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Rationality as a Process

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ABSTRACT

Individual decision-making is not adequately portrayed by focusing on static rationality properties. The static approach can mistake rationality-in-process for bounded rationality or irrationality. We consider a sampling of intellectual frameworks that address decision-making rationality as a process, including intrapersonal arbitrage, Wicksteed's principle of price, dialectical reasoning, and error-driven learning. We conclude that the approach to normative analysis shared by both neoclassical and behavioral economists is not the only possible one and that, in fact, it misses an important aspect of human decision-making. Evaluations based on the static approach are at best incomplete and likely to be misleading.

The rationality norms accepted by neoclassical economists and applied by behavioral economists are static. The individual is either "rational" or he is not. His preferences are either completely ordered, consistent through time, and transitive, or they are not. In the neoclassical version of rational choice theory, actual behavior conforms to the static axioms of preference,[1] whereas in the behavioral version it falls short. In each conception, the individual's rationality is described in terms of preferences and beliefs at a given point in time. For some types of analysis – like simply predicting the direction of change in an endogenous variable – this may not be a problem. On the other hand, in welfare and prescriptive analysis it can be inappropriate. If we only take a snapshot of the individual at a moment in time, we will fail to see how the individual's decision-making evolves. We may simply have of picture of it in an inchoate state. This is especially relevant for policies that aim to intervene in decision-making. If individuals are in the midst of a decision-making process, then the evaluation of their behavior even at a

[1] In brief, the most important rationality properties are completeness and transitivity of the preference ordering. In addition, actual behavior must be consistent with the preference ordering.

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point in time should be made through the lens of that process. To put matters another way, the unit of evaluation should not be a *part* of the process but the process as a whole.

The purpose of this article is to argue that individual decision-making is not adequately portrayed by focusing on static rationality properties. The static approach can mistake rationality-in-process for bounded rationality or irrationality. In what follows we consider a sampling of intellectual frameworks in increasing order of their "radicalness" in addressing decision-making rationality as a process. Some may be familiar to the reader; others less so. Our fundamental purpose is to show that the approach to normative analysis shared by both neoclassical and behavioral economists is not the only possible one and that, in fact, it misses an important aspect of human decision-making. Evaluations based on the static approach are at best incomplete and likely to be misleading.

1 Intrapersonal Equilibrium

There are many manifestations of equilibrium in economics.[2] Among the least explored is intrapersonal equilibrium. What is sometimes called the "equilibrium of the individual" generally refers to the adjustment of an individual's various actions into a coherent whole or, viewed intertemporally, parts of a single plan. This equilibrium is said to be attained immediately. However, in another sense, it is not really attained at all but is "simply" a consistency property, and hence equivalent to a definition of abstract rationality. Accordingly, for standardly rational agents, in either interpretation, (a) every decision is made without the elapse of time and (b) all of these decisions are always mutually consistent. Neoclassical economists accept this both normatively and descriptively, while behavioral economists accept it only normatively.

There is good reason to believe that this state of affairs is not likely ex ante. To assume otherwise would be to assume that an individual would have settled, in effect, on a life plan from the beginning of their consciousness. Such an intrapersonal state of equilibrium is analogous to the Arrow-Hahn-Debreu model of general equilibrium that incorporates demand functions for all commodities in every contingent state of the world, at every time and in every location. The equilibrium of the individual excludes a trial-and-error process by which individuals discover in particular cases what they want and how to get it (Dold, 2018; Plott, 1996).

Furthermore, the notion of a *fully consistent* equilibrium ignores the costs of discovering inconsistencies and then resolving them. There is no reason that an individual can or should try to achieve such consistency, as the cognitive cost of doing so likely exceeds the benefits. "The expected marginal benefit of discovering and/or forming these preferences presumably declines as the

[2]For a discussion of different types of equilibrium concepts see Tieben (2012).

compared options get further from one's likely future experience" (Whitman and Rizzo, 2015, p. 419). At some point, then, achievement of additional degrees of consistency will fail the cost-benefit test.

1.1 Intrapersonal Equilibrium: Austrian Background

Precise adherence to formal features of economic rationality was considered unrealistic in the Austrian economics tradition, even before the formalization of the axioms of rational preference and choice. One of the early criticisms of marginal utility theory was that it presupposed deliberations about the value across goods on various margins that are too complicated for real-life individuals to perform. In the late nineteenth century, Böhm-Bawerk (1959 [1889]) replied to this criticism by saying that the individual will, in effect, satisfice, that is, "his performance will do well enough for his purposes" (202). Generally, precision is not to be expected because this can only be achieved at the cost of significant scarce mental effort.[3] Therefore, even in a state of complete individual equilibrium, there is not likely be precise determination of marginal valuations.

In his criticism of indifference analysis, the interwar Austrian Mayer (1994 [1932]) pointed out that Pareto's characterization of the individual agent was based on an equilibrium construct in which all of the relevant "magnitudes operative in genetic-causal sequence [are portrayed] *as if these existed together at the same time*. A state of affairs is *synchronized* in the 'static' approach, whereas in reality we are dealing with a *process*" (92). While Mayer did not carefully distinguish between the equilibrium of the individual and the determination of equilibrium prices, his criticism is quite general. For Mayer the idea of an individual with a preference or indifference ordering that satisfies all the requirements of consistency *ex ante* would confuse the possible result of a process with a collection of synchronic characteristics.[4]

Robbins (1935) characterized one of the central consistency criteria of neoclassical rationality, the transitivity of preferences, as a claim "that in a state a perfect equilibrium the possibility of advantage from further 'internal

[3]Böhm-Bawerk suggests a useful maxim: "In really important things, be really exact; in moderately important things be moderately exact; in the myriad trifles of everyday economic life, just make the roughest sort of valuation" (202). This maxim captures the idea that the value of precision may be different in different circumstances and so the degree of precision in decision-making will be context- and content-dependent.

[4]In fairness to Pareto he sometimes did recognize the existence of a completed process. "A man who buys a certain food for the first time may buy more of it than is necessary to satisfy his tastes, price taken into account. But in the second purchase he will correct his error, in part at least, and thus, little by little, will end up procuring exactly what he needs. *We will examine this action at the time when he has reached this state*." (Pareto, 1971 [1906], 103, emphasis added). Pareto extended this idea to reasoning itself: "Similarly, if at first he makes a mistake in his reasoning about what he desires. He will rectify it in repeating the reasoning and will end up making it completely logical" (103). Pareto's analysis is of the completely logical state.

arbitrage operations' is excluded" (92). This internal equilibrium is analogous to the perfectly competitive market equilibrium insofar as all problems due to lack of foresight, costs of decision-making, or insufficient awareness of opportunities for gain are absent. For the individual as for the market, at any point in time, the process of (internal) arbitrage may not be complete. Nevertheless, economics, in Robbins's view, is not "limited to the explanation of situations in which action [is] perfectly consistent" (92). Indeed Robbins thought that "it is only in terms of irrational choice, that many of the more complex situations which economics has to study can be explained" (1934, 101). Here, Robbins uses the word "irrational" to mean intransitive, yet he is arguing for adopting a more inclusive model that does not require transitivity.

Modern-day economists working in the Austrian tradition have often expressed dissatisfaction with neoclassical models built on the assumption of equilibrium. The equilibrium "solution" to such a model is a state of affairs that satisfies all defining assumptions of the model at once. It is a state of rest with no internal tendency to change. The classic supply-and-demand model is a simple example: at the equilibrium price and quantity, all expectations are fulfilled. The situation is self-reinforcing and therefore, absent any exogenous changes, it should persist.

Austrians' concern with this equilibrium-based theory is that it ignores the process by which equilibrium is obtained. If we start in a situation where the "solution" is not already in place – where, for instance, we have disequilibrium prices – then how does the system get from here to there? Economists have process stories they tell their students, of course. In the case of supply-and-demand, the usual story involves competitive bidding by buyers and sellers that pushes the price toward equilibrium, or perhaps a story about how producers react to empty shelves or excess inventories. But importantly, none of those stories are inherent in the model. Indeed, they are *ruled out* by the standard competitive model of supply and demand, which is based on the assumption of price-taking consumers and producers.

Consequently, modern Austrians typically prefer a "market process" analysis that illuminates the forces that will tend to push a system toward equilibrium – or, possibly, away from it. Kirzner (1979), for instance, posits entrepreneurial alertness to profit opportunities as a factor that will tend to push market processes toward equilibrium. Others, most notably Lachmann (1986), have argued that the inevitable discovery of new information over time will tend to upset patterns.

The Austrian critique of equilibrium-based theorizing has typically been applied to social equilibria such as market-clearing conditions. But the essence of the critique applies to intrapersonal analysis as well. The problem with the standard approach, shared by neoclassical and behavioral economists, is that it implicitly defines *rationality as an intrapersonal equilibrium*: a state of affairs in which there are no contradictions, no inconsistencies, and thus no inherent

tendency to change. Deviations from this standard, such as those identified by behavioral economists, are deemed "irrational." In a process-based account, by contrast, contradictions and inconsistencies would not constitute *ipso facto* evidence of irrationality. Rationality would be understood in terms of how agents respond to such contradictions and inconsistencies. They provide grist for the mill of rationality. When they manifest, either in behavior or simply in mental awareness, they may trigger certain processes of adjustment. The adjustments might eventually lead to something resembling an equilibrium – or maybe not.

Some Austrians have already applied process-based analysis to the intrapersonal sphere. Kirzner (1979), for instance, applied his alertness model even in the isolated ("Robinson Crusoe") state. In general he argues that "*nothing in purposeful action . . . by itself guarantees that every available opportunity must be instantaneously perceived*" (130). To the extent that internal arbitrage opportunities are present due to internal inconsistencies, they will not be remedied even to the optimal or cost-justified extent immediately. This is because alertness (or as we might prefer to say, attention) to opportunities is not always consciously deployed as an ordinary resource might be. It may be an undeliberate and unconscious insight that is manifested in behavior over time (169). Either because of the deliberate and costly intellectual effort required for internal consistency or because of the lack of alertness in recognizing the opportunity to apply effort, perfect consistency is unlikely to be observed.

1.2 Internal Arbitrage

What does internal arbitrage look like? What forms does it take? These are underexplored questions, but some writers have offered tentative answers. Ainslie (1992) has suggested that personal resolutions to lose weight, quit smoking, and so forth can be understood as cooperative agreements between the present self and a collection of future selves, all making small sacrifices in exchange for the gains created by the others' similar sacrifices. Whitman (2006, pp. 6–9) has argued that different selves – or aspects of the self with differing values or preferences – can strike mutually beneficial Coasean bargains. Such bargains might take the form of mental accounts, specified "zones" for self-indulgence, and self-reward schemes.

Should we expect that internal arbitrage will necessarily result in a *fully consistent* intrapersonal equilibrium? This seems unlikely once we consider the "opportunity cost of internal arbitrage" (Robbins, 1934, p. 101). Inconsistencies can be present in both a system of preferences and in a system of beliefs. To the extent that many preferences are not for intrinsic goods but for intermediate goods, and thus depend on the individual's beliefs about the relationship of means to ends, the two inconsistencies will be interrelated. If the individual were to fully arbitrage these inconsistencies, what would that entail? In the

first place he would have to be aware of or recognize the inconsistencies. This can get costly. For example, a person who has a mere twenty beliefs (or preferences) needs to check 190 possible pairs of beliefs (or preferences) for consistency. And that would not be enough, as it only considers pairwise consistency; the person would also need to check all triples, quadruples, and so on. Then, for any inconsistency found, he would have to determine in what way preferences or beliefs should change to render them consistent. In the simplest two belief or two preference case, he could change x or y or both. In the larger case, the problem is obviously more complex, as the typical person has far more than just twenty beliefs or preferences. In the context of beliefs, there is the additional issue that consistency with each other does not necessarily mean consistency with reality. It seems highly implausible that an individual would attempt to perform all of these checks and corrections, given the high cognitive cost and declining marginal benefit of doing so (Arkes *et al.*, 2016).

However, even if we assume more modest practical problems for the individual, there is also the issue of whether processes generated by perceived inconsistencies move the individual toward greater consistency. There are some like List (2003, 2011) and List and Millimet (2008) who seem to think so, as we briefly discuss below. However, this presupposes the ecological or pragmatic rationality of fulfilling the standard abstract rationality requirements. There may be no reason for the individual to attempt to do so for particular problems in particular contexts.[5] Nevertheless, in either case the conclusion we draw for welfare economics is that the fulfillment of static rationality criteria is not an appropriate normative standard. We are dealing with movement, not stasis.

With this background, let us now ask: What would the world look like if we were to reject the assumption of instantaneous internal consistency of the individual's decisions?

2 A Wicksteedian Framework

Early in the twentieth century, Wicksteed (1967 [1910]) addressed the issue of "irrational" behavior quite directly and developed an *implicitly* process-oriented theory of rational behavior and cognition. Wicksteed did not provide, however, anything more than introspective evidence. But his theoretical insight is important.

Wicksteed was willing to admit into his analysis, and not just as *en passant* observations, that people experience myopia, susceptibility to framing, and inconsistency in preferences. They also engage in behavior that is far from deliberate: unconscious and impulsive behavior is not outside of the scope

[5]For instance, for most people there is little to gain from testing their beliefs about politics for internal consistency, as the personal loss from holding wrong or inconsistent beliefs in that context is negligible (Caplan, 2011, p. 115).

of his thought. What unifies Wicksteed's analysis of behavior and cognition is the susceptibility of each to the terms on which they can be indulged or manifested. He referred to this as the *principle of price*.[6]

Some of the specific examples Wicksteed gives have a very modern behavioral cast. This example of myopia is one of several:

> For example, we lie awake (or what we call awake next morning) half the night consciously suffering from cold, when without even getting out of bed we could reach a blanket or a rug which would secure comfortable sleep for the rest of the night. We cannot say that we deliberately prefer the discomfort we have encountered to the discomfort we have escaped. Perhaps the psychological analysis is that we prefer each second of the discomfort of cold, as it comes, to the discomfort that would accrue during that second if we secured peace for the rest of the night. At any rate our choice is irrational, *yet the principle of price is at work all the same; for there is a degree of chill discomfort which, if reached, will break the spell and induce us to put on the extra blanket* (29–30, emphasis added).

Wicksteed's principle generalizes: Inconsistencies will tend to be reduced as the cost of indulging them becomes greater. Then they will more likely come to light and be subject to the criticism of reason. "But the greater the range of that scale that is present to our minds *at one and the same time*, and the more precise our mental estimates, the fewer will be our inconsistencies" (34, emphasis added).

As we have said, Wicksteed's approach is only implicitly processual because he does not spell out the type of process by which changes take place. In effect, he makes only comparative static statements. Nevertheless, these are sufficient for many purposes. Furthermore, Wicksteed in some sense accepts many of the standard criteria of rationality – irrelevance of framing, consistency of choice, absence of present bias – but only as tendencies toward which specific action will move under the influence of cost. At no point does he claim that the "irrationalities" will be completely eliminated. They will, however, be reduced in cases where their associated costs are high. This will be the result of both conscious and unconscious "corrective" behavior.

[6]"Our irrational shrinkings then, as well as our rational preferences, 'have their price.' And as irrational aversion or dread does not supersede the principle of price, so neither does irrational attraction or fancy" (31). It would be a mistake to concern ourselves very much about Wicksteed's characterization of certain choices as "irrational." What he means simply is that behavior which people have taken to be irrational because of lack of deliberation, myopia, inconsistency and so forth is still affected by the terms on which alternatives are offered. In today's perspective, most of these types of behavior are violations of the usual neoclassical assumptions of rationality. See text below.

A significant amount of current research can be viewed in the light of Wicksteed's framework even if the originators of that research were not explicitly working in his paradigm. In this section, we discuss a paper by Becker and Rubinstein (2011) on the effect of suicide bombers on behavior in Israel. It too takes a comparative static approach.

During the last intifada there were suicide bombings both on buses and in cafés. Each of these was followed by tremendous news media publicity and public discussion. The general public appeared to be quite fearful. Based on "availability bias" (Tversky and Kahneman, 1973), individuals would have greatly exaggerated the subjective probability of harm from riding on buses or going to cafés ("terror-infected goods"). This fear would be expected to reduce bus travel and café attendance to an "irrational" extent. However, the actual probability of harm from consumption of the terror-infected goods remained extremely low and so "rational" individuals would not be affected.

Becker and Rubinstein hypothesize that the greater the cost of a person's fears in the form of lost utility from the terror-infected goods, the more he will expend effort to reduce those fears. People do not actually reduce the very small objective probability of the terrorist threat by self-protective actions, but they work to reduce their irrational fear. Therefore, those to whom bus travel or café attendance is most important should be least affected in their consumption behavior.

Becker and Rubinstein find interesting proxies for the importance of consuming the terror-infected good. In the case of buses, they compare the effect of the bombing events on purchasers of monthly tickets versus those who purchase daily tickets. The former are more intensive users of bus services and presumably suffer a larger cost from fear than less intensive users. In the case of cafés, they compare attendance between married and single people. Cafés are a popular meeting place for those seeking friendship or romance. Presumably single people will incur a greater cost if they let their irrational fears keep them away.

Consistent with their hypothesis, Becker and Rubinstein find that there is an effect on those less intensive users of the terror-infected goods but no effect on the more intensive users. In fact, *all* of the total effect is concentrated on the less intensive users. The interpretation is that the latter used more psychological "effort" to counteract the exaggerated fears due to availability bias.[7] Like Wicksteed, their hypothesis is a comparative static one since they do not specify the process by which the fears are reduced. They do not take a position on the degree or extent to which this process is conscious or not.[8]

[7]The theoretical assumption is that through effort individuals can control, reduce or rationalize their fear and hence their behavior.

[8]It is not essential that this be done in an explicit or conscious way. Learning and the behavioral response to learning is often tacit. Just as we know more than we can say, we can learn in ways we do not fully understand.

In this approach, rationality does not lie in the original psychological reaction to the terrorist bombings. This can be "irrational" or biased by availability. It can depart from the standard of rational expectations. Indeed, the model does not even require that the subjective probabilities assigned to harm be reduced as long as the behavioral-consumption response is consistent with the almost-no-change in the objective probabilities.[9]

People are not rational ex ante. They may become more nearly rational, in the sense of the standard criteria, under the pressure of cost. Rationality may be the result of bearing the consequences of one's own "irrationality"– a notion that Bryan Caplan has given the somewhat oxymoronic label *rational irrationality* (Caplan, 2011).

3 Inconsistency as Dialectical Reasoning

From a normative perspective, it may seem that consistency is a necessary characteristic of rationality. It might be said that without consistency, there is no rationality. However, consistency in the realm of thought is not a prerequisite for rationality, but an ideal, a desideratum (Rescher, 1987). Conclusions obtained by valid deductions from *premises we take as true* do not just pop into our heads. But it is only from this kind of reasoning that we can be assured of the consistency of the conclusions with each other and with the set of premises. Getting to this stage of inferential argument is the result of a dialectical process in which the reasoner approaches an issue first from one perspective, then from another, and so on for perhaps many stages. Many different premises may be plausible and yet none are certain or likely enough to be settled on. Errors will be eliminated until some reasoning equilibrium is achieved. The key element of the process is that the same issue will be revisited again and again albeit from different, often incompatible, perspectives.

In an analogous way, we can apply the idea of dialectical reasoning to decision-making. Since decision theorists and economists model choice as a deductive process, the obvious prior question is how did the individual get all of his "premises" or "data" lined up in one consistent framework? In the simple theory of constrained utility maximization, the individual typically has a utility function with several goods as arguments and with well-defined subjective tradeoffs among them. He also faces a world in the form of well-defined objective tradeoffs implicit in the prices he faces and a constraint in the form of income he can spend. All of this represents the agent at the instant of decision. The data and the deduced choice are the equilibrium of

[9]Of course, one could say that the intensive users behaved as if they had rational expectations.

the individual. The term equilibrium is especially apt because it presupposes that all of the disequilibrium work (dialectical reasoning) has already been completed.

What does the individual value and what rates of tradeoff seem appropriate to him? What objects in the real world represent the corresponding objects of choice? What are the "objective" tradeoffs, especially if they are in the future or do not concern market prices (such as the tradeoff between cake and health)? These data, analogous to the premises in Rescher's discussion, are not simply given to him. They are constructed, discovered, or invented, and not just there from day one.

Let us now imagine an individual in the process of trying to figure out whether he should stop smoking. Of course he values his health, but he also values the enjoyment he gets from smoking and he is not keen on experiencing nicotine withdrawal. He is twenty years old. He knows that the negative health consequences from smoking will most likely not appear for many years. He also knows that if the past forty years are any guide, the progress of medical science over his lifetime will be great. Even now it seems that deaths from lung cancer are declining somewhat because of new detection methods. Arteries can be cleaned out. Who knows what miracles are in store? The future course of medical technology, especially over long periods, is radically uncertain. Of course, he can try to offset some of the heart-related dangers of smoking by exercise and controlling his weight. In fact, he enjoys sports and doesn't have a particularly strong sweet-tooth. How much all these counter-measures will help is not definitely known. In terms of family history, his mother lived until 95 but his father died at 70. He father never smoked but his mother did. How much weight he should give to his own parents' atypical outcomes versus general population statistics related to smoking, he does not know.

He has all these things to consider. But there is more. When costs are hypothetical, they do not seem as "real" (salient) as when they are experienced. The planning self may only have a general idea of what it means to break a nicotine habit. The acting self may feel it acutely. Neither self is right or wrong, just different.

The dialectical reasoner goes over the various aspects of the problem: *first* from this point of view (the doctor warning him) and *then* from that point of view (the possibility that new technology may make the costs much lower), and *another time* from a third point of view (his "indoctrinated" young child telling him that his teacher said smoking is bad). So the same issue is revisited time and again, with perhaps different and incompatible (smoke; don't smoke) tentative decisions planned each time.

Often this kind of decision is modeled by behavioral economists as if the individual is planning to stop smoking on the basis of a deductive choice-inference given his data (the "rational" choice), but then he simply does not

have the "willpower" to go through with it.[10] The second decision is viewed as a decision-making defect or inconsistency.[11] But the label "inconsistency" is awkward. In one sense the word doesn't apply. Logical consistency refers to a relationship among propositions that are held at one moment in time. The actions themselves take place at different points in time, so there is no question of true logical inconsistency among statements reporting the facts of his behavior. The only way the economist can see this as inconsistency is if he explains both behaviors (say, planning and not implementing) by one utility function that the agent has in his "mind" *at every instant in time*. In the widely used behavioral model known as quasi-hyperbolic discounting, his utility function has built into it a high short-term discount rate ("present bias") that affects him at the moment of choice and a lower long-term rate that he uses in planning before that moment. So the inconsistency *per se* may be an artifact of the modeling technique. Economists, in general, do not like utility functions to change. Therefore, they try to model changing behavior as if it were the execution of a single plan. Here the plan is an inconsistent one.[12]

Alternatively, from the dialectical perspective we may have changing tentative plans. At one moment the individual sees things in such a way as to plan to stop smoking; at another moment he may decide that this plan is in error and decide to throw it out or modify it. In each case he has reasons for what he does. Thus in a very basic sense his behavior is not "irrational." However, it is not *settled* rationality. He is not in equilibrium. He continues to revisit the issue *time and time again* without a definite decision. This does not imply that he never makes a final decision, but that it seems reasonable to say that we often see people in the midst of thinking things through. They are quite literally making up their minds.[13] We see no reason to regard that as irrational.

[10] Alternatively, this can be modeled as "present bias."

[11] The reader should be alert to the distinction between the agent himself viewing this as a defect and the behavioral economist viewing it as a defect.

[12] Having modeled the individual in this way, the normative behavioralist then criticizes the individual for being inconsistent.

[13] Some behavioral economists and philosophers like to view decision problems like quitting smoking or dieting as having a "weakness of the will" component. The idea is very old. Socrates, according to Plato, argued that it is not possible to truly know what is better (for yourself, not necessarily society) and yet do the worse. Aristotle argued that it was possible. There can be a gap between our knowledge and our willingness to act. The idea is called akrasia or weakness of the will. Behavioral economists want to argue the latter so that they can say we have "true preferences" based on our reason but cannot implement the satisfaction of these preferences. The view implicit in standard economics is the Socratic. In either case, the matter reduces to which non-falsifiable framework seems more useful. For normative purposes, however, there is also a moral commitment or perspective here that seems more the provenance of the individual rather than the behavioral economist or "society." See, in general, Rizzo (2016).

3.1 Framing Inconsistency

The previous discussion considered a plausible process whereby an individual settles on a course of action or a consistent plan of actions. The process ends, if it does at all, in definitively setting up a framework of pre-ordered preferences, options, and constraints. There is, however, another aspect of this process. This is how the agent *understands* the options before him (Schick, 1991). Schick illustrates this point with a story of George Orwell's experience in the Spanish civil war. Orwell wanted to kill fascists. But when he saw one running with his pants falling down, he viewed him not as a fascist but as a fellow human being. Orwell realized that the two propositions "There is a fascist in the field" and "There is a fellow human being in the field" *report the same fact*. To put matters in our terms, the two frames are equivalent. They point to the same person. This is what philosophers call "ostensive equivalence." However, let us assume that Orwell was initially unsettled about his way of seeing this fact, that is, he was unsettled in his understanding. So now he sees the man as a fascist; then he sees the man as a fellow human being. If he should see the man as a fascist, he would shoot him; if as a fellow human being, he would not. In neither of these cases are Orwell's pre-ordered preferences nor his beliefs (including constraints) different. And yet depending on the frame, Orwell's decision would be different.

If an analyst were to "photograph" Orwell under one frame and then under the other, "inconsistency" might be asserted. After all, preference orderings, options, and constraints are the same in each photo but the decision outcome is not. The comparative static viewpoint seems to expose an irrationality or an instance of less-than-perfectly-rational behavior. Is one of these understandings the right one and the other the wrong one? Without bringing in our own moral values, it is difficult to argue that Orwell should have seen things in one way rather than another. So in either case, taken separately, there seems to be no defect of rationality. But is Orwell being less-than-rational in not unambiguously choosing or accepting his frame *ex ante*? Or if he initially settles on one and then changes, is he somehow defective from the perspective of rationality?

First, if it is normatively allowable, as we argued above, for individuals to take time in arranging or creating the "data" of their situation as a consistent whole, then it would also seem allowable that they can take time in settling on a way of understanding that data. Second, there is no violation of normative standards if he settles on one understanding and then shifts to another. Today Orwell may see a fascist. And tomorrow, in the same objective circumstances, he may see a fellow human being. Today he shoots; tomorrow he does not. It seems superficial to say that he is inconsistent. He is "inconstant" to be sure, but within each frame he acts consistently with his understanding at that time. Indeed, "[e]xpected utilities . . . depend on the understandings the agent has,

and different understandings might establish different expected utilities for him" (Schick, 1991, p. 87). Thus rationality in the standard sense is relative to the agent's understanding. And we are arguing that understandings themselves may be neither rational nor irrational in the standard sense.[14]

4 Errors and Learning

When people are in the process of learning they make errors. It is likely that their errors are not completely random because they will be generated by previous frameworks and conceptions of the world. Thus the errors may be explicable in terms of some theory. A static analysis of behavior may reveal systematic and predictable errors as in cases where, for example, people initially ignore or underweight base rates.[15] Nevertheless, in both animal and human experiments, learning appears to be driven by errors. In the classic "blocking experiments," if a reward is fully predicted by a given pre-trained stimulus the individual will stop learning (Schultz, 2004; Schultz and Dickinson, 2000). Specifically, when a new stimulus with no predictive value is paired with the fully-predicting stimulus, the individual loses his ability to learn that this new stimulus is associated with the reward. The first predictive stimulus blocks learning about the new one. The latter is informationally redundant; it has no marginal predictive value. Thus, nothing is learned from it. On the other hand, if a given initial stimulus is not established as a predictor of the reward and is paired with a new stimulus, then, after several successful trials, individuals will learn to associate this new stimulus with the reward. In this case the new stimulus is a much better *marginal* predictor than in the first case.

Looking again at the first case, we can see that there are no predictive errors in that experimental learning context. But in the second there are predictive errors since neither of the stimuli have complete predictive value.

[14] However, in some cases two equivalent understandings (frames) can convey or express different information and thus operate on beliefs. Consider the description of a medical treatment. It can be offered to a patient as one that has a survival rate of p or a mortality rate of (1-p). Assuming that all the patient cares about is survival, does either of these logically equivalent statements convey different information – are they informationally equivalent? In many contexts it appears that they are not. McKenzie and Nelson (2003) show that people select and interpret the different logically equivalent formulations when they are implicitly comparing the result relative to a norm or expected result. The p-description is more likely when the framer is conveying that the survival data is better than might be expected, that it may be better still if certain structural features in the world have changed, or if there is reason to think that in the case at hand the degree of belief in a successful result is greater than the statistical frequency. See also Sher and McKenzie (2006).

[15] The real issue in a classical Bayesian framework is whether they ignore prior probabilities. Often the identification of base rates and prior probabilities is made. See Tversky and Kahneman (1980).

The predictive error is the difference between the actual reward and the predicted reward.[16] The critical point is that only in the second case does learning take place. The prediction errors generate learning processes. Without them there is no learning (Schultz and Dickinson, 2000, p. 476).[17]

When individuals expect more reward than they get, there are negative prediction errors. This causes the strength of the association between the predictor and the reward to weaken. The individual will predict a lower value of reward because either the magnitude of the actual reward or the probability of its occurrence is lower or both. At each trial or stage in the learning process there is a reduction in predictive quality of the signal-event or stimulus. These reductions accumulate until prediction errors are extremely small and learning ceases (Schultz and Dickinson, 2000, p. 477).

This picture of the importance of prediction errors in generating learning processes is largely based on behavioral experiments. However, parallel to the behavior are supporting neuronal processes. Neuronal learning also depends on reward prediction errors. Unexpected rewards induce activation of dopamine neurons while unexpected omission of rewards induces depression of neuronal activity (Schultz and Dickinson, 2000, p. 482). While this has been clearly documented in animals, it has also been found to be the case in human subjects who were given juice rewards and were faced with situations of instrumental learning similar to those discussed above (Tobler *et al.*, 2007).

When an individual predicts that he will experience a certain reward as a consequence of his action but does not, dopamine neurons and other neurons emit a negative signal in the form of decreased activity (Waelti *et al.*, 2001). If there is unexpectedly no reward at all, then the behavior oriented toward attaining the reward ultimately stops (Schultz, 2000, p. 200). In effect, there is "unlearning." When an individual predicts a certain level of reward (say, duration or intensity) but the level is lower than expected, there is also depression of neuronal activity. In this case there is partial unlearning in the sense of reduced association of stimulus and reward. Behaviorally, there is a reduction in approach or consumption activity (Schultz, 2006, p. 94).

These supporting neuronal and behavioral responses to prediction error are roughly what we should expect on the part of broadly rational actors. Predictions are updated and behavior is adjusted. It may also be the case that brain mechanisms effect these adaptations in an efficient manner. It is suggested that "[r]ather than processing the full and often redundant amount of

[16] More exactly, "[r]eward prediction errors usually represent the scalar difference in value (magnitude × probability) between a delivered and predicted reward" Schultz (2004, p. 142).

[17] "Outcomes whose magnitude or frequency is different than predicted modify behavior in a direction that reduces the discrepancy between the outcome and its prediction. Changes in predictions and behavior continue until the outcome occurs as predicted and the prediction error is nil. No learning, and hence no change in predictions, occurs when the outcome is perfectly predicted" (Schultz and Dickinson, 2000, p. 476).

incoming or outgoing information, neurons may simply compute the differences between the predicted and current input or output, thereby making neuronal processing more efficient." (Schultz and Dickinson, 2000, p. 494).

4.1 Systematic Errors

As discussed above, errors are not simply by products of decision-making; they are drivers of better decision-making. To the extent that individuals learn from errors, the errors cannot be inherently random; they must be associated with frameworks that generate them. The systematicity of errors within some framework is the key to the discovery of new frameworks and better methods of coping with the environment. In new and unfamiliar contexts, especially, people will make systematic errors for a certain period of time. The precise length of time it takes to learn will vary from problem to problem and environment to environment as well as with the learning propensities of the individual. This process will only be visible if we follow an individual through time. Static or cross-sectional "photographs" of individuals may give the impression of persistence, in the sense that when these errors are tested for in a large population we "always" find them. But a processual view may reveal a different story of individuals learning in real time even though there will always be, at any given point in time, some fraction of the population making errors. Errors and therefore learning are always taking place.

Finally, there is another sense in which systematic errors are a part of the learning process. Suppose that an individual could only remember a series of three or four words. Once a speaker goes beyond that number of words, the listener cannot remember the first part of the sentence. His memory failure is systematic and persistent. Wouldn't it be good if he could remember a longer series of words? Not necessarily. Gigerenzer (2005) discusses psychological research that shows this very type of memory failure by small children helps them learn a language. They first master the meaning of words and grammatical structure in small sentences, ignoring the more complex sentences with clauses and big words. The ability to ignore the latter is crucial to their ability to learn a language. In fact, a neural network with enormous memory would not do as well as a child with limited memory.

Thus cognitive limitations, even of a systematic and persistent kind, can be part of the learning process. "Errors" must be viewed in the context of other, associated cognitive processes.

4.2 Learning – Sort of

Much of the current work by economists on learning in the context of behavioral anomalies straddles the fence between comparative static and true processual accounts. This is because no particular learning mechanism is postulated.

Furthermore, behavioral research on learning tends to be dominated by the idea that a rational equilibrium consists in the satisfaction of standard neoclassical choice axioms and their implications. The idea that ecologically or adaptively rational behavior rather than the standard criteria could be the endpoint of a process is not considered. Finally, behavioral research on learning seems to accept the view of equilibrium in which at some point the equilibrium of the individual is actually attained in real time. Nevertheless, these studies do adopt the premise that rationality is not "complete" *ex ante*, and therefore they constitute a significant improvement over the usual completely static perspective.

The main difficulty in learning about learning experimentally is the relatively short time span of most experiments.[18] Nevertheless, progress has been made especially in field experiments. In a sports card trading experiment, List (2003) found that the endowment effect in the form of deviations of willingness to accept payment from willingness to pay are largely eliminated after trading experience. Similarly, under-trading (another symptom of the endowment phenomenon) dissipates after six months of trading experience (List, 2011). To avoid confounding the experience effect with a self-selection effect, List (2011) and List and Millimet (2008) randomly assign participants to the experience treatment of the experiment. Again, experience seems to erode GARP[19] violations in the first case and the endowment effect in the second.[20] Relatedly, Castillo *et al.* (2008) suggest that it is not experience per se that erodes non-standard behavior but experience in *competitive* markets. Interestingly, they find that those working in competitive labor markets act in accordance with expected utility theory and hence do not exhibit loss aversion (one of the claimed causes of the endowment effect).[21]

5 Conclusions

The static character of rationality norms, accepted by both neoclassical and behavioral economists, hides a more interesting and profound form of rationality. Real human beings do not make decisions instantaneously and without error. Nor do they know all of their goals, and their fully specified willingness to trade them off against each other, prior to making any decisions. Nor do

[18] Of course, the comparison of the behavior of novices and experts in some task may shed light on the effects of learning or experience.

[19] The Generalized Axiom of Revealed Preference is a requirement for consistent choice and the existence of a standard utility function.

[20] In a study of market behavior in rural Ethiopia 98.5% of farmers and 81.8% brokers originally had at least one GARP violation. After market experience these percentages fell to 73.1% and 58.3% respectively. See Cecchi and Bulte (2013).

[21] However, Castillo *et al.* (2008) are not able to distinguish between sorting of individuals into a particular market and experience in that market.

they hold beliefs that are instantaneously consistent with each other and the world. Forming one's preferences and beliefs is a process, and therefore it seems natural to evaluate them in terms of that process. In doing so, we find that the static approach implicitly conflates rationality with a form of omniscience. If our normative standard is the flawless or optimal solution to problems as defined and understood by the analyst, we will no doubt find many violations of "rationality." However, these may not be the agent's problems. They may be problems of inadequate and superficial analysis, driven by the analyst's static conception of rationality. As an alternative, we suggest the possibility of a process-driven account of rationality that includes a role for intrapersonal bargaining and arbitrage, dialectical reasoning, responsiveness of alleged biases to cost, and learning in response to error. Such an account would surely be preferable on normative grounds, but it also holds the promise of better positive accounts of human behavior.

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