BOUNDED RATIONALITY IN SYSTEM DYNAMICS EXPANDING THE PERSPECTIVE

Manuel Liz
Margarita Vázquez

Facultad de Filosofía
Universidad de La Laguna
38201-La Laguna
Santa Cruz de Tenerife. Islas Canarias
España

manuliz@gmail.com
margavazquez@gmail.com

Abstract

There are narrow connections between System Dynamics and what Simon called "bounded rationality". Typically, bounded rationality emphasizes cognitive limits and environmental constrictions. This paper wants to take a step further. System Dynamics is also in tuning with many other alternatives to classical rationality. We will analyze them briefly. In particular, we will consider 1) the sort of "communicative rationality" displayed in the processes of construction and use of System Dynamics models, 2) the sort of "expressive rationality" displayed when the implicit knowledge about a system, encapsulated in mental models, is made explicit through the production of a simulated behavior, and 3) the sort of "evaluative rationality" displayed when new possibilities of decision and action are showed and experimented through those simulation models. To take seriously into account these expansions of bounded rationality would be important not only from a theoretic perspective. It would improve also the practice and methodology of System Dynamics.

Key Words: System Dynamics, Rationality, Classical Rationality, Bounded Rationality, Expressive Rationality, Evaluative Rationality, Mental Models, Simulation.

There are many important works examining the connections between System Dynamics (hereafter SD) and bounded rationality. The linkages are narrow. Complex systems, mainly socio-economical ones, make strong pressures over the agents. It is not only that when the agents try to behave in the best ways, from their points of view, this is not possible. It is that the agents do not know clearly even what the best ways of behaving may be. In spite of all of that, the behaviors of the agents are not completely arbitrary or

nonsense. Furthermore, the agents can be said to be more or less rational in some more modest sense. In that sense we can speak of a "bounded rationality". See (Sterman, 2000), (Aracil, Vázquez, and Liz, 1995) and (Vázquez, Liz, and Aracil, 1996).

The interest of SD in bounded rationality is clear. Moreover, there are many SD analyses, including the use of SD models and computer simulations, trying to study the main factors that can either enforce or inhibit human bounded rationality. See, for instance, (Rouwette, Größler, and Vennix, 2004.)

Some years ago, in a very suggesting paper, John Morecroft argued that

> "... the structure of system dynamics models implicitly assumes bounded rationality in decision making and the recognition of this assumption would aid system dynamics in model construction and in communication with other social science disciplines" (Morecroft, 1981).

In this context, "bounded rationality" is basically understood as a rationality conditioned by 1) the cognitive limitations in the subjects and by 2) the complexities of the systems in which those subjects have to take their decisions. In this paper, we want to argue that the perspective of a bounded rationality that is relevant for SD has to be expanded to cover also other important sorts of phenomena. It would have to include other ways in which recent conceptions of rationality have separated from classical conceptions.

Section 1 introduces briefly the discussion between classical conceptions of rationality and conceptions of a bounded rationality using three important dichotomies. Section 2 calls the attention towards some relevant phenomena putting aside in those discussions. Section 3 focuses on a number of ways to enlarge the perspective of bounded rationality in close tuning with the activities of modeling and simulation in SD.

1. Classical Conceptions of Rationality and Conceptions of a Bounded Rationality

Briefly, we can define briefly the contrast between classical conceptions of rationality and conceptions of a bounded rationality according to the following points:

<u>Classic Rationality</u>

1. Rationality consists in thinking and behaving maximizing some utility functions.
2. All our utilities are given, they are well ordered and we can know them is easy ways.
3. Hence, we can aspire to rationality in a classic sense

<u>Bounded Rationality</u>

1. Even in ideal situations, maximization may be an impossible aim. Hence, rationality has to consist in something else.

2. Many utilities are progressively discovered and many of them are construed in interaction with other subjects.
3. Hence, we can only aspire to rationality in a bounded sense

Intending to offer a more complete characterization, we can understand the contrast between classical conceptions of rationality and conceptions of a bounded rationality as different ways of taking sides with respect to the following dichotomies:

- Epistemic Rationality / Practical Rationality
- Facts / Values
- Means / Ends

Classical conceptions of rationality make a sharp distinction between epistemic (or theoretic, or cognitive, etc.) rationality and practical rationality. The first one is governed by logic and mathematics. Facts are primarily quantitative facts and propositionally articulated facts. The paradigm of scientific rationality is science and the paradigm of facts are scientific facts. In turn, practical rationality is basically instrumental. It concerns the optimization of a function of utility in relation to some given ends and values. What are the optimal points of a utility function has to be determined by epistemic rationality, in the last terms by science, existing also optimal points in these epistemic processes of optimization. Values convert some possible states of affairs in aims. But, ultimately, values have only a conventional, even many times subjective, source.

In contrast, conceptions of a bounded rationality claim that there are crucial limits in our cognitive processes. Mainly, these limits have to do with our fallible ways of gathering information, storing it and recalling it, and with the complex ways of calculating the consequences of our decisions and actions when we try to apply logical and mathematical strategies. Conceptions of a bounded rationality also claim that epistemic (or theoretic, or cognitive, etc.) rationality interacts in many ways with practical rationality, as well as values with facts, and as well as ends with means. Moreover, typically these interactions involve all sorts of prejudices and bias. This makes very difficult the determination of the optimal points of our utility functions. Furthermore, even in an ideal situation, there is no guarantee that there exist such optimal points. It is very reasonable to think that perhaps our more important utility functions only have a number of more or less points of satisfaction without any optimal point.

Simon's crucial claim is that rationality is bounded by the cognitive limitations of the human agents in their processes of decision making and by practical limits in their capacity to undertake the corresponding actions in the context of complex systems. But, we are not merely erratic or capricious in our knowledge. Moreover, we are not so in our practice either. In many cases, both our knowledge and our action make sense with respect to their rationality. According to Simon, the consequence is that the sense of rationality we find in our knowledge and action is out of the scope of classical conceptions of rationality. See (Simon, 1955) and (Simon, 1956)

The problems with classical conception of rationality can be resumed in three theses: 1) Our rationality has severe limits, 2) there are also unavoidable and complex relationships among rationality and other phenomena, and 3) even in an ideal situation we do not have any guarantee that we can be rational in the sense of optimizing our utility functions.

2. Expanding the Perspective of a Bounded Rationality

We think that the perspective of a bounded rationality can be enlarged paying more attention to the following factors:

1. The creation and development of complex relationships among rationality and other phenomena in some special contexts.
2. The circumstantial importance of achieving some satisfaction points, even some minimal ones, in our utility functions given that perhaps there are no optimal points.

In the tradition of bounded rationality, "optimization" has been many times contrasted with "satisfaction". To satisfy some levels of utility, even in a minimal sense, would count as being rational in many circumstances. Rationality, so understood, becomes a feature strongly dependent on the circumstances.

But let focus on factor 1. There are many phenomena maintaining relevant relationships with rationality. But some of them have received much more attention than other ones. We can find many analyses about the following issues:

- How cognitive and evaluative prejudices, bias, etc., can have an effect over decision-taking processes.
- How intuitive knowledge is constituted, and how it is operative in substitution to other sorts of propositional, rule-following knowledges.
- How interactive processes can produce adaptive behaviors in a spontaneous way.
- How social phenomena and institutional structures have influence on the exercise of our rational capacities.

There are, however, other not less important phenomena that usually have been outside the scope of the conceptions of a bounded rationality. In the next section, we will consider three of them having a very special relevance in the context of SD. They constitute "fields of rationality" that, not falling inside what has been traditionally considered the domain of classical rationality, are not generally taking into account either from the perspective of a bounded rationality.

3. Communicative Rationality, Expressive Rationality, Evaluative Rationality

The sort of bounded rationality involved in SD is closely connected with some very special fields of rationality involving:

1) communicative processes associated to SD activity,
2) the making explicit what is implicit in the mental models of the subjects involved in the modeled systems, and
3) the acquisition and maintenance of values supported by experimentation in virtual scenarios.

These three fields give place to new peculiar senses in which human beings can be said to be rational. They involve phenomena that have been studied in the context of bounded rationality, but rarely they have been taken into account in a differential way. However, they are crucial in SD practice.

1. Communicative Rationality

SD is an activity typically mediated by communicative processes. Some of the most important communicative contexts involved in SD are the following ones:

- The context of learning SD
- The context of building SD models
- The context of using SD models

There are many differences between these three contexts. However, two common features are 1) the need of a variety of communication channels among different subjects with very different capacities and intellectual skills, and 2) the intervention of some peculiar sorts of objects: the SD models (in very diverse formats).

What is communicated are both conceptual and non-conceptual contents. Communication can be either verbal or non-verbal. The aims and ways of communicating are peculiar in each case. But communicating is a cooperative collective action. And that collective action can be done in more or less rational ways.

Communicating is also a cognitive and practical achievement. Sometimes, it is governed by rules and strategical decisions. Other times, it is guided by intuition and prototypes. In any case, it is a strongly interactive and adaptive process. Moreover, it is a process that presupposes the compromise with some shared norms and values.

The German philosopher Jurgen Habermas has written a lot about the connections between rationality and communication (Habermas, 1981). Some years ago, he coined the expression “communicative rationality”. Habermas’s bet is that something like a minimal universal ethics can be obtained analyzing the normative and evaluative presuppositions and compromises involved in every communicative interaction.

Perhaps this is a too much ambitious project. However, another very suggesting objective is to analyze the ways to improve the rationality of communication in the three contexts above noted. See about that, (Vennix et al., 1992)

As we have noted, the aims are different in each of those contexts. Hence, the norms and values involved in each one of them would be different too. And so would have to be the communicative rationality present in them. To study in detail these interactions would be very important.

2. Expressive Rationality

Typically, modeling and simulation through SD requires the appeal to the mental models of some agents involved in the real systems modeled. Sometimes, these mental models are the main source of structural knowledge about the system, or even the only source at our disposal.

The main point is that mental models offer a sort of intuitive structural knowledge. It is a knowledge mostly implicit. The SD building process tries to make explicit that implicit knowledge. Moreover, the SD building process tries to make explicit the dynamical consequences of the structures supposed in the real systems.

This movement from the "implicit" to the "explicit" has been recently analyzed in depth by Robert Brandom. It will be worthy to explain it with some detail. The main work of reference is (Brandom, 1994). It is a complex and highly technical book, mainly. However, a very useful resume of his position can be found in (Brandom, 2002).

Working on philosophy of language and philosophy of logics, Brandom's approach is completely opposed to what has been the current representationalist paradigm. Representationalism would consider features such as "reference" or "truth conditions" applied to mental contents, or to linguistic contents, as primitive. According to Brandom, the representational paradigm has been ubiquitous in Western philosophy ever since the Enlightenment, and it is not easy to imagine other alternatives. One opposed line of thought, however, is present in Romanticism. As opposed to the Enlightenment image of the mind as a "mirror", Romanticism proposed the image of a "lamp". Mental activity is understood not as a passive representation, but as an active revelation, full of creative and experimental ingredients. The basic picture used by Herder, for instance, is the process by which the "inner" becomes "outer" when a feeling is expressed by a gesture. In more complex cases, our attitudes are expressed in all sorts of actions, including verbal behaviors.

Brandom proposes analyzing all those complex cases of expression as a matter of making explicit, in a conceptually articulated way, what is implicit in our intuitive practices. To make explicit is to turn something we initially only "do" into something we can conceptually "say". It is a process of converting a "knowing-how" into a "knowing-that", and this entails conceptualization and re-conceptualization. Only when concepts are applied, we can make assertions on what is only implicit in our practices. And these assertions are the sorts of things that can enter as premises or consequences

in our inferences and reasonings. This would open the door for a reflective understanding and a rational revision of our practices and their normative components.

Brandom's approach has powerful implications for the philosophy of logic. And we focus on that point because it can have important implications for us as well, in the context of SD. The standard way of understanding logic is as giving us access to very peculiar kinds of ideal truths: logical truths. From the "expressivist perspective" offered by Brandom, logic can be understood in a very different way. Logic can be seen as a set of expressive recourses for "saying" something about what we "do" when we make inferences.

Logic would make explicit something that is implicit in our discursive inferential practices. Logical vocabulary (mainly, logical constants) serves to make that know-how explicit. The use of logical vocabulary allows us to explicitly say what we implicitly do when we apply certain concepts or when we infer some claims from other ones. Logical vocabulary allows us to make explicit the implicit inferential commitments and entitlements that articulate our speech acts and our thoughts. And this would be the only source of epistemic justification or validation of logical truths. Logic would not be describing any ideal realm of "logical truths".

Through the process of making conceptually explicit what is implicit in our inferential doings, we get an important kind of conceptual "self-consciousness". Furthermore, we are then placed in a position to rationally change and improve our inferential practical mastery. Brandom calls this kind of reflective rationality "expressive rationality".

The sort of expressive rationality we are describing is closely connected with the way we construct our social and institutional worlds. All social and institutional entities are the result of our decisions and actions. Sometimes, they come from conscious intentional decisions and actions. But, generally, we are not fully conscious of the results of our decisions and actions. Expressive rationality would make discursively conscious all those non-conscious constructions. Because of that, the peculiar sort of rationality we are describing has been also called "Socratic rationality". (Vázquez and Liz, 2013a.)

Mental models not only are important in the building of SD models. They also have a crucial role to play in the use of the SD models. From this perspective, the move from the implicit to the explicit would not be only a, many times necessary, source of knowledge, but a powerful motor of decisions and actions. About that, see (Vázquez and Liz, 2013b) and (Liz and Vázquez, 2013).

3. Evaluative Rationality

Sometimes, we value positively something because we think it has a, let us say, "intrinsic value". Other times, we value it positively because it has an "instrumental value" in the sense of being a mean to obtain something we value positively. Classical approaches in the theory of value do not consider other sources of value. But there are other ones. Sometimes, we value positively something because "other subjects in fact value it". Fashion is a very good example of this way of generating positive value. Other times, we value positively something simply because "we imagine that it could be positively valued". In that case, it is enough to imagine that something could be positively valued, for some subjects in certain circumstances.

Let us pay attention to the last two sources of value. In general, education tries to inculcate values showing that some things either are in fact positively valued or could be positively valued. More concretely, literature, movies, discussions of moral dilemmas in fictional situations, etc., inculcate values showing that something could be positively valued for some subjects in certain circumstances. A very interesting survey of the role of imagination in a variety of fields, from knowledge to desire, action, value, etc., can be found in (Gendler, 2013)

SD produces "simulated worlds" in which we can virtually experiment the result of our decisions and actions in a number of hypothetical scenarios. In that respect, SD is like literature and movies. Even we can find in SD some correlates of the discussions of moral dilemmas in fictional situations. Simulation creates virtual scenarios and a peculiar kind of virtual experience. Our imagination is empowered. And that way, the sources of value are expanded.

Here, we must refer to Senge's analyses about how to convert a company into a learning organization (Senge, 1990). These analyses would be also good references in relation to what we have called "communicative rationality" and "expressive rationality". In fact, communication is the more usual way to make explicit the implicit. And the relevant communicative processes are improved through the use of system concepts. The use of simulation models adds something more. It adds something that is also new. When simulations are involved, we enter into new forms of "experimenting with values" in our decisions and actions. The virtual scenarios produced by SD models become a strong source of positive value.

To analyze the processes that give place to these new ways to value positively things, perhaps through the construction of SD models, would be to analyze the main features of what can be called "evaluative rationality".

4. Conclusions

The linkages between SD and bounded rationality have been stressed by many authors. We have argued that the field of bounded rationality has to be enlarged in order to pay attention to some phenomena closely connected with SD. We have introduced the notions of a "communicative rationality", of an "expressive rationality" and of an "evaluative rationality". The important point is that the phenomena suggesting these

peculiar fields of rationality have a very strong presence in SD. Hence, to take into account the expansions of bounded rationality in the three lines proposed, perhaps building specific SD models about their particular dynamics, would benefit both to practitioners and to theoreticians of System Dynamics.

For classical conceptions of rationality, the paradigm of rationality was science. To pay attention to those new varieties of rationality (communicative rationality, expressive rationality, evaluative rationality) would contribute to make of SD a paradigmatic example of bounded rationality.

5. Acknowledgments

This paper has been supported by Research Project FFI2014-57409, *Points of View, Dispositions and Time. Perspectives in a World of Dispositions* (Ministerio de Economía y Competitividad, Spanish Government).

We also want to express our gratitude to the anonymous reviewers of the paper for their useful commentaries and advises.

References

Aracil J., M. Vázquez, and M. Liz. 1995. An Epistemological Framework for System Dynamics Modelling. *Revue Internationale de Systémique*, 9-5, 461-489.

Brandom R. 1994. *Making it explicit. Reasoning, Representing, and Discursive Commitment*. Cambridge, Harvard Univ. Press.

Brandom R. 2002. *Articulating Reasons*, Cambridge, Harvard Univ. Press.

Gendler T. 2013. Imagination. In *The Stanford Encyclopedia of Philosophy* (Fall 2013 Edition), Edward N. Zalta (ed.), [http://plato.stanford.edu/archives/fall2013/entries/imagination/].

Habermas J. 1981. *The Theory of Communicative Action*. Doston, Bacon Press.

Liz M., and M. Vázquez. 2013. The Cognitive Relevance of System Dynamics Modelling. In *31st International Conference of the System Dynamics Society*, Boston, 2013.

Morecroft J. 1981. System Dynamics: Portraying Bounded Rationality. In 1981 *System Dynamics Research Conference, The Institute of Man and Science*, New York, October 14-17, 1981.

Rouwette E., A. Größler, and J. Vennix. 2004. Exploring influencing factors on rationality: A literature review of dynamic decision making studies in system dynamics. *System Research & Behavioral Science*, vol. 21, nº 4, July/August, 351-370.

Senge P. 1990. *The Fifth Discipline: The Art & Practice of the Learning Organization*, New York, Doubleday.

Simon H. 1955. A Behavioral Model of Rational Choice. *Quarterly Journal of Economics*, 69 (1), 99-118.

Simon H. 1956. Rational Choice and the Structure of the Environment. *Psychological Review,* 63 (2), 129-138.

Sterman J. 2000. *Business Dynamics - Systems Thinking and Modeling for a Complex World*. Boston, Irwin McGraw-Hill.

Vázquez M., and M. Liz. 2013a. Simulation Models of Complex Social Systems. A Constructivist and Expressivist Interpretation. In L. Magnani (ed.) *Model-Based Reasoning in Science and Technology. Studies in Applied Philosophy.* Heidelberg, Springer. 2013, 563-582.

Vázquez M., and M. Liz. 2013b. System Dynamics Simulation Models and Points of View. *31st International Conference of the System Dynamics Society*, Boston, 2013.

Vázquez M., M. Liz, and J. Aracil. 1996. Knowledge and Reality: Some Conceptual Issues in System Dynamics Modelling. *The System Dynamics Review*, 12-1, 21-37.

Vennix J., D. Andersen, G. Richarson, and J. Rohrbaugh. 1992. Model-Building for Group Decision Support: Issues and Alternatives in Knowledge Elicitation. *European Journal of Operational Research*, 59 (1), 28-41.