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The Handbook of Rationality

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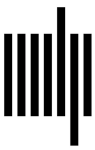

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1.2 The Rationality Debate in the Psychology of Reasoning: A Historical Review

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Summary

For most of its history, the psychology of reasoning assessed people's ability to evaluate logical arguments without formal training, on the assumption that logic provided the standard for rational reasoning. Numerous experiments reported from the 1960s onward showed that logical errors, cognitive biases, and content-dependent reasoning were common in university student populations. This led to great debate about human rationality, in which philosophers were involved. This chapter traces the history of that debate, in which arguments were made (a) that standard logic is not necessarily the correct norm for human reasoning, (b) that apparent errors may reflect misinterpretations of the task or instructions, and (c) that the experiments were artificial and unrepresentative. Ultimately, most psychologists were unwilling to label participants as irrational, and toward the end of the 20th century, a number of them formed a "new paradigm" psychology of reasoning, in which use of prior beliefs and expressions of uncertainty in reasoning is regarded as rational.

1. Reasoning and Rationality

Traditionally, the psychology of reasoning has consisted of giving people logic problems to solve and comparing their deductions with the dictates of formal logic. The first such experiments were published early in the 20th century (Wilkins, 1928; Woodworth & Sells, 1935) and immediately demonstrated some basic findings that were to occupy a large field of study in the later part of the century (see Evans, Newstead, & Byrne, 1993). First, people make many logical errors. In particular, they frequently endorse fallacies, that is, arguments whose conclusions could be true, given the premises, but are not necessary and valid inferences. People are also systematically biased by both the linguistic form of the premises and their content or meaning. That is to say, they respond to factors unrelated to the logic of the problems. Given a philosophical heritage that decreed that logic was the basis for rational human thought (Henle, 1962), the rationality debate in the psychology of reasoning was always likely to happen. It eventually exploded into life in the 1980s and has never really subsided. It did, however, cause many researchers in the field radically to rethink their approach, eventually leading to a "new paradigm" in 21st-century psychology of reasoning. How and why the field got from its origins to this new paradigm is a story I shall tell in this chapter.

Although the concept of rationality has become much more nuanced in recent publications, a basic distinction that is commonly made is between instrumental and epistemic rationality. *Instrumental* rationality is served when organisms achieve their goals, and it is evident that both humans and other animals need to be rational in this sense if they are going to survive and reproduce. *Epistemic* rationality is the acquisition and maintenance of true beliefs about the world. Epistemic rationality is clearly subservient to instrumental rationality, but in higher organisms and especially humans, the maintenance of accurate knowledge about the world around us is required for rational actions that will achieve our goals. For example, animals must know how and where to obtain food and water. The notion of epistemic rationality is much more developed for us human beings with our unique possession of language, explicit belief systems, and capacity for reasoning. Deductive reasoning is a key concept. If the fundamental beliefs we hold are true, then so too will be any others that we deduce from them in a logically valid manner—hence, the traditional emphasis on logic as the basis of rational thought.

The modern psychology of reasoning dates from the 1960s and especially the pioneering studies of the British psychologist Peter Wason (see Wason & Johnson-Laird, 1972). The belief that logic provided the basis for rational thinking was dominant at that time and not simply because psychologists were influenced by philosophical

tradition (Henle, 1962). It was also the heyday of Jean Piaget, whose theoretical work was enormously influential. Piaget had proposed that children's thinking and reasoning develop through a series of stages culminating in "formal operations" by adulthood (Inhelder & Piaget, 1958). In other words, Piaget proposed not only that logic *should* be the basis for adult human thought but that this actually was so. By contrast, Wason accepted logic as the normative framework but argued strongly that people were illogical and therefore irrational. His ideas presaged the rationality debate to come.

2. Origins of the Rationality Debate: The Case for Irrational Reasoning

2.1 Bias and Error in Deductive Reasoning

As already mentioned, the field of deductive reasoning has early origins. Prior to Wason, most studies used syllogistic reasoning tasks, based on the simple system of logic developed by Aristotle. Even the earliest studies showed evidence of cognitive bias. For example, Woodworth and Sells (1935) showed an "atmosphere effect" in abstract syllogistic reasoning, the first in a number of accounts of why people often accept invalid conclusions due to syntactic properties of the premises or their arrangement (see Evans, Newstead, et al., 1993, chapter 7). Consider the example

(1) Some *A* are *B*
Some *C* are *B*
Therefore, some *A* are *C*

Due to the atmosphere effect, it was argued, people are more likely to accept this conclusion as valid than, say, "All *A* are *C*," which has a different quantifier. Both conclusions are, of course, logically invalid. (Consider, for example, "Some men are golfers; some women are golfers; therefore, some men are women.")

Mental model theorists later described a "figural bias," which operates through the order of terms (Johnson-Laird & Steedman, 1978). Consider the case

(2) Some *A* are *B*
Some *B* are *C*
Therefore, some *A* are *C*

The terms *A*, *B*, and *C* here run in the same order in premises and conclusions, leading to more inferences of this type than if the order is as shown in (1). Perhaps the most sophisticated model of bias in abstract syllogistic reasoning is that presented by Chater and Oaksford (1999). They showed that people tend to choose the form of the least informative premise as that of the conclusion—the "min-heuristic." Hence, the validity judgments of participants, normally university students, are often influenced by factors other than logical reasoning.

From the very beginning, it was also discovered that when content-rich syllogisms are used, the prior beliefs that people hold influence their decisions. In particular, as first shown by Wilkins (1928), there is a tendency for people to endorse the validity of syllogisms because they believe the conclusion to be true, now generally known as the *belief bias effect*. This was followed by various studies of questionable methodology, reviewed by Evans, Barston, and Pollard (1983). These authors, however, established the reality of the belief bias phenomenon with improved methodology leading to the modern study of the effect, with many studies published (for recent examples, see Dube, Rotello, & Heit, 2010; Klauer, Musch, & Naumer, 2000; Trippas, Handley, & Verde, 2013). Consider the following two syllogisms used by Evans et al. (1983):

(3) No addictive things are inexpensive
Some cigarettes are inexpensive
Therefore, some addictive things are not cigarettes

(4) No millionaires are hard workers
Some rich people are hard workers
Therefore, some millionaires are not rich people

The two syllogisms have the same form, and neither is valid. However, Evans et al. found that 71% of participants declared (3) a valid syllogism, compared with only 10% for (4). The difference, of course, is that the conclusion to (3) is believable and that to (4) unbelievable. The importance of this basic finding for the present purposes is quite simple: despite being told clearly to assume the premises and decide whether the conclusion follows logically, participants are quite unable to ignore their (logically irrelevant) actual beliefs. By the time I wrote my first book reviewing the psychology of deductive reasoning (Evans, 1982), much evidence had been accumulated in the psychological experiments for illogicality, systematic biases, and a strong influence of prior belief on reasoning, and many similar findings have continued to be reported since.

One influential approach has been the proposal that people reason by use of mental logics comprising inference rules, which are instantiated for particular contexts (Braine & O'Brien, 1991, 1998; Rips, 1983, 1994). However, this approach attracted strong criticisms (Johnson-Laird, 1983; Oaksford & Chater, 1991), and Philip Johnson-Laird and colleagues went on to propose a highly influential alternative view that people reason by imagining and eliminating possibilities. This led to a major research program (see Johnson-Laird, 2006; Johnson-Laird & Byrne,

1991) with a very large number of published studies. However, mental model theorists have mostly stuck quite closely to propositional logic as a normative account (e.g., Byrne & Johnson-Laird, 2009; Johnson-Laird & Byrne, 2002), in contrast with researchers in the new paradigm, discussed later. Mental model theorists have, however, investigated cognitive biases and demonstrated cognitive illusions (Johnson-Laird & Savary, 1999). Their approach to rationality is that people are rational in principle but fallible in practice, mostly due to limitations in working memory capacity. This complies with the idea of bounded rationality proposed by Herbert Simon (1982). Johnson-Laird (2006) has further clarified two fundamental bases for human rationality within the mental models framework: first, our ability to search for and identify counterexamples, which demonstrate invalid arguments, and, second, our ability to understand and reason about what is true or false. He maintains that rationality does not depend upon any form of internalized logical rules, providing a radical alternative account of epistemic rationality and deductive competence.

2.2 Peter Wason and the 2 4 6 and Selection Tasks

Peter Wason was a British psychologist who published most of his work in a 25-year period starting in the late 1950s. He is particularly famous for the invention of two fiendish reasoning tasks that appeared simple but led most of his participants into logical errors. Of equal significance for this historical review are the comments that he wrote about these tasks, now rarely read and noted by modern students of the field. His first invention was the "2 4 6" task (Wason, 1960), which continues to be studied to the present day (for a full history, see Evans, 2016b). For a highly cited paper, it is actually quite short, only a few pages long; it contains a study that can scarcely be described as an experiment as it has only one condition with no controls or comparisons. As with the first presentation of his even more famous four-card selection task (Wason, 1966), the reader is simply invited to compare the poor performance of his participants to their prior expectation that the task *ought* to be simple and straightforward. While the selection task enjoyed a "heyday" between 1980 and 2000, in which it was the focus of a number of major theoretical papers, citations of Wason's work on this continue to increase to the current day (Evans, 2016a)—remarkable when one considers that Wason's last major article was published more than 30 years ago.

Wason considered his tasks to be "deceptively simple," by which he presumably meant that they look easy while being anything but. The 2 4 6 task is so called because participants are told that the experimenter has a rule in mind that classifies triples of whole numbers, an example of which is 2 4 6. They were to discover the rule by offering triples of their own and being told whether or not they conformed to the experimenter's rule. The actual rule was any ascending sequence, much more general than the deliberately biasing example of 2 4 6 suggests. Two unusual features of the task were that participants were required to write down the reasons for their choice of triples and also, if they announced the wrong rule, to continue with the task until they gave up or a time limit was reached. What happened was that people formed more specific hypotheses, such as "ascending with equal intervals," and got repeated positive feedback from testing triples that conformed to it (e.g., 1 3 5, 10 30 50, etc.). Few people solved this problem without announcing wrong rules and some not at all. Wason also published example protocols that showed how people became convinced their hypotheses were correct and often reformulated them in other words, so that they announced the same wrong rule more than once.

The 2 4 6 task does not fit the standard psychological paradigm for studying deductive reasoning and perhaps has elements of induction (rule discovery) or abduction (reasoning to best explanation), although it also requires hypothetico-deductive reasoning. The selection task also falls outside of the standard paradigm, although it is generally studied by deduction researchers. In the original task (Wason, 1966), participants were told that a set of cards each had a letter on one side and a number on the other. They were also told that a rule applied to these four cards and might be true or false:

> If a card has a vowel on one side then it has an even number on the other side.

They were then shown four cards lying on a table, whose facing sides displayed a vowel, a consonant, an even number, and an odd number, for example,

E P 4 7

Their task was to choose those cards, and only those cards, that needed to be turned over in order to decide whether the rule was true or false. Wason maintained (and most subsequent researchers of the task agreed) that the correct choices were the vowel and the odd number, E and 7 in the example given. This is because, logically, the conditional statement can only be false if a card is found with a vowel on one side that does not have an even number on the other. Very few people gave this response—later estimates of solution rates are usually around 10%. Most people chose only the vowel or the vowel and the even number (e.g., E and 4).

Wason believed that both tasks showed that participants had a verification bias, contrary to the then fashionable view of Karl Popper (1959) that the rational approach to hypothesis testing was falsification. Verification or confirmation bias has not withstood the scrutiny of later researchers as an account of either task, but the details are not relevant for current purposes. Of more concern is Wason's assertion that failure on these tasks demonstrated that people were fundamentally irrational. The case was made in a number of places, including an influential book of the time (Wason & Johnson-Laird, 1972). People were illogical and therefore did not develop formal operational thought as Inhelder and Piaget (1958) had proposed; they verified, and failed to falsify, their hypotheses and hence violated Popper's prescriptions for scientific thinking. Wason drew the strongest possible conclusion from his studies of the selection task:

> The selection task reflects [a tendency towards irrationality in argument] to the extent that subjects get it wrong. . . . It could be argued that irrationality rather than rationality is the norm. People succumb all too readily to logical failures. (Wason, 1983, p. 59)

Wason was being controversial and knew it. He was well aware, for example, of a philosophical traditional that made logical reasoning the centerpiece of rational thinking, as he included the famous paper of Henle (1962) in one of his edited collections. Henle asserted that apparent failures of logical reasoning were due to misinterpretations, additions of unstated premises, or "failures to accept the logical task." Wason railed against this tradition as well as the overbearing influence of Piaget in the psychology of that period (Wason, 1977). He believed—with clear justification at the time—that he had discovered that people were fundamentally irrational in their reasoning.

The selection task went on to have a long and distinguished history of study (Evans, 2016a), especially since it was discovered quite early on that versions using realistic content could be much easier to solve. This led initially to a belief in a general thematic facilitation effect, but the story proved a good deal more complicated as later research unfolded (see Evans, Newstead, et al., 1993; Evans & Over, 2004). Not all realistic versions facilitate, and most versions that do switch from indicative to deontic logic (Manktelow & Over, 1991). That is, the rules tested are typically permissions and obligations such as "If you drink alcohol in a bar you must be over 18 years of age," and the task set is to check whether or not the rule is obeyed rather than whether it is true or false. I will return to this when discussing evolutionary approaches later in the chapter.

2.3 The Influence of Kahneman and Tversky

In the early 1970s, when belief in irrationality was at its peak in the psychology of reasoning, the consensus view in a different tradition—the study of judgment and decision making (JDM)—was still that people were essentially rational. This changed dramatically when Amos Tversky and Daniel Kahneman started to publish their famous papers, which launched the heuristics and biases tradition (e.g., Tversky & Kahneman, 1974). Many reasoning researchers also paid attention to the JDM literature, so this work also had a clear influence on the rationality debate in the psychology of reasoning. The combined impact of studies in both fields helped to stimulate the historically important critique of Cohen (1981).

Prior to Kahneman and Tversky's work, the field of judgment and decision making had enjoyed a belief in rationality similar to that promoted by Henle and Piaget. While it was conceded that people had calibration issues, they were generally considered to be good intuitive statisticians (Peterson & Beach, 1967). Economic decision theory had exerted a big influence on the study of decision making thanks to Ward Edwards (e.g., 1961) with attempts to propose subjective versions of both probability and utility to fit the model of the "rational man" of decision theory. Tversky and Kahneman blew this cozy consensus away with a series of papers demonstrating systematic biases in statistical judgment and, later, decision making (Kahneman & Tversky, 1979). Kahneman would later receive the Nobel Prize for Economics for this work, Tversky being by then deceased and hence ineligible. I have no space to review this work in detail here but note that the fundamental idea was that people relied on simple heuristics such as representativeness (Kahneman & Tversky, 1972) and availability (Tversky & Kahneman, 1973) when making probability judgments. While sometimes helpful, these heuristics frequently led to systematic biases, as they demonstrated in a series of ingenious experiments. This set in train a tradition known as "heuristics and biases," which was studied mostly by other researchers as time went on, with collections of papers later published in influential books (Gilovich, Griffin, & Kahneman, 2002; Kahneman, Slovic, & Tversky, 1982).

Unlike Wason, Kahneman and Tversky generally avoided direct claims that they were showing people to be irrational, but their many admirers and followers were less restrained. There was great interest in this work in business schools, which increased when they added

prospect theory (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992) as an alternative to the traditional teaching of economic decision theory. By the end of the 1970s, the idea that people were fundamentally irrational in their reasoning, judgment, and decision making was taking a strong hold and was no longer confined to the journals of academic psychology. However, strong reaction from the defenders of human rationality was soon to arrive.

3. The Critique of Cohen (1981): Three Arguments for Rationality

Jonathan Cohen (1981) was by no means the only author to react against the emerging view of irrational thinking in the psychology of reasoning and judgment, but his paper was the most influential both at the time and for many years to follow. Cohen was a philosopher and hence employed a priori rather than empirical arguments. He posed the question, "*Can human irrationality be experimentally demonstrated?*" in his title and provided the answer in his text: an emphatic "no." This position and ones like it have later been dubbed "Panglossian" (see, e.g., Stanovich, 2011). However, Cohen made several strong arguments, which I later described (Evans, 1993) as falling into three broad categories:

1. The normative system problem
2. The interpretation problem
3. The external validity problem

Since these three basic arguments have also arisen in much more recent debate about rationality, I will take a little time to explain them. The *normative system problem* is that when participants are judged to be right or wrong, this is done by reference to a standard normative theory, which itself may be subject to argument and alternatives. For example, Wason adopted Popper's falsificationist philosophy of science as his normative system when he described verification bias on the 2 4 6 and selection tasks. Popper argued that lawful scientific statements were strict universals and could hence never be logically verified, but they could be falsified. Popper's work was recent and "hot" in the early 1960s when Wason was writing but has been severely challenged since, with some contemporary philosophers and psychologists preferring a Bayesian philosophy of science, in which belief in scientific theories is gradually acquired or lost as evidence accumulates (Howson & Urbach, 2006).

Although most psychologists still accept Wason's statement of the correct solution to the selection task, it has been famously challenged (Oaksford & Chater, 1994). The "alternative norms" problem later became a major issue for debate in the field (e.g., Stanovich, 1999): you do not need to be a Panglossian to recognize the ambiguity of norms. Much more recently, Elqayam and Evans (2011) discussed the normative system problem at length in order to argue their case that normative rationality has no useful part to play in cognitive psychology. They argued that ambiguous and alternative norms frequently arise in the literatures on reasoning and decision making. Indeed, it was the questioning of standard binary logic and the material conditional that led to the new paradigm psychology of reasoning discussed at the end of this chapter. So the problem here is that if people are to be judged to be reasoning incorrectly and therefore to be irrational, do we actually have a clear and agreed standard for what is right and wrong in the first place?

The second type of objection made by Cohen and others (e.g., Henle, 1962; Smedslund, 1970, 1990) is that participants may not *interpret* the problem in the way that the experimenter intends and assumes. If, for example, they add or omit premises in deductive reasoning, then the conclusion that follows from their interpretation cannot be compared to the one prescribed by the experimenter. In the statistical reasoning literature, a good example is provided by the *conjunction fallacy* originally reported by Tversky and Kahneman (1983) and much investigated thereafter: people make an apparent logical error by judging that the probability of $A \& B$ is greater than the probability of A. In the famous Linda problem, Linda is described in a way that provokes the stereotype of a feminist. Participants then appear to judge as more likely that she is a bank teller *and* a feminist than just a bank teller, which is logically impossible. However, the context might suggest that the "bank teller" option is really a bank teller who is *not* a feminist. With this interpretation, there is no error. A number of authors have proposed interpretational explanations of the conjunction fallacy (see Moro, 2011).

Cohen also suggested that psychological experiments can be artificial and unrepresentative, dismissing the Wason selection task as a "cognitive illusion." I call this the *external validity problem*. Actually, the 2 4 6 task is a better example, as Wason's claim that it showed a verification bias was challenged almost immediately (Wetherick, 1962). Wetherick's objections were essentially correct, if largely ignored at the time. The paper was not even cited by Wason and Johnson-Laird (1972), whose well-read book popularized Wason's original view of the task. However, from the 1980s onward, other authors made similar arguments, which are now widely accepted (see Evans, 2016b). The general argument is that while

Wason showed a preference for positive hypothesis testing, this only has the effect of repeated confirmation due to the fact that participants have been induced to adopt a hypothesis much more specific than the actual rule. Moreover, it has been argued that positive testing of hypotheses is generally an adaptive and effective strategy in science (Klayman & Ha, 1987) and that the adoption of a verification or falsification attitude in scientific hypothesis testing makes no practical difference to the effectiveness of a test (Poletiek, 2001).

In the case of the 2 4 6 task, it does seem that the original experiment suggested a misleading interpretation and that it was indeed unrepresentative of real life. However, of Cohen's three arguments, the external validity problem is the weakest. It is implausible to suggest that psychologists consistently contrive to demonstrate errors and biases that only occur as laboratory tricks. As a bias researcher myself, I can attest that there is no conspiracy among psychologists to denigrate human rationality. In the heuristics and biases tradition, in particular, most of the cognitive biases discovered originally on artificial laboratory tasks have been shown to apply in real-world contexts and with expert groups (Gilovich et al., 2002; Kahneman et al., 1982). That is not to say, of course, that there may not be a number of laboratory demonstrations of biases that are, nevertheless, misleading.

4. The Great Rationality Debate

Following Cohen's critique, psychologists started to stake out various positions on the topic of rationality in reasoning and decision making, most of which were well established by the end of the 20th century. This has been labeled the "Great Rationality Debate" by Keith Stanovich (2011), who in an earlier book (Stanovich, 1999) had already categorized them as falling into three main camps, which he termed "Panglossian," "Meliorist," and "Apologist." *Panglossians*, like Cohen, essentially argue that irrationality is not possible and there can be no gap between descriptive and normative accounts of human behavior (see Stanovich, 1999, p. 5). *Meliorists* claim that, while often convergent, such accounts can also diverge. People can fail to attain normative rationality due to lack of education, cognitive capacity, or rational attitude, but much of this divergence can be addressed by education and training. Meliorists include Jonathan Baron (1985) and Stanovich himself. Finally, *Apologists* attempt to explain why performance often fails to match normative standards and give much weight to computational limitations, in the "bounded rationality" tradition of Simon (1982).

Not all authors seem to fall into Stanovich's categories, including myself, as I have consistently questioned the value of normative theory itself in the study of reasoning since my earliest papers on the topic (Evans, 1972). Authors such as myself may be termed "descriptivists" (Elqayam & Evans, 2011). In a collaboration with the philosopher David Over, I suggested that normative rationality (conforming to a normative theory) may often diverge from instrumental rationality (acting in such a way as to achieve one's goals)—see Evans and Over (1996). (This view was strongly contested by Stanovich, e.g., 1999, who regards normative theory as a description of instrumental rationality.) Evans and Over (1996, chapter 2) strongly critiqued decision theory as lacking the boundaries and constraints necessary for comparison with actual human choices. In a later book (Evans & Over, 2004), we challenged the binary logic that has traditionally been used to provide norms for deductive reasoning. We also picked out the case of belief bias as being a possible artifact of experimentation (Cohen's external validity problem), since in the real world, it is rational to reason from *all relevant belief* (Evans, Over, & Manktelow, 1993). However, when I later teamed up with Shira Elqayam to present a critique of normative rationality in *Behavioral and Brain Sciences* (Elqayam & Evans, 2011), it became apparent from the commentaries it elicited that many authors disagree with us. The majority view appears to be that normative theory does have an important role to play in the descriptive study of reasoning and decision making, and it continues to play a central role in the Great Rationality Debate.

4.1 Evolutionary and Ecological Approaches

While the philosopher Cohen started the rationalist backlash against research on cognitive biases, the cause of humanity was taken up later by psychological writers. Many assumed that human beings would be adapted to their environment, which may occur by evolution, learning, or a combination of both. Gerd Gigerenzer emerged in the early 1990s and launched a series of attacks on the work of Tversky and Kahneman as providing an inaccurate picture of irrationality. This eventually led to an exchange in the pages of *Psychological Review* (Gigerenzer, 1996a; Kahneman & Tversky, 1996). One of Gigerenzer's arguments was that people are able to reason with frequencies rather than probabilities and that apparent cognitive biases could be made to disappear when frequencies were used in the word problems instead (Gigerenzer, 1991; Gigerenzer & Hoffrage, 1995). This was supported by the work of the evolutionary psychologists Cosmides and Tooby (1996; see also chapter 10.6

by Cosmides & Tooby, this handbook) but resulted in a flurry of papers from skeptical authors disputing their explanation, based on Darwinian algorithms, of *why* frequency formats make the problems easier. Critics suggested that these formats cued simple mental models that facilitated reasoning for reasons that have nothing to do with evolution (see Barbey & Sloman, 2007, for an extended review and discussion of this debate).

Leda Cosmides and John Tooby set out a more general argument for *massive modularity* (Cosmides & Tooby, 1992; Tooby & Cosmides, 1992), according to which the mind comprises specialized self-contained modules. Cognitive modularity was originally proposed by Fodor (1983), who argued that many such modules are contained in the mind, for example, to process language or to explain much of the working of the visual system (although many authors, including Cosmides and Tooby, use the term without subscribing to all of his detailed definitions). Importantly, Fodor argued that there must also be a general-purpose reasoning system, something that the massive modularity hypothesis denied. Cosmides and Tooby argued that evolution could only produce specialized and not general reasoning systems, a highly controversial position. Fodor (2000, 2001) was among their many critics, and a more general coverage of the debate can be found in Over (2003). In the psychology of reasoning, these arguments were first applied to the Wason selection task. As mentioned earlier, the task is much easier when people are asked to check whether permissions or obligations have been complied with. Cosmides (1989) argued that these versions of the task comprised *social contracts*, for which we have evolved a cheater-detection module. In later work, this was extended to include a hazard-avoidance module (Fiddick, Cosmides, & Tooby, 2000), which applied to other contexts in which the task becomes easy. Their work on this topic was also supported by Gigerenzer and Hug (1992).

Again, all these claims proved highly controversial and were subject to critiques of methodology and the postulation of rival theoretical accounts that did not depend upon evolutionary mechanisms. The relevance to the rationality debate is the argument that people have an inherent rationality in their reasoning provided by their genes but that it only operates in contexts of evolutionary relevance. One problem with this approach, pointed out by Stanovich (2004), is that evolutionary and individual rationality can diverge. For example, the craving for fat and sugar that made great evolutionary sense to our ancestors has become a cause of obesity and health problems in the modern world. Modern humans can also frustrate the goals of the genes, for example, by enjoying sex with contraception. Stanovich (2004) claimed that human beings are the one species that the genes lost control of, as we can think for ourselves and pursue our own goals.

Gigerenzer and colleagues developed a major research program based on "fast and frugal heuristics," which are taken from an evolutionary toolbox similar to the modular mind of Cosmides and Tooby (Gigerenzer, 1996b; Gigerenzer & Todd, 1999). In contrast with the heuristics of Kahneman and Tversky, these are portrayed as making us smart without the need for much thought. In fact, Gigerenzer claims that ignorance often trumps knowledge and that we are better off relying on gut feelings than engaging in reasoning (Gigerenzer, 2007), ironically employing masterful reasoning to make his case! Again, we see the denial of any useful role for a general-purpose reasoning system, which puts this approach in direct conflict with the "dual-process theories" of reasoning discussed later. In fact, Gigerenzer is a strong critic of dual-process theory (Gigerenzer, 2011; Kruglanski & Gigerenzer, 2011). Evolutionary arguments have also been made to explain our reasoning facility without attributing to it the importance that is usually attached to it. For example, it has been proposed that reasoning evolved for purposes of argumentation rather than problem solving (Mercier & Sperber, 2011), although a more complex story has emerged in later development of this account (Mercier & Sperber, 2017).

Evolutionary rationality is closely related to the idea of *ecological rationality*, which comes from a slightly different tradition. *Rational analysis* is a tradition in cognitive psychology started by John Anderson (1990, 1991). It has been applied to the psychology of reasoning and decision making in a major program led by Mike Oaksford and Nick Chater (Oaksford & Chater, 1998, 2007), one of the roots of the new paradigm psychology of reasoning discussed at the end of this chapter. It is grounded in ecological rationality and related to other psychological work in this tradition (Gibson, 1979; Hammond, 1966). The approach takes it as axiomatic that behavior is adapted to the environment and that therefore an analysis of the environment itself is required in order to see what is the optimal way of operating within it (a computational-level account, in the terminology of Marr, 1982). Normative theory, while important, is subservient to this ecological rationality. As Oaksford and Chater (2007) put it, "According to this viewpoint, formal rational principles relate to explaining everyday rationality because they specify the optimal ways in which the goals of the system can be attained in a

particular environment" (p. 32). They also make it perfectly clear that if a *standard* normative theory, such as binary or propositional logic, fails to achieve that task, then it must be discarded and replaced. Much of their research, starting with their alternative account of the selection task (Oaksford & Chater, 1994), has consisted of providing alternative normative accounts that render the actual observed behavior of their participants normatively correct, in the spirit of Cohen's first argument for rationality. Their position evolved to one of arguing that human rationality is based upon Bayesian decision theory rather than logic.

4.2 Dual Processes, General Intelligence, and Individual Differences

Dual-process theories have become highly popular in cognitive and social psychology but have diverse origins and many different implementations (Evans, 2008; Evans & Frankish, 2009). They are also highly controversial and have been the subject of many criticisms (see Evans & Stanovich, 2013). What all have in common is the assertion that there are two fundamentally different kinds of human thought, one fast and intuitive and the other slow and reflective. These are sometimes referred to as "System 1" and "System 2" (Kahneman, 2011; Stanovich, 1999), although both Stanovich and I now prefer the more neutral reference to "Type 1" and "Type 2" processing in our current writing. Modular cognitive processes would be automated and therefore Type 1, but such processing can also be based upon associative or implicit learning (Reber, 1993) or on the automation of knowledge that was once explicit and processed in a Type 2 manner. Type 2 processing is now generally thought to involve a central general-purpose working memory system of the kind described by Baddeley and his coworkers (Baddeley, 2007) and is related to the concept of general intelligence. Hence, dual-process theory strongly asserts the existence of a general-purpose reasoning system, in stark contrast with the evolutionary approaches discussed above.

Traditionally, dual-process theory has largely explained cognitive biases in terms of Type 1 processing and correct reasoning or decision making in terms of Type 2 processing (Evans, 1989; Kahneman, 2011; Stanovich, 1999). However, this is oversimplified as intuitions can be sound and reasoning flawed. Type 2 processing, for example, can go awry because of insufficient cognitive capacity, lack of relevant education or "mindware," or a failure to adopt a rational attitude in which intuitions are carefully checked (Evans, 2007; Evans & Stanovich, 2013; Stanovich, 2011). Nevertheless, much has been made of the fact that general intelligence correlates not only with working memory capacity but also with normatively correct answers on a wide range of laboratory reasoning and decision tasks (Stanovich, 1999, 2011; Stanovich, West, & Toplak, 2016). However, the same research program has always shown that another individual difference factor has a significant, if weaker, influence on correct performance. This is *rational thinking disposition*, assessed by a variety of psychometric scales. In essence, it appears that some people are inclined to make quick decisions based on intuitions and others to check them out by more careful reasoning. Since most laboratory tasks are designed to minimize the value of Type 1 processing (previous experience is unhelpful) and to maximize the role of Type 2 processing (problems are novel and load on working memory), a rational thinking disposition aids solution.

Stanovich has discussed rationality at length in his several books on this topic. In the first of these (Stanovich, 1999), he rejected the argument that rationality is revealed by alternative normative accounts, as in the work of Oaksford and Chater. He points out that on most of the tasks studied, general intelligence correlates with the *standard* normative solution. For example, even on the very difficult abstract form of the Wason selection task, the few people who do manage to solve it have higher IQs than those who do not (Stanovich & West, 1998). In this and later books, he develops the idea that rationality should not, however, be equated with IQ, due to the strong influence of rational thinking dispositions: there should therefore be a Rationality Quotient, or "RQ," that takes both into account (Stanovich, 2009). In a recent major project, Stanovich and his collaborators explored the psychometric properties of a large range of laboratory tasks in order to provide the foundation for such an RQ test (Stanovich et al., 2016), called the "CART." The CART still loads heavily on general intelligence, however, and currently lacks both the item analysis and validation studies that would be required to turn it into a marketable psychometric instrument.

Dual-process theory is currently undergoing something of a crisis due to a series of results that show that correct answers on many of the tasks may be given quickly and intuitively and do not benefit from slower reflection (see a number of papers in the collection edited by De Neys, 2017). Recent findings also suggest that people of higher IQ have better intuitions, or Type 1 processes, than those of lower intelligence. This is leading some authors, previously sympathetic to the theory, to question the traditional dual-process account in which better normative performance on tasks and by individuals is achieved by Type 2 processing. I personally think

that some of this pessimism is premature as much of the research is based on relatively simple tasks in which "logical intuitions" are less surprising than they would be on tasks that load heavily on working memory.

5. The Rejection of Binary Logic and the New Paradigm Psychology of Reasoning

The rationality debate in the psychology of reasoning has produced a tangible result: a new paradigm. The traditional method, dubbed the "deduction paradigm" by Evans (2002), provides no instruction in logic and rejects participants who have such training. The idea is to see if people are inherently logical in their reasoning. Generally, they are given the premises of an argument, which they are told to assume are true, and asked if a particular conclusion necessarily follows. Their decisions are then compared with those of standard logics such as the propositional calculus. By the end of the 20th century, this paradigm was creaking under the weight of a mass of findings showing that people (a) made many logical errors, (b) had systematic cognitive biases, and (c) frequently reasoned on the basis of actual beliefs rather than assumed premises. A Kuhnian crisis was looming (Evans, 2002). There were also powerful voices, such as those of Oaksford and Chater, arguing that the normative model of standard logic was simply inapplicable to everyday reasoning.

With the pressure of the rationality debate upon them, reasoning researchers were basically faced with two choices: (1) defend the deduction paradigm and conclude that people were massively irrational or (2) abandon the paradigm, especially the use of standard logic as a normative system. Many chose the latter and moved toward a new paradigm, although the mental model camp put up a lot of resistance, as mentioned earlier. A key development came in the study of conditionals when psychologists became increasingly aware that many philosophers reject the material conditional of propositional logic as a description of the ordinary conditional of natural language (Edgington, 1995). In this system, "If p then q" means the same thing as "Either not-p or q," but this leads to absurd and paradoxical inferences. Such a conditional is always true when either p is false or q is true (or both). So, for example, "If Hillary Clinton is president of the USA, then the UK is at war with France" must be true.

Also taking the lead from philosophers, psychologists became interested in the Ramsey test, which is the idea that we evaluate a conditional by imagining p to be true and then evaluating q in a thought experiment. This was quickly linked with the idea that the probability of the conditional statement should be equal to the conditional probability, that is, $P(\text{if } p \text{ then } q) = P(q \mid p)$, known as "the Equation." Psychological evidence was gathered in the early 2000s that many people complied with the Equation and not with the material conditional when judging the likelihood of conditional statements (Evans, Handley, & Over, 2003; Oberauer & Wilhelm, 2003; Over, Hadjichristidis, Evans, Handley, & Sloman, 2007). David Over and I presented a suppositional theory of conditionals (Evans & Over, 2004) developing the Ramsey test into a full-blown psychological account of conditional thought. This work, together with the case that Oaksford and Chater had been pressing for a decade, led to what is now clearly recognized as a new paradigm in the psychology of reasoning (Elqayam & Over, 2012; Oaksford & Chater, 2010; Over, 2009).

Researchers within the new paradigm agree on the rejection both of the traditional methods and of the normativity of binary logic. Participants are more likely to be asked to reason with uncertain premises or to draw uncertain conclusions. For some researchers, pragmatics is key, as ordinary reasoning is now recognized as belief based. For others, the new paradigm involves an attempt to replace binary logic with alternative normative systems, such as Bayesian decision theory, probability logic, or multivalued logic. Researchers may, however, subscribe to Bayesianism in a strict or a soft sense (Elqayam & Evans, 2013), the latter falling short of a normative theory. The new paradigm is a looser concept than the old paradigm as there is as yet no real general agreement as to its priorities, methods, and theoretical framing (Evans, 2012). It is quite clear, though, that the rationality debate played a critical role in moving most of the field away from the traditional study of logicality in human reasoning.

6. Final Thoughts

Throughout cognitive psychology generally, there is no rationality debate. People are not accused of irrationality for having poor memories or succumbing to visual illusions, for example. Even within the psychology of thinking, cognitive failure does not necessarily lead to imputations of irrationality; for example, we do not expect that people should be able to compute the square roots of large numbers in their heads. The issue is pretty much restricted to the study of reasoning and decision making—so what makes these topics different? The only answer that I can see is the strong influence of philosophy. The issue of rationality and the efficacy of different normative systems are primarily philosophical

issues. However, psychologists have become highly engaged with them, to the extent that they have tried to approach rationality as an *empirical* question. The only way that this can be done is to observe human reasoning and decision making and compare it with a normative standard. But as we have seen, such a path is rife with pitfalls. All normative theories are themselves contestable, for example. And should the outcome be that people appear irrational, strong arguments can be made on evolutionary and ecological grounds that this conclusion must be false. But if the conclusion is prejudged, why bother asking the question at all?

Personally, I think these fields of study should be approached like the rest of cognitive psychology: we should describe the processes of reasoning and decision making and simply try to understand the cognitive and neural mechanisms that underlie them. However, this is not the popular view and certainly does not reflect the history of the psychology of reasoning in which the rationality debate has played such a prominent role. If the Panglossians are right, then they must agree with me on how the topic should be studied, as the issue of human rationality can never be decided empirically. In reality, however, most psychologists have focused on right and wrong answers throughout the history of the psychology of reasoning and continue to do so today. When people were shown to be intransigent in their lack of respect for logic, standard logic was abandoned in favor of a new paradigm. People are now seen to concern themselves with degrees of belief rather than truth and to reason with uncertainty. But normativity has not gone away in this new paradigm: psychologists continue to hunt for new formal descriptions of rational reasoning that might account for the way in which people actually think.

One final thought is on the nature of evolution. We are what we are and do what we do because we evolved to do so. We became the dominant species on Earth—at least by some measures—as a result and certainly the only one that can with great power and flexibility design its environment to suit itself, rather than evolving to fit the environment. Our scientific and cultural achievements are extraordinary. But the 21st-century world is also striven with war, disease, and starvation, and there is every likelihood that the failure to control climate change or to manage the horrendous weapons of mass destruction we have designed will bring the whole project to a premature end. To me this reflects the nature of evolution: it does not optimize, and it does not accord with some philosophical ideal of rationality. It is driven mostly by what worked in the past and provides no guarantees for the future. The ultimate test of the rationality of human beings lies not in the psychologist's laboratory but in the highly uncertain and dangerous real world that we inhabit.

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