# Distributed Cognition in Innovative Problem Solving

Michael Öllinger[1,2,4] and Rolf Pfister[3,4]
[1]Parmenides Center for the Study of Thinking, Pullach, Germany
[2]Psychological Department, Ludwig-Maximilians-University of Munich, Germany
[3]Munich Center for Mathematical Philosophy, Ludwig-Maximilians-University of Munich, Germany
[4]Cognostics AG, Pullach, Germany

Corresponding Author
Michael Öllinger
Parmenides Center for the Study of Thinking
Kirchplatz 1, 82049 Pullach
michael.oellinger@parmenides-foundation.org

Insight problem solving, creativity and innovative problem solving share the need to search for and combine new and remote semantic concepts (Jung-Beeman et al., 2004; Öllinger & von Müller, 2017). We propose a cognitive model that rests on the interplay of distributed cognition and attempt to utilize concepts and mechanisms of the domains of insight problem solving and creativity to model innovative problem solving. Innovation as problem solving is defined as a solving applied technological or societal problems.

We assume that innovation is driven by often ill-defined problems. These characterizes problems whose initial and goal representation is unclear, or different and competing goals exist. Facebook can be seen as innovation which allows user to share, provide, and distribute social information (such as images, comments etc.) via the internet (Jiang & Thagard, 2014).

It solves the problem to connect distant people via the internet. Innovation needs preparedness that means that certain information and technological developments are already available. Although innovation creates something new, it is based on already existing information and concepts.

Consequently, an innovative cognitive system has to consider information processing from two directions. First, there is a known and significant problem, such as finding new solutions for public transportation in a city. Second, the cognitive system generates new and remote combinations of already existing semantic information and searches for potential applications of those new findings, and utilizes problem solving by analogies (Gentner et al., 2001).

Our proposed cognitive system relies on a combination and the concerted interplay of implicit and automatic as well as explicit and deliberate processes. The core of our framework is an associative semantic search machinery which provides coarse and remote semantic search through the existing knowledge space. A Bayesian process will generate and test candidate solutions from the knowledge space. After repeated failure of candidate solutions the system will reach an impasse. To overcome an impasse, we assume that a representational change is necessary. Constraint

relaxation helps to overcome a restricted search space and providing a larger search space. A larger space requires even more efficient search strategies to find a proper solution (Ohlsson, 2011; Öllinger et al., 2014). A representational change can be elucidated by a generative neo-Darwinian process which replicates existing concepts with tiny variations (Fedor et al., 2017). This implicit process is steered by deliberate creative abduction which allows the system to come up with the discovery of new solution approaches and provides criteria for the selection of the best candidate solution. The latter is important to restrict the search space after constrains are relaxed by a representational change.