Darwinian Neurodynamics

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EU CHALLENGES

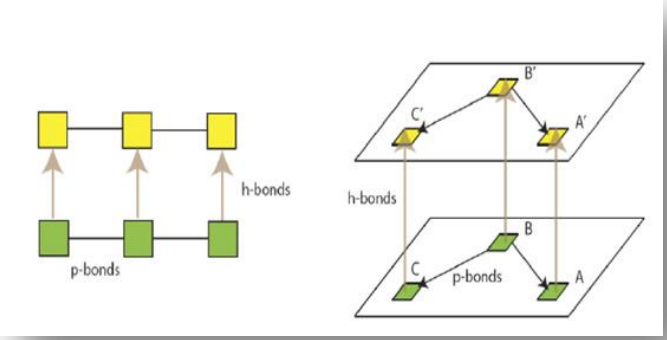
To understand the function of the human brain is one of the greatest scientific and philosophical challenges of our time and one of the ultimate frontiers of modern biology. The brain is the source of our intellectual capacities and emotional behaviour. Thus, it is essential for our professional and private life, and our participation on society.

During the last decades, brain research has made great progress on all fronts but much more is still to be discovered.
Brain research is a particularly difficult challenge and involves a multidisciplinary approach from genetics, cell biology, physiology, imaging, bioinformatics, anatomy and clinical investigations, to behavioural sciences.
Advances in neuroscience are therefore crucial to keep our ageing societies and our economy healthy. Deciphering how our brain works is good for our health, our society and our industrial competitiveness. It has an important role to play for the achievement of the Europe 2020 strategy and of the Innovation Union.

THE MISSION

The remarkable and deep similarities between thought and evolution enticed the researchers to propose a hypothesis called the Neuronal Replicator Hypothesis (NRH) that states that a Darwinian process of production of cognitive adaptations by natural selection can run in real-time in the neuronal network of the human brain during its lifetime.

There is a growing desire to test the claims of the NRH.



On the left is DNA replication, and on the right is neuronal replication. Green squares represent nucleotides and neurons of the parent. Yellow squares represent nucleotides and neurons of the offspring. Hydrogen bonds are equivalent to between-layer vertical connections, and phosphodiester bonds are equivalent to within-layer connections.

THE GOALS

- Develop a Cognitive Architecture based on Darwinian neurodynamics capable of open-ended learning, implement it in a robot, and use it to explain human insight learning data gathered in experiments.
- Develop realistic neuronal models of Darwinian neurodynamics that explain neurophysiology data and provide a means of implementing FCG in the brain.
- Construct a firm theoretical basis for Darwinian neurodynamics based on evolutionary theory.
- Demonstrate neuronal informational replication in foetal rat neuron cultures using MEAs.
- Understand FCG within the Darwinian neurodynamics/insight learning framework and implement the resulting algorithms in a robotic language learning system.
- Construct a range of robotic platforms that demonstrate open-ended learning abilities by the use of Darwinian neurodynamics.

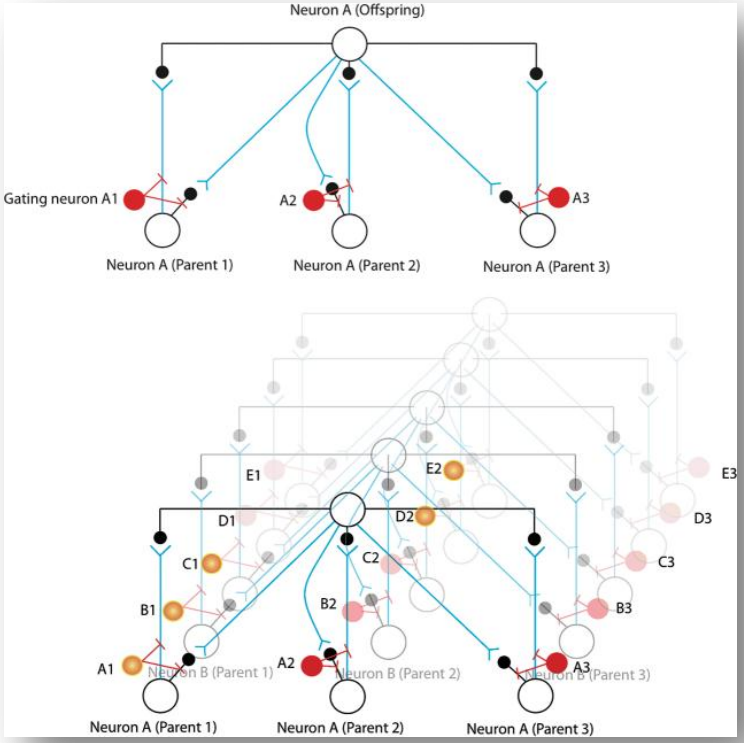
PROJECT CHALLENGES

Open-ended human problem solving and learning remain far superior to what can currently be achieved by machines, despite considerable progress in modeling and implementing routine problem solving. We are particularly lacking adequate algorithms for insight problem solving, so important in human understanding.

Insight, a concept introduced by the German Gestalt psychologist Karl Bühler, **is a process of creating new and more useful representations of a problem that in many cases enhances the understanding of cause and effect, and guides future search.**

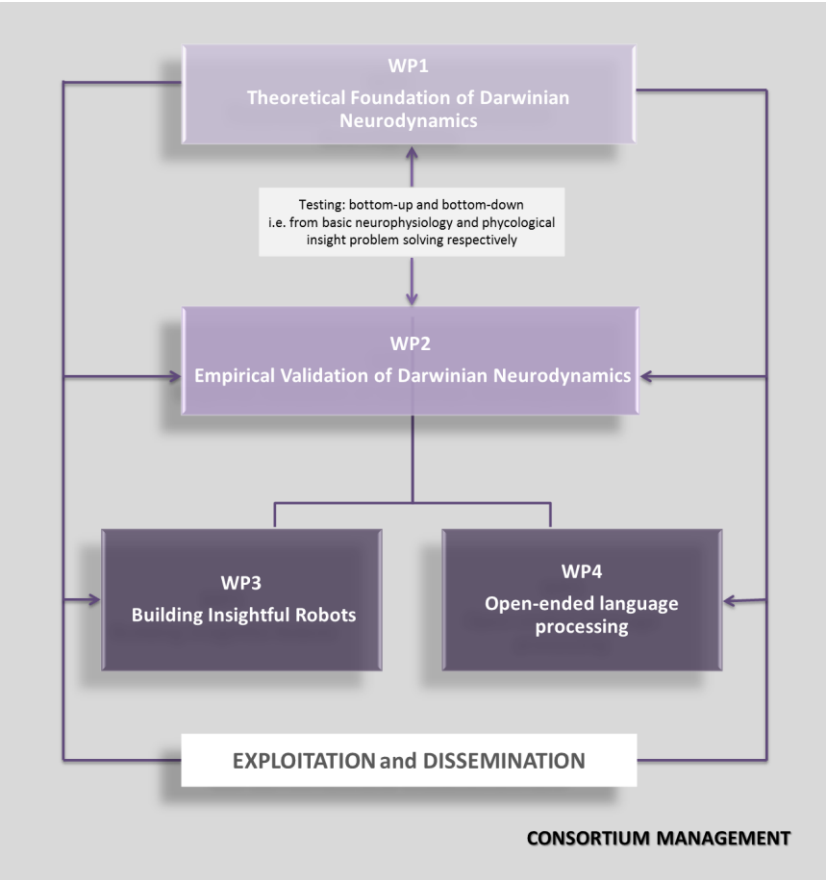
It has become increasingly clear that genetic evolution is a process of insightful search, because it is also able to learn from past environments to structure and improve futuresearch operators.

PROJECT CHALLENGES



The neuronal recombination circuit *is an extension of the simple replication circuit.*
Here, instead of a one-to-one reciprocal circuit, there is a many-to-one reciprocal circuit. Instead of a gating vector, there is a gating matrix. The top diagram shows the minimal unit from which the system is composed. It consists of a population size of 3, with genome length=1.
Gating can determine which of the parental states are to be copied to the offspring.
The bottom figure shows five of these units combined together, forming three parents with genome length = 5. Recombination is simply undertaken by opening, for example, gates, A1, B1, C1 and D2, E2.
Once the offspring has been formed and its fitness assessed, it is recopied back to the parent that mostresembles it.

WORK FLOW DESCRIPTION



CONSORTIUM

The INSIGHT project involves 6 entities from 5 different Countries, each of them with specific roles and different levels of involvement.

The Consortium is composed by:
- 1 Foundation
- 3 Universities
- 1 Academic institution
- 1 Company

THE COORDINATOR

The Parmenides Foundation, headquartered in Pullach/Munich in Germany, is dedicated to fostering multi-disciplinary research on thinking at the interface between the natural sciences and the humanities.

http://www.parmenides-foundation.org/

PARMENIDES FOUNDATION

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SCIENTIFIC PART

These slides should be completed by the partner with the scientific aspects (project results, challenges, researchers performed and so on).