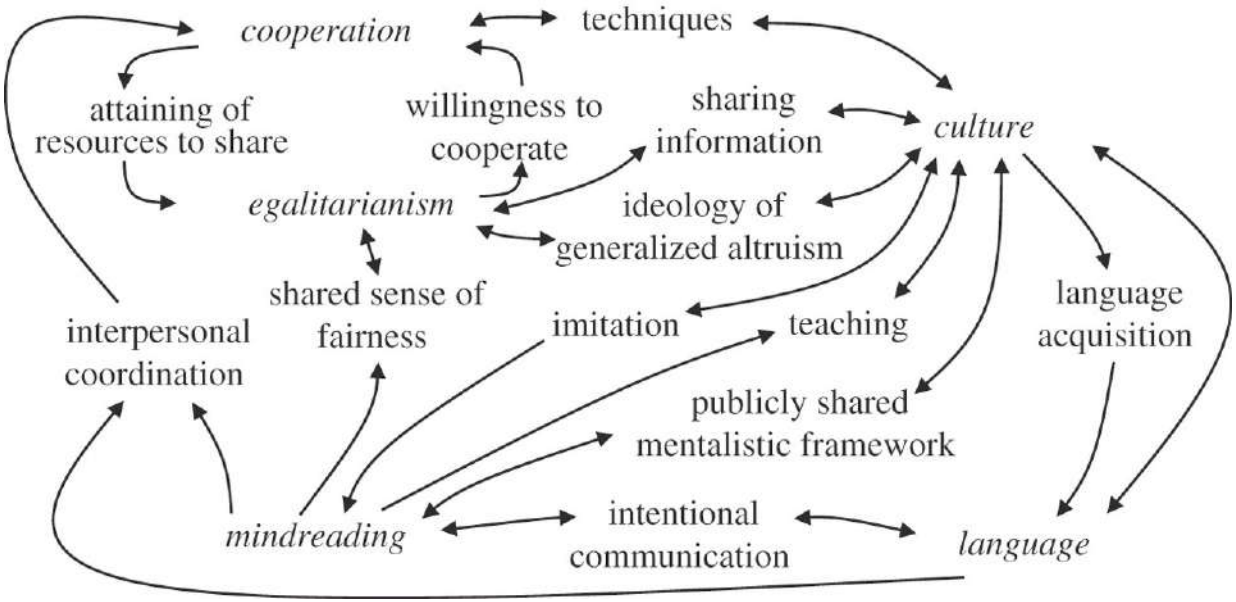
Representation and Reality in Humans

Infocomputational agency-based Hierarchies of Levels

Human connectome ?

http://outlook.wustl.edu/2013/jun/human-connectome-project

In the book we are connecting domain specific language accounts, from molecules to human languages:



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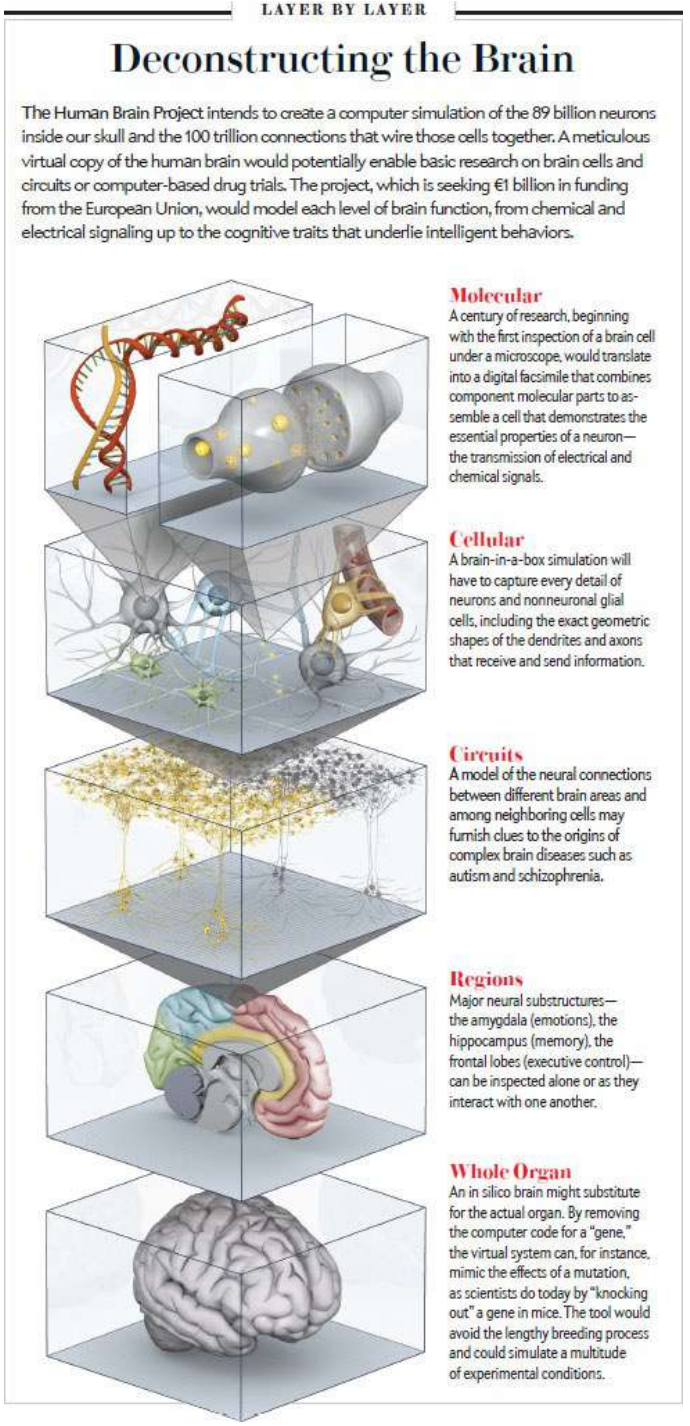
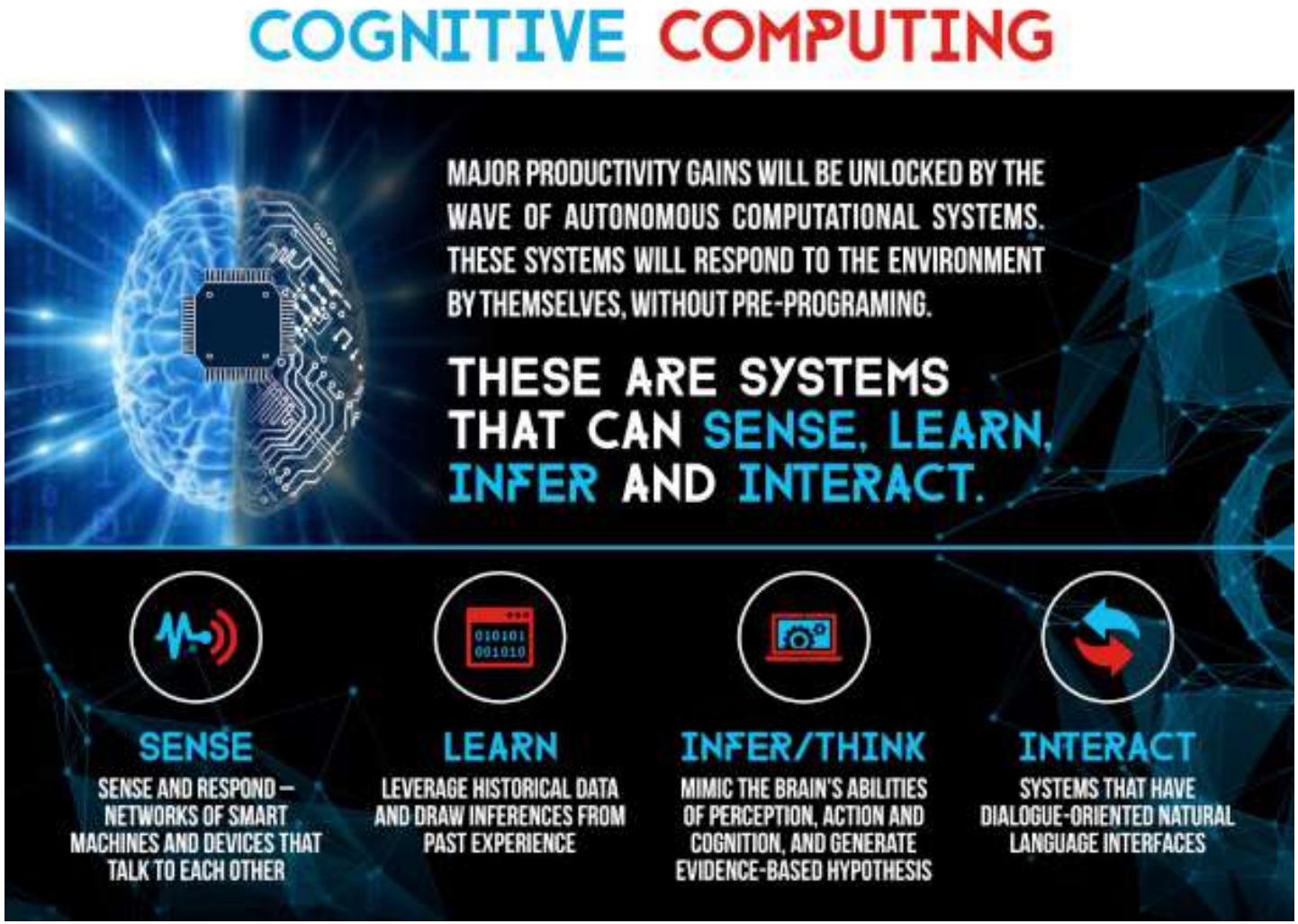


http://www.nature.com/scientificamerican/journal/v306/n6/pdf/scientificamerican0612-50.pdf The Human Brain Project

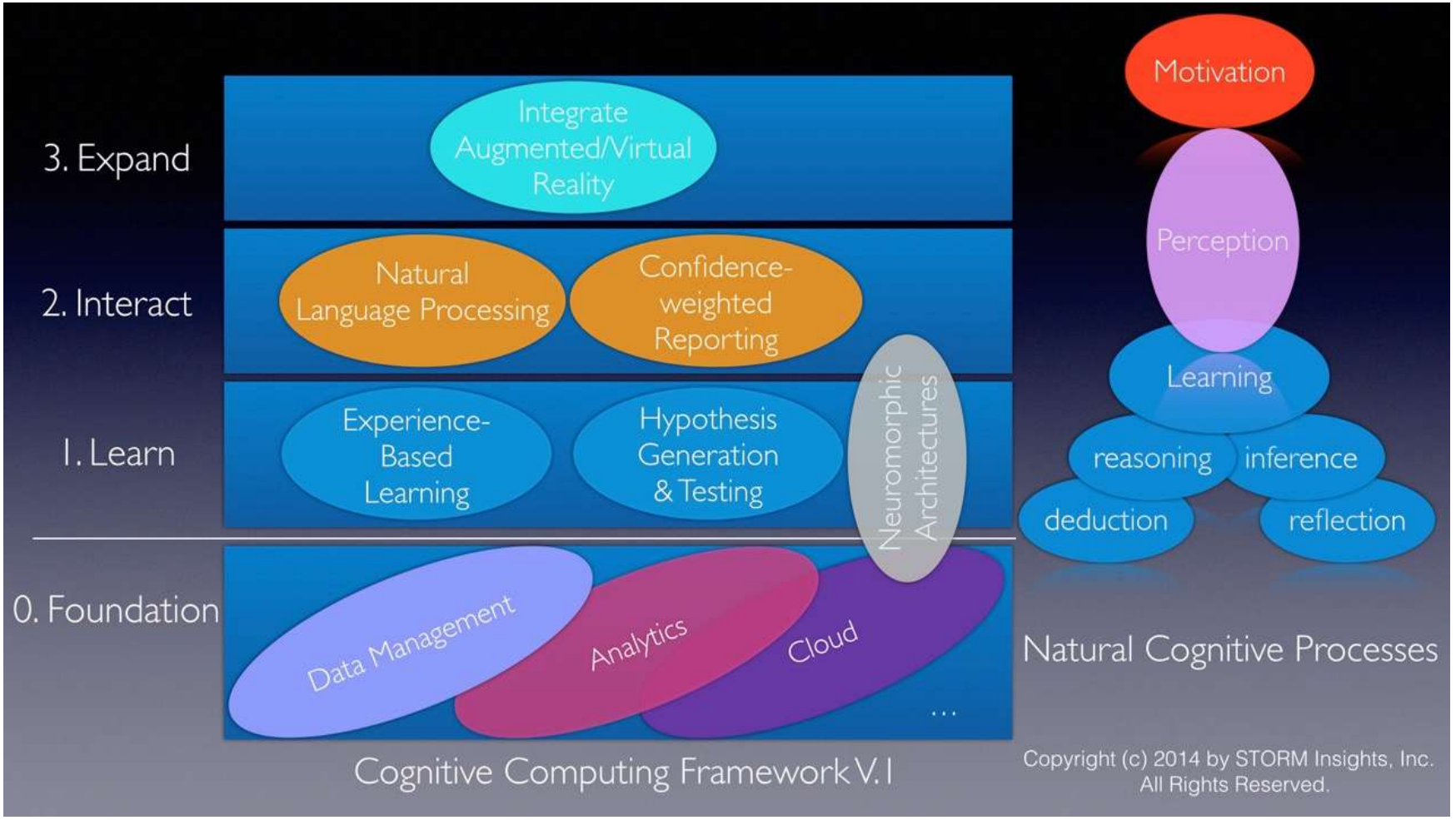
Representation and Reality in Machines

Infocomputational agency-based Hierarchies of Levels



http://www.enterrasolutions.com/media/Wipro-Cognitive-Computing-2.png

Cognitive Computing vs. Natural Cognitive Processes

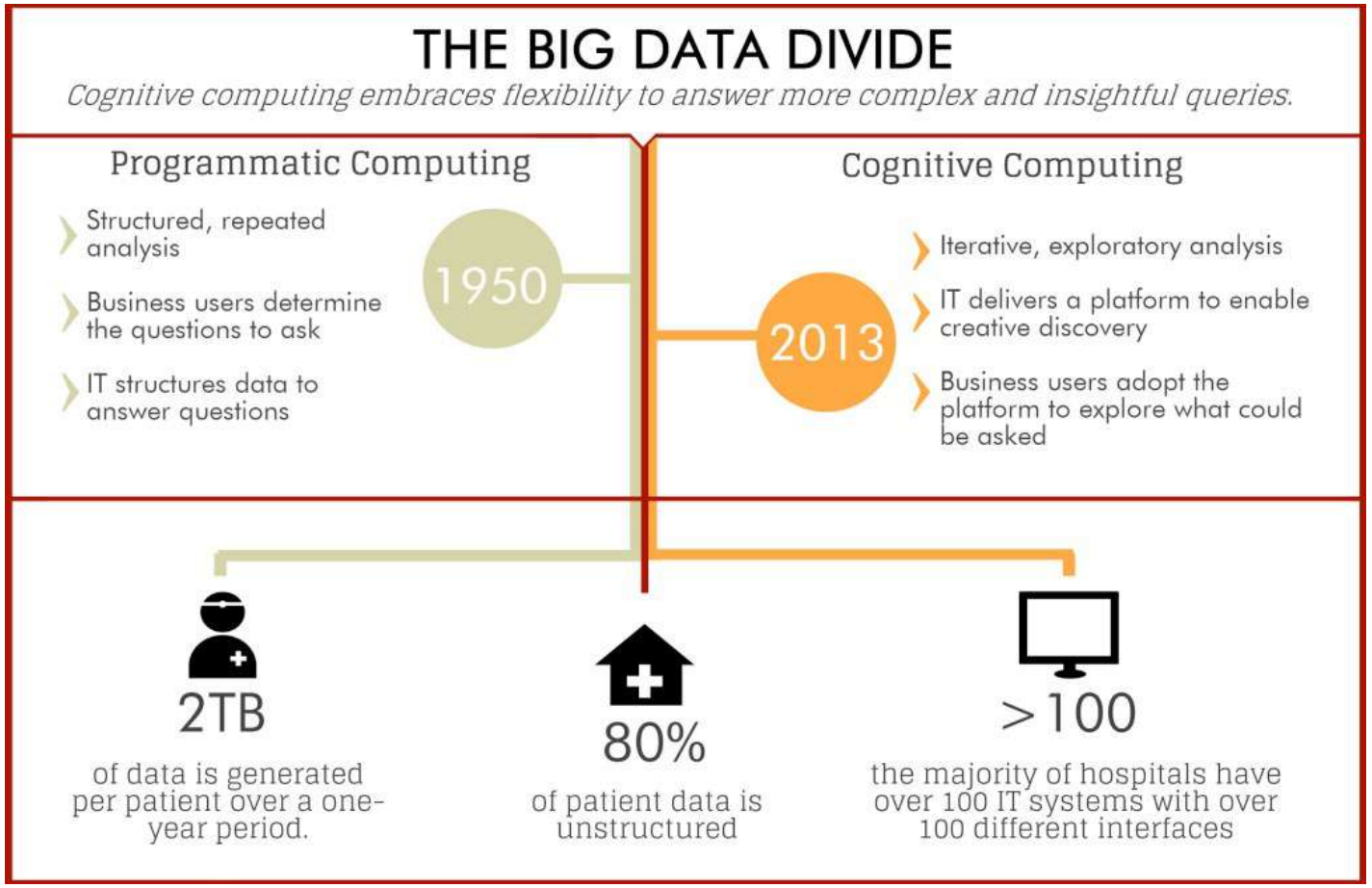


http://blog.parityresearch.com/wp-content/uploads/2014/08/Adrian-Bowles-Storm-Insight-Cognitive-Computing-Framework-300x168.jpeg

Daniel Dennett stated in a talk at the International Computers and Philosophy Conference, Laval, France in 2006: "AI makes Philosophy honest."

I would add: "Philosophy makes AI meaningful." [in a deeper sense than just *useful*]

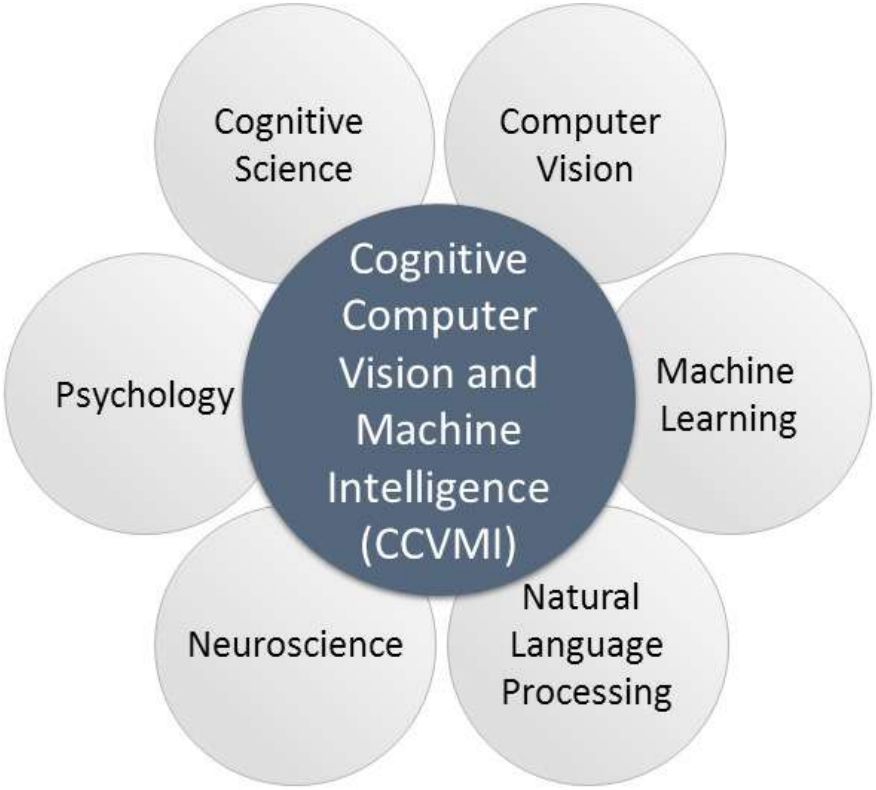
Representation and Reality in Machines –
Managing Big Data Cognitively



http://www.mdbuyline.com/wp-content/uploads/2014/03/HFMA-Watson-3-13-2014-1024x661.jpg

Representation and Reality in Machines

- Transdisciplinary Research Endevour



In order to obtain rich understanding of phenomena of representation and reality in machines we need insights from several research fields . Similarly we need variety of disciplines to cover the same topic in humans and animals (and plants and microorganisms).

https://www.edgehill.ac.uk/computing/files/2015/07/CCVMI.png

Mechanisms of knowing

Information, computation, cognition.

Agency-based Hierarchies of Levels

1. Information constitutes a structure consisting of differences in one system that cause the differences in another system. In other words, information is <observer>-relative.

2. Computation is information processing (dynamics of information). It is physical process of morphological change in the informational structure (physical implementation of information, as there is no information without physical implementation.)

Mechanisms of knowing

Information, computation, cognition.

Agency-based Hierarchies of Levels

3. Both information and computation appear on many different levels of organisation/abstraction/resolution/granularity of matter/energy in space/time.

4. Of all agents (entities capable of acting on their own behalf) only living agents have the ability to actively make choices so to increase the probability of their own continuing existence. This ability of living agents to act autonomously on its own behalf is based on the use of energy and information from the environment.

Mechanisms of knowing

Information, computation, cognition.

Agency-based Hierarchies of Levels

5. Cognition consists of all (info-computational) processes necessary to keep living agent's organizational integrity on all different levels of its existence.
   Cognition = info-computation
6. Cognition is equivalent with the (process of) life.
   Its complexity increases with evolution.
   This complexification is a result of morphological computation.
   Morphology = material, shape, structure (arrangement)

Morphology is connecting information and computation. Morphological computing is a mechanism that leads to changes of informational structures via processes of self-organization of information. The modeling of behavior proceeds by abstracting the principles of information self-structuring through physical interactions.

Information structures as a fabric of reality for a cognizing agent

"Information is the difference that makes a difference. " Gregory Bateson

It is the difference *in the world* that makes the difference *for an agent*. Here the *world* includes agents themselves too.

"Information expresses the fact that a system is in a certain configuration that is correlated to the configuration of another system. Any physical system may contain information about another physical system." Carl Hewitt

Bateson's definition describes the mechanism of identification of atomic information (data)

Bateson, G. (1972). *Steps to an Ecology of Mind*: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology pp. 448–466). University Of Chicago Press.

Hewitt, C. (2007). What Is Commitment? Physical, Organizational, and Social. In P. Noriega, J. Vazquez, Salceda, G. Boella, O. Boissier, & V. Dign (Eds.), Coordination, Organizations, Institutions, and Norms in Agent Systems II (pp. 293 –307). Berlin, Heidelberg: Springer Verlag.

Information structures as a fabric of reality for a cognizing agent

Informational structural realism (Floridi, Sayre) argues that information (for an agent) constitutes the fabric of reality:

Reality consists of informational structures organized on different levels of abstraction/resolution.

See also:

Van Benthem and Adriaans (2008) *Philosophy of Information*, In: Handbook of the philosophy of science series. http://www.illc.uva.nl/HPI

Ladyman J. and Ross D., with Spurrett D. and Collier J. (2007) *Every Thing Must Go*: *Metaphysics Naturalized*, Oxford UP

The relational definition of information

Combining definitions of Bateson:

" Information is a difference that makes a difference." (Bateson, 1972)

and Hewitt:

"Information expresses the fact that *a system is in a certain configuration that is correlated to the configuration of another system*. Any physical system may contain information about another physical system." (Hewitt, 2007), we get:

Information is defined as the difference in one physical system that makes the difference in another physical system.

Information is *relational.*

Structures and processes

For all living agents, information is the fabric of reality, reveling the structure of the world.

But: the knowledge of *structures* is only half a story.

The other half are changes, *processes – information dynamics*.
(In classical formulation: *being* and *becoming*.)

Information processing will be taken as the most general definition of *computation*. (This includes data processing as data are seen as atoms of information.)

This definition of computation has a profound consequence –
if computation is the dynamics of informational structures of the universe, the dynamics of the universe is a network of computational processes (natural computationalism).

Gordana Dodig-Crnkovic, Dynamics of Information as Natural Computation, Information 2011, 2(3), 460-477; Selected Papers from FIS 2010 Beijing, 2011.

Reality for a cognizing agent: Informational structure with computational dynamics

Information is defined as the difference in one physical system that makes the difference in another physical system.

This reflects the *relational* character of information and thus *agent-dependency* which calls for agent-based or actor models.

As a *synthesis of informational structural realism* and *natural computationalism*, I propose info-computational structuralism that builds on two basic concepts: information (as a structure) and computation (as a dynamics of an informational structure) (Dodig-Crnkovic, 2011).

(Dodig-Crnkovic & Giovagnoli, 2013) Information and computation are two basic and inseparable elements necessary for naturalizing <cognition>. (Dodig-Crnkovic, 2009)

SUMMARY
Representation and Reality in Humans, Other Living Organisms and Intelligent Machines

Different perspectives with focus on different aspects of the relation between cognizing agents and reality:

Cognitive

Computational

Natural sciences

Philosophical

Logical

Machine