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Decision Science: From Ramsey to Dual Process Theories

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Abstract. The hypothesis that human reasoning and decision-making can be roughly modeled by Expected Utility Theory has been at the core of decision science. Accumulating evidence has led researchers to modify the hypothesis. One of the latest additions to the field is Dual Process theory, which attempts to explain variance between participants and tasks when it comes to deviations from Expected Utility Theory. It is argued that Dual Process theories at this point cannot replace previous theories, since they, among other things, lack a firm conceptual framework, and have no means of producing independent evidence for their case.

In 1954 Edwards put forward the *Normative Man* hypothesis, i.e. the idea that human reasoning and decision-making could be roughly modelled by Expected Utility theory. As long as thirty years ago declarations that the hypothesis had all but been refuted were not uncommon,[2] and since then alternative theoretical proposals have been made.[3] However, Normative Man lives on in the increasingly popular Dual Process theories.

Essentially, Dual Process theories argue that human cognitive architecture contains not one but two systems of reasoning, one which is associative, has evolved over a long period and is implicit (System 1), and a more recent, rule-based, explicit system (System 2). We will argue that proponents of Dual Process theories often treat System 2 as an approximation of Normative Man, and that System 1 is an add-on system required to explain decades of psychological research indicating that Normative Man is not descriptively adequate for human reasoning.

Here is how we will proceed. Although early authors like Edwards formulated the Normative Man hypothesis quite explicitly and referred back to a substantial body of economic literature describing the hypothesis in detail, the view has now become so entrenched that it often is referred to, without supporting citations, in rather vague terms such as "the traditional, formal theory of decision-making".[4] We will take a closer look at the Normative man hypothesis and at Prospect theory, one of the first descriptive theories of decision-making that were put forward to replace Normative Man. Our purpose here is to demonstrate that they were quite dependent on this view, both for their formulation and justification. This dependence is important since the additional process in Dual Process theories is often modelled on these descriptive attempts. If one (or indeed both) of System 1 and System 2 essentially depends on Normative Man, then the status of Dual Process theories can be questioned. We will then evaluate if and if so how dual process theories contribute to our understanding of decision making.

1. Normative Man

Ramsey (1926)[5] laid the foundations of the modern theory of subjective probability. He showed how, under ideal conditions, people's beliefs and desires can be measured with a betting method, and that if some intuitive principles of rational behaviour are accepted a measure of our "degrees of belief" will satisfy the laws of probability. He

formulated the Dutch book theorem and he laid the foundations of modern utility theory and decision theory.

One aim of Ramsey's work is to analyze the connection between the subjective degree of belief we have in a proposition and the (subjective) probability it can be given, and to find a behavioural way of measuring degrees of belief. His aim is to understand how a single (decision) processor works. More precisely, Ramsey wants to show, first, that we can measure the degree of belief a subject has in a given proposition; and, second, that if the subject is rational, this measure, or "subjective" probability, will satisfy the axioms of probability theory. In other words, Ramsey's aim is to establish that, given his method of measuring the strength of "partial beliefs", the degrees of belief of a *rational* agent or processor will obey the laws of probability.

Ramsey shows that people's beliefs and desires can be measured with a traditional betting method. As he says, it is a "sound" method, but one that is not completely "general" and not very "exact". He proves a representation theorem stating that a subject's (a single processor's) preferences can be represented by a utility function determined up to a positive affine transformation. It is the binary preferences that are represented, and the very goal of the theorem is to isolate the conditions under which such preferences can be seen as maximizing expected utility. The representation guarantees the existence of both a probability function and an unconditional utility function such that the expected utility defined by this probability and utility represents the agent's preferences.[6]

Ramsey did not subscribe to de Finetti's famous dictum that "probabilities" (meaning objective probabilities) "do not exist"; rather he claimed that some types of probability are a matter for physics and not for logic. He would undoubtedly have argued that some probability assessments are not rational. Where a subject has a degree of belief not reflecting the chances given by an accepted theory, the subjective probabilities are clearly not well calibrated. Note that this suggests two types of rationality – one external (how we relate to our surroundings) and one internal (how our beliefs intertwine).[7]

Among psychologists generic expected utility theory has received wide approval as *the* normative model of rational decision-making. The hub of this generic theory is something like Ramsey's or Savage's theory.[8] The basic idea of expected utility theory is that two main types of factor determine our decisions: our *desires* and our *beliefs*. These determine the utilities and probabilities, respectively, of the possible outcomes of our decisions. Expected utility theory provides us with a model of how to handle our desires and beliefs and an account of how they combine in rational decisions.[9] The fundamental decision rule of this model says that, in a given decision situation, we should choose the alternative with maximal expected utility (the principle of maximizing expected utility). This is a single-processor model.

During the early decades of cognitive psychology it was accepted, as a working hypothesis, that human reasoning could be roughly modelled by theories that had been developed to best solve problems and make decisions. Exactly which theories were referred to here was sometimes left unclear, but the assumption was that we basically reason as we should reason, despite the occasional mistake. Let us call the

reasoning figure imagined in this base line theory Normative Man. Normative Man is a congener of Ramsey's ideal decision agent – Ramsey's description of an ideal agent made into a norm.

Edwards explicitly formulated the Normative Man hypothesis for psychology. A decade later Wason (1966) extended the hypothesis to "deductive reasoning" and Peterson and Beach (1967) provided an alternative formulation for statistical inferences:

> For many uncertain situations, statistical theory provides models for making optimal inferences. The psychological research consists of examining the relation between inferences made by man and corresponding optimal inferences as would be made by "statistical man". (Peterson and Beach 1967, 29)

The stage was set for a torrent of empirical research.[10]

2. Violations

In the decades following Edwards' introduction of the Normative Man hypothesis psychologists demonstrated that there are cases where humans violate the axioms of generic expected utility theories such as those of Savage and Ramsey; and it has been argued that these violations show the theory to be an inadequate descriptive model of human decision behaviour. Following Kahneman and Tversky, the *certainty effect*[11] has been taken to show that our choices violate expected utility theory; and the *reflection effect* appears to show that, if gains are replaced by losses in a decision problem, a majority of us reverse our behaviour. Again, Prospect Theory reports that subjects dislike *probabilistic insurances*. Finally, the so-called *isolation effect* may result in a violation of the expected utility theory, because[12]

> a pair of prospects can be decomposed into common and distinctive components in more than one way, and different decompositions sometimes lead to different preferences. (Kahneman and Tversky 1979, 192)

Clearly, then, serious doubts have been raised about the descriptive adequacy of rational models of judgment and decision-making. A straightforward reaction to the empirical findings is to conclude that Normative Man (and his Rational congener) has been refuted. In fact, mere hints that Normative Man was not best suited to describe of human reasoning were once the starting point of endless debates about human rationality or irrationality. We shall not trace this debate here.[13] However, for present purposes three reactions to the attempted overturning of the Normative Man model can be usefully, albeit briefly, identified:

(1) *Normative Man is not a theory of human decision-making* and therefore cannot be falsified. Did Ramsey himself refute Normative Man, at least as a viable empirical hypothesis? He says:

> I have not worked out the mathematical logic of this in detail, because this would, I think, be rather like working out to seven places of decimals a result only valid to two. My logic cannot be regarded as giving more than the sort of way it might work. (Ramsey 1926/1990, 180)

In his familiar, cryptic style Ramsey tells us that his theory is not a theory of human decision-making, but a theory of how, under ideal circumstances, an ideal decision maker would work. Cohen (1982) presents a reversed, slightly twisted and headstrong version of this argument: since norms are extracted from human reasoning, it is not possible to demonstrate discrepancies between the two.[14]

(2) *Normative Man is not falsified*. Another reaction to the results is to question them. Although Normative Man might, in principle, be refuted, the available data do nothing of the kind. In this denial camp, we find both those re-interpreting the available experimental tasks, such as Sperber et al. (1995), and those arguing that Normative Man has been misrepresented (Gigerenzer 1991).[15]

(3) Among those that provided the experimental demonstrations, *pleading guilty* is naturally the most common approach. Normative Man has been refuted, and we need a new theory of human reasoning (e.g. Kahneman and Tversky 1982; Wason and Shapiro 1971). Normative Man is not "descriptively adequate" (Kahneman and Tversky 1974/1982, 124).

For the sake of the argument we will endorse the third of these reactions, pleading guilty, and assume that Normative Man is to some extent refuted, or descriptively inadequate. What consequences does this have for theories of human decision-making? One of Kahneman and Tversky's responses was to reframe Normative Man. They gave us Prospect Theory.

3. Prospect Theory: a Reframing of Normative Man

Phenomena such as the certainty effect, the reflection effect and the isolation effect indicate that expected utility theory is not a descriptive theory. It is important to bear in mind, however, that the relevant type of preference here does not always, and without a number of boundary conditions, violate expected utility theory. In other words, it would be a mistake to suppose that the results show *without proviso* that we do not use a Ramseyian process to make decisions.[16] Expected utility theory does not, for example, say that probabilistic insurance is superior to regular insurance. To prove that it is, one has to make the auxiliary assumption that the utility function is concave. But this is an empirical assumption, not an axiom of the theory. The same is true for findings of the Allais-type. To secure violation of the utility theory we must assume that the subject has the same utility function in the pair of choice situations that figure in the type of experiment devised by Kahneman and Tversky. In the case of the certainty effect the inconsistency disappears if we assume that the subjects employ distinct utility functions in the two decision situations;[17] and nothing prevents Normative Man from changing his (or her) preferences.

Expected utility theory tells us that our desires and beliefs can be represented by a *utility* function u(.) and a *probability* function P(.), respectively. As a descriptive model, it claims that the decision maker can compute the total value of the various decision alternatives, i.e. their expected values ($EU(a_i) = P(s_1)u(o_{i1}) + ... + P(s_m)u(o_{im})$, where a_i, s_j, o_{ij} denote the action alternatives, possible states, and outcomes, respectively). Prospect Theory, by contrast, claims the existence of two functions: the *weighting* function $\pi(.)$ and the *value* function $v(.)$. Together these give

the total value of an edited prospect. π assigns a decision weight to the stated probabilities – making, for example, small probabilities over-weighted. For small stated probabilities π is also a sub-additive function of p, and in addition we have both sub-certainty and sub-proportionality.

In Prospect Theory v assigns values, not to final states, but to changes in wealth or welfare, in accordance with well-known principles of perception and judgment. From this perspective, an adaptation level, a reference point or a level of aspiration, becomes important as a basis of evaluation. Besides this very essential characteristic of the value function, experimental findings indicate that v should generally be concave for gains and convex for losses, and steeper for losses than it is for gains. This means that the experimental results are best characterized by an S-shaped value function (both for gains and for losses).[18]

Does this type of research enable us to understand the psychological mechanisms of human decision-making? Does it offer any indication of whether and how to change the theories used to predict the results of the experiments? We think not – at least, not in the way intended by the experimenters. There is limited value in "testing" a normative theory.[19] These theories are not models of human decision-making. Ramsey's theory, for example, describes an ideal agent. It portrays rational decision-making. Reflection tells us that, as human beings, we are bound to fail mathematical and structural axioms. Continuity axioms and Archimedean axioms are for those with far greater computational capacities. The ontological axioms structure the world in an ideal way. And what reason do we have to assume that the rationality axioms, static as they are, without both dynamic and evolutionary content, can be used to model human decision-making?[20]

Thus the discovery that expected utility theory, the Normative Man hypothesis, lacks descriptive value is not very helpful when it comes to developing a theory of human decision-making. "Falsifying" expected utility theory does not guide us towards a descriptive theory of analytical power and empirical resilience.

4. Dual Process Theories – Intellectual Background

From the above analysis of Prospect Theory we can draw the following conclusions. First, Normative Man might not be the best model for human decision-making. For the formal character, or rather conceptual framework, Normative Man incorporates is not enough to capture the precise process(es) of decision-making; and attempts to test the model empirically have not been favourable (we have assumed). Second, because of this, it is not enough to reformulate the theory by, for instance, tweaking its functions.

Thus a new theory of human reasoning is needed. One possibility is to revise the Normative Man hypothesis. Human behaviour is rational, but not in the way the researchers trying to falsify Normative Man understood it to be. This approach is represented today by authors such as Gigerenzer, Todd and the ABC Group (1999), who propose an Ecological rationality. Note, however, that if they are to have empirical content, reformulations of Normative Man require either heavy auxiliary assumptions or additional assumptions about the processes of human decision-making.[21]

Dual Process theories, on the other hand, retain Normative Man, but introduce an additional process, better equipped to explain deviations from the norm. In Kahneman's words: "In the context of a dual-system view, errors of intuitive judgment raise two questions: 'What features of System 1 created the error?' and 'Why was the error not detected and corrected by System 2?'" (Kahneman and Frederick 2002, 52).[22] Such a model attempts to account for both *variance between participants* and *variance between tasks* when it comes to testing the Normative Man hypothesis.[23] There are clusters of Dual Process theories in the literature, and how they map on to one another is at present rather unclear (cf. Evans 2008). Typically, however, the operations of the two systems are described in the following way:

> ... the most important distinction between the two systems is that they tend to lead to different types of task construals. Construals triggered by System 1 are highly contextualized, personalized and socialized. [...] The primacy of these mechanisms leads to what has been termed the fundamental computational bias in human cognition (...) – the tendency towards automatic contextualization of problems. In contrast, System 2's more controlled processes serve to decontextualize and depersonalize problems. This system is more adept at representing in terms of rules and underlying principles. It can deal with problems without social content and is not dominated by the goal of attributing intentionality nor by the search for conversational relevance." (Stanovich and West 2000, 658-659)

The task construals of System 2 are those expected of Normative Man (when decontextualized and not led astray by social or conversational considerations), whereas System 1 explicitly produces "the fundamental computational *bias*". Not surprisingly, Dual Process theories tend to give similar descriptions of System 2 (Normative Man), while differing with respect to System 1: "System 2 appears a more coherent and consistent concept in the generic dual-system theory than does System 1 as there are multiple systems of implicit cognitive processes" (Evans 2008). We suspect that the heterogeneity of System 1 partly depends on the types of deviation from the norm that are to be explained.[24]

If the perspective is to accommodate the empirical findings in this way, one of the processors in Dual Process theory must be assumed to be consistent with Normative Man. Limits on the kinds of process that Dual Process theories are assumed to be operating with are also necessary when it comes to pinpointing the nature of the research programme. We can identify various kinds of process on almost any level of a scientific discipline. In particular, this can be done in decision sciences. Thus, for instance, in one respect the classical subjective expected utility theory is a kind of two (or three) process research programme.[25] But it is clearly of a different nature, since it examines the combination of a mechanism assigning values to information and a mechanism assigning values to outcomes. And although the work of Kahneman and Tversky can be categorized as a test of one Process theory (Normative Man), it too argues for the existence of a complex of processes. Ramsey's descriptive theory, on the other hand, starts with something unitary, an expectation, and divides it into constituent parts.[26] For these reasons it is imperative that we fix the level of inquiry we are working on, and keep it fixed. We will stipulate that in the context of Dual

Process theories of judgment and decision-making, System 2 is supposed to be consistent with Normative Man.

However, even when we keep one of the processes fixed, and even if we acknowledge the existence of robust deviations from it, System 2 is not in itself enough to motivate Dual Process theories. It could be that the deviations are better explained as the malfunctioning of the single process in System 2. This is where two other arguments come into play. First we have arguments from evolution suggesting that System 1 is the older version of *Homo sapiens*, whereas Normative Man is a more recent addition to our reasoning capabilities.[27] Then we have the refutation of the malfunctioning hypothesis by results that the deviations from Normative Man are much too systematic to explain.

But the explanation of System 1 in terms of deviation from Normative Man is much too weak to make it substantive, let alone to qualify it as a distinct theory. We begin by adding to the professed contents of System 1. However, it might still be useful to focus on differences between the two processes, but this time with a positive characterization of System 1.

5. System 1 and System 2: Different Causes and Effects?

The empirical justification of Dual Process theories creates an interesting challenge. What evidence is there that such processes exist, and what evidence could there be? They might differ in respect of the intrinsic qualities of the two processes: System 1 is perhaps unconscious, while System 2 has to be conscious. Suggestions of this kind will be listed in the next section. Another possibility is that System 1 and 2 have different stimulus conditions or different outcomes, so that we can argue for their dual existence in terms of a difference in the causes and effects of the two systems.

It is often claimed that System 1 is preferentially activated when decision makers work under pressure of time. For instance, people are more likely to commit the typical biases when they are hastening to do something.[28] Similarly, System 1 is more often assumed to be active when cognitive load is high.[29] Such claims motivate a categorization of the interplay between Dual Processes in terms of either default-interventionist or parallel-competetive processes – a categorization reminiscent of Elster's type A and type B mechanisms.[30] If System 1 and System 2 are of the default-interventionist kind, then only one process is active at a time. System 1 is often assumed to be the default process. According to this view, System 1 is perhaps always activated at first, but when there is time and sufficient working memory, System 2 takes over control. This view of the interplay between System 1 and System 2 nicely captures the idea that Dual Processes can be disentangled in terms of what triggers them.

Dual Processes of this default-interventionist type should also differ in their effects. If System 2 is equated with Normative Man, the majority of responses produced by the system have to be compatible with "the norm" (we have to allow for random error), whereas the responses of System 1 may or may not deviate from the same norm. When the two systems respond differently to a stimulus, Sloman's (1996) Criterion S might be satisfied. This happens when participants "simultaneously believe two contradictory responses" and "the tendency to provide the first response continues to

be compelling irrespective of belief in the second answer, irrespective even of certainty in the second answer" (Sloman 1996, 11). Thus Sloman (1996, 12) argues, in relation to the Linda Problem, that the fact that "people tend to make judgments on the bases of representativeness that violate a rule, a rule which most are happy to grant" is evidence of dual processing: one process (approximately System 1) produces responses that are in line with representativeness, whereas the other grants a rule which, it is argued, is directly associated with Normative Man.[31]

A stronger version of this view is that System 1 and System 2 are "modular" in Fodor's sense. Fodor equates modularity with informational encapsulation:[32]

> A module is (inter alia) an informationally encapsulated computational system an inference-making mechanism whose access to background information is constrained by general features of cognitive architecture, hence relatively rigidly and relatively permanently constrained. One can conceptualize a module as a special-purpose computer with a proprietary database, under the conditions that (a) the operations that it performs have access only to the information in its database (together, of course, with specifications of currently impinging proximal stimulations); and (b) at least some information that is available to at least some cognitive process *not* available to the module. It is a main thesis of *Modularity* that perceptual integrations are typically performed by computational systems that are informationally encapsulated in this sense. (Fodor 1985, 75)

Obviously, it is much harder to claim that robust empirical evidence favours Dual Process theories if the causes and effects of the processes can intertwine. However, this very intertwining is a plausible outcome of Dual Process theories of the parallel-competitive, or type B, kind. The following figure, adapted from Loewenstein et al., illustrates the point (2001).

FIGURE I

Here all the parts of System 1 and System 2 seem to be connected. All respond to the same input, and give potentially the same output. Clearly, in Loewenstein's depiction, the Dual Process theory does not contain encapsulated systems; and as a matter of fact this appears to be a feature of all Dual Process theories. The very history of Dual man excludes the idea of informational encapsulation. After all it is the variance within and between subjects when it comes to answering *the same types* of question that Dual Process theories aim to explain. So perhaps, the whole idea of identifying different causes and effects of the Dual Processes is misguided.

6. System 1 and System 2: Different Kinds of Process?

Another reason to focus on the intrinsic differences of the alleged Dual processes rather than their causes is that, while System 1 is often conceived of as being triggered by a specific stimulus, System 2 is typically labelled in a non-causal way. This is nicely illustrated by some of the pairs of terms that have been employed in the psychological literature in place of the neural "System 1" and "System 2". In Evans (2008) overview, for example, we find the following: "Automatic/Controlled",

"Impulsive/Reflective", "Reflexive/Reflected" and "Stimulus-bound/Higher-order". These terminological substitutes appear to indicate that while System 1 might usefully be described in terms of causes and effects, System 2 may or may not. Moreover, a number of the pairs listed allude to qualitative differences between the two rather than differences in their causes and effects: "Unconscious/Conscious", "Low effort/High effort", "Rapid/Slow", "Associative/Rule-based", "Domain-Specific/Domain-General", "Contextualized/Abstract", and "Parallel/Sequential". We will follow just one attempt to distinguish between Dual Processes along lines such as these here.

Recently Melissa Finucane and her colleagues have begun, in a series of articles, to study what they call the "dance of affect and reason". According to them, affect is a conscious or unconscious experience of goodness or badness.

> Stimulus representations associated with affect can include external events and objects as will as internal representations (e.g. memories). Individuals differ in the strength and speed of their positive and negative reactions… An affective reaction can be an enduring disposition… but can also be a fleeting reaction. (Finucane, Peters & Slovic, 2003, 328)

They continue to point out how context-dependent affective reactions are upon those aspects of the stimulus that are most significant at that moment in time.

According to Finucane et al. vast quantities of empirical data support the claim that affect is a key player in judgement and decision-making. We have, for example, the proportion dominance studies. Many studies in the domain of life-saving interventions have shown what has been called "psychophysical numbing". For example, proportions, saving "nearly all" in a small group, is far more important as decision triggers than expectations, i.e., for example, saving the maximum number of individuals. This type of behaviour has also been found in other domains of decision-making. Proportions even matter when we chose between ice cream containers, as Hsee (1998) shows.[33]

The context-dependence of affective processes means that the suggested model is sensitive both to individual characteristics and idiosyncrasies, to the structure (or structuring) of the decision problem, and to environmental factors – in fact, so sensitive that it might be difficult to get solid experimental data providing appreciable support for an independent affect-based decision process. It is one thing to have scattered empirical evidence hinting at an affect process capable of systematization under a broad and vague affect umbrella. It is quite another thing to have a conceptually well-articulated affect-based Dual Process theory which, independently of Normative Man, can be tested. This problem generalizes to any distinction between System 1 and System 2 expressed in terms of the further distinction between what is contextualized and what is abstract.

A decision maker like Normative Man, or Ramsey's ideal agent, reasons, it is argued, logically and consciously, encodes reality in symbols, words and numbers, seeks justification – processes that are generally slow. Affective decision-making, on the other hand, encodes reality in images, metaphors and narratives, and reacts swiftly on the basis of memories or images of good and bad, pleasure and pain[34] – processes that

are generally swift. But are there two systems, or is there but one system that operates differently under different boundary-conditions? Or are there more than two systems?

7. Towards a Contemporary Decision Science

We began this paper outlining Ramsey's descriptive theory, the first complete narrative of an ideal decision maker. Eight decades of theoretical and empirical research on decision-making has taken us from a description of an ideal, via Normative Man, by way of irrationality claims and Prospect Theory, to Dual Process theory. Are we on the right track? We do not think so. We will end this paper by highlighting some of the philosophical and empirical problems that Dual Process theory faces.

What is a process? If processes are to be at the core of contemporary decision science a reasonably rigid definition of the concept of process is required. But as far as we can see the concept has never been properly defined. How it is used varies from author to author, and also within one and the same paper (a neurological process, for example, is definitely something rather different than an affective process or logical reasoning).

One way to clarify what we mean when we talk about a Dual Process theory is to assume that the processes are default-interventionist. The extreme option would be to work within Fodor's framework of an informationally encapsulated computational (read, decision) system. This gives us a rigid but tidy framework. An advantage of this option is that System 1 and 2 will be kept apart. A disadvantage is that we want to know when, and what happens if, the two decision systems conflict. Is System 2 (Normative Man) always interventionist? Or do we need a third system regulating conflicts between System 1 and 2? It seems rather odd to assume that we (as it were) turn into Normative Man as soon as time permits.

Another clarificatory manoeuvre is to assume a Dual Process theory of the parallel-interactive kind. An example of this is the theory sketched by Loewenstein (see the figure above). But this type of theory is far too vague. Are any types of datum such that they cannot be explained by this Dual Process theory? Certainly, with many interactions between the two processes few outcomes will be prohibited by it.

The lack of independent evidence. Most evidence favouring System 1 is indirect; and most of it originates in experiments designed to disprove the Normative Man hypothesis. Of course, to show that one hypothesis is untenable is not automatically to show that another is verified. One cannot establish System 1 merely by disproving the notion that System 2 operates alone. Hence we need independent and direct empirical evidence to render Dual Process theory feasible in its own right. We do not say that it is impossible to obtain this type of direct evidence; only that at present it is lacking.

The lack of a conceptual framework. We need to make both epistemological and ontological assumptions if we are to arrive at an understanding of human decision-making. Theoretical concepts have to be introduced and linked together. The mere provision of concept pairs like fast/slow, logical/narrative, good/bad, low effort/high effort, contextualized/abstract, does not constitute a theory. What the Dual process idea seem to be lacking is a theoretical framework which can be introduced and

explained without reference to Normative Man. The ontological commitments must be made clear. They have to be better and more realistic than Ramsey's.

The value of inductive systematization. A well-known problem with many of the empirical findings published on human decision-making is that they tend to be the type collected in experience rather than in theory testing. The more elaborate experiments inductively systematize a vast body of collected experience and come up with an empirical rule or hypothesis. However, their explanatory value is poor. Thus the psychological quiz has rather limited scientific value, regardless of whether the evidence received is direct or indirect. If we want to *understand* why people do what they do, we need to develop a conceptual framework appropriate to the task. We need, not more experimental questions and answers, formulated in the light of Normative Man, but a conceptual framework that tells us how to ask the relevant questions. If we cannot (so to speak) take leave of Normative Man, there is little, if any, hope that we will obtain a theory, or substantial model, of human decision-making.

The incredible Normative Man. Even if we ignore the empirical evidence that has accumulated during the last half century there is no reason to assume that Normative Man offers a viable description of human decision-making. Theories of rational decision-making are theories for rational angels (to borrow a phrase from Isaac Levi), not for human beings. But Dual Process theories seem to assume that each of us is half-angelic.

References

Allais, M. (1953). Le comportement de l'homme rationnel devant le risque : Critique des postulats et axiomes de l'école américaine. *Econometrica*, 21, 503-46.

Baron, J. (2004). Normative models of judgment and decision making. (In D. J. Koehler & N. Harvey (Eds.), *Blackwell Handbook of Judgment and Decision Making* (19-36), London: Blackwell).

Baron, J. (2008). *Thinking and Deciding*. 4th edition. (Cambridge: Cambridge University Press).

Carruthers, P. (2002). The cognitive functions of language. *Behavioral and Brain Sciences, 25*, 657-726.

Cohen, J. L. (1981). Can human irrationality be experimentally demonstrated? *Behavioral and Brain Sciences*, *3(3)*, 317-370.

Cohen, J. L. (1982). Are people programmed to commit fallacies? Further thoughts about the interpretation of experimental data on probability judgment. *Journal for the Theory of Social Behavior*, *12(3)*, 251-274.

Cohen, J. L. (1986). *The dialogue of reason: An analysis of analytical philosophy*. (Oxford: Clarendon Press).

Edwards, W. (1954). The theory of decision making. *Psychological Bulletin*, *51*, 380-417.

Elster, J. (1999). *Alchemies of the mind*. (Cambridge: Cambridge University Press).

Elster, J. (2007). *Explaining social behavior*. (Cambridge: Cambridge University Press).

Evans, JStBT (2006). The heuristic-analytic theory of reasoning: Extension and evaluation. *Psychonomic Bulletin and Review*, *13(3)*, 378-395.

Evans, JStBT (2008, in press). Dual-processing accounts of reasoning, judgment and social cognition. *Annual Review of Psychology.*

Evans, JStBT & Over, (1996). *Rationality and reasoning*. (Hove: Psychology Press).

Fishburn, P. C. (1981). Subjective expected utility: A review of normative theories. *Theory and Decision*, *13*,139-199.

Finucane, M. L., Peters, E. & Slovic, P. (2003). Judgement and decision making: The dance of affect and reason. (In Schneider, S. L. & Shanteau J. (Eds.), *Emerging perspectives on judgment and decision research* (327-364), Cambridge: Cambridge University Press).

Fodor, J. (1983). *The modularity of mind*. (Cambridge, Mass: MIT Press).

Fodor, J. (1985). Précis of the Modularity of mind. *Behavioral and Brain Sciences*, *8*, 1-42.

Gärdenfors, P. & Sahlin, N.-E. (1988). *Decision, probability, and utility: Selected readings*. (Cambridge: Cambridge University Press).

Gigerenzer, G.. (1991). How to make cognitive illusions disappear. (In W. Stroebe and M. Hewstone (Eds.), *Review of social psychology* (83-115), Chichester: Wiley).

Gigerenzer, G.., Todd, P. & The ABC Group (1999). *Simple heuristics that make us smart* (Oxford: Oxford University Press).

Hsee, C. K. (1998). Less is better: when low-value options are valued more highly than high-value options. *Journal of Behavioural Decision Making*, *11*, 107-121.

Kahneman, D. & Tversky, A. (1973). On the psychology of prediction. *Psychological Review*, *80*, 237-251.

Kahneman, D. & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica 47*, 263-291.

Kahneman, D. & Tversky, A. (1982). On the study of statistical intuitions. *Cognition*, *11*, 123-141.

Kahneman, D. & Frederick (2002). Representativeness revisited: Attribute substitution in intuitive judgment. (In T. Gilovich, D. Griffin & D. Kahneman (Eds.), *Heuristics and biases: The psychology of intuitive judgment* (49-81), Cambridge: Cambridge University Press).

Keys, D. J. & Schwartz, B. (2007). 'Leaky' rationality: How research on behavioral decision making challenges normative standards of rationality. *Perspectives on Psychological Science*, *2(2)*, 162-180.

Loewenstein, G. F., Hsee, C. K., Weber, E. U. & Welch, N. (2001). Risk as feelings. *Psychological Bulletin, 127(2)*, 267-286.

Nisbett, R. E. & Borgida (1975). Attribution and the social psychology of prediction. *Journal of Personality and Social Psychology*, *32*, 932-943.

Persson, J. (2005). Tropes as mechanisms. *Foundations of science, 10(4)*, 371-393.

Peterson, C. R. & Beach, L. R. (1967). Man as intuitive statistician. *Psychological Bulletin*, *68(1)*, 29-46.

Ramsey, F. P. (1926). Truth and probability. (In D.H. Mellor (Ed), Ramsey, F. P. (1990). *Philosophical papers*, (1990), Cambridge: Cambridge University Press).

Roberts, M. J. & Newton, E. J. (2001). Inspection times, the change task, and the rapid-response selection task. *Quarterly Journal of Experimental Psychology*, *54(4)*, 1031-1048.

Sahlin, N.-E. (1990). *The Philosophy of F. P. Ramsey*. (Cambridge: Cambridge University Press).

Sahlin, N.-E. (1991). Baconian inductivism in research on human decision making. *Theory & Psychology*, *1*, 431-450.

Sahlin. N.-E. & Vareman, N. (2008). Three types of decision theory. (In M. C. Galavotti & R. Scazzieri (Ed), *Rationality and patterns of reasoning*, Stanford: CSLI Publications).

Savage, L. J. (1972). *The foundations of statistics*. (London: Dover (1st edition), 1954, New York: Wiley).

Schneider, W. & Shriffin, R. M. (1977). Controlled and automatic human information processing I: Detection, search and attention. *Psychological Review*, *84*, 1-66.

Sloman, S. A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin*, *119*, 3-22.

Slovic, P. (2006). "If I look at the mass I will never act": Psychic numbing and Ggenocide. *Judgment and Decision Making*, *2(2)*, April 2007, 79–95.

Sperber, D., Cara, F. & Girotto, V. (1995). Relevance theory explains the selection task. *Cognition*, *57*, 31-95.

Stanovich, K. E. (1999). Who is rational? Studies of individual differences in reasoning. (Mahway, NJ: Lawrence Erlbaum Associates).

Stanovich, K. E. & West, R. F. (1998). Cognitive ability and variation in selection task performance. *Thinking and Reasoning*, *4*, 193-230.

Stanovich, K. E. & West, R. F. (2000). Individual differences in reasoning: Implications for the rationality debate? *Behavioral and Brain Sciences*, *23(5)*, 645-664.

Stein, E. (1996). *Without good reason: The rationality debate in philosophy and cognitive science*. (Oxford: Clarendon Press).

Tversky, A. & Kahneman, D. (1983). Extensional versus intuitive reasoning: The conjunction fallacy in probability judgment. *Psychological Review*, *90(4)*, 293-315.

Wason, P. C. (1966). Reasoning about a rule. *Quarterly Journal of Experimental Psychology*, *20*, 273-281.

Wason, P. C. & Shapiro, D. (1971). Natural and contrived experience in a reasoning problem? *Quarterly Journal of Experimental Psychology*, *23*, 63-71.

Wason, P. C. & Evans. JStBT (1975) Dual processes in reasoning? *Cognition*, *3*, 141-154.

[1] In no particular order. The authors wish to thank Jonathan Baron and Niklas Vareman for valuable comments.
[2] See Kahneman and Tversky (1974) and Nisbett and Borigida (1975).
[3] E.g. Prospect Theory, Heuristics and Biases, and Ecological Rationality.
[4] Keys and Schwartz (2007, 163). It is well-known but worth noting that there are many theories of normative decision making. We have the theories suggested by, for example: Ramsey, Savage, Anscombe & Auman, Luce & Krantz, and Jeffrey. They make different assumptions; have different axioms and special features. That is, there is not one and only one Normative man, but a set of Normative men. With this in mind one should take a sceptical attitude towards the Normative man hypothesis. See Fishburn (1981), and Gärdenfors and Sahlin (1988).
[5] In Ramsey (1990, 52-94).
[6] A subject can have more or less any degree of belief whatsoever in a proposition provided the set of beliefs to which it belongs is coherent (consistent). It is essentially this feature of Ramsey's theory that makes the theory subjectivist.
[7] See Sahlin and Vareman (2008).
[8] See Savage (1954/1972).
[9] There are alternative readings and perspectives, see, for example, Baron (2004), and Sahlin and Vareman (2008).
[10] An interesting historical fact is that violations had already been found by this time. See, for example, Allais (1953).
[11] Kahneman and Tversky asked subjects to choose between:

A:	2500 (Israeli pounds)	with probability .33
	2400	with probability .66
	0	with probability .01

and

B:	2400 (Israeli pounds)	with certainty

Subjects also had to choose between:

C:	2500	with probability .33
	0	with probability .67

and

D:	2400	with probability .34
	0	with probability .66

It was found that 82 per cent of the subjects preferred B to A, and that 83 per cent preferred C to D. Assuming that u(0 Israeli pounds) = 0, and that subjective probability assessments mirror stated probabilities, these two choices, in combination, violate expected utility theory. Together they imply a pair of incompatible utility inequalities.
[12] It is obvious that these effects do not give a direct violation of Expected utility theory. Assumptions has to be made about the curvature of the utility function, for example that it is concave, and this is an extra-empirical assumption, not an axiom of the theory. See Sahlin (1991).
[13] For reviews, see e.g. Stein (1996).
[14] See also Cohen (1981, 1986).
[15] E.g. Gigerenzer (1991, 109): "what have been called "errors " in probabilistic reasoning are in fact *not* violations of probability theory. They only look so from a narrow understanding of good probabilistic reasoning that ignores conceptual distinctions fundamental to probability and statistics".

[16] See e.g. Sahlin (1991).
[17] It is important to keep this in mind when discussing single or double processors.
[18] Note that defining the value function in terms of deviations from the reference point gives the prospect theory properties that the utility theory lacks. But the same effect can be secured within the framework of expected utility theory if one makes the reasonable assumption that our utility function is context-dependent. Furthermore, since expected utility theory conveys no information whatsoever about the actual shape of an individual's utility function, adding such additional assumptions to the theory will significantly augment its explanatory power.
[19] For an alternative view, see Baron (2008).
[20] See Sahlin and Vareman (2008) and Sahlin (1991).
[21] Efforts have been made to meet these requirements: e.g. Ecological rationality has been coupled with explicit process models of decision-making.
[22] E.g. consider: "...the Linda Problem maximizes the tendency for the two systems to prime different responses and this problem produced a large difference in cognitive ability. Similarly, in nondeontic selection tasks there is ample opportunity for the two systems to cue different responses." (Stanovich and West 2000, 659). Or: "In support of dual-process accounts are several different forms of evidence including (a) the inclusion of more logical and less belief based reasoning under strong deductive reasoning instructions, (b) the association (in general) of better logical accuracy with higher ability participants when problems cannot also be solved by a pragmatic route and (c) the finding that working memory load or instructions to respond rapidly increase levels of typical biases as well as reducing logical accuracy." (Evans 2008, 22)
[23] Not all participants deviate from Normative man, and not all tasks entail equally blatant deviations from it. Take the famous female bank teller, for instance (Tversky and Kahneman, 1983). Although most participants indeed judge that the statement "Linda is a bank teller in the feminist movement" is more probable than the statement "Linda is a bank teller", they are still very likely to accept a general statement such as "The probability of X is always greater than the probability of X and Y".
[24] Thus we find a range of Systems 1, ranging from heuristics (Kahneman and Fredericks 2002; Evans 2006), and associations (Sloman 1996), to implicit (Evans and Over 1996), or automatic processes (Scheider and Shriffin 1977).
[25] One process assigning values to outcomes, another assigning uncertainties to states and a third forming an expectation qua basis for action.
[26] See Sahlin (1990).
[27] See e.g. Evans and Over (1996), Stanovich (1999) and Carruthers (2002).
[28] E.g. Schroyens, Schaeken and Handley (2003).
[29] E.g. Sloman (1996, 17); c.f. Roberts and Newton (2001).
[30] Evans (2008), Elster (1999), Elster (2007) and Persson (2005).
[31] E.g. the conjunction rule is described as "perhaps the most elementary principle of probability theory". Kahneman and Tversky (1982, 496).
[32] Incidentally it should be added that Ramsey's theory is an attempt to develop the necessary tools and techniques to look into an informationally encapsulated decision (computational) system. Ramsey simply assumed that the system he studied, Normative man, behaved as an inference-making mechanism and was rigidly and permanently constrained.
[33] See Finucane et al. (2003), and Slovic (2006) for references and further examples.
[34] See Slovic (2006).