Developmentally informed agent-based modeling of symbolic constrains in interaction

For science, the very mundane ability, such as using natural language, is still a mystery. How is it possible, that our continuous bodies, with their continuous actions and interactions in the environment, can produce and understand discrete and abstract symbols that seem to be describable in formal terms? If we still might have doubts about natural language (if it is indeed amenable to formalization) it seems quite clear for mathematics or programming languages – after all, also things humans are capable of.

The problem for years has been termed the "symbol grounding" problem: how the symbols we use get their meaning from being connected to continuous bodies in continuous realities and not just to other symbols, turning around vacuously in empty forms. For years, the solutions to the problem consisted of the attempts of grounding the symbols through mapping them to concepts in the minds or to objects in reality. It occurs however, that this mapping is not straightforward, as what symbols mean depends on the context and the reality does not want to break neatly in easy-to-map objects and events. In cognitive sciences we feel a growing discontent with such solutions to the grounding problem.

In our project we are trying another approach. We ask: what if the problem itself is ill-posed? After all, when asking about "grounding" one already assumes the existence of some ungrounded entities that need grounding. What if we started, in a sense, from the other end, and treated, e.g., utterances of language as purely physical things, not endowed, as yet by symbolic properties? Posing the problem in this way makes us aware that elements of symbolic systems, such as natural language, are indeed tightly and naturally connected to ongoing events, influencing the course of interactions among people. A good situation to observe how this happens is in language development: before language emerges as a symbolic system, utterances are parts of everyday co-actions of parents and infants, affecting how they unfold. The question becomes: how from such simple controls in interactions utterances become words, i.e., elements of a more advanced "language system"?

In our project, we follow the lead of the researchers who tried to pose the problem in this way, for example a physicist and philosopher of biology Howard Pattee, and who proposed a theory of how the symbolic control in interaction might emerge, such as anthropologist Terrence Deacon. In our earlier work, together with Deacon, we applied his theory to language development, and in the present project our goal is to elaborate and clarify this theory through building a computational model of this process. Building such models is an increasingly frequent strategy for the construction of explanations in the cognitive sciences, which is very useful when the explained phenomena are – as in this case – very complex. Our computational model will be agent-based, which means it will consist of multiple autonomous cognitive systems, which interact with each other. Our research will be performed both purely computationally, through simulating the agents' interactions in simulated environments and in real, low-cost, mobile robots (e-pucks), which are often used in similar research. This will allow a better demonstration of the similarity of the emergent communication systems to human communication as well as reveal the potential of such systems for designing artificial intelligent systems coordinated by such communication.

This novel perspective revives some of the most important ideas in systems science and cybernetics for the study of human cognition and behavior, and we hope it will help us understand better how humans communicate and coordinate in collective systems. It will be important both for new guidelines for improving this communication and coordination as well as for the design of the artificial systems, which, in interaction with humans, can expand our abilities, while bringing forth the best of us.