From computational neuroscience to computational learning science : modeling the brain of the learner and the context of the learning activity

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We share a new exploratory action known as Artificial Intelligence Devoted to Education (AIDE) launched with the support of Inria (Mnemosyne Team) and Nice INSPÉ from Côte d´Azur University (LINE laboratory) in connection with the Bordeaux NeuroCampus. It positions artificial intelligence in a somewhat original way ... not [only] as a disruptive tool, but as a formalism allowing to model learning human in problem-solving activities.

Introduction

In computational neuroscience and bioinspired artificial intelligence (AI), different studies aim at understanding the mechanisms of perception such as shape recognition and sensori-motor coordination such as grasping or pinching [1]. A step further, as in the Mnemosyne research program, cognitive mechanisms are analyzed to better understand brain circuits responsible for reasoning and problem-solving, by a biological or algorithmic agent.

On the other hand, the LINE laboratory is developing research protocols for the study of human problem-solving through a digital manipulative task-oriented approach. Through modular educational robotics, LINE research program aims to advance the characterisation of computational thinking competency in relation to creativity and problem-solving [2], but also in relation to the demystification of AI in education and [3] design based research on techno-creative activities for K16 education[1].

Through a recent collaboration[2], we aim to study[3] how the computer science models that found computational neuroscience, allow us to develop a functional description of brain circuits supporting cognitive functions. Transdisciplinarity is not only considered from the perspective of epistemological and theoretical perspective, but also from the perspective of

[1] For this research agenda a set of techno-creative problem-solving tasks using digital and non-digital technological objects has allowed us to advance in the task modelling and the creation of the system supporting the learning analytics required to understand the learner behavior during the task. These experiments open a new field of research that can be called Computational Educational Learning Science [4], which can be considered within the digital humanities perspective.
[2] See the AIDE AEx project presentation https://team.inria.fr/mnemosyne/aide for details.
[3] These approaches can be useful for modeling problem-solving processes in educational science and, in return, the theoretical coding schemes and the experimental practices developed in the learning science can also contribute to better shape the AI and biological modeling activity. Applying coding schemes to observational behavioral data can also be a complementary data source to triangulate the computer science models developed from a computational neuroscience perspective.

data triangulation in terms of different ways of evaluating the learners' activities through different strategies.

The problem-solving task challenge

Problem-solving is a key skill highlighted by all of the contemporary skill sets [5]. However, even on simple tasks of problem-solving, we do not yet have a model that encounters the underlying cognitive processes of the learner's brain, in link with the dynamic state of the activity system assessment that takes place at the task level.

Faced with this challenge[4], our research program aims to build such models to analyze a specific problem-solving activity that presents a well-defined task model, to better understand the interaction between brain processes and problem-solving activity from a behavioral perspective analysed based on learning analytics generated automatically, also through the human analysis of this activity based on coding schemes.

Problem-solving with interactive objects that are unfamiliar to the subject requires both exploration processes (understanding the affordances of objects for problem solving) and hypothetico-deductive processes giving rise to episodes of problem-solving within full problem-solving activity. The combination of the different phases of exploration and hypothetico-deductive processes within the problem-solving activity is one of the current challenges in the field of learning science but also a fundamental aspect to improve computer science models of problem-solving and their application to artificial agent-based systems.

During the exploration process, divergent thought processes require the generation of a first idea, but then taking into account previous ideas and their voluntary inhibition to allow new ideas to be generated. The hypotheses[5] tested and their evaluation should be taken into account in order to allow the subject to reduce the problem space while developing an internal model of the problem.

Conclusion

Difficulties in the use of exploratory or hypothetico-deductive processes depending on the specific state of the activity can lead the subject to encounter difficulties which can make him lose confidence in this capacity to solve a task. By better understanding the regulatory process on exploratory or hypothetico-deductive processes we can better understand one of the mechanisms which can permit perseverance in educational settings.

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[4] Our study focuses on the manipulation of interactive visuospatial constructive objects having physical and software affordances. These affordances are linked to both episodic memory (memorizing examples that link an object with its possible role) and semantic processes (implementation of rules linking this object relation to its use). Understanding the inter-relations of perceptive, sensori-motor and evaluative processes in relation to the human-robot interactions is part of the challenges we are addressing in the AIDE project.

[5] This is exactly what happens within the loops involving the cortex, thalamus, basal ganglia and the hippocampus, which are today linked to reinforcement learning models (including those called episodic and meta-learning, major topics of interest today in machine learning).

More generally, this program contributes[6] to Computational Learning Science in which AI is not (only) used as a set of tools but as a modeling framework.

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[6] A concrete outcome of the AIDE project is to better characterize educational perseverance which is a key societal issue in our societies. Maintaining a motivation to achieve a goal is a big issue in learning activities. Modeling perseverance as part of a resolution activity is still to be defined, predicting when and how subjects can give up or not.