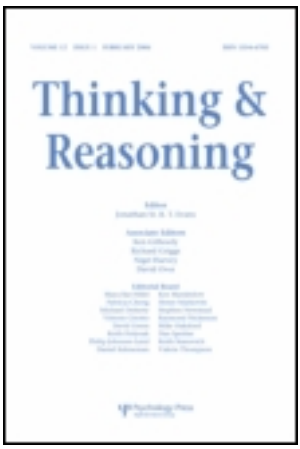

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New paradigm psychology of reasoning: An introduction to the special issue edited by Elqayam, Bonnefon, and Over

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New paradigm psychology of reasoning: An introduction to the special issue edited by Elqayam, Bonnefon, and Over

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The new paradigm in psychology of reasoning is becoming increasingly established. In this editorial to the special issue of *Thinking & Reasoning* we introduce the paradigm and explore some of its dimensions. The old paradigm focused on binary truth and truth preservation from assumptions, whereas the new paradigm puts subjective degrees of belief centre stage, represented as probabilities. Subjective psychological value, or utility, and social pragmatics also play a central role. Dual process theories provide the algorithmic-level underpinning to these computational-level functions. The new paradigm aims to integrate the psychology of reasoning with study of judgement and decision making, leading to a much more unified field of higher mental processing.

Keywords: New paradigm; Probability; Utility; Dual processing; Rationality.

Over the last decade or so, trends that were apparent in the psychology of reasoning since the early 1990s have reached fruition, culminating in what some have described as a "new paradigm" (Baratgin, Over, & Politzer, in press; Chater & Oaksford, 2009; Elqayam & Over, 2012; Evans, 2012; Manktelow, Over, & Elqayam, 2011; Over, 2009). This new development emphasises the role of probability and utility judgements in human reasoning, with the aim of integrating the psychology of reasoning with the study of judgement and decision making. It can thus be seen as a response in the psychology of reasoning to the immense impact that Bayesian theories have had in cognitive science (Chater & Oaksford, 2008). It goes beyond the traditional "deduction paradigm" (Evans, 2002), which was based on binary distinctions—between truth/falsity, consistency/inconsistency, and validity/

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invalidity—and focused primarily on drawing inferences from arbitrary assumptions according to the rules of extensional textbook logic (Johnson-Laird & Byrne, 1991). These binary distinctions can still be made in the new paradigm but it advances beyond them, most notably by distinguishing between different degrees of subjective probability and utility.

This change has profoundly transformed the field, creating new research questions and leading to novel research practices. We have looked up the keyword "probability" in the indices of popular textbook introductions to the field. In a survey from the heyday of the traditional binary paradigm (Evans, Newstead, & Byrne, 1993) the term does not even appear, and a total of only three pages (1% of the book pages) were devoted to "probabilistic inference". A textbook first published at the time the new paradigm was gaining momentum (Manktelow, 1999) had a later chapter on probability, and the index counts 46 pages of references to probability (18%). In the latest, 2012, edition of the same text (Manktelow, 2012), the chapter on probability is the first in the book, and the number of pages devoted to the topic has almost doubled (to 30%). The very semantic field associated with reasoning is changing.

The new paradigm also recognises utility judgements as an essential aspect of some (perhaps even all) types of reasoning. Consider an example taken from one of the precursors to the new paradigm, Manktelow and Over (1991). A mother tells her child: "If you tidy your room then you may go out to play". For the mother, a tidy room is desirable; for the child, playing is desirable. These psychological values affect what the mother and the child are likely to infer from this conditional. Moreover, the more the child believes that tidying the room will actually result in the promised reward, the more likely he is to do it (Evans, Neilens, Handley, & Over, 2008). In everyday life we seldom hold any belief with absolute certainty, and the new paradigm takes seriously the uncertainty present in almost all ordinary and scientific reasoning and decision making (Oaksford & Chater, 1998). The child might have reasonable confidence that his mother will keep her promise to the letter, and the mother would have some confidence that the young devil could be finally enticed to tidy up, but previous experience with similar contexts might inspire less than perfect confidence in either of them. So the crucial parameters are psychological values, degrees of subjective utility, and subjective probability, degrees of belief. These two parameters—probability and utility—are at the heart of both reasoning and decision making in the new paradigm.

The new paradigm rests on the foundation of contemporary subjective probability and utility theory, which goes back to de Finetti (1936/1995, 1937/1964, 1972) and Ramsey (1926/1990). The approach of the new paradigm has been called Bayesian (Oaksford & Chater, 2007, 2009), but it could more widely be termed "probabilistic" and "decision theoretic". The label "Bayesian" can take on quite different meanings (Jones & Love, 2011; also

see Elqayam & Evans, 2013), so to avoid confusion we will stick to the neutral "new paradigm".

As the new paradigm becomes established, research within it is becoming increasingly diverse, exploring new territories and new dimensions of established research practices. This special issue of *Thinking & Reasoning* aims to showcase this recent progress, as well as serve as an introduction to the new paradigm for those new to the field, psychologists and other cognitive scientists and philosophers. It follows in the wake of two symposia on the new paradigm, both held in the summer of 2012, and both convened by the editors of this special issue: A symposium (at the International Conference on Thinking, 2012, London) on the basic aspects of the new paradigm, convened by Elqayam and Over, with Bonnefon as the symposium key note speaker; and a symposium (at the International Congress of Psychology, 2012, Cape Town) on the applied aspects of the new paradigm, convened by Bonnefon. Contributors to these two symposia were invited to contribute a paper to this special issue. Before we outline these contributions, however, we start with a brief introduction to research themes in the new paradigm, for the benefit of readers new to the field.

CONDITIONALS, CONDITIONAL PROBABILITY, AND THE PROBABILISTIC NOTION OF VALIDITY

Conditionals are necessary for ordinary and scientific reasoning, and nothing better illustrates the limitations of the old, binary paradigm in the psychology of reasoning than the treatment of conditionals in an influential work in this old paradigm, by Johnson-Laird and Byrne (1991). Consider the conditional, "If we buy a ticket in the UK national lottery then we will win millions". This example is an indicative (roughly, "descriptive") conditional of the form *if p then q*. Johnson-Laird and Byrne (1991) noted that this type of conditional is true when p is true and q is true (in this example, when we buy a ticket and win millions), and is false when p is true and q is false (we buy a ticket and do not win millions). But they then asked whether *if p then q* is true or false when p is false (when we do not buy a ticket). They replied, "It can hardly be false, and so, since the propositional calculus allows only truth or falsity, it must be true" (1991, p. 7, and see also p. 74). The propositional calculus is the formal logic for the binary and extensional *material conditional*: the *truth functional conditional*, which is always true or false. But this truth functional logic was originally formulated for abstract mathematical reasoning; why should it force us to conclude that a natural language conditional is true when its antecedent is false? There are other logical systems which would allow us to judge it false (Stalnaker, 1968; and compare Rips, 1994, for a psychological proposal about a logic for human reasoning). To move away from the binary, still other logical systems would

allow us to consider a conditional with a false antecedent as "void", lacking an objective truth value at all, but having varying degrees of subjective probability (Adams, 1998; Baratgin, Over, & Politzer, 2013; Gilio, 2002; Pfeifer, 2013; Pfeifer & Kleiter, 2010, 2011). We do not believe that our example conditional is true when we judge that it is irrational to take part in the lottery and so are determined not to buy a ticket, for otherwise why do we find it irrational to take part? This old paradigm theory of the natural language conditional cannot be integrated with a satisfactory account of human decision making (see Johnson-Laird & Byrne, 2002, for later developments in the mental models account of conditionals and Evans & Over, 2004; and Evans, Over, & Handley, 2005, for a critique).

Most new paradigm theorists hold that people make judgements about indicative conditionals by using a general process known as the *Ramsey test*, which has deeply influenced logicians and philosophers (Edgington, 1995; Ramsey, 1929/1990). To apply this process to our example, we would assess how likely we were to win millions after hypothetically supposing that we bought a lottery ticket. The test turns a probability judgement about the conditional into a judgement about the conditional probability that we will win millions given that we buy a lottery ticket. Non-compulsive gamblers would clearly conclude that the conditional is highly improbable, since this conditional probability is extremely low. Psychological work on the Ramsey test highlights its resonance with what psychologists know about the human ability to think hypothetically about potential consequences in uncertain situations (for reviews see Evans & Over, 2004, and Oaksford & Chater, 2007, 2009).

When the lottery is over, and we know for sure that we did not buy a ticket and did not win, we could find the indicative conditional "void" in some sense (de Finetti, 1936/1995, 1937/1964; Politzer, Over, & Baratgin, 2010; Ramsey, 1929/1990), and turn to the counterfactual, the thought about what might have been: "If we had bought a lottery ticker then we would have won millions". To evaluate this counterfactual, we could use an extension of the Ramsey test due to Stalnaker (1968), which is to assess how likely we were to win millions after hypothetically supposing that we bought a lottery ticket and hypothetically making changes to our beliefs. These changes would be minimal, so as to maintain consistency in our beliefs: for example, we might suppose that we were enticed to buy a ticket while shopping for groceries, but we are unlikely to suppose that we used the TARDIS to travel back in time and buy a ticket. A possible way to implement this extension would be to recall our state of mind before it was certain that we did not buy a ticket and did not win, and then to use the original Ramsey test as before. There is some psychological evidence that people do use recollection in this way to make probability judgements about at least some counterfactuals (Over, Hadjichristidis, Evans, Handley, & Sloman, 2007; and see

Sloman, 2013, and the other papers in that issue of *Cognitive Science* for the latest work on counterfactuals).

The formal position that the probability of a natural language conditional, P(*if p then q*), is the conditional probability, P($q|p$), is so important in logic and philosophy that it has simply been called *the Equation* (Edgington, 1995). Psychologists have turned the Equation into an empirical prediction as the *conditional probability hypothesis*, P(*if p then q*) = P($q|p$). This hypothesis was first proposed by Rips and Marcus (1977), but it has only relatively recently been tested in experiments and strongly supported (Douven & Verbrugge, 2010; Evans, Handley, & Over, 2003; Fugard, Pfeifer, Mayerhofer, & Kleiter, 20011; Oberauer & Wilhelm, 2003; Over et al., 2007; Politzer et al., 2010). This work shows that people evaluate the probability of conditionals as the conditional probability for a wide range of conditionals: abstract conditionals such as "If the shape is square, then it is green"; everyday conditionals such as "If global warming continues, London will be flooded"; and so on.

An empirical paradigm which has become strongly associated with the Equation is the probabilistic truth table task (e.g., Evans et al., 2003; Oberauer & Wilhelm, 2003; Over et al., 2007). In this task participants are presented with a conditional sentence of the form *If p then q*, and the corresponding four truth-table possibilities, *p & q*, *p & not-q*, *not-p & q*, and *not-p & not-q*. The probabilities of the latter are either given (in the case of the abstract task), or elicited from participants in a separate task (in the case of everyday conditionals). For example, participants might be asked (Over et al., 2007) to evaluate the probability of the conditional "If global warning continues, London will be flooded", and separately the probabilities of the following combinations:

Global warming continues and London is flooded *(p & q)*

Global warming continues and London is not flooded *(p & not-q)*

Global warming does not continue and London is flooded *(not-p & q)*

Global warming does not continue and London is not flooded *(not-p & not-q)*

From these, conditional probability can be computed, as the probability of *p & q* divided by the summed probabilities of *p & q* and *p & not-q*. Then participants' judgement of the probability of the conditional is compared with this computed conditional probability. If human reasoning reflects the Equation, the computed conditional probability should strongly predict participants' estimates of the probability of the conditionals. The accumulated psychological evidence overwhelmingly supports this. A conditional that

satisfies the equation has been called a *probability conditional* (Adams, 1998), a *conditional event* (de Finetti, 1936/1995; Pfeifer & Kleiter, 2010, 2011), and a *suppositional conditional* (Evans & Over, 2004). A Bayesian account of people's conditional reasoning can be given if the Equation describes people's judgements about conditionals (Oaksford & Chater, 2007, 2009).

The Equation/conditional probability hypothesis fundamentally relates the psychology of reasoning to probability judgements and the study of judgement and decision making. Another linchpin making this connection is *probabilistic validity*, or *p-validity*. Inferences that are binary valid cannot lead to false conclusions from premises assumed true. In effect the assumptions are held to be certain, and this binary logic can be called the logic of certainty (de Finetti, 1972). But to make useful inferences from degrees of beliefs or confidence, de Finetti (1936/1995) and Ramsey (1926/1990) argued that a logic of subjective probability or of partial belief, degrees of belief, is the relevant standard. Later logicians developed this standard as that of p-validity (Adams, 1998; Gilio, 2002). Informally, an inference is p-valid if (and only if) it cannot coherently lead to an unbelievable and so improbable conclusion from believable and so probable premises.

A good way to illustrate the significance of p-validity is to use the well-known conjunction fallacy of Tversky and Kahneman (1983). Participants were given a thumbnail description of a woman, Linda, which triggers the characteristics of a feminist stereotype. As a result, they judged Linda as more likely to be a feminist and a banker, than just a banker. But clearly, the set of bankers includes both the set of feminist bankers and the set of non-feminist bankers, and so being a feminist banker cannot be more probable than being than just a banker (feminist or otherwise). In more technical terms, a conjunction, p & q, cannot be more probable than either of its conjuncts, p alone or q alone. It is p-valid to infer that Linda is a banker from Linda is a feminist and a banker, because it is impossible for the probability that Linda is a feminist and a banker to be coherently greater than the probability that she is a banker. The conjunction fallacy is a logical fallacy: it is a violation of a p-valid inference form.

There is a crucial difference here, important for psychologists as much as it is for philosophers. Binary validity preserves *truth* from assumed premises, and it can be shown to be a special case of p-validity by restricting all probabilities to 1 (truth) and 0 (falsity). In contrast, probabilistic validity, p-validity, is more general and preserves varying degrees of *confidence*. An important point for psychology is that p-validly opens up the study of people's deductive inferences from their actual beliefs, which they often hold with less than full confidence (see Evans & Over, 2013, for more on p-validity). The function of p-valid inference is to preserve confidence in beliefs. Much more generally still, the new paradigm can use its probabilistic approach to study people's non-deductive inferences, such as the many types

of inductive inference, from their actual beliefs. In the old paradigm the main narrative was about truth, and yet truth is a logical and perhaps metaphysical concept, and it is belief (of varying degrees) that is a psychological state. In the new paradigm the focus changes to belief and its relation to the topics of our next section.

UTILITY, PSYCHOLOGICAL VALUE, AND PRAGMATICS

Utility is the technical term used both in psychology and economics for what we might simply call psychological value: What we find desirable, or undesirable. For example, winning the lottery bears utility, but so does going on a holiday, or being bitten by a dog (negative utility in the latter case). One of the advantages of the new paradigm over previous approaches is the seamless integration of utility and probability in one decision-theoretic framework, in the same way in which this is done in the study of judgement and decision making. In psychology of reasoning, discussions of utility first appeared onstage in the context of the Wason selection task (for reviews see Evans & Over, 2004; Oaksford & Chater, 2007). In one version of this task participants are presented with a conditional expressing a deontic rule (that is, a rule about obligation or permission), such as "If someone drinks beer then they must be over 18 years of age" (Griggs & Cox, 1982). In this deontic version, four cards represent drinkers and show the person's age on one side, and the beverage they were drinking on the other side: Beer, Coke, 22, and 16. Participants are instructed to turn over the cards that will enable them to find out if the rule is being violated. About 75% choose "Beer" and "16", and this is the widely accepted normatively correct response. But the original version of this task was much more difficult for participants. It had an abstract form (Wason, 1960), using an indicative conditional like "If there is a D on one side, then there is a 3 on the other side", and cards such as D, K, 3, and 7. In this abstract form participants are instructed to turn over the cards that will enable them to find out whether the indicative conditional is true or false. Unlike the drinking age problem, only about 10% of participants manage to pick the classically normatively correct cards, D and 7 (although see Oaksford & Chater, 1994, for an alternative view on which cards should be considered normatively correct).

The difference between these versions—deontic and indicative—goes deeper than (as it was first thought) the fact that the drinking age problem presents familiar thematic contents. As Manktelow and Over (1991) first pointed out, the psychological value—technically utility—associated with each of the cards is crucially important in determining which card will be turned. Recall our case of the tidying up rule from earlier. Participants reasoning from the mother's perspective tended to select the cards with the highest (negative) utility for her; those which represented the child not

tidying up but nevertheless sneaking out to play. Those who reasoned from the child's perspective chose the cards with the highest utility for the child; the cards representing cases in which the child tidied up yet the mother defaulted on her promise to let him play.

Several aspects are worth highlighting here, as they set the stage for much of what was to follow in the new paradigm. First, the selection task is an experimental example of decision-making problems that bring together conditional reasoning and judgements of probability and utility (Evans & Over, 2004). Second, note the central role, in deontic forms of the task, played by social pragmatics; the roles that people play in everyday situations. This, too, brings the new paradigm closer to everyday life. This version paved the way to further studies into what, years later, Bonnefon (2009) was to dub "utility conditionals"; conditional sentences which bear utility, such as promises (e.g., Evans et al., 2008; Thompson, Evans, & Handley, 2005).

We also should make a brief note of the relevant formal system here: deontic logic, the logic of rules and regulations, permissions and obligations (McNamara, 2010). For example, promises are deontic speech acts, in that they create a set of permissions and obligations. Our tidying up example creates, under specific circumstances, both a permission for the child to play and an obligation for the mother to let him do so. Much research that followed examined both utility and probability aspects of deontic reasoning (e.g., Over, Manktelow, & Hadjichristidis, 2004; Perham & Oaksford, 2005). In contrast, publications on deontic reasoning in the old paradigm tended to be few and far between, and typically focused only on the truth conditions of deontic reasoning (see Bucciarelli & Johnson-Laird, 2005, and their appeal to a "principle of truth").

Note, however, that the role of utility is not restricted to deontic conditionals. Oaksford and Chater (1994) later argued that expected information gain—what can be looked at as a kind of expected epistemic utility (Evans & Over, 2004)—explains card choice in the abstract selection task just as the more mundane sort of utility explains the deontic tasks. This seminal early contribution to the new paradigm was also the first attempt to present a formal, Bayesian system to explain a classic reasoning task, covering both utility and probability. One prominent offshoot of this line of research is the work into Bayesian analysis of informal argumentation (Corner, Hahn, & Oaksford, 2011; e.g., Hahn & Oaksford, 2007), recently feeding into a special issue of *Thinking & Reasoning* (see Hornikx & Hahn, 2012, for the introduction). The recent surge of interest in argumentation, boosted by Mercier and Sperber's (2011) proposal that argumentation was the main function of all human inference, is entirely in the spirit of the new paradigm, both in the emphasis on social pragmatics, and the combination of probability and utility to explain argumentative effectiveness. It provides a paradigm case of the productivity of the new paradigm, and its potential to extend reasoning research to everyday inference.

Lastly, and importantly, note how discussions of utility bring reasoning research even closer to judgement and decision making, especially when discussed in conjunction with probability. As noted earlier, these are the two most important parameters in models of decision making, and this holds for normative and descriptive theories alike. Normative Bayesian theory (Ramsey, 1926/1990; von Neumann & Morgenstern, 1947) and the more descriptive—and vastly influential—prospect theory (Kahneman & Tversky, 1979) differ on what is portrayed as the relationship among utility, probability, and decision making, but not in the very inclusion of these parameters.

In conclusion, research in the new paradigm redirected enquiries from questions focusing solely on binary truth conditions to questions focusing on uncertain belief, utility, and social pragmatics, bringing reasoning research much closer to work in judgement and decision making. The jury is still out on how close to normative conceptions of utility and probability human reasoning is (or ought to be), but there is little doubt that they both have pivotal roles in human reasoning. But even now, we have not presented a complete picture.

BEYOND PROBABILITY AND UTILITY: DUAL PROCESSING AND THE QUESTION OF RATIONALITY

If so far we have given the impression that probability and utility are all that the new paradigm is about, this is not the case. To adopt Marr's influential distinction, the new paradigm concerns itself with questions of algorithmic nature as well as computational questions. Computational analysis focuses on *what* it is that a computational system actually computes. The answer, in the case of the new paradigm, is that the system computes psychological value (utility) and subjective degrees of belief (probability/uncertainty). Algorithmic analysis, on the other hand, explores questions of processing and representation—*how* the system computes whatever is being computed. Which brings us to dual processing and dual system theories.

Popular in many areas of cognitive science, dual processing theories (for recent reviews see Evans, 2008; Evans & Stanovich, 2013) distinguish between two types of processes. Type-1 or system-1 processes are fast and resource frugal; they allow fast responses to well-known situations. Type-2 or system-2 processes are slower and draw heavily on working memory and attentional resources, but support the type of hypothetical, consequentialist thinking necessary for processing novel situations. Although historically dual processing theories go back to the old binary paradigm, they have now evolved so as to be a prominent aspect of the new paradigm—the algorithmic aspect (Elqayam & Over, 2012; Manktelow et al., 2011; Oaksford & Chater, 2011, 2012). Indeed, Bonnefon (2013) identifies utility, probability, and dual processing as the "three pillars" of the new paradigm. Dual process

theories in the binary paradigm drew a strong parallel between type-2 processes and logical responding; in fact, one formative contribution (Evans, Barston, & Pollard, 1983) described it as a conflict between logic (type-2) and belief (type-1). New paradigm research into dual processing, in contrast, no longer identifies type-2 processing with any normative system, let alone classical logic (see also Evans & Stanovich, 2013).

Moreover, new developments in dual processing now create an even stronger link between dual process theories of reasoning and deciding and the new paradigm notion of confidence and uncertainty, with confidence in the initial response providing a crucial on/off switch for type-2 processing (Thompson, Prowse Turner, & Pennycook, 2011). When reasoners are confident (have a *Feeling of Rightness*) about their initial response, they are less likely to engage in the effortful processing required to change it.

Lastly for this introduction, we come to issues relating to the bigger picture. The new paradigm is an approach to reasoning, a family of theories, rather than a single theory. As such it is unavoidable that, alongside the widespread consensus on core issues, there are also areas of divergence and issues that are not yet resolved (see Evans, 2012, for a review). Perhaps the most pertinent of these is the treatment of rationality. There is an inherent paradox to human rationality (Evans & Over, 1996). On the one hand, humans as a species are highly intelligent, with massive achievements in creating complex systems of science, law, politics, as well as normative systems of rationality such as logic and probability. On the other hand, humans in the lab deviate markedly from these self-same normative standards, inviting the conclusion that humans are irrational.

In the new paradigm the jury is still out on how this paradox should be treated. Some of the new paradigm contributions to the debate (e.g., Oaksford & Chater, 2007, 2009) have been described (Stanovich & West, 2000) as *Panglossian*. That is, they argue that humans should be regarded as basically rational, and that choosing the appropriate normative system will eliminate all appearances of the paradox—this normative system being Bayesianism. Yet others are *Meliorist* (Stanovich, 1999, 2011), and see human rationality as flawed but amenable to education. Meliorists consider Bayesian models normative, but are far less sanguine about the match between them and human reasoning. Lastly, the newly formed *Descriptivist* approach (Elqayam & Evans, 2011; Evans & Elqayam, 2011) argues that perusal of normative standards is unsuitable for an empirical science of human thinking and is best left out of the picture.

Contributions to the new paradigm are rich and varied, and it is hard to give a brief summary about it that everyone contributing to it would accept. We can safely say, however, that everyone within the new paradigm has made the probabilistic turn and recognises the fundamental importance of understanding "the probabilistic mind" (Chater & Oaksford, 2008).

Studying probability judgements will tell us much more about the psychology of reasoning than trying to find out how far people conform to binary extensional logic in any deductive reasoning in which they engage. Beyond this point, we also see a greatly increased research interest in utility judgements and pragmatic factors in human reasoning. But there is less agreement on what the relevant normative theory should be for the new paradigm, whether it should be some form of Bayesianism, or indeed whether the new paradigm should concern itself with normative issues at all (see also Evans, 2012). In this special issue of *Thinking & Reasoning*, we bring together diverse contributions, which illustrate the basic elements of, and debates within, the new paradigm. As befits the nature of the symposia which triggered them, some of the contributions are basic science and some applied, and we have both theoretical and experimental papers, although all the latter are theoretically driven.

OVERVIEW OF THIS SPECIAL ISSUE

Probability and degrees of belief

We start with five papers that focus on the role of probability and validity. **Evans and Over** explore the relations between deduction and induction. The paradigm shift in the psychology of reasoning has moved away from the highly restricted study of extensional inference under assumptions, in effect held to be certain, to probabilistic reasoning from actual beliefs. One major aim of the new approach is to integrate research on deductive inference with studies of inductive reasoning and of judgement and decision making. But the question then arises whether deductive and inductive inference can any longer be clearly separated theoretically or psychologically. Evans and Over argue that deduction and induction are not identical in the new paradigm. There is a probabilistic definition of logical validity, p-validity, which can be used to distinguish between deduction and induction. Deduction and induction are closely connected theoretically and in people's reasoning, but are distinct and serve different purposes.

Epistemic modals—particularly for probability and its cognates—are ubiquitous in everyday and scientific reasoning, and illustrate the basic point of the new paradigm that almost all significant reasoning takes place in contexts where there are varying degrees of uncertainty. The epistemic modals are used to express these degrees. **Over, Douven, and Verbrugge** initiate the study of how people respond to the scope ambiguities caused by the modals. They provide evidence that people understand the probability modals, both categorical and graded, to have wide scope over conditionals. Their findings also add to the growing support for the conditional probability

hypothesis—that the probability of a conditional is the probability of its consequent given its antecedent—and its far-reaching implications.

There are two substantial bodies of psychological research that support a new paradigm view of the natural language conditional. One provides direct confirmation of the conditional probability hypothesis: that people judge the probability of the natural language indicative conditional to be the conditional probability of its consequent given its antecedent. The other confirms that people produce a so-called "defective" truth table for the indicative conditional, in which false antecedent cases are judged irrelevant to its truth or falsity and make it "void". **Baratgin, Over, and Politzer** explain why it is much better to call this three-valued truth table the 2×2 *de Finetti table*. Then, taking a new approach, they show how de Finetti generalised the table to a much more realistic 3×3 table, in which the antecedent and consequent can be uncertain rather than simply labelled true or false (de Finetti, 1936/1995, 1937/1964). They confirm that de Finetti's 3×3 table tends to be reproduced in people's judgements about conditionals.

Binary truth functional logic was the logic of certainty for de Finetti (1972). As a much more general and useful alternative, he proposed a logic of probability, which for him was a logic of subjective probability, degrees of belief (de Finetti, 1936/1995, 1937/1964; and see also Ramsey, 1926/1990, on the logic of partial belief). **Pfeifer** proposes a *mental probability logic* based on de Finetti and later developments (Adams, 1998; Gilio, 2002; see also Gilio & Over, 2012). In mental probability logic, an indicative conditional is what de Finetti called the conditional event and others have termed the probability conditional or the suppositional conditional (Evans & Over, 2004; Oaksford & Chater, 2007). Pfeifer provides additional experimental support for what we have called the conditional probability hypothesis: that the probability of indicative conditional is the conditional probability of its consequent given its antecedent. He also analyses one of the "paradoxical" inferences which result from interpreting the natural language indicative conditional as the material, truth-functional conditional. He explains how experiments disconfirm this interpretation and support seeing this indicative conditional as de Finetti's conditional event.

Last to this section on probability, the new paradigm has directed attention to the non-monotonic reasoning found in dynamic inference and belief revision or updating, which were almost totally neglected topics in the old paradigm, in spite of their fundamental importance in everyday and scientific thought. **Oaksford and Chater** have broken new ground in the psychology of reasoning with their approach to these topics (see also Baratgin & Politzer, 2010). In this paper they develop the study of dynamic conditional inference and the associated belief revision, covering their learning account, causal Bayes nets, and suppression effects. They address some problems in the study of dynamic inference, including the learning of

conditional information, and point out that it is still unclear what the constraints should be on going from one probability distribution to another in belief revision.

Utility and social pragmatics

We now come to three contributions dealing with the role of utility and social pragmatics. **Bonnefon** asks whether the new paradigm can offer to the psychology of reasoning the public outreach that it never had. He offers a bleak assessment of the public influence of the psychology of reasoning, compared to that of close fields such as judgement and decision making or moral psychology, and he argues that this sorry state of affairs might be the legacy of the deduction paradigm. He suggests that based on its three pillars (probability, utility, and dual processes), the new paradigm has acquired brand new opportunities to investigate high-stake problems, and to pursue full integration with judgement and decision making and moral cognition, with the aim of bringing a rapid increase of its relevance to people's daily challenges and societies' greater ambitions.

Utility also provides a bridge into a pertinent aspect of human cognition, the role of emotion. **Blanchette and Caparos** explore how emotion affects processing of classic reasoning tasks. They highlight the paradox of emotion effects on reasoning, which can be either detrimental or beneficial. Their proposed solution to the paradox is the utilitarian role played by integrated emotion. When emotion—even negative emotion, such as memories of abuse or combat trauma—is an integral part of task contents, it bears epistemic utility in the sense that it highlights relevance of the contents, as well as more mundane utility insofar as it facilitates future planning so as to avoid the negative experience. Hence negative emotion, when integral, can have positive utility. This disappears when emotion is induced independently of task contents.

Harris, Corner, and Hahn provide an illustration of how the new paradigm can explore new territories thanks to its simultaneous consideration of probability and utility. They address the phenomenon of Faint Praise, in which a positive appreciation can lead to a negative impression. For example, a reference letter that merely stated that the applicant is "polite and punctual" would lead to a negative impression of this candidate's capabilities. Under the deduction paradigm, this kind of inference would have been off-limits, and labelled as a pragmatic effect. Under the new paradigm, a decision-theoretic framework incorporating Bayes' theorem and epistemic closure can provide a satisfying, general theoretical model of the Faint Praise phenomenon and its conceptual relationship with other argumentative phenomena.

Rationality and dual processing

Our special issue concludes with two papers, one on dual processing and one on rationality. During a paradigm change, it is not uncommon that some tasks and protocols move from centre stage to remote periphery. One would have thought that the venerable Wason selection task might have suffered such a fate during the transition to the new paradigm psychology of reasoning. This would have been a loss, since there is great value in using well-known, well-calibrated tasks in novel ways, to investigate novel models. This is what **Thompson, Evans, and Campbell** do when they utilise the selection task to explore a dual-process, metacognitive model of reasoning biases.

The last paper explores the role of Bayesian models in the new paradigm. A major source of inspiration to work within the paradigm, Bayesianism has nevertheless also been a bone of contention, not least in relation to its status as normative system. **Elqayam and Evans** point out both consensus and contention, and propose that Bayesian contributions to the new paradigm can be placed on a range between a "strict" and a "soft" pole. Stricter Bayesian approaches start with close adherence to the Bayesian model, which they regard both as a normative system and as close proxy for a good descriptive system. Softer Bayesian approaches adopt Bayesian principles for their psychological features, such as subjectivity, but regard them as idealisations, rather than accurate descriptive models, and not necessarily normative.

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