Chapter 6

Don't Blame the Norm. On the Challenge of Ecological Rationality

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Abstract. Enlightenment thinkers viewed logic and mathematical probability as the hallmarks of rationality. In psychological research on human (ir)rationality, human subjects are typically held accountable to this arcane ideal of Reason. If people fall short of these traditional standards, as indeed they often do, they are biased or irrational. Recent work in the program of ecological rationality, however, aims to rehabilitate human reason, and to upturn our traditional conception of rationality in the process. Put bluntly, these researchers are turning the tables on the traditionalist, showing that human reasoning often outperforms complex algorithms based on the traditional canons of rationality. If human reason still appears paltry from the vantage point of capital-R Rationality, then so much the worse for Rationality. Maybe the norms themselves are in need of revision. Perhaps human reasoning is *better than rational.* Though we welcome the naturalization of human reason, we argue that this backlash against the classical norms of rationality is uncalled for. Ecological rationality presents two apparent challenges to the traditional canons of rationality. In both cases, we contend, the norms emerge unscathed. In the first category, norms of rationality that appear violated by individual reasoners re-emerge at the level of evolutionary adaptation. In the second category, the norms under challenge simply turn out to be not applicable to the case at hand. Moreover, we should keep in mind that, when they are assessing the efficiency of human reasoning, advocates of ecological rationality still use the traditional norms of rationality as a benchmark. We conclude that, even if we accept all the fascinating findings garnered by the advocates of ecological rationality (and there is ample reason to do so), we need not be taken in by the rhetoric against classical rationality, or the false opposition between logical and ecological rationality. When the dust has settled, the norms are still standing.

1. Introduction

The rationalist tradition of the Enlightenment conceived of human reason as a unique and defining faculty lifting us above the realm of nature and radically separating humans from animals (Talmont-Kaminski, 2007). The canons of rationality, according to Enlightenment thinkers, were logic and mathematical probability. Of course, Enlightenment thinkers were well aware that the average human falls short of this ideal. In practice, they admitted, reason is often clouded by prejudice, emotion and magical thinking. In one of the dualities typical of Enlightenment thinking, rationality was set in stark contrast to the dark and

irrational forces of human nature. Irrationality, indeed, was characterized as a different mode of thinking altogether, a *sui generis* form of deficient reasoning.

In the wake of Darwin's theory of evolution by natural selection and the maturation of psychology as a scientific discipline, human reason has been brought down to earth. Human rationality is a natural faculty acquired over a long process of undirected evolution, not a spark of divinity separating us from the lower animals. Still, the traditional canons of rationality were upheld as a yardstick to measure the performance of human reason. Not that human reasoning lived up to the ideal. As cognitive psychologists began to investigate actual human reasoning, they amassed a wealth of evidence that is quite an embarrassment to our self-image as Rational Animals: we suffer from all sorts of incorrigible biases and commit elementary fallacies of logic and probability. Popular summaries of research on irrationality are fond of putting humans down: we are characterised as stupid, irrational, mindless, biased and stubborn (Sutherland, 2007; Singer & Benassi, 1981; Shermer, 2011; Ariely, 2009; Piattelli-Palmarini, 1996; Polonioli, 2013). De-biasing efforts seem undertaken to little avail, or even backfire: we often fail to learn from our mistakes. Many share the sentiment expressed by Bertrand Russell: "Man is a rational animal—so at least I have been told. Throughout a long life, I have looked diligently for evidence in favor of this statement, but so far I have not had the good fortune to come across it." (Russell 2009, p. 69)

Luckily, *Homo sapiens* is not completely beyond the pale. The psychologists who have documented and corrected our mistakes are members of the human species, after all. If they can spot the errors of their fellow human beings, then perhaps we can correct each other's blind spots, and all is not lost. This line of reasoning assumes, however, that those who chastise human reason are not deluded themselves. Psychologists, when accusing their subjects of cognitive error, usually use some established rule of logic and probability as a benchmark. (Nisbett & Ross 1980; Kahneman, Slovic *et al*. 1982). But what if the norms themselves are in need of revision? Perhaps human reason looks irrational only because we are applying bad or inappropriate norms.

This is exactly the promise held out by the program of *ecological rationalit*y. Launched by Gerd Gigerenzer & Peter Todd in the late 1990s, and mostly centered around the Adaptive Behavior and Cognition (ABC) centre in Berlin, this research program aims to unseat our traditional view of rationality and thereby rehabilitate human reason. Starting from the finding that our simple heuristics perform very well in ecologically valid contexts, even outperforming algorithms based on classical rationality (on which more below), these researchers have turned the tables on Classical Rationality: if human reason appears paltry seen from the vantage point of Rationality, then so much the worse for our capital-R ideal of Rationality. In other words: down with the norms.

Is this backlash against traditional normative criteria of rationality warranted? We explore two ways in which the program of ecological rationality might seem to pose a threat to the classical norms. In both cases, we will see that the norms are actually left intact. First, by presenting the prowess of human reasoning in an "ecologically valid" context, defenders of ecological rationality have not so much jettisoned the traditional norms as relegated them to the locus of evolutionary adaptation. The "rationality" of human cognition simply re-emerges at the evolutionary level. Sensible "decisions" made by evolution (i.e. solutions to adaptive problems) may translate into mindless or even norm-violating behaviour at the level of individual reasoners. This point is based on the concept of *locus shift*, which we developed in an earlier paper, in the context of human irrationality (Boudry, Vlerick, & McKay, 2015).

Second, we discuss cases where human reasoning *appears* to violate some norm of rationality, but on closer inspection, these instances simply fall outside the domain of application of those norms, through no fault of the latter. Again, the norms are left standing.

Once the dust has settled, the backlash against traditional canons of rationality seems unwarranted. Traditional conceptions of rationality remain valid after the human mind has been thoroughly naturalized.

2. Ecological Rationality

The debate over human rationality has been waged for decades (Stein, 1996; Evans & Over, 1996; Krueger & Funder, 2004; Stanovich & West, 2000; Mercier & Sperber, 2011). Ever since its emergence in the 1970s, the heuristics and biases program spawned by Kahneman and Tversky has had its detractors. For example, psychologist David Funder lamented the negative slant in much cognitive and social psychology (Funder, 1987), particularly the bad habit of interpreting any deviation from content-blind norms of reasoning as *ipso facto* demonstrations of "irrationality". This "one-sided emphasis on what people do wrong" (Funder, 1987, p. 83) results in an endless compendium of fallacies and biases, with little understanding of underlying cognitive processes. In a paper co-written with Dianne Krueger, he writes that many of his colleagues still have an "inordinate fondness for errors" (Krueger & Funder, 2004, p. 317). One could take Funder's lament one step further: what if there were no errors in the first place? What looks like an error, viewed from an idealized angle, may turn out to be a successful judgment in real life. Proponents of *ecological rationality* have argued precisely this, challenging the bleak view of human reason. Many of the classical demonstrations of irrationality, fallacies and illusions (Kahneman, 2011; Kahneman *et al.*, 1982), they claim, evaporate once we view human cognition in its proper ecological framework.

Gigerenzer sees a clash between two competing conceptions of rationality. The traditional view is based on the content-free canons of logic and probability theory, whereas ecological rationality consists of an "adaptive toolbox" of heuristics (Todd & Gigerenzer, 2012; Gigerenzer & Todd, 1999; Gigerenzer, 2008), each suited to a particular set of challenges endemic to a particular environment. In contrast with unbounded models of rationality, which typically assume unlimited resources both with regard to information gathering and computational processing, ecological rationality is "fast and frugal".

In order to appreciate the ecological rationality of a heuristic, one needs to look at the way in which it exploits the structure of the environment (Gigerenzer & Todd, 1999, p. 13). Environment and cognition work hand in hand to produce good judgments and smart decisions. In Herbert Simon's famous metaphor, mind and environment act like two blades of a pair of scissors (Simon, 1955). As Gigerenzer argues, rationality does not reside in the mind alone, but is a feature of the mind plus the environment.

Fast and frugal heuristics are quick and computationally cheap, requiring few and simple computational steps, and working on a limited input. Based on the traditional conception of rationality, one would expect that such quick-and-dirty rules sacrifice accuracy for frugality and speed. More information and computation, after all, can only improve judgment. Gigerenzer and colleagues have challenged this common wisdom, documenting many cases in which ignoring information leads to better decision-making. "Humans and other animals rely on heuristics in situations where these are ecologically rational, including situations where less information and computation lead to more accurate judgments" (Gigerenzer *et al.*, 2011, p. 261). One striking instance of such less-is-more effects is the recognition heuristic, whereby people take advantage of their own ignorance to derive inferences about the unknown. In judging which out of two German cities has a larger population, for example, people use name recognition as a cue for population level. If they recognize only one city, they assume that must be the most populous one. A certain

level of ignorance, it turns out, is the secret to excellence in this task (Goldstein & Gigerenzer, 2002).[1] The recognition heuristic has been shown to be remarkably successful in a wide range of domains. For example, a stock portfolio consisting of companies recognized by naive passers-by has been demonstrated to beat market analysts and financial experts (Borges *et al.*, 1999).

Gigerenzer has also demonstrated cases where ignoring information leads to better decision making. There is a family of heuristics for making decisions based on one reason only. The take-the-best heuristic, for example, chooses between two items by searching for the first cue that discriminates between them, and ignoring all the other cues. Again, one would expect that such simple-minded heuristics would perform worse than more complex decision algorithms that integrate the information of different cues. But this turns out to be false: one-reason decision is highly successful in a range of circumstances.

Fast and frugal heuristics seem to violate one of the cornerstones of our traditional conception of rationality: the assumption that more information and computation leads to better decisions. How can ignorance possibly lead to better decisions than knowledge? How can someone who knows less about German cities be at an advantage on this topic compared to a more knowledgeable person? Less-is-more effects in ecological rationality, where using less information leads to better decisions, seem to violate what Rudolf Carnap has called the *principle of total evidence* (Gigerenzer & Sturm, 2012), according to which the rational course of action always takes into account all available information.

Nothing beats success, says the proponent of ecological rationality. If decision rules based on classical norms of rationality fail, then we should reject those norms. In the real world, the content-blind norms of classical rationality are not "reasonable norms" (Gigerenzer, 2008, p. 12), because the real world is too messy and complicated to be captured by formal norms of rationality, and because human reason has "other goals than logical truth or consistency" (p. 12). If you use the classical norms as a benchmark for human reasoning, all you end up with are spurious demonstrations of "irrationality" and "simple-mindedness" that fail to do justice to human reasoning: "Often what looks like a reasoning error from a purely logical perspective turns out to be a highly intelligent social judgment in the real world" (Gigerenzer, 2007, p. 103). In a recent volume on adaptive rationality, Fiedler and Wänke (2013) wrote: "At the normative level, we have seen that absolute, unique standards of rationality can hardly be upheld." The traditional canons of rationality must be supplanted by a new set of ecological canons – enter ecological rationality.

In the next section we show how the tension between classical and ecological rationality rests on a false opposition, based on a slippage between different *loci* of rationality. The program of ecological rationality need not lead to a backlash against classical rationality. It is possible to defend human reason without relinquishing classical canons of logic and probability.

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[1] Support for the ecological conception of human reason has also come from evolutionary psychology, in particular adaptationist analyses of human reason in the Santa Barbara school. Evolutionary psychologists are not surprised that the human mind is better designed than the pessimists would have us believe. The human brain is the craftwork of natural selection, after all, and evolution does not tolerate slapdash engineering (Pinker, 1997, but see Boudry & Pigliucci, 2013). Evolutionary psychologists Haselton & Nettle have urged us to dispel the "unnecessarily dreary outlook on human cognition" (Haselton & Nettle, 2006, p. 62).

3. Evolutionary Rationale

Ecological rationality resides not so much in either blade of Simon's pair of scissors (mind/environment), but in the alignment of the two blades. But what process ensures that the blades align? In principle, research on fast and frugal heuristics is neutral with respect to how heuristics originate. Some may be constructed on the basis of learning or experience, some may be innate. And there are intermediate possibilities: for example, it may be the case that we have an innate toolbox of heuristics, but still need to learn under what conditions to use them (Hutchinson & Gigerenzer, 2005). In the end, however, the fundamental building blocks of cognition are the result of evolutionary processes. The work of Gigerenzer & Todd contains little explicit evolutionary theorizing, but they do acknowledge the ultimate evolutionary origins of heuristic reasoning: "evolution would seize upon informative environmental dependencies such as this one and exploit them with specific heuristics if they would give a decision-making organism an adaptive edge." (Gigerenzer & Todd, 1999, p. 19)

In other words, natural selection has aligned our minds with the environment, equipping us with an adaptive toolbox for navigating the world. But evolution often leaves animals perfectly clueless about the rationale for their behavior (Hutchinson & Gigerenzer, 2005; Sterelny, 2006). Just as the spider has no idea of the intricacy of her web, and the cicada has no clue about prime factoring, human reasoners can be blissfully unaware of the rationale for their heuristics. In a previous paper, we have argued that, though it is important to appreciate the evolutionary roots of human reason to understand its foibles, we should be wary of a certain *locus shift* in attributions of rationality (Boudry *et al.*, 2015). In some of their arguments, advocates of ecological rationality have tried to get human reasoners off the hook by providing an adaptive rationale for their weird beliefs (e.g. superstitions). But human folly is perfectly compatible with adaptive behaviour. Sometimes, given costs and energy constraints, the most fitness-enhancing strategy is the mindless or stupid one. This distinction between the evolutionary and individual locus of rationality, introduced in our earlier paper, is also helpful to clarify the confusion about norms of rationality.

Heuristics are the proximal implementation of evolutionary adaptations. If we argue that the traditional norms of rationality stand in need of revision because certain evolved heuristics, while demonstrably successful, seem to violate them, we are oblivious of the evolutionary process which shaped these heuristics. Much of the "credit" for the R&D of fast and frugal heuristics, particularly of course in the lower animals, does not pertain to the executive control of the organism itself, but to the evolutionary process responsible for its cognitive make-up. This means that, if the decision rules and heuristics enacted by human reasoners flout the traditional canons of rationality, while being 'successful' nonetheless, we should not jump to the conclusion that those standards of rationality are otiose. "Seizing" upon informational dependencies in the environment, as evolution did, by implementing simple heuristics to exploit them, is hardly a violation of the traditional standards of rationality.

Evolution, to be sure, is a mindless process, but that is irrelevant to the current point about the locus of rationality. If heuristics are successful, that is because evolution has been able to track recurrent statistical properties in the environment, and has equipped us with the appropriate cognitive mechanisms to successfully navigate that environment. *These* statistical principles, it will turn out, do not violate the traditional canons of rationality. If we can reach better decisions by ignoring information, this is because evolution by natural selection has first "learnt" when it is useful for an organism to do so. This is not magic or cognitive luck. Without the preceding R&D work carried out by evolution, stumbling in the dark would be a very bad idea indeed.

In contrast to other animal species mindlessly using their evolved heuristics, humans have unprecedented higher reasoning faculties with which they can reconstruct and spell out their own intuitive heuristics. Thanks to the human invention called 'science', we can identify the underlying statistical principles *and* explain why they work so well in the real-life contexts in which they are being applied. However, in order to appreciate the effectiveness of our heuristics in their proper environment, we need the tools of classical rationality. We use Bayesian probability theory to evaluate the performance of different heuristics against classical approaches (Martignon & Laskey, 1999). Moreover, we need these same tools of classical rationality to *understand* the statistical principles underlying the success of fast and frugal heuristics.

The success of simple heuristics is not miraculous. It is based on solid statistics. By using the tools of classical rationality, we also understand why simple rules of thumb are not *always* better. Statisticians can now identify the conditions under which simple heuristics outperform or are beaten by complex decision-making strategies. In complex, noisy environments with a small sample size, simple heuristics outperform more complex and information-hungry algorithms. That is because the latter have the tendency toward overfitting, translating noise into complex patterns. With larger sample size and less noise, by contrast, complex weighting strategies have an edge. Philosophers of science have begun to appreciate the rationale behind our intuitive preference for simple explanations, and now see that the value attached to parsimony in science is not a purely aesthetic one (Forster & Sober, 1994; Hitchcock & Sober, 2004). In a way, they are rediscovering what natural selection "knew" all along.

For example, when we employ the recognition heuristic, we intuitively rely on statistical correlations holding between the probability that an item is recognized and the value of interest. If the heuristic is to work, this "recognition validity" needs to outweigh the "knowledge validity", which is the probability of giving a correct answer when both items are recognized. In other words, your ignorance must be more valuable than your knowledge. Evolution must have hit upon this rationale, even though it is not inscribed anywhere in our brains or in our genes. What this means is that classical rationality *itself* is not threatened by the victory of simple and frugal heuristics over Bayesian networks, multiple regression or other standard approaches. In fact, the traditional approaches are needed to show why in certain contexts the particular heuristics with which evolution endowed us outperform traditional algorithms.

Apart from the fact that you actually need the traditional canons of rationality to appreciate the excellent performance of heuristics, there is another problem with the view that the success of heuristic-based reasoning casts a bleak light on classical rationality. Suppose that an engineer is asked to design robotic life forms that are capable of surviving on a distant planet. Such an engineer may equip her creatures with simple decision rules if she knows that those will prove useful in the particular environment in which she intends the robots to live. The creatures may blindly use these heuristics, because there is no need for them to know anything about the structure of the environment. If the designer has done her job well and the heuristics are successful, however, we would be mistaken to conclude that the "simple-mindedness" of these robots violates the traditional conception of rationality. The ultimate rationality of these heuristics does not reside in their decision rules, after all, but in the foresighted work of their designer. The robots were just programmed to carry out the designer's instructions. The programmer is calling the shots, and for her the benchmark will still be the familiar framework of statistics, Bayesian updating, logic, etc. The same goes for that blind engineer we call natural selection. What underlies the success of heuristics is precisely the statistical and logical relations that natural selection has exploited. Indeed, if the ancestral environments had been such that, say, the average validity of the recognition cue were low (weighted over fitness costs and

benefits), then evolution would not have endowed us with the recognition heuristic in the first place. In a similar way, an engineer who develops a computational toolkit for a robot to survive in a novel environment will only design and implement heuristic principles if they promote success in the kind of environment that the robot will encounter.

It is tempting to think that the remarkable success of fast and frugal heuristics flouts the standards of rationality, if you focus only on the proximal implementation of these heuristics. For example, as a violation of the rationality of coherence norms, Gigerenzer mentions that prey animals often display "inconsistent behavior" when interacting with their predators, to reduce the predictability of their behavior (Gigerenzer & Todd, 1999, p. 22). But this is hardly a violation of coherence norms. When taking penalty shots, soccer players are trying to outsmart the goalkeeper: the goalkeeper tries to predict which corner the shooter is going to aim at, while the shooter tries to behave in an unpredictable manner, possibly also tricking his opponent into *thinking* that he (the shooter) is predictable (and then aiming for the other corner). Nothing in this strategic game violates coherence criteria of rationality: a rational agent can decide to engage in unpredictable behavior for strategic reasons. Whether or not hunted animals engage in any *conscious* deliberation as to what their next move will be, it is clear that the logic of deception and counter-deception is undergirding their behavior (von Hippel & Trivers, 2011). If the animal hasn't figured this out, then surely evolution must have. As Dennett wrote, if we discover that an animal is too simple-minded to harbor an adaptive rationale, we do not discard the rationale, but are simply forced to "pass the rationale from the individual to the evolving genotype" (Dennett, 1983, p. 351).

3.1   *General and Content-Free Rationality*

At the level of the heuristic-wielding organism, reasoning looks like a jumble of simple tools and tricks. But the rationality that arises at the evolutionary level is general and context-free in the sense envisaged by proponents of classical rationality. Natural selection is a content-free and general process, an abstract algorithm that works whenever certain minimal conditions are satisfied (variation, heritability, differential reproduction) (Dawkins, 1983; Dennett, 1995). It "learns" by aggregating statistical information about the success of various genotypes in various environments. It does not learn by using a bag of tricks. This mindless process produces only a simulacrum of rationality (de Sousa, 2007), but it is a simulacrum that respects the norms of classical rationality, and that we can understand using classical tools. For example, the theory of error management in evolutionary biology (Galperin & Haselton, 2012; Haselton & Buss, 2000) is essentially an application of expected utility theory and signal detection theory to adaptive problems encountered by evolution.

There is thus something ironic about the claim of evolutionary psychologists Tooby and Cosmides that human reason is "better than rational", in the sense that it beats traditional methods:

> For the problem domains they are designed to operate on, specialized problem-solving methods perform in a manner that is better than rational; that is, they can arrive at successful outcomes that canonical general-purpose rational methods can at best not arrive at as efficiently, and more commonly cannot arrive at all. Such evolutionary considerations suggest that traditional normative and descriptive approaches to rationality need to be reexamined. (Cosmides & Tooby, 1994, p. 329)

In a trivial sense, this cannot be true. If simple heuristics breed more success than sophisticated methods in certain environments, given some agreed goal or benchmark, then

ipso facto it is (instrumentally) rational to prefer these heuristics. It is rational to prefer methods with demonstrable success. More importantly, the only reason why our fast and frugal heuristics outperform general-purpose methods of rationality is that they were designed by a general-purpose information-processing algorithm in the first place: evolution by natural selection. If evolution had not done the hard work for us, we would be stumbling in the dark. Or we would not be here at all. Tooby and Cosmides, of all people, should be sympathetic to this point.

If one loses sight of the crucial role of evolution in aligning the two blades of Simon's pair of scissors, the proficiency of our heuristics and intuitions seems almost miraculous, or a matter of sheer luck. Matheson (2006, p. 142) worries that the program of ecological rationality situates rationality "partly outside of the mind", as heuristics are only successful relative to a certain environment. This would amount to a form of "cognitive luck", according to Matheson, which abandons one of the central tenets of the Enlightenment view of rationality, according to which rationality inhabits the mind alone. But how could we be the source and imprimatur of our own rationality? There was a time when there were no humans around. If the source of our rationality were "wholly within our minds", as Matheson put it, we would have pulled ourselves up by our own hair, a godlike feat. It would be more accurate to say that Gigerenzer's program shifts part of the credit for the "rationality" of human behavior to the evolutionary process giving rise to it. It is evolution by natural selection that ensures that there is a *match* between our mind and the environment. This may be a fortuitous arrangement as far as human beings are concerned (at least most of the time), but it is certainly not a matter of *accident.*

4. Individual-level rationality

The traditional canons of rationality have not been vanquished. They have merely been relegated to the locus of evolutionary adaptation. As Orgel's second rule has it, Evolution is cleverer than we are. In our previous paper on the program of ecological rationality (Boudry *et al*., 2015), however, we discerned a second strand in the research spearheaded by Gigerenzer, which does not involve any adaptive locus shifts. This second strand argues that experimental demonstrations of "irrationality" are often the result of artificial set-ups, which truncate the nuances and complexities of real-life contexts. Psychologists hold subjects accountable to a norm of reasoning that simply fails to capture the ecological complexity of real life.

Take the phenomenon of preference reversals, which have (previously) been interpreted as a form of inconsistent behavior, violating the norms of transitivity (if A < B, B < C; then it follows that A < C). Recent research, however, shows that such behavior can be seen as adaptive, provided we take into account the changing context under which decisions are being made (Schuck-Paim *et al.*, 2004). For instance, the organism may be in (slightly) different states when making choices, which affects the fitness value assigned to A, B and C. Does this show that there is anything wrong with coherence criteria of rationality? No. If choice A turns out to be valued differently by the organism, depending on the context, there is no such thing as 'the' fitness value of A, and the alleged violation of transitivity disappears. Houston *et al.* (2007) have also shown that 'intransitive' behavior may be fitness-maximizing even if the organism is in the same state when making different choices. In their model, the organism is presented with two out of three alternatives each time (A or B; A or C; B or C), while having varying internal energy levels. Within a certain range of energy levels, choices across settings may appear intransitive, for instance ranking A over B, B over C, and C over A. This phenomenon occurs because the availability of an option,

even when not chosen, changes the fitness value of the preferred option, because its presence "may act as an insurance against a run of bad luck in the future" (Houston *et al.* 2007, p. 365). Humans and other organisms often (reasonably) assume that the same options will persist in the future (i.e. that the environment will stay roughly the same). Because organisms make different predictions about future options, sometimes intransitive ranking may maximize fitness. But of course that is no reason to jettison the transitivity norm as an axiom of rationality. As Houston *et al.* explain:

> Decisions appear to violate transitivity if an observer interprets a single choice by an animal with given reserves as indicating a straightforward preference for one option over another, instead of viewing the choice as a consequence of following the optimal reserve-dependent strategy. (Houston *et al.*, 2007, p. 367)

In other words, the violation of transitivity is in the eye of the beholder. To use a well-known analogy from Karl Popper (1963, 2002), when you add two drops of water, they join and form a single drop. But that does not mean that arithmetic (1+1=2) has been falsified.

As another example, let us consider the conjunction rule of probability theory: the principle that the conjunction of two events can never have a higher probability than that of either event happening alone. This rule was allegedly violated in the famous Linda problem:

> Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.
>   Which is more probable?
> (A) Linda is a bank teller.
> (B) Linda is a bank teller and is active in the feminist movement.

In their original research on what became known as the "Linda problem", Tversky and Kahneman (1983) held human reasoners accountable to the conjunction rule, which entails that B cannot be more probable than A. Still, the majority of subjects answered B.

Gigerenzer, however, pointed out that "probable" can also mean plausible, sensible, or supported by evidence (Gigerenzer, 1996; Hertwig & Gigerenzer, 1999). Kahneman and Tversky expect subjects to interpret "probable" in the sense of mathematical probability, but as a number of researchers have pointed out (e.g. Dulany & Hilton, 1991), this construal violates pragmatic rules of conversational inference, in particular the maxim of relevance (Grice, 1989).[2] If subjects interpret the story as Kahneman wanted them to, it becomes a trivial logical exercise, in which the whole description of Linda becomes irrelevant.

We think Gigerenzer is on solid ground here. But does this mean there is anything wrong with the conjunction rule, or that subjects have violated it? Gigerenzer strongly implies that the answers to these questions is yes: "[T]he Linda problem creates a context [...] that makes it perfectly valid not to conform to the conjunction rule" (Gigerenzer, 1996, p. 593); "[A]dhering to social norms, here conversational maxims, is rational, although it conflicts with classical rationality" (Hertwig & Gigerenzer, 1999, p. 300). Whereas Kahneman & Tversky choose to retain the norms, after having demonstrated that humans routinely violate them, Gigerenzer urges us to "rethink the norms" themselves (Gigerenzer, 2008, p. 7). Similarly, Polonioli's (2013, p. 6) conclusion about the work of the ABC

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[2] For a relevance explanation of human performance on the Wason Selection Task, see Sperber, Cara, and Girotto (1995).

research group on the Linda problem is that "violating the norms of coherence might be a key condition for successful communication".

But the conjunction rule of classical probability theory emerges unscathed after the ecological reframing of Linda, because if subjects construe the problem as Gigerenzer thinks they do, the rule is never "violated" in the first place. The conversational maxim of relevance can hardly clash with the conjunction rule if the former simply dictates a construal of the problem that falls outside the latter's domain of application.

Part of Gigerenzer's demonstration that Kahneman has underestimated his subjects is that, when presented in a frequency format, the so-called "cognitive illusion" disappears. In this version of the problem, subjects are told that

> There are 100 people who fit the description above (i.e. Linda's). How many of them are
> (A) Bank tellers?
> (B) Bank tellers and active in the feminist movement?
> (Gigerenzer, 2000, p. 250)

This presentation of the problem avoids the ambiguity of the term "probable" and narrows down on the construal of mathematical probability. In this case, subjects give the appropriate response, as indeed they *should* do. Even Gigerenzer implicitly admits that the conjunction rule is normatively binding *to the extent that it is applicable*. In other words, the problem lies not with the norm, but simply with certain misapplications of the norm.[3]

5. Discussion

There are two ways in which the program of ecological rationality can be construed as a challenge to the canons of classical rationality. First, advocates of ecological rationality have pointed to forms of heuristic intelligence that, though apparently at odds with classical rationality, fare quite well in the real world. What looks like an error, from the myopic view of classical rationality, turns out to be an effective judgment in proper ecological context.

If one loses sight of the 'hidden engineer' – i.e. natural selection – invisibly shaping these successful heuristics, it is tempting to conclude that the benchmark of traditional rationality against which human behavior had been judged is somehow deficient. It is not. The norms simply re-emerge at the evolutionary level, where the adaptive rationale of human cognition resides. The cognitive heuristics of the gene-carrying vehicles – us – are merely proximal implementations of evolution's acquired wisdom about ancestral environments – their success is not miraculous, and they would not work in all environments. Fast and frugal heuristics can beat sophisticated algorithms only because the R&D has already been carried out by evolution. And that R&D exploits the traditional canons of rationality. Moreover, heuristics can and do err, for instance when there is a

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[3] In this context, Gigerenzer has also made the additional argument that Kahneman and his colleagues stick with one conception of probability, ignoring alternative conceptions in the field of statistics (e.g. Gigerenzer, 2000, pp. 241-266). In particular, Kahneman adopts a Bayesian conception of probability and neglects the influential frequentist school, according to which single-event probabilities such as the ones used in the Linda problem are meaningless in any case. If the human mind is frequentist, as Gigerenzer claims it is, people cannot make the mistakes that Kahneman attributes to them. However, we think this is a red herring that detracts from the main problem with Kahneman's demonstration of the conjunction fallacy, which is the ambiguity of the word "probable" and the conversational implicatures. For a good criticism of Gigerenzer's resort to pluralism about statistical norms, see Bishop and Trout (2005, pp. 118-137).

mismatch between the environments to which they were adapted and the one in which they are now being applied. In such cases, evolution cannot get us off the hook: adaptive explanations cannot exculpate blatant forms of human irrationality (Boudry *et al.*, 2015).

As for the second challenge, when we consider how content-free logical norms fail to capture the intricacies and nuances of human judgment, it is tempting to conclude that there must be something wrong with those norms. But again, this is mistaken. Effective judgment can hardly violate the traditional norms of rationality when these norms do not apply. Bayesian theory, the conjunction rule and the transitivity rule (and other coherence norms) emerge intact after the ecological gestalt switch. The problem here is the rigid (mis)application of content-free logical norms, not the norms as such. Indeed, we need those tools to understand why fast and frugal heuristics are successful in the first place.

While we welcome a naturalized and evolutionary take on human reason, and we agree with Gigerenzer that it is time to correct the bleak picture of human reason, we have argued that the rhetoric against the traditional canons of rationality is unwarranted. Ecological rationality does not challenge, let alone refute, the classical norms of rationality.

Acknowledgments

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