

Agent-based modeling for understanding social intelligence

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The advantages of agent-based modeling for a general theory of intelligence at the individual and social level are emphasized over other existing approaches mainly relying on rationality theories. As was pointed out during the National Academy of Sciences Sackler Colloquium session “Implications of Agent-Based Modeling for Understanding Human Rationality and Learning,” held in October 2001, properties of social intelligent agents include adaptability and learning capacity, as well as the capacity to produce and employ artifacts and manipulate symbols.

As authors like Herbert Simon have extensively and convincingly argued, computational agent-based modeling is quintessential for the study of human intelligence.

Less obviously, agent-based modeling is also fundamental for the study of social intelligence, both at the individual and at the supra-individual level. That agent-based modeling helps understand individual social action is not surprising. Many cognitive psychological experiments have shown that the behavior of natural agents deviates systematically from the expectations of rationality theories. In particular, natural agents cooperate more than would be rational (i.e., individually convenient) for them. Hence, political scientists call for what they call a “behavioral approach” to the rational-choice theories of social and collective action. Cognitive scientists, evolutionary theorists, and social scientists in all disciplines began to explore the use of heuristics and norms of behavior, such as reciprocity. Results achieved so far indicate that it is possible to provide a firmer behavioral foundation for the study of collective and social action.

As a consequence, social scientists interested in the understanding of cooperation and social order find now necessary to load the “thin” model of rationality (1) with crucial cognitive notions (referring to sets of symbolic representations) such as *trust*, *reciprocity*, and *reputation*. But how do these representations work in the mind? How and why are they acquired, manipulated, and propagated? These questions require computational instruments for the social aspects of intelligence that are equivalent to those used in the cognitive scientific and AI-based study of other, nonsocial properties of the mind (e.g., memory, planning, and decision-making).

That intelligence is inherently social was quite obvious to the pioneers of cognitive

science. In its early days, the program for a general theory of the mind included several social scientific disciplines (2), such as sociology and anthropology. Later on, two antagonistic variants of cognition, social and asocial, emerged. Interestingly, the asocial overlapped with the connectionist, nonsymbolic “soul” of cognitive science (†; <http://lchc.ucsd.edu/People/Localz/MCole/santabar.html>), which ignored or overlooked the role of social and cultural artifacts. Meanwhile, adaptability, flexibility, and learning capacity began to be perceived by social and cognitive scientists (within both the social and asocial variant) as important properties of intelligent agents. As these properties cannot be accounted for in purely formal terms, they played a major role in drawing the attention of scientists on agent-based modeling. This observation was pointed out unequivocally at the National Academy of Science session on “Implications of Agent-Based Modeling for Understanding Human Rationality and Learning,” and can be now considered as consolidated scientific knowledge. Moreover, the emphasis laid on adaptive agents certainly challenged the isolated, context-independent approach to intelligence typical of rationality theory. However, agent-based approaches are required to model not only adaptability, flexibility, and learning capacity, but also the capacity to use artifacts, and consequently to manipulate symbols. As was pointed out by Simon (3) “symbol systems are almost the quintessential artifacts, for adaptivity to the environment is their whole *raison d’être*.” Social agents manipulate symbols to (inter)act in their environment. Symbols operate within the agents in their cognitive representations. They act through and across the agents in interaction. Artifacts are symbol-carriers mediating between action and the environment. Social action is not only adaptive but also inherently cognitive because it is mediated by symbolic

artifacts. Hence, the necessity to include cognition into an agent-based program for the study of social action.

The hegemony of the asocial variant of cognitive science is currently threatened. At least, a reunification of the two souls, the a-social and the social, of cognitive science is to be expected under the influence of the 2000–2010 Decade of Behavior (<http://www.decadeofbehavior.org>), which follows the Decade of the Brain. “The Decade of the Brain was successful in many ways; it gave neuroscientists a focus and resulted in some important public education initiatives . . . Planners for the Decade of Behavior are working on ways to have a similar . . . impact” (4) on a number of important social issues, such as prosperity, safety, education, and participation. Among other things, social scientists become increasingly aware that dealing with social issues requires cognitive modeling. “Even as strides in genetics and neuroscience have captured the public’s imagination, . . . what people think, and decide, and do drives some of society’s best achievements, as well as some of its worst failings” (4).

The reunification of social and behavioral science on the grounds of computational cognitive modeling bears implications also for the purpose of social theory (5), which bear portentous consequences on the fates of western societies and civilization and on the future of mankind as a whole, can be drawn

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†Cole, M. (1997) *Culture and Cognitive Science*, Talk Presented to the Cognitive Science Program, University of California, Santa Barbara, May 15, 1997.

from current events at the international level. For example, does a growth in the volume of economic transactions at world-wide level lead to increase in conflicts or to social appeasement? Because economic superiority is no more universally correlated to cultural hegemony, which culture/ideology is likely to acquire hegemony, and why? How can we answer such questions without an explicit cognitive theory of the sources of conflict at the microlevel on one hand, and of the reasons and ingredients of cultural “appeal” on the other? How can we predict whether conflicts multiply as a direct effect of increasing trade volume, without an explicit model of the under-

lying cognitive mechanisms? As a once-political scientist Herbert Simon (6) found the opportunity to clarify his views on the effect of computational agent-based modeling on social theory during a famous interview “how do you add rigor to concepts in political science like political power . . . ? I saw the limits of using tools like differential equations to describe them.” A rigorous study of social and political phenomena requires that the cognitive implication of social scientific concepts is recognized, and an agent-based approach is adopted; formal and even computational modeling is insufficient unless cognitive representations and operations are described and reproduced.

It is important to perceive that cognition is not necessarily a property of individual agents. Symbols act on the agents, under the form of cultural and institutional artifacts, whether norms, institutions, values, civilizations, ideologies, doctrines, or religions. Indeed, adaptability required that agents evolved a capacity to undergo the influence of symbols. Nonsymbolic cognitive science has ignored the role of social and cultural artifacts. Worse, it has misperceived the role of the first and more fundamental of artifacts, the mind (3). The mind is inherently social, if only because cultural and social artifacts are implemented on it.

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3. Simon, H. (1981) *Sciences of the Artificial* (MIT Press, Cambridge, MA).
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