Ongoing Discussion "Thought Piece"

Shared Mental Models

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Aerojet Rocketdyne's

InThinking Network

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A postscript

Arthur T. Denzau, Douglass C. North and Ravi K. Roy

From the perspective of ten years, how do we view our ideas about shared mental models now? We are gratified that so many people have noted our work and attempted to make use of its ideas. So far, almost 100 publications have cited our *Kyklos* paper.

One of the key issues we raised in that paper that has not been adequately addressed in subsequent research, so far as we can tell, is the interaction of learning with the pre-existing shared mental models in a person's head, and in the heads of the people of a society. This is closely related to the question of how shared mental models evolve, and thus how institutions and ideologies might evolve.

Introduction

"For most of the interesting issues in political and economic markets, uncertainty, not risk, characterizes choice-making" (Denzau and North, 1994: 2). When "Shared Mental Models" was being written over ten years ago, our intention was to make changes in the economic model of constrained choice that preserved the valuable contributions of that model, but avoided the obvious flaws. The value of the model in some situations of choice was clear to us, and worth preserving. It seemed nonsensical to believe that people did anything other than maximize their expected utility (recognizing that concerns for others can be included in that utility). However, the model assumed not only maximizing, but that people were substantively rational; i.e. they make the best feasible choice at all times.

This involves not just the simple behavioral assumption that, as Ronald Coase has said, given the choice, people prefer more money to less. It also heroically assumes that people have correct models of the world in their heads when they make choices. Such models are assumed to accurately predict the set of possible outcomes and a probability distribution over those outcomes. In this approach, the only role of learning is truly Bayesian, that of improving the parameters of the probability distribution estimates relating actions to outcomes. It leaves no room for people to have the wrong model of the world.

Wrong models may not have been that important as long as one only applied the choice model to everyday market choices. Such regular choices provide frequent feedback of information that helps make the choices good and the chooser behaves as if substantively rational. But the economic model has been taken into many areas that do not involve choices that are that "simple," and this means that there is little reason to believe the chooser has accurate models of the world for the choices being made.

Denzau and North attempted to lay out some of the implications of the idea that people have models in their heads, mental models, that may typically start out wrong. When man first confronted living in the world, he was not provided with an owner's manual stating the relevant action–outcome relations for all possible choices that he could make. With the entrance of Her, the problem multiplied in complexity.

If the mental models people have are not always accurate, then we need to explain the similarity of the models that people seem to have as well as why they remain different, failing to converge. We noted that people live in families and societies, and socialization in those settings trains people to have similar models, hence *shared* mental models. Such things as language and culture involve sets of mental models that make communication and cooperation possible, and seem essential to understanding how humans deal with the economic problem.

Our rudimentary gathering of ideas from psychology and anthropology seemed to us the obvious way to extend the economic model of choice to allow for people to have disparate and often wrong models of the things they were choosing. A fundamental theme of our paper was that one never sees things as they are, but rather only through the lens of the mental models in our heads.

Shared Mental Models and its reception in various literatures

Quite unexpected to us was the wide variety of literatures in which our paper has had some sort of impact. Our audience was economists, both neoclassical and those already working within the New Institutional Economics (NIE) approach (see Eggertsson, 1990). There have been almost 100 citations to the original paper. Over half were reasonably classifiable as NIE topics, but the next most frequent field for citations was in Public Administration/Public Policy. Also consistent with our expectations were a similar number of citations in Public Choice/Political Economy. But over one-third of the hits were outside our expected audience, with several citations in the following areas: World Politics, Technology Assessment/Management, International Relations and Comparative Politics. Even beyond this variation in fields, there was also a wider set of fields whose journals published these papers citing ours: Development, Business

and Law journals, Regional Studies, General Social Science, and a single citation each in Evolutionary Economics, Ergonomics and Ecology.

What are some of the ideas that have been taken from the paper? Thinking in terms of mental models helps one understand certain ideas that are meaningless in terms of the usual rational choice approach. The importance of framing in how we interpret external reality becomes clearer, as does the difficulties with game theory as ordinarily taught. In the next section, we take up the issue of framing. Following that, we consider the problem of learning models of the world, as opposed to parameter learning within a given model. In the final section of this chapter, we apply the Shared Mental Models framework to help us explain neoliberalism in various conceptual dimensions.

Mental models and framing

The importance of the mental model being used to interpret the world can be seen in the notion of framing. Framing involves a set of concepts used to interpret the world (one aspect of mental models), highlighting certain features and ignoring others. In looking at market transactions, a neoclassical economist's focus is on the transaction price and quantity, not on the class, wealth or accents of the exchange partners. A Marxist or sociologist might be drawn to those latter features instead.

In William Riker's (1986) *The Art of Political Manipulation*, framing involves the use of language, symbols, and rhetoric for strategic purposes to build political support for policy agendas.[1] For example, framing some public expenditure as necessary to national defense has always seemed to make it easier to gain political acceptance for that spending. Thus, the US Interstate Highway System was actually authorized as the National Interstate and Defense Highways Act of 1956 (PL627) with the stated aim of making it easier to move military troops and materiel around the nation.

Another example illustrates the powerful cognitive implications of framing. The Wason experiment (1966) involves presenting a set of cards to a person and a rule as to how the symbols on the front and back of the cards are related. The subject is to determine which cards should be turned over to determine if they violate the rule. Presented as such an abstract problem of logic, some 25 percent of subjects make the correct choice. However, the exact same logical problem can be framed as one involving cheating in a social situation. Presented in this form, some 70 percent to 80 percent of subjects get the problem right (see Barkow, Cosmides and Tooby, 1992: 181–185). Framing seems to cue different modules of our mental capabilities to operate on the problem unconsciously, so that it becomes a simple question of detecting cheaters in situations of exchange – this ability is well developed in a social species such as man. Abstract logic does not cue the same cognitive skills in most people.

The relevance of mental models and framing to learning can also be seen in the ways we teach. With students with a strong mathematical background, one might begin teaching economics from solely a mathematical viewpoint, eschewing verbal and graphical presentation. We would consider that a mistake, from several viewpoints. Learning purely in a symbolic manner, such as mathematically, may not provide one with the mental models needed for intuitive discovery or metaphorical leaps. These may come from combining elements from several areas of knowledge that may be linked by related metaphors or concepts. Further, the two types of thinking, conceptual and logical, seem to be processed in different halves of our brains. The right brain usually focuses on conceptual, holistic thinking, while the more linear and logical approaches of mathematics are usually done in the left brain. These different types of processors can act as parallel, partially independent discovery engines, and the standard jury theorem argument suggests that even two independent processors trying to learn the same thing can learn it faster than can one.

How does all this affect social science reasoning? The strong assumptions about rationality embodied in standard game theory can be weakened to create a new version that is more consistent with the above view of human neurocognition. The result is one in which standard game theory is a particular subset.

Mental models and game theory: three notions of equilibrium

How can the notion of mental models affect our interpretation of game theory? Game theory utilizes the notion of common knowledge of the game to avoid the communication issues focused on in our paper. We can consider this an *objective* interpretation of a game – the stated game is common knowledge to all participants, and is objectively true.

If we see the world through mental models, as argued in Denzau–North, and not as it is, then this objective interpretation of game theory is problematic. The people interacting in a game may see the world through different mental models, not a common objective one (see Appendix A). And even if they do agree on the same mental model for their interaction, that mental model may not be objectively true. We acknowledge that even science is about tentative truths, using a method we believe may lead us *toward* the truth. To assume at the outset that agents know that truth seems a curious contradiction.

To avoid assuming the participants know the objective truth, we can consider a game that is common knowledge among the participants, but which is not necessarily a true statement of objective circumstances. This incorporates the basic Popperian notion of science as a tentative set of statements about reality, always viewed as hypotheses and as potentially wrong. We thus need to replace the Nash Equilibrium (NE) solution

concept, which involves each player doing the best for themselves as they can, given what all the other players are doing. Our approach to game theory would be an intersubjective interpretation, with a corresponding ISNE (InterSubjective Nash Equilibrium) solution. In this case, the game could be viewed as a shared mental model among the players. This leaves traditional objective game theory as a subset of the intersubjective, and the Objective ONE (Nash Equilibrium) an element (if unique) of the possible ISNE that might exist.

Finally, if the game is not even common knowledge among the players, then we have a purely subjective interpretation, with corresponding Subjective Nash Equilibrium (SNE). The players may have quite different notions about the game they are playing, but achieve a Nash nonetheless. Whether or not players might learn the same game, or the objectively true game, is a question that can be pursued, but it seems likely that this would often not be the case. This would especially be true to the extent that out-of-equilibrium play is essential to sustain an equilibrium, as these plays may never actually occur in the usual view of finding a Nash. This approach to game theory is further developed in Denzau and Roy (2005) (see also Cardenas and Ostrom, 2001).

Of course, if the players consciously realize this problem, then their play would probably not correspond to the prescriptions of Nash. If players are not sure about their model of the game, they may purposely explore the possibilities in order to learn more about it. With both players doing the same, it may be very difficult for each player to learn much – the complexity of the situation could be substantial.

In the theoretical world, the assumptions of ONE and ISNE can be easily made. But the real world is much more problematic. First of all, human understanding of what is rational and what is not rational are often based on imperfect, imprecise, and asymmetric information about the world in which we live. According to Denzau and North (1994), "people act in part upon the basis of myths, dogmas, ideologies and 'half-baked' theories." As a result their preferences are often shaped by limited and imprecise information about their environment. Under these conditions, players' knowledge about their options is often unclear, making objective rational decision-making extremely difficult. As a result their preferences and strategies they pursue relative to others may often result in solutions that are objectively sub-optimal, even if the outcomes are subjectively Nash equilibria.

As noted above, if the players realize the tentative veracity of their mental models, then their play might not correspond to the prescriptions of Nash. When unsure about the game, each player may explore the possibilities in order to learn more about it, thus greatly increasing the complexity of the learning problem. This type of exploration was done by just a few of the participants in the Coursey and Mason (1987) study in which participants were asked to maximize an unknown function. Just as differ-

ent mental models can induce different behavior in the same objective circumstances, different players may react to their lack of certainty in different ways.

The usual economist's model of learning, that of Bayes, ill fits with our view of mental models. The basic problem is that a Bayesian learner may be very slow to update, in the light of new data, and more importantly, cannot learn things that were not previously viewed as conceivable (see Blume and Easley, 1982). This latter limitation can be very problematic, as is argued in Denzau and Roy (2005), when it is necessary to learn entirely new models of the world.

Mental models and learning: learning models versus learning parameters

Even in such a setting involving learning, traditional game theory would still be descriptive and prescriptive if people could learn sufficiently so they could be substantively rational. As noted in Denzau and North (1994), the choice situation must be relatively simple (with low dimensionality of the model to be learned); information must be of good and be based on sufficient feedback from choices; and the learner must be sufficiently motivated to incur the costs of learning. Under those circumstances, a learner may be able to learn the correct mental model through which to see the world, and choice models based on such an assumption are more likely to be accurate.

Without those assumptions, we must consider an alternative situation in which our mental models are not accurate, and may differ substantially across individuals. Mental models help shape the way human beings structure their environment and how they operate in it. According to Denzau and North (1994) an understanding of how "mental models evolve and the relationship between them is the single most important step that research in the social sciences can make to replace the black box of the 'rationality' assumption used in economics and rational choice models."

The gradual learning by economic writers about the causes of international trade is instructive about this learning process. The oldest views about trade are usually termed as the "vent for trade" argument – nations export their excess production of some products. This was joined by a model of absolute advantage – nations export those products that they can produce at the cheapest cost. Both arguments involve the use of prices that are viewed as given, either output or input prices, and do not provide a way to predict from prior considerations the pattern of trade. Ricardo, in 1817, presented the comparative advantage argument for trade – nations export those products which they have a relative, or comparative, advantage in producing. This advanced the model, but left open the more ultimate causes of the assumed productivity differences. It was only with the Heckscher–Ohlin model that relative endowments of resources

(capital and labor, or land and human capital, etc.) enabled one to predict a priori the resulting pattern of trade. At each step, the current best model was believed by many and used to draw policy recommendations, even though none of these models is necessarily objectively true.

Based on the model one believes, one can attempt to learn the parameters of that model. For example, a Marxist might believe in the labor theory of value; i.e. that the labor content of a product determines its exchange value. The parameters to measure are thus the labor content and the exchange prices. As Stigler (1958) notes, this gives a relatively good predictive model for many goods. But it is precisely the cases it fails to predict accurately that provide the most information as to what to bring into a better model. Much, if not most, of the value of a piece of electronic gadgetry is in the semiconductor devices (the chips) used in the gadget. However, the labor content in these devices is very small, and remains small even if one adds in the labor content equivalent of the capital used in their production (this labor is termed stored labor in some analyses). These measurements of labor content fail to predict the market prices by a substantial margin. One needs a much more substantial theory of capital to build a better understanding of the production cost of such products and a model of market power to better understand the pricing of such goods. Instead of just learning the labor content parameter, one needs to find a better model that deals with more variables than the simple labor theory of value.

If learning has to do with gaining greater understanding about how the world functions and operates, then our ability to do so to rests upon our ability to distill and organize facts. But what facts we focus on and which we ignore are largely determined by the mental models or beliefs we hold about a subject. In such settings, it has been argued that we think not as sequential logic engines, but rather by pattern recognition and neural nets (see Bechtel and Abrahamsen, 1991) or by the use of metaphors (Lakoff and Johnson, 1980).

In both of those approaches, learning is often contextual. We learn in relationship to what else we know, what we believe, our prejudices and our fears. We assimilate new knowledge by building upon our existing structure of beliefs. And in contexts where existing knowledge of a subject matter is scarce or incomplete, uncertainty looms. In such contexts mental models become critical in shaping how individuals process, construe, and regard new and unfamiliar facts and evidence. Under conditions where there is no preexisting knowledge of a subject matter or where new or unfamiliar facts present themselves in the face of existing knowledge, mental models becomes pivotal in shaping our understanding of what is rational and what is not. It is in such situations when our existing models fail that Bayesian learning gets us nowhere, and new approaches are required.

Neoliberalism as a shared mental model

One application of the study of the influence of shared mental models is in the field of Political Economy and the study of the various experiments with market ideas around the world. The collapse of the Soviet Union in the early 1990s caused many policymakers to rethink Marx-based dependencia and statist political–economic ideas in various countries around the world. Neoliberalism is a term often used in political economy very broadly and vaguely to refer to market-oriented policy ideas and strategies in the second half of the twentieth century. Unfortunately, the conceptual analysis on this subject has been rather scant. We can apply the Shared Mental Models framework to explain how neoliberalism can be understood as both a reference to the distinct but related experiments applying market-oriented ideas in various political, social, and economic contexts. The term is also used as a broader reference to certain core ideas that are shared among them.

The Shared Mental Models framework can be used to help develop an improved conceptual understanding of neoliberalism and the variations and innovations that occurred in its application across regional and national contexts. When applying the Shared Mental Models framework, we begin with the premise that individual countries develop and adopt internal understandings and constructions of the world that are shaped by their unique social, political, economic, and institutional contexts. This affects how policymakers in individual countries and regions construe the meanings of ideas such as what markets are, how they work and what they accomplish. This in turn has shaped distinct neoliberal experiments within individual countries and regions and explains divergences in their respective neoliberal paths. What unites them is that they all converge to varying degrees, emphasizing the primacy of the market and the importance of fostering economic environments that encourage entrepreneurial-led growth. We may analyze neoliberalism as both a set of distinct but related mental models that are informed by a similar set of shared ideas, which we refer to as a *shared* mental model.

APPENDIX 2A: SUBJECTIVE GAME THEORY

An Objective Nash Equilibrium example

Consider an asymmetric coordination game of the form shown in Table 2.1. Row has a strategy of playing {Up} if she believes her opponent would

Table 2.1 ONE form of a game

	Left	*Right*
Up	3, 1	−1, 2
Down	−1, −1	0, 0

play {Left}, and {Down} if {Right}, while Column's play is similarly contingent. It has two Nash equilibria at {Up, Left} and {Down, Right}.

The example with mental models for both players

As the game is not common knowledge among the players, then we have a subjective interpretation, with corresponding Subjective NE (SNE). Here, Table 2.2 shows the initial beliefs of the players about the game. Player Row misperceives the game. She has the right general mental model, but has details of the game wrong – note the off-diagonals. Column also misperceives the game, but as a Prisoner's Dilemma, perhaps due to unfamiliarity or the use of signals that trigger the wrong mental model of the situation. Given their subjective notions of the game, the only ones they have to determine best responses, Row chooses {Up} as a dominant strategy, and Column chooses {Right} also as a dominant strategy. This yields the payoff of (−1, 2) for the players from the objective version of the game.

Note that at this point, Column, the player with the completely wrong view of the game, finds her beliefs confirmed by the result. Row, on the other hand, has the right general model, but finds the payoff to not be what she expected, −1 instead of 2.

From this failure, it is not clear what Row would learn, but Column has no reason to change his view of the game. Not only is the payoff what he expected, but Row's play in his view is her dominant strategy. For illustrative purposes, we can simply have Row learn through discussion with Column, who might be quite persuasive, that the game is as Column sees it, a PD.

Table 2.2 SNE forms of the same game

	Player Row	
	Left	*Right*
Up	3, 3	2, 0
Down	0, 1	0, 0
	Player Column	
	Left	*Right*
Up	1, 1	−1, 2
Down	2, −1	0, 0

The example with the same mental models for both players

Table 2.3 illustrates that this would lead to the players playing a PD they now both believe themselves to be playing, and choosing {Down, Right}, leading to a payoff of (0, 0).

Table 2.3 ISNE form of the same game

	Left	*Right*
Up	1, 1	−1, 2
Down	2, −1	0, 0

We can interpret this as a game that is common knowledge among the participants, but which is not necessarily a true view of objective circumstances. This incorporates the basic Popperian view of science and results in an ISNE solution. They have intersubjective agreement on the same model of reality, and play to a Nash equilibrium given those beliefs (mental models). In this case, the game could be viewed as a SMM among the players. Mental models are the internal representations that individual cognitive systems create to interpret the environment. Shared mental models by players are shared inter-subjectively, but do not necessarily relate as a true one-to-one with reality. Different individuals with convergent models will likely entail shared interpretations about problems, solutions, and preferences. This leaves traditional objective game theory as a subset of the intersubjective.

Note

1 According to Benford and Snow (2000), the conceptual applications of framing have been significant in the social sciences. They argue that framing has gained currency in the field of cognitive psychology such as Bateson's (1972) *Steps to an Ecology of the Mind* and Tversky and Kahneman's (1981) "The framing of decisions and psychology of choice." In the field of linguistics and discourse analysis, important applications of framing have been developed in Tannen's (1993) *Framing in Discourse* and Van Dijk's (1977) *Text and Context Exploration in the Semantic and Pragmatics of Discourse.* Similarly, framing has been applied in the field of communication and media studies in Pan and Kosicki's (1993) "Framing analysis: an approach to news discourse," and Scheufele's (1999) "Framing as a theory of media effects" in important ways. In the field of Political Science and policy studies, Benford and Snow cite the seminal work of Schon and Rein's (1994) *Frame Reflection: Toward the Resolution of Intractable Policy Controversies* and Triandafyllidou and Fotiou's (1998) "Sustainability and modernity in the European Union: A Frame Theory Approach to Policymaking." And, Joshua William Busby (2003) cites Sidney Tarrow, Mayer Zald, and David Snow as important contributors to the application of framing to the literature on social movements (p. 8).

Zald (1996) defines frames as "the specific metaphors, symbolic representa-

tions, and cognitive cues used to render or cast behavior and events in an evaluative mode and to suggest alternative modes of action" (p. 262). Busby (2003) asserts that frames provide a method "by which policymakers can sort information and provide a number of concomitant functions" (p. 8).

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Ravi Roy – Shared Mental Models

Biography

Ravi Roy holds a B.A. in political science from the University of California, Los Angeles (College of Honors); an M.A. in public policy from Claremont Graduate University in Claremont, California; and a Ph.D. in political science (with a concentration in comparative political economy/public policy), also from Claremont Graduate University. He was also a post-doctoral fellow at the Claremont Institute for Economic Policy Studies.

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In addition, Ravi has written or co-written three books and was the lead editor on a fourth, which focused on the role of ideas and mental models in shaping people's discrete understandings of the choices available to them and how these, in turn, inform their various policy preferences.

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