The Foundations of Epistemic Decision Theory*

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Abstract

According to *accuracy-first epistemology*, accuracy is *the* fundamental epistemic good. Epistemic norms — Probabilism, Conditionalization, the Principal Principle, etc. — have their binding force in virtue of helping to secure this good. To make this idea precise, accuracy-firsters invoke Epistemic Decision Theory (EpDT) to determine which epistemic policies are the best means toward the end of accuracy. Hilary Greaves and others have recently challenged the tenability of this programme. Their arguments purport to show that EpDT encourages obviously epistemically irrational behavior. We develop firmer conceptual foundations for EpDT. First, we detail a theory of praxic and epistemic good. Then we show that, in light of their very different good-making features, EpDT will evaluate epistemic *states* and epistemic *acts* according to different criteria. So, in general, rational preference over states and acts won't agree. Finally, we argue that based on direction-of-fit considerations, it's preferences over the former that matter for normative epistemology, and that EpDT, properly spelt out, arrives at the correct verdicts in a range of putative problem cases.

Keywords. Epistemic Decision Theory, Accuracy, Direction of Fit, Epistemic Rationality

1 Introduction

Credences have a range of epistemically laudable properties. They are more or less *specific* and *informative*. They encode more or less *simple* and *unified* explanations of *prima facie* diverse phenomena. They are more or less *appropriate* or *justified* in light of our evidence. And importantly, they are closer or further from *the truth*, i.e., more or less *accurate*. According to *accuracy-first epistemology*, this final virtue — accuracy — is *the* fundamental epistemic good. It is the primary source of epistemic value. The higher your credence in truths and the lower your credence in falsehoods, the better off you are all epistemic things considered.

Norms of epistemic rationality, on this view, have their binding force in virtue of the following fact: they are good means toward the end of securing accuracy. Obeying them in some way helps in the pursuit of accurate credences. To spell this out, accuracy-firsters co-opt the resources of practical decision theory. Just as decision-theoretic norms explain why certain practical policies — economic policies, environmental policies, etc. — are bad means to practical ends, and hence irrational, they also explain why certain *epistemic* policies are bad means to the epistemic end of accuracy, and hence irrational. For example, Pettigrew (2013, 2014a,b) uses standard decision-theoretic norms — Dominance, Chance Dominance, Maximize Expected Utility, Maximin — together with an appropriate measure of accuracy, to explain why violating various epistemic norms — Probabilism, the Principal Principle, Conditionalization, the Principle of Indifference — is bad epistemic policy. Violating them is a bad means to the epistemic end of accuracy.

Despite these promising beginnings, recent challenges have cast doubt on the tenability of this project. Hilary Greaves (2013) has forcefully argued that any accuracy-first approach sanctions epistemically irrational behavior in problem cases, the most vexing of which is the following:[1]

Imps Emily is taking a walk through the Garden of Epistemic Imps. A child plays on the grass in

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[1]Caie (2013) and Berker (2013) raise related concerns. Our treatment of Greaves' problem cases extends naturally to theirs as well.

front of her. In a nearby summerhouse are 10 further children, each of whom may or may not come out to play in a minute. They are able to read Emily's mind, and their algorithm for deciding whether to play outdoors is as follows. If she forms degree of belief $x = 0$ that there is now a child before her, they will come out to play. If she forms degree of belief $x = 1$ that there is a child before her, they will roll a fair die, and come out to play iff the outcome is an even number. More generally, the summerhouse children will play with chance $(1-0.5x)$. Emily's epistemic decision is the choice of credences in the propositions C_0 that there is now a child before her, and, for each $j = 1, \ldots, 10$ the proposition C_j that the j^{th} summerhouse child will be outdoors in a few minutes' time.

In this case, Emily is offered an epistemic bribe. If she can get herself to deny the manifest and have credence 0 in C_0, she can guarantee herself perfect accuracy in propositions $C_1, \ldots, C_{10}$. So, although her credence in C_0 would be maximally inaccurate, her *overall* level of accuracy would be highest if she took the bribe.[2]

Any plausible way of spelling out an accuracy-first epistemology, Greaves thinks, will sanction taking this epistemic bribe. The reason: any reasonable accuracy measure will assess the accuracy of one's credal state *globally*. It will take the accuracy of all of your credences considered individually, weigh them up in some sensible way, and deliver a 'summary statistic' that captures how accurate they are as a whole. As a result, the accuracy measure will be open, so to speak, to sacrificing accuracy in a relatively small number of propositions in exchange for gaining accuracy in a large number of other propositions. Our intuitive notion of epistemic rationality, however, does not sanction taking this epistemic bribe. It does not sanction lowering one's credence in C_0 to 0 *when the child is standing right there in plain view*.

By entangling Emily's epistemic choices with the external state of the world, IMPS brings forth an issue lying at the foundation of any decision theory, practical or epistemic. Compare: Savage-style unconditional expected utility theory (SAVAGE) — the 'standard model' in practical decision theory since Savage's seminal *The Foundations of Statistics* (1954) — comes with a tacit warning: only apply if probabilities of states are independent of acts (IND). Determining what to do when states and acts are entangled—and thereby doing away with IND—motivated the move from SAVAGE to a Jeffrey-style evidential decision theory (EDT), and eventually to causal decision theory (CDT). In the process, we learned something deep about the nature of practical rationality.

In the early formulations of EpDT, accuracy-firsters have likewise presupposed IND. They only consider cases in which probabilities of states do not depend on which credences you adopt. Doing away with IND, Greaves argues, teaches us something deep about the nature of *epistemic* rationality. It teaches us that epistemic rationality is non-consequentialist. Or at least: the most popular brand of epistemic consequentialism — accuracy-first epistemology — cannot capture our intuitive notion of epistemic rationality.

We agree that cases like IMPS require accuracy-firsters to establish a firmer conceptual foundation for epistemic decision theory (EpDT). But, *pace* Greaves, we do not think that they show epistemic rationality to be non-consequentialist. By drawing the proper moral from developments in practical decision theory over the last 60 years (progressing from SAVAGE to EDT to CDT), we hope to show why accuracy-first epistemology, spelt out correctly, handles Greaves' problem cases in just the right way.

Part of our task will be clearing up just what it is that needs to be explained in Greaves' problem cases. To this end, we ought to make an important observation right away, to which we will return at various points. When an agent adopts a credence function c, there are two very different ways to evaluate her in terms of her overall accuracy. First, we can evaluate how closely the epistemic *state* she occupies conforms to the world. We can evaluate how close her credences for various propositions are, at any particular time, to the actual truth-values of those propositions. Second, we can evaluate how much accuracy her coming-to-occupy c (which we denote $\overline{c}$) produced. That is, we can evaluate the epistemic *action* of *adopting* c as her credence function. Cases like IMPS bring out this distinction: If Emily has credence 0 in C_0 and credence 1 in $C_1, \ldots, C_{10}$, she knows the credence function that assigns 1 to C_0 and $C_1, \ldots, C_{10}$ is more accurate than her own. However, *were she to adopt that state*, she would end up less accurate than she currently is.

EpDT ought to evaluate epistemic states and epistemic actions by different criteria. Epistemic ac-

[2] Taking the bribe in this particular case leads to more accuracy only on some measures. However, for any measure $\mathcal{I}$ of accuracy, we can formulate a case such that bribe-taking leads to the most accuracy according to $\mathcal{I}$.

tions, like all actions, are properly assessed in terms of their causal impact on the world. They are valuable to the extent that they *make* the world fit our desires; to the extent that they *cause* the world to be good (desirable). Epistemic states, on the other hand, are assessed in terms of their fit *to the world.* They are valuable to the extent that they encode an accurate picture of the world, not to the extent that they causally influence the world so as to make it fit that picture.

Accuracy-first epistemology will yield evaluations both of epistemic states and epistemic acts. But the deliverances of epistemic rationality, we will argue, track evaluations of epistemic *states*, not acts. The reason: epistemic states, rather than acts, have the epistemically interesting direction of fit, *viz.*, mind-to-world.

In IMPS, then, accuracy-first epistemology says: The *action* of taking the bribe does the best job of getting Emily what she wants (if all she wants is accuracy). Nevertheless, she would be epistemically irrational for occupying a *state* that assigned credence 0 to C_0.

Here's the plan. In §2, we discuss the theory of the praxic and epistemic *good.* §3 introduces our own theory of praxic and epistemic *preference*, which specifies how to evaluate epistemic actions and states, respectively, in light of their very different good-making features. In §4 we apply the results of our discussion to diagnose the apparent epistemic dilemmas posed by IMPS and related cases. Finally, §5 discusses EpDT's recommendations and their implications for epistemic rationality.

2 A Theory of the Good: Praxic and Epistemic

Rational agents, on our view, line up their preferences over options—acts, epistemic states—with their unconditional best estimates of the value—prudential value, epistemic value—of those options. This *general theory of preference* is the common core of practical and epistemic decision theory. The key to spelling out the correct practical decision theory, we will argue, is to pin down the correct theory of *prudential value* or *praxic good* (see §3). The key to spelling out an accuracy-first epistemology is to pin down the correct theory of *epistemic value* or *epistemic good.* In the remainder of §2, we will argue that both causal decision theory's account of praxic good, and the accuracy-firster's account of epistemic good are independently motivated. They fall naturally out of the direction-of-fit metaphor, once it is properly unpacked.

2.1 Direction of Fit

It's a common adage that beliefs have a mind-to-world direction of fit, while desires have a world-to-mind direction of fit. You might understand this *descriptively*, *e.g.*, as a causal claim:

> A belief that p tends to go out of existence in the presence of a perception with the content that not p, whereas a desire that p tends to endure, disposing the subject in that state to bring it about that p. (Smith, 1994, p. 115)

or perhaps a claim about higher-order attitudes:

> The thetic/telic difference [difference in direction of fit between beliefs and desires] is a difference in the structure of a controlling conditional intention [a higher-order intention]. . . . The controlling background intention in the case of belief is . . . [the intention] not to believe that p, given that (or: in the circumstance that) *not* p . . . in the telic [desire] case, the intention is that it be the case that p, given the telic attitude toward p. (Humberstone, 1992, pp. 75–6)

It would be better, though, to understand the direction of fit metaphor *evaluatively*, as Anscombe does (*cf.* Sobel and Copp 2001).[3] To illustrate Anscombe's position, imagine that a man writes a shopping list and goes to the store. As he shops, a detective hired to follow him writes down everything that she thinks the man is buying. What is the difference between the shopping list (which reflects the man's *desires*) and the detective's records (which reflects her *beliefs*)?

> It is precisely this: if the list and the things that the man actually buys do not agree . . . then the *mistake* is not in the list but in the man's *performance* (if his wife were to say: 'Look, it says butter and you have bought margarine', he would hardly reply: 'What a mistake! we must put that right' and alter the word on the

[3] Sobel and Copp (2001) explore whether the best theory of direction-of-fit could provide an account of belief and desire. While we *do* think Anscombe's proposal best explicates the direction of fit metaphor, we do *not* endorse using it for such a purpose.

> list to 'margarine'); whereas if the detective's record and what the man actually buys do not agree, then the *mistake* is in the record. (Anscombe, 1957, p. 56; emphasis ours)

When you desire to buy butter and you put margarine in the basket, your *action* is bad (mistaken), or lacking value (*prudential* value). Your action fails to make the world bend to your will. It fails to causally influence the world in a way that satisfies your desire. And exerting the right sort of causal influence — making good (desired) outcomes come about — is what gives actions (prudential) value.

Desires seem to have a world-to-mind direction of fit, then, in just this sense: the means to satisfying them, *viz.*, actions, are *better* (more valuable) to the extent they *make the world conform to those desires.* They are better to the extent that they *causally influence* the world in the right way, so that those desires are satisfied.

In contrast, when you *believe* there's butter in the basket, but there's not, your *belief* is bad (mistaken) and thereby lacks *epistemic* value. Your belief fails to accurately represent the world. And accurately representing the world, or 'getting close to the truth', is what gives beliefs (epistemic) value.

So beliefs have a mind-to-world direction of fit in the following sense: they are *better* (more epistemically valuable) to the extent that *they* conform to the world. They are better to the extent that they accurately represent the world. Unlike actions, they are *not* valuable in virtue of causally influencing the world, so as to make themselves accurate. Of course, rational inquirers are part of the causal system that they hope to investigate. As such, they may, by adopting some belief or other, influence the world in any number of ways. But — and this is the crucial point — influencing the world in (epistemically) good or bad ways is not what *makes* them epistemically valuable. What *makes* them epistemically valuable — the primary source of all-epistemic-things-consider value — is just accuracy.

To take an example, if God believes there is now light when there is not, then God's belief is not *epistemically* valuable on this view. It lacks any peculiarly *epistemic* virtue. This is so even if God's belief *causes* there to be light. Such a causally efficacious belief is valuable *once true.* But it is not valuable *in virtue of* causally influencing the world in some way or other.

On Anscombe's view, then, the direction of fit adage is best understood as encapsulating a theory of the good. In particular, it is best understood as encapsulating a theory of praxic and epistemic good, respectively. A theory of praxic good specifies which factors conspire to make *actions* (the means to satisfying desires) prudentially good or valuable, and how they do so. A theory of epistemic good specifies which factors make *beliefs* (or doxastic states more generally) epistemically good or valuable. In a bit more detail, our theories say:

> *Praxic Good.* An action A is prudentially valuable at a world w, relative to a state of desire D, to the extent that A makes w satisfy D, by causally influencing it in the right way.
>
> *Epistemic Good.* A doxastic state B is epistemically valuable at a world w to the extent that B is close to the truth (accurate) at w.

2.2 Praxic Good

To make this more precise, we will focus our attention on an agent whose state of belief or opinion is given by a credence function c defined on a finite algebra Ω, and whose non-instrumental desires are given by a utility function u defined on the atoms w of Ω (the finest-grained possibilities that the agent can distinguish between).[4] An agent's credence $c(X)$, roughly speaking, measures the strength of her confidence in X, where $c(X) = 0$ and $c(X) = 1$ represent minimal and maximal confidence, respectively. An agent's utility $u(w)$ measures the strength of her desire that w be true.[5]

In addition to unconditional opinions, captured by c, we will suppose that our agent has various conditional opinions. Her confidence in X on the indicative supposition that Y is given by her credence for X conditional on Y, $c(X|Y)$.[6] So, for example, if she is next to certain that someone else killed Kennedy if Oswald in fact did not, then $c(\textit{Someone else killed K}|\textit{Oswald did not kill K}) \approx 1$. In contrast, her confidence in X on the subjunctive supposition that Y is given by her credence for X *imaged* on Y, $c(X\|Y)$. Roughly speaking,

[4] More carefully, Ω is a finite set of propositions closed under negation and countable disjunction.

[5] For ease, we'll assume that all credence functions under consideration are probability functions, though this restriction is unnecessary.

[6] When $c(Y) > 0$, $c(X|Y)$ is just $c(X\&Y)/c(Y)$. For a theory of conditional probability that allows $c(X|Y)$ to be defined when $c(Y) = 0$, see Rényi 1955 and Popper 1959.

$c(X \| Y)$ shifts the credence spread over $\neg Y$-worlds to Y-worlds in proportion to their estimated similarity to the actual world (*cf.* Lewis 1986, p. 310). Imagine, for example, that our agent is certain that Oswald acted alone, and no one else would have killed Kennedy if Oswald had not. Then $c(\textit{Someone else killed K} \| \textit{Oswald did not kill K}) \approx 0$.

Typically, $c(\cdot \| A)$ will reflect our agent's views about A's causal powers (Joyce 1999, §5.4; 2000, pp. S10–11; 2002, p. 74). In particular, $c(X \| A) > c(X)$ only if she thinks that A has a positive incremental causal impact on X. That is, $c(X \| A) > c(X)$ only if she thinks (i) A causally promotes X, and (ii) A increases the degree to which the totality of causally relevant factors promote X.[7]

Imagine that you wake up on the roof of an abandoned building. You cannot remember who you are or where you come from. Your identity is a mystery. You look down at your hands — a rifle. Frantically, you search for a clue; any hint as to why you are in this mess. Then you notice: there is a gathering in the square below; a terrible despot is about to take the stage. You grab the binoculars at your feet and scan the buildings surrounding the square. Three government snipers, maybe more. You doubt you are part of their team though. They are dressed to the hilt in body armour. You are dressed in ratty jeans and a stained t-shirt.

"Who am I?" you mutter. Maybe you are a lone vigilante who has been planning to end the despot's reign of terror singlehandedly. Or maybe you are just a patsy, placed on the building by the government to take the fall after the snipers complete their mission.

The despot takes the stage. The snipers lift their rifles. "Should I shoot too?" you wonder. On the one hand, it would be bad news to learn you took the shot. If you actually have the nerve to shoot, you reason, then you are probably the sort of person who has been planning to assassinate the despot for some time. But the despot's security team are notoriously adept at sniffing out lone vigilantes. They almost certainly have sussed out your plan (if you have one) and put extra security measures in place to help foil any attempt on the despot's life. Your credences are as follows:

Sec^+	*Shoot*	*Death*	Credence
T	T	T	.2854
T	T	F	.2935
T	F	T	.1013
T	F	F	.1063
F	T	T	.0058
F	T	F	0
F	F	T	.0002
F	F	F	.2075

So, for example:[8]

$c(\textit{Death}) = .6$

$c(\textit{Death} | \textit{Shoot}) = .498$

$c(\textit{Security}^+ | \textit{Shoot}) = .99$

$c(\textit{Security}^+ | \neg\textit{Shoot}) = .5$

"On the other hand," you think to yourself, as you lift your rifle and notice how steady your hand is, "taking the shot will make a positive difference." Whether the despot's security team put extra protective measures in place (*Security*$^+$) or not ($\neg$*Security*$^+$), having an extra steady-handed marksman (you) take a shot (*Shoot*) raises the chance that the despot will meet his end (*Death*), even if only by a small amount. Perhaps you think that each of the three government snipers has a 90% chance of hitting the despot if there is no extra security in place, and a 20% chance even if there is. And you think that *you* have a 75% chance of hitting the despot if there is no extra security in place, and only a 1% chance if there is. Then adding your shot to the mix raises the chances that *someone* will hit the despot from .488 to .493, if there is extra security, and from .999 to .99975, if not.[9]

$$
\begin{array}{lll}
c(\textit{Death} | \textit{Sec}^+ \& \textit{Shoot}) & = 1 - .8^3 \cdot 99 & = .493 \\
c(\textit{Death} | \textit{Sec}^+ \& \neg\textit{Shoot}) & = 1 - .8^3 & = .488 \\
c(\textit{Death} | \neg\textit{Sec}^+ \& \textit{Shoot}) & = 1 - .1^3 \cdot .25 & = .99975 \\
c(\textit{Death} | \neg\textit{Sec}^+ \& \neg\textit{Shoot}) & = 1 - .1^3 & = .999
\end{array}
$$

Shooting raises the chances in this way because it has a positive incremental causal impact on the despot's death. Shooting *promotes* that end, and moreover increases the degree to which the *totality* of causally relevant factors promote that end. (It is not swamped by other causal factors.)

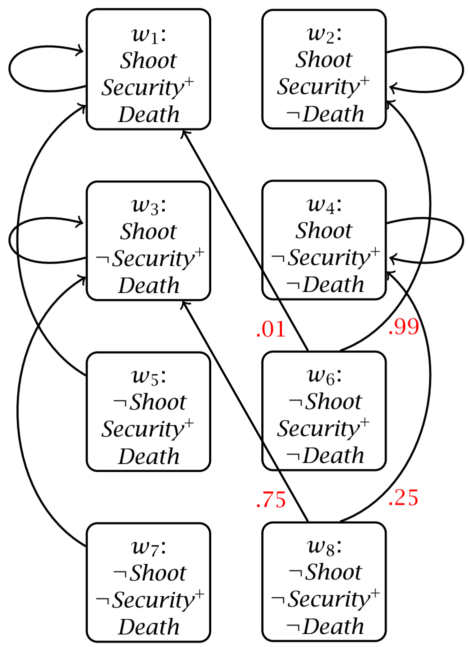
These opinions about the causal structure of the

[7]Imaged credences will not so straightforwardly reflect one's causal opinions in cases of preemption and trumping. See Lewis 1986, 2000.

[8]For illustrative purposes, we suppose that $c(\textit{Death} | \textit{Security}^+ \& \textit{Shoot}) = 1 - .8^3 \cdot .99$ because: (i) you think, given that there's extra security, each of the three snipers has a 0.8 chance of missing the despot; you have a 0.99 chance of missing; (ii) the chance of killing the despot is 1 minus the chance of everyone missing, *viz.*, $.8^3 \cdot .99$. *Mutatis mutandis* for the various other conditional credences.

[9]Assuming that your respective chances of success are independent.

world are reflected in your subjunctive conditional (imaged) credences. In particular, the fact that you think shooting has a positive incremental impact on the despot's death is reflected in the fact that $c(Death \| Shoot) > c(Death)$. If you were to shoot, the despot would be more likely to die, in your best estimate, than he currently is. Your current credence that the despot will be killed, $c(Death)$, is 0.6. Assuming that $c(\cdot\|\cdot)$ satisfies a few plausible constraints (*cf.* Joyce 1999, §6.3), so that imaging on *Shoot* shifts your credences around as follows:



we have:

$$\begin{aligned} c(Death \| Shoot) &= \sum_i c(w_i \| Shoot) \cdot \chi_{w_i}(Death) \\ &= (.2854 + .1013 + .01 \cdot .1063) \cdot 1 \\ &\quad + (.2935 + .99 \cdot .1063) \cdot 0 \\ &\quad + (.0058 + .2075 + .75 \cdot .0002) \cdot 1 \\ &\quad + (0 + .25 \cdot .0002) \cdot 0 \\ &\quad + 0 \cdot 1 + 0 \cdot 0 + 0 \cdot 1 + 0 \cdot 0 \\ &= .601213 \end{aligned}$$

where χ_w is w's characteristic function, *viz.*, $\chi_w(X) = 1$ if X is true at w and $= 0$ if X is false at w.

One measure of *how large* an incremental causal impact your shooting has is the 'imaged Bayes factor': $c(Death \| Shoot)/c(Death)$. Since $c(Death \| Shoot)/c(Death) = .601213/.6 = 1.002$ is marginally greater than 1, shooting has a small, but positive incremental impact on the despot's death, according to this metric.

Of course, $c(X \| A)/c(X)$ is neither perfect nor the *only* measure of A's incremental causal impact on X. But it will help illuminate why causal decision theory provides the wrong sorts of tools for building up an accuracy-first epistemology, so we'll be using it as our official measure in what follows. And the morals we draw at the end of the day are entirely general. They do not depend on this particular choice of measure.

With a measure of incremental causal impact in hand, we can fill in our schematic theory of praxic good.

> *Praxic Good.* An action A is prudentially valuable at a world w, relative to a state of desire D, to the extent that A makes w satisfy D.

An action A makes the world w satisfy D to the extent that (i) A helps to make w true (false), by having a positive (negative) incremental impact on w, and (ii) w is desirable (undesirable), according to D. On the view we've settled on, A's impact on w is measured by $c(w \| A)/c(w)$. And w's degree of desirability is measured by $u(w)$, our agent's utility for w. Given this, we ought to fill in our schematic theory of praxic good as follows:

> *Praxic Good**. An action A's prudential value at a world w, relative to credences c and utilities u, is given by:
> $$\mathcal{V}_A(w) = [c(w \| A)/c(w)] \cdot u(w).$$

According to our measure, $\mathcal{V}_A$, if w is a positively desirable state of the world, so that $u(w) > 0$, then A's prudential value, $\mathcal{V}_A(w)$, increases as $c(w \| A)/c(w)$ increases. It is more valuable the more it does to help make w true. If w is an undesirable state of the world, so that $u(w) < 0$, then A's value increases as $c(w \| A)/c(w)$ decreases (approaches zero). It is more valuable the more it does to help make w false.

Suppose, for example, that w_1:

is a highly desirable state of the world. Perhaps $u(w_1) = 10$. Then shooting has high prudential value in w_1:

$$\begin{aligned}\mathcal{V}_{Shoot}(w_1) &= [c(w_1 \| Shoot)/c(w_1)] \cdot u(w_1)\\ &= [.3878/.2854] \cdot 10\\ &= 13.6\end{aligned}$$

The reason: shooting has a positive incremental causal impact on w_1: $c(w_1 \| Shoot)/c(w_1) = .3878/.2854 = 1.36$. It helps to *make* w_1 true. And w_1 is a desirable state of the world. The upshot: shooting makes the world, w_1, satisfy your desires to a high degree. According to the theory of praxic good on offer, this is exactly what gives an action prudential value.

2.3 Epistemic Good

According to accuracy-first epistemology, what makes a credal state epistemically valuable at a world — the primary source of its all-epistemic-things-considered value — is its accuracy, or closeness to the truth at that world. In order for this idea to be useful in a formal decision theory, we'll need a more precise way of quantifying accuracy.

The appropriate mathematical tools for this task are *epistemic scoring rules*, which can be thought of as *in*accuracy scores.[10]

Let $\text{Prob}(\Omega)$ be the set of probability functions over the algebra Ω. An *inaccuracy score* is a function $\mathcal{I} : \text{Prob}(\Omega) \times \Omega \to \mathbb{R}_{\geq 0}$ that measures how close a credence function c is to the truth if w is actual. If $\mathcal{I}(c, w) = 0$, then c is minimally inaccurate (maximally close to the truth) at w. Inaccuracy increases as $\mathcal{I}(c, w)$ grows larger.

Reasonable inaccuracy scores satisfy a range of constraints (*cf.* Joyce 1998, 2009, and Predd et al. 2009). For example, moving credences uniformly closer to the truth should always improve accuracy; if $|b(X) - w(X)| \leq |c(X) - w(X)|$ for all X, and $|b(Y) - w(Y)| < |c(Y) - w(Y)|$ for some Y, then $\mathcal{I}(b, w) < \mathcal{I}(c, w)$. Instead of detailing these constraints, though, we'll simply focus on one particularly attractive inaccuracy measure: the Brier score.[11]

Let w be a world, $X \in \Omega$, and χ_w be w's characteristic function, *viz.*, $\chi_w(X) = 1$ if X is true at w and $= 0$ if X is false at w. The Brier Score is:

$$\text{BS}(c, w) = \frac{1}{|\Omega|} \sum_{X \in \Omega} (\chi_w(X) - c(X))^2$$

That is, the Brier Score identifies c's inaccuracy with its mean-squared divergence from truth-values at w.

With a more precise notion of inaccuracy in hand, we can fill in our schematic theory of epistemic good.

> *Epistemic Good.* A doxastic state B is epistemically valuable at a world w to the extent that B is close to the truth (accurate) at w.

> *Epistemic Good**. A credal state c's epistemic value at a world w, $\mathcal{V}_c(w)$, is given by $-\mathcal{I}(c, w)$.

3 Rational Preference: Praxic and Epistemic

Our next task is to detail and defend a theory of epistemic preference. Such a theory specifies when an agent with credences c and evidence E ought to prefer one credal state b to another b^*. It specifies when, in view of E, she ought to see b as a preferable state to occupy to b^* (whether she or anyone else is currently, or will come to be in that state). When an agent (weakly) prefers b to b^*, we write $b \trianglerighteq b^*$.

Our strategy is as follows. We will explore two ways of generalising SAVAGE that yield EDT and CDT as special cases. The first is Joyce's (1999; 2000; 2002). The second is our own. Both generalisations illuminate what is at issue between EDT and CDT, in a way that tells us something about their suitability for furnishing a theory of epistemic preference. But our generalisation provides *positive* advice too. It tells us how to use our theory of the epistemic good to arrive at the correct theory of epistemic preference.

On Savage's (1954) model, a decision-maker uses her credences about which *state of the world* is actual to choose between *actions* that produce more or less desirable *outcomes*. For expositional ease, we follow Jeffrey (1983) in thinking of states of the world and actions as propositions: elements of the partitions $\mathcal{S} = \{S_1, ..., S_n\}$ and $\mathcal{A} = \{A_1, ..., A_m\}$, respectively.[12] The states S_i are the loci of her uncertainty. The actions A_i are the propositions whose

[10] We use *in*accuracy instead of accuracy for technical convenience. Accuracy is simply negative inaccuracy.

[11] So long as the scoring rule is strictly proper, nothing we say below will hinge on this choice.

[12] In the case of EpDT, we set $\mathcal{A} = \{\overline{c} | c \text{ a credence function over } \Omega\}$.

truth-values she can (more or less directly) control. The outcome of performing action A in state of world S, $o[A,S]$, is the conjunction $A\&S$.[13] Importantly, for the agent's decision problem to be well-posed, outcomes must be grained finely enough to reflect everything that she cares about. Formally, this means: for any $A \in \mathcal{A}$ and $S \in \mathcal{S}$, we have $u(w) = u(w')$ for all $w, w' \in o[A,S]$.

According to Savage, an agent should evaluate her options as follows:

> *Theory of (Praxic) Preference*: An agent ought to weakly prefer act A to B, $A \succeq B$,
>
> iff
>
> $$Est_c(A) \geq Est_c(B)$$

Typically, an agent's best estimate of A's utility (or any other quantity) is given by its expected value; $Est_c(A) = \sum_i c(S_i) \cdot u(o[A,S_i])$. (When harmless, we will talk directly of expectations. But, in certain pathological evidential circumstances, of the sort we examine in §4, this would be a mistake.)

Savage also insisted — though this is not explicit in his formalism — that to properly apply the theory, probabilities of states must be independent of acts (Savage 1954, p. 73). Supposing that you perform act A should not change the credence that you assign to state S, for any $A \in \mathcal{A}$ and $S \in \mathcal{S}$. Otherwise, SAVAGE would countenance absurdities such as this. When you face the following decision problem every evening:

	Eat Heartily	**Go Hungry**
Leave Oven Off	*Satisfied & Don't Pay for Gas*	*Unsatisfied & Don't Pay for Gas*
Turn Oven On	*Satisfied & Pay for Gas*	*Unsatisfied & Pay for Gas*

you ought to prefer (and choose) to leave your oven off. The reason: leaving your oven off *dominates* turning your oven on, relative to this partition of states of the world. It has a better outcome in every state. So its unconditional expected utility is higher, whatever your credences are.

Properly understood, then, SAVAGE comes with the following caveat:

[13]For Savage, outcomes are disjunctions of Jeffrey outcomes $A_i\&S_j$. This is unimportant for our purposes. All that matters is this: if $w \in A\&S$, then $w \in o[A,S]$. So we have: if $w \in A\&S$, then $u(w) = u(o[A,S])$.

IND SAVAGE only applies if probabilities of states are independent of acts.

The reason SAVAGE comes with this caveat, Joyce argues, is that it evaluates actions from the wrong epistemic perspective. SAVAGE enjoins agents to evaluate actions from the perspective of their *unconditional* credences. But actions ought to be evaluated *on the supposition that they are performed*. They ought to be evaluated not from the perspective of one's unconditional credences c, but from the perspective of c updated on A. To do otherwise is to ignore relevant information. Let $c(\cdot \,|||\, A)$ go proxy for the appropriately updated credence function, whatever it is. All decision theorists should agree, then:

> *Joycean General Theory of Preference*: An agent ought to weakly prefer act A to B, $A \succeq B$,
>
> iff
>
> $$\sum_i c(S_i \,|||\, A) \cdot u(o[A,S_i]) \geq \sum_i c(S_i \,|||\, B) \cdot u(o[B,S_i]).$$

What evidential and causal decision theorists will disagree on is this: what sort of supposition is appropriate for evaluating actions.

According to EDT, $c(\cdot \,|||\, \cdot) = c(\cdot|\cdot)$. That is, the sort of supposition appropriate for evaluating actions is *indicative* supposition. Your indicative-conditional opinions reflect your views about which outcomes are likely to occur if you do, in fact, perform one act or another. And that's precisely the information that you ought to take into account in decision-making, according to EDT. So actions ought to be evaluated from the perspective of your conditional credences, $c(\cdot|\cdot)$, which capture your indicative-conditional opinions.

In contrast, CDT says: $c(\cdot \,|||\, \cdot) = c(\cdot \| \cdot)$. That is, the sort of supposition appropriate for evaluating actions is *subjunctive* supposition. Your subjunctive-conditional opinions reflect your views about what sort of *causal influence* your actions will have. And *that* is the information that you ought to take into account in decision-making, according to CDT. So actions ought to be evaluated from the perspective of your imaged credences, $c(\cdot \| \cdot)$, which capture your subjunctive-conditional opinions.

These assumptions, together with Joyce's General Theory of Preference, yield the following:

> EDT*'s Theory of (Praxic) Preference*: An agent ought to weakly prefer act A to B, $A \succeq B$,

iff

$$\sum_i c(S_i|A) \cdot u(o[A,S_i]) \geq \sum_i c(S_i|A) \cdot u(o[B,S_i]).$$

CDT*'s Theory of (Praxic) Preference*: An agent ought to weakly prefer act A to B, $A \succeq B$,

iff

$$\sum_i c(S_i \| A) \cdot u(o[A,S_i]) \geq \sum_i c(S_i \| A) \cdot u(o[B,S_i]).$$

Neither of these theories require that probabilities of states be independent of acts. Further, when states *are* independent of acts, they reduce to SAVAGE.[14]

Joyce's General Theory of Preference illuminates what is at issue between SAVAGE, EDT and CDT in a way that tells us something about their suitability for furnishing a theory of epistemic preference. They disagree about which epistemic perspective to adopt when evaluating actions. For the purposes of building out an accuracy-first epistemology, the important question is this: which theory (if any) — SAVAGE, EDT or CDT — identifies the right perspective for evaluating *epistemic states*, rather than *actions*?

Our theory of epistemic value seems to gesture toward an answer. Compare: the fact that actions are valuable or good to the extent that they *make* the world desirable *suggests* that we ought to evaluate actions from a perspective that reflects your causal opinions. It suggests that CDT's epistemic perspective is the right one for evaluating actions. But epistemic *states* are good (epistemically valuable) to the extent that *they* conform to the world. They are valuable in virtue of encoding an accurate picture of the world. They are *not* valuable in virtue of causally influencing the world, so as to *make* themselves accurate. So, it seems, you should *not* evaluate epistemic states from a perspective that reflects your views about the extent to which they will do *exactly that*, *viz.*, causally influence the world in good (accuracy-conducive) ways. You should instead evaluate them from a perspective that reflects your best estimates about the way the world is. You should evaluate them from the perspective of your *unconditional credences*. So SAVAGE's epistemic perspective is the right one for evaluating doxastic states.

If this is right, then the correct theory of epistemic preference is:

Theory of Epistemic Preference: An agent ought to weakly prefer credal state p to q, $p \trianglerighteq q$,

iff

$$\sum_w c(w) \cdot \mathcal{I}(p,w) \leq \sum_w c(w) \cdot \mathcal{I}(q,w).$$

Still, it would be nice to have a general theory of preference that does more than *suggest* what the right perspective is for evaluating epistemic states. It would be nice, in particular, to have a theory that allows you to simply *plug in* a theory of the good (praxic or epistemic), and have the preferred perspective *fall out*. We will now provide such a theory.

On our view, rational agents line up their praxic preferences — preferences over acts — with their best estimates of the prudential value or goodness of those acts. They also line up their epistemic preferences — preferences over doxastic states — with their best estimates of the epistemic value of those states. In particular:

Our General Theory of Preference: An agent ought to weakly prefer act A to B, $A \succeq B$

iff

$$\sum_w c(w) \cdot \mathcal{V}_A(w) \geq \sum_w c(w) \cdot \mathcal{V}_B(w).$$

She ought to weakly prefer credal state p to q, $p \trianglerighteq q$,

iff

$$\sum_w c(w) \cdot \mathcal{V}_p(w) \geq \sum_w c(w) \cdot \mathcal{V}_q(w),$$

where $\mathcal{V}_A(w)$, recall, is the the prudential value of action A at world w, and $\mathcal{V}_p(w)$ is the epistemic value of credal state p at w.

According to *our* generalisation, what is at issue between SAVAGE, EDT and CDT is this: SAVAGE employs the wrong theory of praxic good.[15] EDT and CDT aim to rectify this, but disagree about what the right theory of the good is. They disagree, in the first instance, about which *quantity* to estimate, for the purposes of evaluating actions (in virtue of disagreeing about which quantity measures praxic goodness). The crux of their dispute

[14] More carefully, when states are *evidentially* independent of acts, so that $c(S_i|A) = c(S_i)$, EDT reduces to SAVAGE: $\sum_i c(S_i|A) \cdot u(o[A,S_i]) = \sum_i c(S_i) \cdot u(o[A,S_i])$. When states are *causally* independent of acts, so that $c(S_i \| A) = c(S_i)$, CDT reduces to SAVAGE: $\sum_i c(S_i \| A) \cdot u(o[A,S_i]) = \sum_i c(S_i) \cdot u(o[A,S_i])$.

[15] Better: SAVAGE identifies a mere constraint on the correct theory of praxic good, *viz.*, $\mathcal{V}_A(w) = u(w) = u(o[A,S])$ if act-state independence holds. It only partially specifies the correct theory of praxic good.

is thus not about which epistemic perspective to estimate quantities (utility) from.

CDT agrees with our theory from §2.2:

> CDT*'s Theory of Praxic Good.* An action A's prudential value at a world w, relative to credences c and utilities u, is given by:
> $$\mathcal{V}_A(w) = [c(w \| A)/c(w)] \cdot u(w).$$

Actions are good to the extent that they *make* the world desirable. EDT, in contrast, says:

> EDT*'s Theory of Praxic Good.* An action A's prudential value at a world w, relative to credences c and utilities u, is given by:
> $$\mathcal{V}_A(w) = [c(w | A)/c(w)] \cdot u(w).$$

Actions are good to the extent that they provide good *evidence* (incremental evidential support) that the world is in a desirable state.

These theories of praxic good, together with our general theory of preference, yield CDT and EDT:[16]

> CDT*'s Theory of (Praxic) Preference*: An agent ought to weakly prefer act A to B iff
> $$\begin{aligned} &\textstyle\sum_w c(w) \cdot \mathcal{V}_A(w) \\ =& \textstyle\sum_i \sum_{w \in S_i} c(w) \cdot \mathcal{V}_A(w) \\ =& \textstyle\sum_i \sum_{w \in S_i} c(w) \cdot [[c(w\|A)/c(w)] \cdot u(w)] \\ =& \textstyle\sum_i \sum_{w \in S_i} c(w\|A) \cdot u(w) \\ =& \textstyle\sum_i c(S_i\|A) \cdot u(o[A, S_i]) \\ \geq& \textstyle\sum_i c(S_i\|B) \cdot u(o[B, S_i]) \\ =& \textstyle\sum_w c(w) \cdot \mathcal{V}_B(w) \end{aligned}$$
> for any partition of states of the world $S = \{S_1, ..., S_n\}$.

> EDT*'s Theory of (Praxic) Preference*: An agent ought to weakly prefer act A to B iff
> $$\begin{aligned} &\textstyle\sum_w c(w) \cdot \mathcal{V}_A(w) \\ =& \textstyle\sum_i \sum_{w \in S_i} c(w) \cdot \mathcal{V}_A(w) \\ =& \textstyle\sum_i \sum_{w \in S_i} c(w) \cdot [[c(w|A)/c(w)] \cdot u(w)] \\ =& \textstyle\sum_i \sum_{w \in S_i} c(w|A) \cdot u(w) \\ =& \textstyle\sum_i c(S_i|A) \cdot u(o[A, S_i]) \\ \geq& \textstyle\sum_i c(S_i|B) \cdot u(o[B, S_i]) \\ =& \textstyle\sum_w c(w) \cdot \mathcal{V}_B(w) \end{aligned}$$
> for any partition of states of the world $S = \{S_1, ..., S_n\}$.

[16] We simply assume regularity, for ease of exposition; $c(w) > 0$ for all $w \in \mathcal{W}$.

This puts us in a better position to explain why CDT provides the right epistemic perspective for evaluating actions. Before, we said: the fact that actions are valuable or good to the extent that they *make* the world desirable *suggests* that we ought to evaluate actions from a perspective that reflects your causal opinions. Now we can say: the right theory of praxic good, *viz.*, $\mathcal{V}_A(w) = [c(w\|A)/c(w)] \cdot u(w)$ *entails* that CDT's epistemic perspective is the right one for evaluating actions, given our general theory of preference. It *entails* that you ought to evaluate actions by $\sum_i c(S_i\|A) \cdot u(o[A, S_i])$.

It also puts us in a better position to explain why you should *not* evaluate credal states from a perspective that reflects your views about how occupying those states will causally influence the world. The reason: credal states are *not* valuable in virtue of causally influencing the world, so as to *make* themselves accurate. You should *not* measure the epistemic value of credal state p at world w by $\mathcal{V}_p(w) = [c(w|\overline{p})/c(w)] \cdot \mathcal{I}(p, w)$, where $\overline{p}$ is the epistemic act of adopting credal state p. Instead, credal states are good to the extent that *they* conform to the world. According to the *correct* theory of epistemic good, $\mathcal{V}_p(w) = -\mathcal{I}(p, w)$. Together with our general theory of preference, this entails:

> *Theory of Epistemic Preference*: An agent ought to weakly prefer credal state p to q, $p \trianglerighteq q$,
> iff
> $$\textstyle\sum_w c(w) \cdot \mathcal{I}(p, w) \leq \sum_w c(w) \cdot \mathcal{I}(q, w).$$

Or to put matters fully generally:

> *Theory of Epistemic Preference*: An agent ought to weakly prefer credal state p to q, $p \trianglerighteq q$,
> iff
> $$Est_c(\mathcal{I}(p)) \leq Est_c(\mathcal{I}(q))$$

We will now use our theory of epistemic preference to explain why accuracy-first epistemology does not sanction epistemic bribe-taking. Before we proceed, though, it is worth contrasting this theory of preference with a closely related one. Suppose that what you care about all things considered is just accuracy — not money, prestige, or fame. Then our theory of praxic preference says:

> *Theory of Preference over Epistemic Acts*: An agent ought to weakly prefer $\overline{p}$ to $\overline{q}$, $\overline{p} \succeq \overline{q}$,

iff

$$\begin{aligned}
&\textstyle\sum_w c(w)\cdot \mathcal{V}_{\overline{p}}(w)\\
&= \textstyle\sum_w c(w)\cdot [[c(w\|\overline{p})/c(w)]\cdot u(w)]\\
&= -\textstyle\sum_w c(w)\cdot [[c(w\|\overline{p})/c(w)]\cdot \mathcal{I}(p,w)]\\
&= -\textstyle\sum_w c(w\|\overline{p})\cdot \mathcal{I}(p,w)\\
&\geq -\textstyle\sum_w c(w\|\overline{q})\cdot \mathcal{I}(q,w)\\
&= \textstyle\sum_w c(w)\cdot \mathcal{V}_{\overline{q}}(w)
\end{aligned}$$

iff

$$\begin{aligned}
&\textstyle\sum_w c(w\|\overline{p})\cdot \mathcal{I}(p,w)\\
&\leq \textstyle\sum_w c(w\|\overline{q})\cdot \mathcal{I}(q,w).
\end{aligned}$$

Epistemic *acts*, like actions more generally, are good to the extent that they *make* the world desirable. Epistemic *states* are not. As a result, a rational agent's preferences over epistemic acts and states will *not*, in general, coincide. Greaves' concerns about accuracy-first epistemology result from running these very different sorts of evaluations — evaluations of epistemic states and acts — together. Carefully separating them out is the key to seeing that accuracy-first epistemology does *not* sanction epistemic bribe-taking.

4 Leap, Promotion and Imps

4.1 Preliminaries

Before analyzing the cases presented above, we'll need two additional principles relating rational preference and chance, since both play an important role in the cases under discussion. The first is the familiar:

Principal Principle An agent with evidence E ought to have a credence function $c:\Omega\to\mathbb{R}$ such that $c(X|\phi_{ch}) = ch(X|E)$, for all $X\in\Omega$ and all ch with $c(\phi_{ch})>0$ in the set of possible ur-chance functions C, where ϕ_{ch} is the proposition that ch is the true chance function.

While variants like the New Principle improve on the Principal Principle, we'll be using the latter primarily for expositional ease, since no added nuance is needed in what follows. Furthermore, since some chance-credence norm like PP is nearly universally accepted in the literature, we won't argue for it here.[17]

For reference below, we note that an agent with credence function c who follows the Principal Principle can calculate her expected inaccuracy with any of the formulæ below:

$$\begin{aligned}
&\sum_w c(w)\cdot \mathcal{I}(p,w)\\
&= \sum_w\sum_{ch\in C}[c(w|\phi_{ch})c(\phi_{ch})]\cdot \mathcal{I}(p,w)\\
&= \sum_{ch\in C} c(\phi_{ch})\cdot\left[\sum_w c(w|\phi_{ch})\cdot \mathcal{I}(p,w)\right]\\
&= \sum_{ch\in C} c(\phi_{ch})\cdot\left[\sum_w ch_E(w)\cdot \mathcal{I}(p,w)\right]
\end{aligned}$$

The second principle relates chance and epistemic preference:

Deference to Chance If an agent with credences c and evidence E is such that:

(i) $\sum_w c(w)\cdot \mathcal{I}(p,w) > \sum_w c(w)\cdot \mathcal{I}(q,w)$

but she is also certain that the chance function ch is such that:

(ii) $\sum_w ch_E(w)\cdot \mathcal{I}(p,w) \leq \sum_w ch_E(w)\cdot \mathcal{I}(q,w)$

in which case she violates the Principal Principle, then nonetheless:

(iii) $Est_c(\mathcal{I}(p)) \leq Est_c(\mathcal{I}(q))$.

That is, she ought to estimate p to be no less accurate than q.

It's always the case, on our theory of epistemic preference, that an agent ought to prefer the credal state that in her best estimate is least inaccurate. Normally, her best estimate of a state's inaccuracy *just is* her expected value of its inaccuracy. However, in special pathological cases like the ones we'll be considering below, the agent may have knowingly diverged from chance in order to secure herself lower overall inaccuracy. For instance, she may know that $ch_E(w)=1$ while her own credence $c(w)=0$. In that case, she should recognize that the expected inaccuracy of an epistemic state p as calculated in the traditional way (i.e., $\sum_w c(w)\cdot\mathcal{I}(p,w)$) is not actually her best estimate of p's inaccuracy. Instead, since she knows the salient objective probabilities, her best estimate lines up with the expected value *chance conditional on her evidence* assigns (i.e., $\sum_w ch_E(w)\cdot\mathcal{I}(p,w)$).

With these additions in hand, we can devote the remainder of the section to the analysis of cases above.

[17] One may wonder why an accuracy-firster would endorse the Principal Principle. For an extended discussion see Pettigrew 2013.

4.2 Imps

While we already gave a preliminary diagnosis of what's happening in IMPS in the Introduction, we'll return to it here for more in depth analysis in light of the theory developed above.

Let's first consider what Emily's evidence E includes. From the description, we know E entails both C_0 and $ch(C_j|c(C_0) = x) = (1 - 0.5x)$. We'll also assume—here and throughout—that Emily's credences are *luminous*. That is, she can tell what her credence function c is. Therefore, E also includes $c(C_0) = x$.

To understand the full range of Emily's epistemic options, we'll evaluate her epistemic *doppelgängers*. The idea here is that we put agents with different credence functions in the same case and then evaluate the epistemic state and behaviour of each.

Here, we'll let Em_x be the Emily doppelgänger who adopts credal state c_x: $c_x(C_0) = x$ and $c_x(C_j) = 1 - 0.5x$ for all $j \geq 1$. So,

- $c_{.8}$: $c_{.8}(C_0) = .8$ and $c_{.8}(C_j) = .6$.
- $c_{.1}$: $c_{.1}(C_0) = .1$ and $c_{.1}(C_j) = .95$.
- c_0: $c_0(C_0) = 0$ and $c_0(C_j) = 1$.

By considering each Em_x we can now determine what EpDT's verdicts are for any epistemic state Emily might be in and for any epistemic action she may have taken.

Regarding epistemic *states*, the question is: How should Em_x evaluate her own credences? Should she prefer her own credal state over the alternatives in light of E? Or should she prefer some other credal state?

The answer: Em_1 ought to prefer her own credal state c_1 to all alternatives b. Since c_1 satisfies PP,

$$\begin{aligned} Est_{c_1}(\mathcal{I}(b)) &= \textstyle\sum_w c_1(w) \cdot \mathcal{I}(b, w) \\ &= \textstyle\sum_{ch' \in C} c_1(\phi_{ch'}) \cdot [\sum_w ch'_E(w) \cdot \mathcal{I}(b, w)]. \end{aligned}$$

Note also that, since she's sure her credences match the chances — $c_1(\phi_{ch}) > 0$ only if $ch_E(C_0) = c_1(C_0) = 1$ and $ch_E(C_j) = c_1(C_j) = 1/2$, for $j \geq 1$ — we have:

$$\begin{aligned} Est_{c_1}(\mathcal{I}(b)) &= \textstyle\sum_w c_1(w) \cdot \mathcal{I}(b, w) \\ &= \textstyle\sum_{ch' \in C} c_1(\phi_{ch'}) \cdot [\sum_w ch'_E(w) \cdot \mathcal{I}(b, w)] \\ &= \textstyle\sum_w ch_E(w) \cdot \mathcal{I}(b, w). \end{aligned}$$

Finally, recall that $\mathcal{I}$ is the Brier score. The Brier score is a 'strictly proper' scoring rule, *i.e.*, $\sum_w p(w) \cdot \mathcal{I}(p, w) < \sum_w p(w) \cdot \mathcal{I}(q, w)$, for any probabilistically coherent credence function p and any $q \neq p$.[18] So we have:

$$\begin{aligned} Est_{c_1}(\mathcal{I}(c_1)) &= \textstyle\sum_w c_1(w) \cdot \mathcal{I}(c_1, w) \\ &= \textstyle\sum_w ch_E(w) \cdot \mathcal{I}(ch_E, w) \\ &< \textstyle\sum_w ch_E(w) \cdot \mathcal{I}(b, w) \\ &= \textstyle\sum_w c_1(w) \cdot \mathcal{I}(b, w) \\ &= Est_{c_1}(\mathcal{I}(b)) \end{aligned}$$

for all $b \neq c_1 = ch_E$. Hence, by our theory of epistemic preference, $c_1 \rhd b$.

On the other hand, if $x \neq 1$, Em_x ought to prefer ch_E — which is such that $ch_E(C_0) = 1$ and $ch_E(C_j) = 1 - 0.5x$ — to her own credal state, c_x. Since she's certain that the true chance function ch is such that

$$\textstyle\sum_w ch_E(w) \cdot \mathcal{I}(ch_E, w) < \sum_w ch_E(w) \cdot \mathcal{I}(b, w)$$

for all $b \neq ch_E$ (including $b = c_x$), by Deference to Chance (DtC), we have: $Est_{c_1}(\mathcal{I}(ch_E)) < Est_{c_1}(\mathcal{I}(b))$. Hence, by our theory of epistemic preference, $ch_E \rhd b$.

Regarding epistemic *acts*, the question is: Assuming she cares only about accuracy, how should Em_x evaluate the *epistemic act* that she performed? How should she evaluate the *action* $\overline{c_x}$ of adopting credal state c_x? Should she prefer it over the alternative epistemic acts she might have performed?

The answer: Em_0, and indeed all Em_x, ought to prefer epistemic act $\overline{c_0}$ to the alternatives $\overline{c_y}$. First reason:

$$\textstyle\sum_w c_x(w \| \overline{c_y}) \cdot \mathcal{I}(c_y, w) = \sum_w ch_E(w | \overline{c_y}) \cdot \mathcal{I}(c_y, w)$$

Em_0 thinks that, were she to raise her credence in C_0 (the proposition that there is now a child before her) from 0 to y, for some $y > 0$, the j^{th} summerhouse child would be less likely to come outdoors (C_j would be less likely). Indeed, she's sure that C_j would be exactly this likely: $ch_E(C_j|\overline{c_y}) = 1 - 0.5y$ ($< c_0(C_j) = 1$). So $c_0(C_j \| \overline{c_y}) = ch_E(C_j|\overline{c_y}) = 1 - 0.5y$. More generally, $c_x(X \| \overline{c_y}) = ch_E(X|\overline{c_y})$. Hence:

$$\textstyle\sum_w c_x(w \| \overline{c_y}) \cdot \mathcal{I}(c_y, w) = \sum_w ch_E(w | \overline{c_y}) \cdot \mathcal{I}(c_y, w)$$

[18] The Brier score is also *separable* (*cf.* Joyce 2009, p. 271). Separability guarantees that the inaccuracy of c_1's credences over the C_i, as well as the inaccuracy of all alternatives b, can be assessed independently of what probabilities they assign to propositions other than the C_i. Further, since c_1 and b agree on all other probabilities (*ex hypothesi*), their comparative accuracy over the C_i is all that matters to comparative accuracy *tout court*. So we restrict attention to the propositions of interest—the C_i—in what follows.

From this, we can derive:[19]

$$
\begin{aligned}
&\sum_w c_x(w \| \overline{c_y}) \cdot \mathcal{I}(c_y, w) \\
&= \sum_w ch_E(w | \overline{c_y}) \cdot \mathcal{I}(c_y, w) \\
&= \sum_w ch_E(w | \overline{c_y}) \cdot \sum_{i=0}^{10} (\chi_w(C_i) - c_y(C_i))^2 \\
&= (1-y)^2 + \sum_{k=0}^{10} \binom{10}{k} \left(1 - \frac{y}{2}\right)^k \left(\frac{y}{2}\right)^{10-k} \\
&\qquad \bullet \left[k \left(\frac{y}{2}\right)^2 + (10-k)\left(1 - \frac{y}{2}\right)^2 \right] \\
&= -\frac{3y^2}{2} + 3y + 1
\end{aligned}
$$

which is uniquely minimized at $y = 0$. So, by our theory of preference over epistemic acts, $\overline{c_0} \succ \overline{c_y}$.

Before elaborating on the dissonance between the evaluation of states and the evaluation of acts in this case, consider Greaves' own commentary on the case. We discuss the disparate intuitions that we label [1] and [2] below:

> …one is torn. **On the one hand: Emily has conclusive evidence that there is now a child before her, so presumably she should retain her degree of belief 1 in the proposition $\mathbf{C_0}$ that indeed there is** [1]. In that case, there will be a chance of 1/2 of each summerhouse child coming out to play, so she should have credence 1/2 in each C_j; this is the best she can do, but she knows that her degree of belief is then bound to be 'one half away from the truth' for each C_i, as the truth-value can only be 1 or 0. **On the other hand, if Emily can just persuade herself to ignore her evidence for $\mathbf{C_0}$, and adopt (at the other extreme) credence 0 in $\mathbf{C_0}$, then, by adopting degree of belief 1 in each $\mathbf{C_j}$ ($\mathbf{j = 1, \ldots, 10}$), she can guarantee a perfect match to the remaining truths**. Is it epistemically rational to accept this 'epistemic bribe'? (2013, p. 4; emphasis ours)

The two different intuitions here track perfectly the two different modes of analysis that EpDT provides. Intuition [1] is driven by Emily's evaluations of credal *states*, not epistemic *acts*. *Every* Emily doppelgänger Em_x should prefer to have a credal state that assigns probability 1 to C_0. Em_1 should prefer her own credal state c_1 to all alternatives b. Em_x should prefer the chance function conditional on her evidence (i.e., $ch_E(C_0) = 1$ and $ch_E(C_j) = 1 - .5x$) to all her alternatives, including her own credal state c_x.

Intuition [2] is driven by Emily's evaluations of *epistemic acts*, not *states*. *Every* Emily doppelgänger Em_x, if she cares exclusively about accuracy, should prefer to perform the *act* of adopting credal state c_0. This is the act that *causes* the world to satisfy her desires to the greatest degree possible. $\overline{c_0}$ influences the truth-values of the C_j in just the right way, so as to make them as close as possible to her credences.

4.3 Leap

Another telling case Greaves (2013) provides is the following:

Leap Bob stands on the brink of a chasm, summoning up the courage to try and leap across it. Confidence helps him in such situations: specifically, for any value of x between 0 and 1, if Bob attempted to leap across the chasm while having degree of belief x that he would succeed, his chance of success S would then be x.

In this case, Bob's evidence E includes $ch(S|c(S) = x) = x$, and because of our luminosity assumption, E also includes $c(S) = x$.

So we can see what EpDT says for any possible credence function Bob might have, we'll let B_x be the Bob-doppelgänger who adopts credal state c_x with $c_x(S) = x$.

Regarding epistemic *states*, the question is: How should B_x evaluate his own credences? Should he

[19] The following observations should clarify the fourth line of this derivation:

1. $ch_E(w|\overline{c_y}) > 0$ only if $\chi_w(C_0) = 1$.
   - In turn, $ch_E(w|\overline{c_y}) > 0$ only if $ch_E(w|\overline{c_y}) \cdot \mathcal{I}(c_y, w) = ch_E(w|\overline{c_y}) \cdot [(1-y)^2 + \mathcal{I}(c_y|_{j\geq 1}, w)]$, where $c_y|_{j\geq 1}$ is the restriction of c_y to $\{C_j | j \geq 1\}$.
2. Given (1), $\sum_w ch_E(w|\overline{c_y}) \cdot \mathcal{I}(c_y, w) = (1-y)^2 + \sum_{k=0}^{10} ch_E(\# = k|\overline{c_y}) \cdot \mathcal{I}(c_y|_{j\geq 1}, \# = k)$, where $\# = k$ is the proposition that exactly k of summerhouse children 1 through 10 come outdoors.
3. $ch_E(\# = k|\overline{c_y}) = \binom{10}{k}\left(1 - \frac{y}{2}\right)^k \left(\frac{y}{2}\right)^{10-k}$
4. $\mathcal{I}(c_y|_{j\geq 1}, \# = k) = k\left(\frac{y}{2}\right)^2 + (10-k)\left(1 - \frac{y}{2}\right)^2$

prefer his own credal state over the alternatives in light of E? Or should he prefer some other credal state?

The answer: Every B_x ought to prefer his own credal state c_x to all alternatives c_y. Since c_x satisfies PP, and is certain that $c_x = ch_E$, we have:

$$\begin{aligned} Est_{c_x}(\mathcal{I}(c_x)) &= \textstyle\sum_w c_x(w) \cdot \mathcal{I}(c_x, w) \\ &= \textstyle\sum_w ch_E(w) \cdot \mathcal{I}(ch_E, w) \\ &< \textstyle\sum_w ch_E(w) \cdot \mathcal{I}(c_y, w) \\ &= \textstyle\sum_w c_x(w) \cdot \mathcal{I}(c_y, w) \\ &= Est_{c_x}(\mathcal{I}(c_y)) \end{aligned}$$

for all $c_y \neq c_x = ch_E$. Hence, by our theory of epistemic preference, $c_x \rhd c_y$.

Regarding epistemic *acts*, the question is: Assuming he cares only about accuracy, how should B_x evaluate the *epistemic act* that he performed? How should he evaluate the *action* $\overline{c_x}$ of adopting credal state c_x? Should he prefer it over the alternative epistemic acts he might have performed?

The answer: Every B_x ought to prefer epistemic acts $\overline{c_0}$ and $\overline{c_1}$ to all alternatives $\overline{c_x}$. The reason:

$$\begin{aligned} &\sum_w c_x(w \| \overline{c_y}) \cdot \mathcal{I}(c_y, w) \\ &= \sum_w ch_E(w | \overline{c_y}) \cdot \mathcal{I}(c_y, w) \\ &= y(1-y)^2 + (1-y)(0-y)^2 \\ &= y(1-y) \end{aligned}$$

which is minimized only at $y = 0$ and $y = 1$.

Again, Greaves identifies two dissonant intuitions:

> One feels pulled in two directions. **On the one hand: adopting an extremal credence (0 or 1) will lead to a perfect match between one's credence and the truth, whereas a non-extremal credence will lead to only imperfect match** [1]. **But on the other: whatever credence one adopts (extremal or otherwise), one's credences will match the chances: they will be the right credences to have given the then-chances** [2]. Is any degree of belief in success epistemically rationally permissible, or only an extremal credence? (2013, p. 2; emphasis ours)

Intuition [1] is driven by Bob's evaluations of *epistemic acts*, not *states*. *Every* Bob doppelgänger B_x, if he cares exclusively about accuracy, should prefer to perform the *act* of adopting credal state c_0 or c_1. These are the acts that *cause* the world to satisfy his desires to the greatest degree possible. $\overline{c_0}$ and $\overline{c_1}$ influence the truth-value of S in just the right way, so as to make it as close as possible to his credence. As a result, $\overline{c_0}$ and $\overline{c_1}$ are, in his best estimate, more prudentially valuable than all alternatives $\overline{c_x}$.

Intuition [2] is intuition is driven by Emily's evaluations of credal *states*, not epistemic *acts*. *Every* Bob doppelgänger B_x should prefer his own credal state c_x over all the alternatives c_y.

4.4 Promotion

For our third case study, we turn to:

Promotion Alice is up for promotion. Her boss, however, is a deeply insecure type: he's more likely to promote Alice if she comes across as lacking in confidence. Furthermore, Alice is useless at play-acting, so she'll come across that way iff she really does have a low degree of belief that she's going to get the promotion. Specifically, the chance of her getting the promotion will be $(1-x)$, where x is whatever degree of belief she chooses to have in the proposition P that she'll be promoted.

Given the setup, Alice's evidence E includes $ch(P|c(P) = x) = 1 - x$. By luminosity, E also includes $c(P) = x$.

Let A_x be the Alice-doppelgänger who adopts credal state c_x with $c_x(P) = x$.

Regarding epistemic *states*, the question is: How should A_x evaluate her *credal state*? Should she prefer it over the alternatives in light of E? Or should she prefer some other credal state?

The answer: If $x = .5$, she ought to prefer her own credal state $c_{.5}$ to all alternatives b. But If $x \neq .5$, she ought to prefer ch_E, which is such that $ch_E(P) = 1 - x$. The reason:

$$\textstyle\sum_w ch_E(w) \cdot \mathcal{I}(c_y, w) = (1-x)(1-y)^2 + xy^2$$

which is uniquely minimized at $y = 1 - x$. By DtC, then, we have $Est_{c_x}(\mathcal{I}(c_{1-x})) < Est_{c_x}(\mathcal{I}(c_y))$ if $x \neq .5$. Hence, by our theory of epistemic preference, $c_{1-x} \rhd c_y$.

Regarding epistemic *acts*, the question is: Assuming all she cares about is accuracy, what should A_x think of the *epistemic act* she ended up performing? That is, what should she think of the *action* $\overline{c_x}$?

The answer: A_x prefers epistemic act $\overline{c_{.5}}$ to any alternative $\overline{c_y}$. The reason:

$$\begin{aligned}&\sum_w ch_E(w|\overline{c_y}) \cdot \mathcal{I}(c_y, w)\\&= (1-y)\mathcal{I}(c_y, w_P) + y \cdot \mathcal{I}(c_y, w_{\neg P})\\&= (1-y)(1-y)^2 + y \cdot y^2\end{aligned}$$

which is uniquely minimized at $y = .5$.

At first glance, it appears that this case lacks any dissonance. Indeed, Greaves thinks that EpDT's recommendation is clear:

> Presumably, in the Promotion case, there is a unique rationally permitted degree of belief in P: Alice must adopt credence .5 in P, because only in this case will her credences match her beliefs about the chances once she has updated on the proposition that she will adopt that very credence in P. (2013, p. 2)

Nevertheless, we maintain that matters are not so simple. If we evaluate Alice's *epistemic acts*, then adopting credence .5 will minimize her expected inaccuracy. Every other option, in her best estimate, *causes* her credence to be less accurate. So, $A_{.5}$ is best from this perspective.

On the other hand, if we evaluate Alice's *credal states*, the problem is more nuanced. If she is in state x, she most prefers to be in state $1-x$. So, for any $x \neq .5$, the optimal credal state to be in, by Alice's lights, is *not* in fact .5. Which alternative state is optimal varies based on which credal state Alice is in. So, while Greaves does not here identify a pull in two different directions, there in fact is one. From the act point of view, adopting credence .5 is uniquely best, regardless of what credal state c_x Alice occupies. From the state point of view, occupying state c_{1-x} is best.

It is true that $A_{.5}$ (and only $A_{.5}$) is in a conflict-free mental state. $A_{.5}$ should prefer both the *credal state* that she adopted and the *epistemic act* that she performed to all the alternatives. Every other A_x should prefer some other state *and* some other act over her own. It does *not* follow from this, however, that accuracy-first epistemology recommends the *state* $c_{.5}$, since not every credal state prefers $c_{.5}$

5 What EpDT Recommends

We've now identified the source of the problem: When the act of adopting a credal state can influence the world, which epistemic acts an agent wants to perform can come apart from which credal states she'd most like to occupy. That is, an agent can prefer to perform epistemic act $\overline{c}$ to an alternative epistemic act $\overline{c'}$ while preferring to be in epistemic state c' to state c.

So, given this dissonance, what does epistemic decision theory recommend in the end? Does it advise agents to go with c or with c'?

In one sense, EpDT equivocates in these cases. It recommends both performing act $\overline{c}$ and occupying state c'. On the face of it, this might seem problematic. These recommendations are not cosatisfiable. You cannot both perform act $\overline{c}$ and occupy state c'.

However, following our discussion of praxic and epistemic good in §2, we nonetheless maintain that EpDT's recommendations concerning which states to occupy are of primary concern to the normative epistemologist, for it is only here that EpDT is returning purely epistemic evaluations and only here that EpDT has implications for purely epistemic rationality. There is a kind of rational dilemma, but not a dilemma of purely epistemic rationality. Instead, these are cases where epistemic rationality and what is ultimately practical rationality come apart. And *this* kind of dilemma is familiar. For example, it might be *epistemically* rational for you to believe that your partner is cheating on you, in light of your evidence, even though it is *practically* rational for you to perform the act of adopting the belief that he is not (if you can).

To see why EpDT's recommendations concerning *states* are the only ones relevant for *epistemic* rationality, recall how we evaluate the epistemic *act* of adopting credence c' from c's point of view:

$$\mathrm{EEU}_c(\overline{c'}) = -\sum_w c(w\|\overline{c'})\mathcal{I}(c', w) \tag{1}$$

Equation (1) is merely an instance of the more general causal decision-theoretic method of evaluation of *any* action whatsoever. I.e., (1) is a special case of:

$$\mathrm{EU}_c(A) = \sum_w c(w\|A) \cdot u(w) \tag{2}$$

There are two ways (1) restricts (2) in particular. First, (1) restricts the domain of actions to merely epistemic actions. Second, it identifies $-\mathcal{I}$ with the utility function u. Thus, EpDT evaluates epistemic acts just as causal decision theory does for an agent whose only concern in life is accuracy. That is, if what you care about all things considered is just accuracy—and not money, prestige, or fame—EpDT and causal decision theory will tell you to perform the same epistemic acts.

But the restriction to epistemic acts is arbitrary. (Worse, it is *incoherent*.[20]) There is no reason why we can't evaluate the expected epistemic utility of building the Large Hadron Collider, or reading your sister's diary, or choosing Lucky Charms over Cap'n Crunch for breakfast. Each of these may effect changes in the world as well as in your epistemic state, and they can therefore be evaluated in terms of the expected accuracy they'll deliver in the same way EpDT evaluates epistemic acts.

We can agree that failing to build the LHC, respecting your sister's privacy, and foregoing breakfast altogether are not in themselves epistemically irrational in the sense we're after. Nonetheless they may lead to less accuracy than you could have achieved through other means and are therefore not the optimal acts for an agent whose only concern is how close her credal state is to actual truth-values. The same, we suggest, is true of 'epistemic' acts. Performing 'the' act (supposing that there is such a thing) of adopting some credence function c may not be *epistemically* irrational, even if adopting c leads to less accuracy than you could have achieved through other means.

The reason: while the utility function $-\mathcal{I}$ cares only for your epistemic and not your practical well-being, EpDT nonetheless *evaluates* epistemic acts like any other act, *viz.*, on the basis of the extent to which it *produces* desirable consequences. But this is a *practical* evaluation. It is a practical evaluation whether you care primarily about accuracy or apple pie. And these sorts of evaluations have no bearing on epistemic rationality *per se*. The direction of fit is wrong.

[20] The very notion of an epistemic act itself is problematic for EpDT. Imagine the following variant of Imps: In order to change from one credence function c to another c', Emily can run one of two cognitive processes $A_{c'}$ and $B_{c'}$. $A_{c'}$ and $B_{c'}$ function like mental switches that Emily can turn on that result in her adoption of c'. Generally, it doesn't matter at all which switch she flips. She simply has two different means of getting herself into state c'. However, in our redux version of Imps, it makes a difference. In particular, if she performs $\overline{c'}$ by initiating $A_{c'}$, then the chance of $C_1, \ldots, C_{10}$ is $1 - \frac{c'(C_0)}{2}$ as before. If she performs $\overline{c'}$ by initiating $B_{c'}$, the chance of $C_1, \ldots, C_{10}$ is $1/2$. Now, EpDT seems to recommend the *act* of $\overline{c_0}$ performed via A_{c_0}, not the act $\overline{c_0}$ *simpliciter*. Indeed, the latter is no longer fine-grained enough to have a place in the space of acts $\mathcal{A}$, since it will lead to different outcomes depending on how it is effected.

On the other hand, EpDT evaluates epistemic states based solely on how well they fit the world, i.e., based solely on how epistemically good they are. Such verdicts don't tell you to change the world, but merely what states are best to occupy given the way the world is. It's then EpDT's recommendations on which epistemic states to prefer that concern purely epistemic rationality.

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