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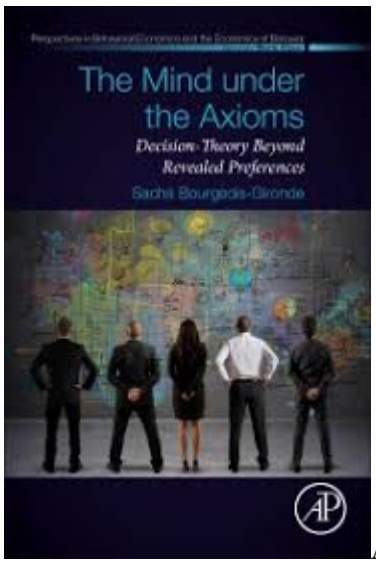
Sacha Bourgeois-Gironde, *The Mind Under the Axioms*

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1 Insofar as decision theory is regarded as a device for application to empirical choice data, it might be thought odd that it is based on axioms. 'Laws of nature', after all, is just a metaphor unless we think, as perhaps Newton did, that units of matter operate under divine orders. The father of modern decision theory, Savage took the view, made

explicit following his confrontation with the nuisance from Allais, that his great achievement is a normative theory for decision-making under uncertainty, a manual advising agents how to avoid sequences of decisions that would undermine their own welfare (Binmore, 2009). This is a comfortable attitude for economists, who unless they represent themselves, increasingly unfashionably, as pure (or 'mere'!) theorists, are expected to provide policy recommendations. But in that case, the various axioms involved in the subjective expected utility theory pioneered by Savage do not seem to be quite on all fours with one another philosophically. An investment manager should see at a glance that she needs to effect reform somewhere if an analyst detects a cycle in her assessment of the expected values of some options. But why should she accept that she is letting down her clients if it is pointed out to her that her preferences are not complete, or that some of them are state-dependent? The economist could say to her: you should worry about these things because the welfare advantages of subjective expected utility theory are guaranteed by the totality of its axioms, and you can't pick and choose from among them. Monsters lurk somewhere, even if we can't say exactly what or where they are. Perhaps this should be convincing up to a point. But in fact we know that some axioms *can* be relaxed consistently with welfare maximization. For instance, if someone lacks complete information, and recognizes that data are likely to be most sparsely drawn from the thin tails of outcome distributions where, respectively, financial security for life and terminal ruin lie, she can sensibly prefer an axiom set that allows for rank-dependent utility (Harrison and Ross, 2018).

2 Economists have another, complementary, attitude they can cite from their classic literature, which seems particularly relevant in the experimental laboratory: the axioms are assumptions that generate what Samuelson (1947) famously called "operationally meaningful theorems", that is, assurance of precise and therefore testable predictions. Experience shows us where adherence to this philosophy leads : to 'exposures' of 'behavioral anomalies' (Thaler, 1992), and efforts to patch them that can result in sacrifice of generality (Camerer, 1995; Binmore, 2007) or alternatively to general theories, such as cumulative prospect theory, with too many free parameters, consequently encouraging sloppy identification practice (Harrison and Swarthout, 2021).

3 These two aspects of axiomatic decision theory—its basis in normative idealization and its generation of precise specifications—set up the context for Bourgeois-Gironde's admirably modest, conscientious, and useful book. Bourgeois-Gironde begins with the premise that the axiomatic structure of decision theory is at least useful for clarity, including clarity in empirical application—so, the Samuelson virtue, but not necessarily Samuelson's implicit commitment to a Popperian posture. Bourgeois-Gironde endorses no fixed doctrine on the extent to which we should expect homeomorphisms between the decision-theoretic axioms and discovered psychological structures and processes, except to reject the view, as propounded by Gul and Pesendorfer (2008), that the relationship between them is merely paramorphic. (The homeomorphic / paramorphic terminology is drawn from Wakker (2010): a model identifiable in some empirical data of interest is homeomorphic if its structure maps onto the underlying cognitive processes that generated the data, and paramorphic otherwise.) He adopts a sensible methodological principle that revealed preference interpretations should be adhered to as closely as possible, but without the theorist being hamstrung by an ontological ban on preferences as being anything other than summaries of actually observed choices—the restriction that makes Gul and Pesendorfer's position possible. This methodological liberalism allows maximum openness to evidence from multiple quarters as Bourgeois-Gironde explores ways in which the axioms can inform design of experiments and experimental data can, in turn, motivate principled and controlled relaxation or modification of the axioms. Traveling with such light philosophical baggage but a full mathematical toolbox is indeed, in my opinion, best-practice methodology for experimental economics.

4 Bourgeois-Gironde does not attempt to produce a comprehensive review of applications of the axioms to experiments, but instead goes deep into three cases. Bravo, again: the pay-dirt here is found by scouring the ground, not by looking down from conceptual heights. The three cases are (1) interpretations of psychological

cardinalism in empirically estimated utility functions; (2) experimental accommodations of the axiom of completeness in expected utility theory given *prima facie* incomplete preferences in the lab; and (3) experimental identification of state-dependent preferences. These cases are not highlighted because they provide fodder for any strong philosophical story that Bourgeois-Gironde wants to spin. Rather, they make an enlightening trio because few experimental microeconomists who venture into design innovations and estimate individual utility functions can avoid having to think hard about them at least from time to time.

5 Each of Bourgeois-Gironde's three main chapters follows a common architecture. First, the author surveys theoretical issues with a view to isolating dilemmas. This is the philosophical part of each chapter, but again I stress: the point is never to buttress a prior conceptual framework, but simply to explain why the problem in question is intellectually challenging in its own terms. Then, the economic literature is scoured for potential working points of homeomorphism between the relevant axioms and psychological structures and processes that predict observable choice effects. In each case, one or two detailed theoretical innovations by other economists are selected for deep analysis. Finally, each chapter ends with a "To the lab" section in which Bourgeois-Gironde sketches an experiment that might efficiently shed light on the leading modeling options and problems revealed by his preceding review. No chapter concludes with a methodological manifesto or promotion of an over-arching strong program. This is ultimately a book for experimenters, and for each of the three cases, Bourgeois-Gironde has given them plenty to think about next time they face a design decision that confronts them with the theoretical issue in question. The book concludes with a small and tasteful dessert, a brief reflection on what experimental economics might look like if its practitioners had a culture that took phenomenology, as opposed to naïve folk psychology, more seriously.

6 The book, though short, is not an easy read. This is because although it provides the mathematical details necessary for clarity, one cannot understand it by working through the equations and skimming the verbal parts at speed. The verbal expositions are lengthy and they are, in fact, the primary content. The English syntax in these sections is not particularly natural, though it is usually formally correct. I got more value out of the book on a second read, once I knew, from having digested the practical messages of each chapter, what hinge points in the verbal reasoning I should particularly be looking for. This is not a criticism. An economic methodology book you can read once through and then put back on the shelf will probably at best have supplied you with some slogans to pull out in your next casual conversation with a colleague about methodology itself. By contrast, as said before, Bourgeois-Gironde's is a book that is supposed to help you think more deeply when you're actually designing experiments. So a reader who wants to get full practical value from it should persuade her experimental co-authors to read it too.

7 I will say a bit about each of the specific case studies.

8 The problem of cardinal utility arises from the fact that vNM cardinality does not necessarily represent psychological cardinalism, that is, the effect on valuation of experienced differences in intensities of riskless preferences. I here borrow terminology from Mandler's (1999) classic study of the relevant intellectual history; a reader who reacquaints herself with Mandler before reading Bourgeois-Gironde will have behaved efficiently. At one point in the chapter, Bourgeois-Gironde states the problem space in which cardinality arises in a crisp formulation that resonates through his whole book: utility functions perform a "dual role" of "representing preference relations and rationalizing choice data." 'Representing' here means: by reference to an explicit representation theorem; hence the role of the axiomatic approach. Then the central question for Bourgeois-Gironde's literature review is: Can we realistically expect to restrict the influence of psychological cardinalism on choice behavior in the form of a novel representation theorem? After considering a number of proposals along this track, Bourgeois-Gironde carefully considers Köbberling's (2006) representation theorem for cardinal differences in utility, and argues that when we assess potential conditions for its application, we can identify specific points of trade-off between "psychological realism and operationalization." An argument follows to the effect that

we cannot avoid the trade-off by abandoning resort to *any* representation theorem, as some authors have urged. The "To the lab" section of the chapter first reviews an attempt by Abellaoui *et al.* (2007) to use eye-tracking data to identify decision weights in a rank-dependent specification of subjects' utility functions under uncertainty. Characteristically, Bourgeois-Gironde finds the result inconclusive but sufficiently promising to motivate follow-up lab work. Finally, he presents intriguing work from his own lab on the hypothesis that patients who suffer from brain disorders that interfere with their emotional connections to past episodic rewards are more likely to follow Savage's orthodox advice in small-stakes Allais scenarios.

9 The chapter on preference incompleteness is the longest and most theoretically intricate in the book. It addresses a philosophical problem and a methodological problem, which in empirical application interact with one another. The philosophical problem is that there is no obvious reason why a person would regard their ambition to be rational as undermined by their failure to hold determinate preferences over options they are unaware of. But the more important aspect of 'rationality' to the economist is arguably that it allows her to make inferences from the assumption that an agent chooses so as to optimize her welfare, and then incompleteness undermines the confidence with which welfare optima can be identified. The methodological problem is that incompleteness and indifference are difficult and sometimes impossible to distinguish from one another on the basis of observed choices alone. These issues are best considered not by reference to epistemically remote prospects, but in contexts where one tries to estimate risk preferences. How finely must an agent discriminate between measurably different probabilities before we pronounce her preferences incomplete, as opposed to simply revealing 'fat' indifference bands? In his section on models for empirical application, Bourgeois-Gironde reviews the following issues and threads of literature: approaches following Aumann (1962) in representing incompleteness through multiple utility functions; efforts at adjusting for incompleteness by modifying axioms other than completeness, particularly transitivity and continuity; and incompleteness as deriving from status quo bias. Models discussed in detail are Bewley's (2002) work on incomplete preferences arising from incomplete beliefs (in addition to status quo bias) and the meta-rationality model of Gilboa and Schmeidler (1989) and Gilboa *et al.* (2011), where agents interrogate themselves on motivated discovery of completeness gaps and repair them. The "To the lab" exercise adds an extra dimension of uncertainty, concerning the extent of indecisiveness over time, to the experimental approach of Danan and Ziegelmeyer (2006), which offers subjects opportunities to pay to defer their choices, in the expectation that their option menus might shift. In this setup, indifference among options should not induce costly deferral, while incomplete preferences might. The theory discussion shows that this approach is compatible with a revealed preference model, requiring only theoretically minor relaxation of WARP (the Weak Axiom of Revealed Preference).

10 The chapter philosophers might find most engaging is on state-dependent preferences. As Bourgeois-Gironde explains, state-dependence calls into question a fundamental principle of decision theory, the assumption that preferences and beliefs can be elicited independently from one another. (Savage's theory depends on this being possible in principle, but he was aware of the challenges it poses for effective elicitation procedures; see Savage (1971).) Experimenters are increasingly alert to the interaction of risk preferences and beliefs about probabilities, which has particularly important effects on accuracy of estimations if one allows (as one typically must) for non-EU utility, as in rank-dependent utility theory. For instance, in my lab, we incentivize subjective belief reports, but in analyzing for bias at the individual level, we apply a correction based on the subject's lottery choices. This is compatible with revealed preference, and with Savage's axiom P3 as long as the risk preferences are held fixed. The situation with respect to axioms P3 and P4, as a pair, is more complicated when one moves to true joint estimation of preferences and beliefs. Bourgeois-Gironde's third chapter includes a longer and deeper philosophical section than either of the preceding ones, because foundational issues are less easily isolated for local management where state-dependence is concerned than with respect to cardinality or completeness. Some methods of handling state-dependence put additivity of preferences into question, or

raise difficulties for distinguishing between states and consequences. Other approaches (set in the framework introduced by Anscombe and Aumann, 1963) involve appeal to hypothetical preferences, and thereby may encourage departure, in empirical applications, from revealed preference. Some theorists have been tempted to metaphysical animadversions on what the concept of a 'state' comes to. Bourgeois-Gironde sensibly resists this: a 'state', he argues, is best understood pragmatically as whatever is sufficient to induce epistemic closure on a decision process. He reviews two models in detail, Karni and Schmeidler (2016), which involve hypothetical preferences, and Drèze (2018), which is compatible with revealed preference. These models in turn inspire the two experimental approaches described in the "To the lab" section, which identify state-dependence by following Drèze's idea of providing subjects with potential moral hazard environments featuring trade-offs that will be decided one way given state-independent preferences and another way given state-dependent preferences. The first experiment applies the Karni and Schmeidler model and thus requires consideration of hypothetical preferences, while the second, directly implementing the Dréze model, avoids this departure from revealed preference.

11 Bourgeois-Gironde has produced exemplary economic methodology here: rigorous, practical, and addressing live concerns in contemporary economics. His book addresses the integration of economics and psychology in a way that, unlike too much recent behavioral economics, does not simply opportunistically import concepts across the interdisciplinary frontier without carefully preparing them for deep integration into their new theoretical contexts. Experimental economists can use ideas from psychology without abandoning the axioms, and doing so is the road to finding relationships of enduring significance, as opposed to isolated behavioral ephemera.

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