**Sequential Choice and the Agent’s Perspective**

Causal Decision Theory reckons the choice-worthiness of an option to be completely independent of its evidential bearing on its non-effects. But *after* one has made a choice this bearing *is* relevant to future decisions. Therefore it is possible to construct problems of sequential choice in which Causal Decision Theory makes a guaranteed loss. So Causal Decision Theory is wrong. The source of the problem is the idea that *agents* have a special perspective on their own contemplated actions, from which evidential connections that *observers* can see are either irrelevant or invisible.

Causal Decision Theory (CDT) both can and should be interpreted as a branch of (1) normative (2) subjective decision theory. (1) It is normative, not descriptive, because its output is what you *ought rationally* to do, not what you *will in fact* do. (2) It is subjective, not objective, because its inputs are (2a) your beliefs and (2b) your desires about the state of the world and the outcomes, not objective facts about the state of the world or the objective goodness of the outcomes. If I *fear* an illness that I *think* this medicine will forestall, then that already makes it CDT-rational to take the medicine, irrespective of (1) whether I in fact take it, (2a) whether it really works and (2b) whether the illness is really that bad.[[1]](#footnote-1)

 On this normative subjective branch its main rival is Evidential Decision Theory (EDT). According to EDT, what matters is not the perceived *causal* efficacy of an act but its perceived *news* value. In the situation that I just described, EDT reckons it rational to take the medicine, not because doing so *makes* you recover but because it is *evidence* that you will.

Practical disagreement between CDT and EDT arises when a contemplated act is *symptomatic* of some undesirable state that it does nothing to bring about. For instance, suppose that what tends to cause people to smoke is a certain kind of genetic defect that makes smoking harmful. You want to smoke, but it matters more to you that you not suffer the harm. EDT advises you not to smoke on these grounds alone, since your smoking is bad news: it tells you that you (probably) have the defect. But CDT may advise you to go ahead, since smoking does nothing to *cause* the presence of the defect.[[2]](#footnote-2)

This paper exploits such cases to construct a decisive case against CDT. Section 1 spells out the basic case, and also EDT and CDT, in more detail. Section 2 extends the case to a situation of sequential choice. Sections 3 and 4 look at various ways of applying EDT and CDT to sequential choice scenarios and identify their recommendations on each of these approaches. Section 5 argues that on any plausible approach to sequential choice, CDT gives plainly disastrous advice. Section 6 considers objections. Section 7 traces the difficulty to a philosophical thesis embodied in the formalism of CDT but not unique to it: namely, that we face reality from two perspectives, as agents and as observers.

**1. The basic case**

Imagine that you are wondering whether to smoke. Imagine that you like smoking. Imagine that what causes people like you to smoke is a mildly undesirable genetic defect. So amongst people like you, more than 75% of smokers have the defect and fewer than 25% of non-smokers have it. The defect is undesirable because smoking *causes* a little harm to people who have it. Finally, imagine that you are willing to sign up to cash equivalents to the possible outcomes of your decision. That is, you think that smoking without the defect is worth $1 to you, etc.

We may then summarize your options, the relevant states of the world and the possible outcomes as follows:

|  |  |  |
| --- | --- | --- |
|  | **D: defect present** | **¬D: defect absent** |
| **O1: you smoke** | -1 | 1 |
| **O2: you don’t smoke** | 0 | 0 |

*Table 1: Dollar-equivalent payoffs to smoking*

In the body of Table 1, the number in each cell indicates your current dollar-value for the outcome that combines the corresponding row- and column-entries. For instance, the ‘1’ in the top-right cell means that you currently value at $1 the outcome in which you smoke and lack the defect.

 The question is whether or not to smoke. What do EDT and CDT recommend? To answer this I should first briefly explain (a) how to quantify your beliefs and desires, and (b) how to get from these to a concrete recommendation.

 (a) We suppose a *credence* *function* Cr, this being a probability function on (a Boolean algebra of) propositions that measures your confidence in their truth. So Cr (P) ≥ 0 for any P, and Cr (P) = 1 if you are certain that P is true. Also, if Cr (P ∧ Q) = 0 then Cr (P ∨ Q) = Cr (P) + Cr (Q): if you are certain that two propositions are not both true then your confidence that one of them is true is the sum of your confidences in each of them taken separately. Finally, define the conditional probability Cr (Q⏐P) =def. Cr (P ∧ Q) / Cr (P) if Cr (P) > 0.

Cr (Q⏐P) is itself a probability function of Q for fixed P; it is the *probability of* *Q given P*. As is fairly standard, I’ll take it to measure the degree to which you think of P as evidence of Q. More precisely, I adopt the Bayesian assumption that a rational agent who learns just P updates her confidence in Q from Cr (Q) to Cr (Q⏐P).

 We also suppose a *value function* V from propositions describing outcomes to real numbers. V measures the desirability to you of whatever outcome the proposition describes. It represents your preferences in the sense that V (P) > V (Q) iff you prefer the outcome that P describes to the outcome that Q describes.

 In the case at hand your credence function reflects your taking O1 as evidence that you have the defect. And your value function reflects the dollar equivalences in Table 1 as well as the fact that you prefer more money to less. More concretely and without loss of generality, suppose (i) that smoking (O1) makes you more than three times more confident that you have the defect than that you lack it; (ii) that not smoking (O2) makes you more than three times more confident that you lack the defect than that you have it; (iii) that your value for an outcome is proportional to its dollar equivalent (i.e. ‘risk-neutrality’ for money). In that case we can write:

1. Cr (D⏐O1) > 0.75
2. Cr (¬D⏐O1) < 0.25
3. Cr (D⏐O2) < 0.25
4. Cr (¬D⏐O2) > 0.75
5. V (O1D) = -1
6. V (O1¬D) = 1
7. V (O2D) = V (O2¬D) = 0

Here and elsewhere I’ll usually write O1D etc. to abbreviate O1 ∧ D etc.

(b) *Causal* Decision Theory says that whether you realize O1 should depend only on its effects. You don’t yet know whether you have the defect, so you don’t yet know what these effects are. If you have the defect then O1 has a net bad effect because it causes unpleasant symptoms. But if you lack it then O1 has only the good effect that your enjoyment of smoking constitutes. So we weight your values for these outcomes by the respective probabilities that you have and that you lack the defect. CDT therefore assigns to each option a *utility* U that these weighted sums define:

1. U (O1) = V (O1D) Cr (D) + V (O1¬D) Cr (¬D)
2. U (O2) = V (O2D) Cr (D) + V (O2¬D) Cr (¬D)

And CDT endorses O1 (resp. O2) if and only if U (O1) ≥ U (O2) (resp. U (O2) ≥ U (O1)).

 Substituting (5) and (6) into (8) and (7) into (9) then gives:

1. U (O1) = -Cr (D) + Cr (¬D)
2. U (O2) = 0

It follows from (10) and (11) that CDT endorses O1 if and only if Cr (¬D) ≥ Cr (D).

 *Evidential* Decision Theory says that whether you realize O1 should depend on the degree to which doing so is evidence of the defect. So when evaluating O1 we should weight your values for the two possible outcomes by the respective *conditional* probabilities, that you have (or that you lack) the defect given O1. Specifically, EDT extends the value measure V from outcomes to acts by means of the following weighted sums:

1. V (O1) = V (O1D) Cr (D⏐O1) + V (O1¬D) Cr (¬D⏐O1)
2. V (O2) = V (O2D) Cr (D⏐O2) + V (O2¬D) Cr (¬D⏐O2)

And EDT endorses O1 (O2) if and only if V (O1) ≥ V (O2) (V (O2) ≥ V (O1)).

 Substituting (1), (2), (5) and (6) into (12), and (7) into (13), gives:

1. V (O1) < –0.75 + 0.25 = -0.5
2. V (O2) = 0

It follows from (14) and (15) that EDT endorses O2 i.e. not smoking. It does not endorse O1.

 So EDT and CDT collide over this case if Cr (¬D) ≥ Cr (D). In that case CDT endorses O1, which it effectively regards as taking a bet at even or better odds on a proposition that is at least as likely as not to be true. But EDT recommends O2, because it regards O1 i.e. smoking as a bet at even odds that you are more likely than not to lose *if you take it*.

 There is no clear winner here. Perhaps some people have the intuition that you should smoke if you are more confident than not that you lack the defect. Probably some people intuit that you should *not* smoke, *whatever* your present confidence that you have the defect. Some philosophers argue that at least in a high-stakes version of this case, CDT makes the wrong call.[[3]](#footnote-3) But that too is disputable. At any rate I shan’t dispute or defend it here, but simply move on to an extension of the case that supports a simpler objection to CDT.

**2. The Insurance Problem**

Call this extended case the *Insurance Problem*. It is a problem of *sequential* choice, and it is in two stages. Stage 1 is just the smoking case from section 1. At Stage 2, which takes place *after* you have decided whether to smoke but *before* you learn whether you have the defect, I offer you the opportunity to bet $1.50, at odds of 1:3, on the following proposition T: *You have the defect if and only if you smoked*. That is, I offer you a bet with the following payoffs:

|  |  |  |
| --- | --- | --- |
|  | **T: O1 ↔ D** | **¬T: O1 ↔ ¬D** |
| **P1: Bet**  | 0.5 | -1.5 |
| **P2: Don’t bet**  | 0 | 0 |

*Table 2: Insurance Problem Stage 2: dollar payoffs*

After you have decided at Stage 2, you learn whether you have the defect and all monies are paid.

It is a harmless assumption that your overall payoffs in this problem are simply the sums of the payoffs from the two stages. It is harmless because we could have assumed from the outset that your payoffs at Stage 1 were monetary rather than health-based, in which case there is no problem with this aggregation. So making it, we can calculate your combined payoffs for this problem as follows:

|  |  |  |
| --- | --- | --- |
|  | **D: Defect present** | **¬D: Defect absent** |
| **O1 P1** | -0.5 | -0.5 |
| **O1 P2** | -1 | 1 |
| **O2 P1** | -1.5 | 0.5 |
| **O2 P2** | 0 | 0 |

 *Table 3: Net payoffs in Insurance Problem*

For instance, if you have got the defect and take O1 at Stage 1, you suffer the symptoms of smoking with the defect, for an initial loss of $1. But if you also bet at Stage 2 then you get 50¢ compensation, for a *net* loss of 50¢. Similarly, if the defect is absent and you decline to smoke at Stage 1 but bet at Stage 2, then you miss out on the $1-equivalent gain that you could have got from O1 but again get 50¢ compensation at Stage 2, for a net *gain* of 50¢. So the bet at Stage 2 could be described as insurance. It is insurance against having made the wrong decision at Stage 1.

 In one sense Table 3 is misleading, as it makes it look as though you are facing a *single* decision problem with four options. In fact you are facing two successive decision problems: the decision between O1 and O2 at Stage 1, and the decision between P1 and P2 at Stage 2. Table 3 should be understood as tabulating not your options but only the terminal payoffs, which are all that concern you, to each possible sequence of choices.

**Figure 1**

Figure 1 makes the sequential nature of the problem explicit. In Figure 1, the agent starts at the leftmost point and takes some path to the right hand side: each such path constitutes one possible sequence of choices, and, where this matters to the payoff, resolution of uncertainty with regard to the defect. Square nodes are *choice* nodes, from which you choose one or another branch. Circular nodes are *chance* nodes, from which each branch represents one of the two relevant possibilities with regards to the defect (either you have it or you don’t). The numbers at the rightmost end of each branch indicate the payoff to the corresponding combination of choices and resolution of uncertainty over D. For instance, the topmost branch corresponds to your choosing to smoke and then to bet (i.e. O1 and then P1). In this case you lose 50¢ for sure, whether or not you have the defect. Again, the fourth branch down corresponds to your choosing not to smoke and then to bet when D is in fact true. In this case you win or lose nothing from Stage 1. And you lose $1.50 at Stage 2, because on this branch both O2 and D are true, so T (i.e. O1 ↔ D) is false, so you lose your Stage 2 bet on T.

This is the Insurance Problem. The next questions are as follows. What can we expect a follower of CDT to do when facing it? And what can we expect a follower of EDT to do when facing it?

**3. What happens at Stage 2**

Answering these questions requires us to address two problems that arise in sequential cases. The first problem is that it may affect your Stage 1 decision, not only which of CDT and EDT you now follow, but also which you *expect* to follow at Stage 2. For what at Stage 1 you think you will do at Stage 2 might matter for your decision at Stage 1. And what at Stage 1 you think you will do at Stage 2 might depend on whether at Stage 1 you think you will follow EDT or CDT at Stage 2.

Your present beliefs about your future motivations, decision rules etc. *can* certainly matter in cases of sequential choice. For instance, your decision whether to embark on some lengthy enterprise, like writing a book, will or at least should depend in part on whether you now think it will still seem to you to be worth completing when you are halfway through it.

 But the issue doesn’t arise for the Insurance Problem, because CDT, EDT and everyone sensible should agree on what you ought to do at Stage 2.

Suppose, for instance, that you follow CDT and that you remember at Stage 2 what you just did at Stage 1. Write Cr1 for your credence function at the outset of Stage 1 and Cr2 for your credence function at the outset of Stage 2: so ‘Cr’ as it appears in (1)-(4), (8)-(10), (12) and (13) should be interpreted as Cr1. Similarly write U1, U2, V1 and V2 for the U-scores and V-scores of the relevant propositions at Stages 1 and 2. If you take O1 at Stage 1, and remember this, then the U-scores for your options at Stage 2 are as follows:

1. U2 (P1) = Cr2 (D) V2 (DO1P1) + Cr2 (¬D) V2 (¬DO1P1)
2. U2 (P2) = Cr2 (D) V2 (DO1P2) + Cr2 (¬D) V2 (¬DO1P2)

From Table 3 we therefore have:

1. U2 (P1) = -0.5
2. U2 (P2) = 1-2Cr2 (D)

So U2 (P1) > U2 (P2) iff Cr2 (D) > 0.75. It follows from (1) and the Bayesian rule for updating that Cr2 (D) > 0.75. So if you take O1 (smoke) at Stage 1 and remember this then CDT will advise you to take P1 (bet) at Stage 2.

 By similar reasoning, which I won’t present here, we can see (i) that if you *don’t* smoke (O2) at Stage 1 and remember this then CDT advises you to bet (P1) at Stage 2; (ii) that if you *forget* what you do at Stage 1 then CDT advises you to take P1 at Stage 2; (iii) that if you follow EDT and remember what you do at Stage 1, then you take P1 at Stage 2 whatever you did at Stage 1; (iv) that if you follow EDT and forget what you do at Stage 1, then again you take P1 at Stage 2. (For details see Appendix A.)

 None of this should be surprising. Everyone sensible should agree that you ought to bet at Stage 2. At Stage 2 you are being offered a bet on whether the correlation between the defect and the smoking holds in your own case. Nothing has happened to affect your confidence in the strength of the correlation, or the evidence for its holding in your case. You would be highly confident of any other person that he or she had the defect if and only if he or she smoked; why then should you not have this same confidence concerning your own past self?

It follows that of course you should take P1 at Stage 2 i.e. bet on T. For if V is a linear function of monetary wealth, which here it is, then it is rational to accept a gamble on a proposition at odds of 1:3 if your confidence in that proposition exceeds 0.75, which here it does. At least, this is true if the act of gambling is itself both causally and evidentially irrelevant to the proposition being gambled upon. That is certainly the case at Stage 2 of the Insurance Problem.

**4. What happens at Stage 1**

The second problem is that whichever of CDT and EDT you accept, it is still an open question what approach you take towards problems of *sequential* choice. Here, I initially consider two approaches. I won’t attempt to adjudicate between them but will just outline the upshot in each case.

(a) *Myopic choice*. The myopic approach towards sequential choice involves selecting, at each stage, the overall sequence that then seems best to you out of those still available, and then realizing the presently available component of that best sequence.[[4]](#footnote-4) In the present case it applies as follows: at Stage 1, you decide which of the four possible sequences is best according to your favoured decision theory. Then you realize the first step of that sequence. At Stage 2, you decide again on the same basis between the two sequences that are still available. At that point you realize the second step of the sequence that seems best to you then.

Writing A n B for ‘A is strictly more choiceworthy than B for you at stage n’, suppose just for illustration’s sake that O1P1 1 O1P2 1 O2P1 1 O2P2 and that at Stage 2 this ranking is exactly reversed. Then at Stage 1 you choose O1 if you are myopic. And at Stage 2 you choose P2, because O1P2 2 O1P1, and these are the only sequences still available. So you end up with O1P2.

Whether you take a myopic attitude towards sequential choice is independent of whether you follow Causal Decision Theory or Evidential Decision Theory. The role of CDT and EDT is to decide which of the sequences is choiceworthy, out of the ones that then remain available to you. If you follow CDT then you will use it to answer this question as it arises at each stage. And if you follow EDT then you will use *it* to answer the same question, as it arises at each stage.

What then does CDT recommend at each stage if you are myopic? At Stage 1 there are four sequences available to you, as summarized in Table 3. The payoff to each sequence depends on whether or not you have got the defect. Whichever sequence you realize is causally irrelevant to whether you have got the defect. So we can apply the same weighting procedure at Stage 1 as we applied in the basic smoking case. On the notational convention that subscripted numbers to Cr and U indicate your subjective credence and utility functions at the corresponding stage, we can write:

1. U1 (O1P1) = -0.5
2. U1 (O1P2) = -Cr1 (D) + Cr1 (¬D) = 1 – 2Cr1 (D)
3. U1 (O2P1) = -1.5Cr1 (D) + 0.5Cr1 (¬D) = 0.5 – 2Cr1 (D)
4. U1 (O2P2) = 0

O1P1 and O2P1 are immediately ruled out. So at Stage 1, O1P2 will look choiceworthy to CDT iff U1 (O1P2) ≥ U1 (O2P2) = 0, and uniquely choiceworthy iff U1 (O1P2) > 0. So by (21), if Cr1 (D) < 0.5 then O1 is rationally mandatory at Stage 1, and if Cr1 (D) ≤ 0.5 then O1 is rationally *permissible* at Stage 1, at least if you are myopic.

 Suppose that the stronger of these conditions holds, so that you *do* smoke at Stage 1. What happens at Stage 2? Well, we already know from section 3 that you bet at that stage i.e. take P1. Putting all of this together we have:

1. CDT makes O1P1 rationally *mandatory* for the myopic agent if Cr1 (D) < 0.5, and rationally *permissible* if Cr1 (D) ≤ 0.5.

What if Cr1 (D) > 0.5 (≥ 0.5)? Since this case makes no difference to the argument I won’t go through it in detail, but briefly: CDT recommends (allows) that a myopic agent with this starting point decline to smoke at Stage 1 and again accept the bet at Stage 2. More specifically:

1. CDT makes O2P1 rationally *mandatory* for the myopic agent if Cr1 (D) > 0.5, and rationally *permissible* if Cr1 (D) ≥ 0.5.

Holding fixed the supposition that you are myopic, let us turn to EDT. At Stage 1, you take your overall sequence of actions to be evidentially relevant to the presence or absence of the defect. *Both* smoking and betting, *and* smoking and not betting, are good signs that you have the defect. The relevant conditional probabilities reflect this:

1. Cr1 (D⏐O1P1) = Cr1 (D⏐O1P2) > 0.75
2. Cr1 (D⏐O2P1) = Cr1 (D⏐O2P2) < 0.25

We therefore have:

1. V1 (O1P1) = -0.5
2. V1 (O1P2) = -Cr1 (D⏐O1P2) + Cr1 (¬D⏐O1P2) < -0.5
3. V1 (O2P1) = -1.5Cr1 (D⏐O2P1) + 0.5Cr1 (¬D⏐O2P1) > 0
4. V1 (O2P2) = 0

It follows that at Stage 1 EDT reckons O2P1 uniquely rational. So if you are myopic and follow EDT you won’t smoke. And by the argument of section 3, we already know that you bet at Stage 2. So *whatever* your initial level of confidence that the defect is present, we have:

1. EDT makes O2P1 rationally mandatory for the myopic agent.

(b) *Sophisticated choice*. What makes ‘myopic’ appropriate is that the myopic agent will initiate or continue a plan *when* it seems ideal to him, without clearly seeing ahead, i.e. without caring whether he will follow through on its later stages. This *looks* irrational, although I am not here going to argue that it is. In any case, the *sophisticated* approach differs from myopic choice on just this point. The sophisticated approach to sequential choice is to work backwards from the final stage. If you can now foresee that by your lights at that final stage a certain option is *then* going to seem rationally compelling, you should now take it for granted that you realize that option. Then you should evaluate what will seem rational at the penultimate stage, *given* your already predetermined decision at the final stage. Iterate until you reach the present stage.

The sophisticated approach is probably the most popular approach to sequential choice. Certainly, those few philosophers who have tried to apply CDT to problems of sequential choice have endorsed it implicitly.[[5]](#footnote-5)

In the Insurance Problem, you will if you are sophisticated first look *forward* to Stage 2 and ask what will then seem best to you by the lights of your favoured decision theory. Once you have reached an answer on that point, you then make your choice at Stage 1, given what you now know about what you will do at Stage 2.

So suppose that you are a sophisticated chooser and start again with the further supposition that you follow CDT. Looking forward to Stage 2: the argument at section 3 should make it clear that whatever you choose at Stage 1, you *will* certainly bet at Stage 2. Briefly to recap the point: it is still true that your Stage 2 beliefs involve Cr2 (T) > 0.75, *whatever* you do at Stage 1. And certainly your choice of bet at Stage 2 is causally irrelevant to whether T is true. After all, T is a biconditional relating two propositions (O1 and D) that describe states and events that obtain or occur strictly before Stage 2, and so nothing that you do at Stage 2 can make any difference to their truth value, nor therefore to T’s truth value.

This means that at Stage 1 you take yourself to be choosing in effect between O1P1 and O2P1.

1. U1 (O1P1) = -0.5
2. U1 (O2P1) = -1.5Cr1 (D) + 0.5Cr1 (¬D) = 0.5 – 2Cr1 (D)

It follows straightforwardly from (33) and (34) that:

1. CDT reckons O1P1 rationally *mandatory* for the sophisticated agent if Cr1 (D) > 0.5, and rationally *permissible* if Cr1 (D) ≥ 0.5

By similar reasoning we have:

1. CDT reckons O2P1 rationally *mandatory* for the sophisticated agent if Cr1 (D) < 0.5; and rationally *permissible* if Cr1 (D) ≤ 0.5

 Now holding fixed your sophistication, suppose that you follow EDT. Again by section 3, you will certainly bet at Stage 2. So at Stage 1 you again conceive of yourself as choosing between O1P1 and O2P1.

1. V1 (O1P1) = -0.5
2. V1 (O2P1) = -1.5Cr1 (D⏐O2P1) + 0.5Cr1 (¬D⏐O2P1)

Since (26) and (27) still hold, the quantity on the right-hand side of (38) exceeds zero, so V1 (O2P1) > V1 (O1P1) in all cases. So whatever the agent’s initial confidence that the defect is present:

1. EDT reckons O2P1 rationally *mandatory* for the sophisticated agent.

The following table summarizes (24), (25), (32), (35), (36) and (39).

|  |  |  |
| --- | --- | --- |
|  | **CDT** | **EDT** |
|  | *Myopic* | *Sophisticated* | *Myopic* | *Sophisticated* |
| Cr1 (D) < 0.5 | O1P1 | O2P1 | O2P1 | O2P1 |
| Cr1 (D) = 0.5 | O1P1O2P1 | O1P1O2P1 | O2P1 | O2P1 |
| Cr1 (D) > 0.5 | O2P1 | O1P1 | O2P1 | O2P1 |

*Table 4: Recommendations in the Insurance Problem*

The entries in the body of the table indicate which choice sequences in the insurance problem are rationally permissible for a given decision theory, attitude towards sequential choice and initial credence. For instance, the appearance of O1P1 *and* O2P2, in the cell corresponding to sophisticated CDT and Cr1 (D) = 0.5, indicates that, as (35) and (36) imply, both of these sequences are rationally permissible for the sophisticated agent as far as Causal Decision Theory is concerned.

 But the important point to take away from this section and section 3 is that whichever attitude you take towards sequential choice, if you have certain reasonable and feasible beliefs, CDT will lead you to take O1P1 i.e. to smoke and then to bet. If you are a myopic chooser whose Cr1 (D) ≤ 0.5 then CDT will lead you into this sequence, or at least allow it. Similarly if you are a sophisticated chooser whose Cr1 (D) ≥ 0.5, then again CDT will either recommend or permit smoking and then insuring. But EDT *never* allows this sequence. Whatever attitude you take towards sequential choice, and whatever your initial confidence that you have the defect, EDT always recommends that you do not smoke and then that you bet.

**5. Disaster**

To repeat: CDT permits O1P1 in the Insurance Problem to myopic agents whose beliefs satisfy the light and coherent condition that Cr1 (D) ≤ 0.5, and to sophisticated agents whose beliefs satisfy the similarly sane and undemanding Cr1 (D) ≥ 0.5.

 This is disastrous. Looking back at Table 3 we see that O1P1 *guarantees* a 50¢ loss. That would not be so bad if any sequence of options involved at least the possibility of greater loss. But this is not so. The alternative sequence O2P2, the alternative of declining both ‘gambles’, guarantees a loss of *zero*. So the Insurance Problem is a Dutch Book for CDT. It is a sequence of offers that CDT will successively advise certain sane and rational persons to take, of which the net result is a guaranteed loss relative to some alternative. That looks like decisive practical grounds for rejecting CDT.

 Let me note that this argument against CDT is quite different from a similar one that arises in the context of Newcomb’s problem. For those who know it[[6]](#footnote-6): it is sometimes argued against CDT that its advice to take both boxes generates an expected loss relative to the alternative of taking one box: those who take just one box usually get $1M whereas those who take both boxes usually get just $1K. This is the ‘Why Ain’cha Rich’ argument against taking both boxes, and by extension against Causal Decision Theory itself.[[7]](#footnote-7) But there are two key differences between ‘Why Ain’cha Rich?’ and the present argument. The first is that ‘Why Ain’cha Rich?’ is based only upon an *expected* relative loss for CDT. Taken over a large number of trials, we expect that people who take both boxes will have lower mean profit than those who take just one box. But it is just not true that somebody who takes one box will *certainly* make more money than somebody who takes both boxes. At least this is not true unless we suppose that the ‘predictor’ or predictive mechanism is *certain* to get it right. This is such an implausible assumption that we should be reluctant to learn very much from it.[[8]](#footnote-8)

 In the Insurance Problem, by contrast, there is no assumption that the correlation between having the defect and smoking is certainly and completely perfect. On the contrary, I assumed only (a) that more than 75% of smokers have the defect and more than 75% of non-smokers lack the defect and (b) that your conditional beliefs as stated in (1)-(4) reflect these statistics. And it needn’t have been as high as 75%. As long as you think that there is *some* act O and state S such that (i) O makes S more likely than not; (ii) ¬O makes ¬S more likely than not; (iii) O is causally irrelevant to S, it is possible to construct an example in which CDT makes a *certain* loss when an alternative guarantees zero loss. For proof of this statement, see Appendix B.

So the point carries over to more realistic cases. And that point is not about long run averages. It is this: in every single case, CDT recommends to some rational agents a course that foreseeably *will* lead to financial loss *both* in absolute terms *and* relative to *anyone* who takes an alternative that was specifiable in advance.

 The second difference is that in Newcomb’s problem, although it is true that following CDT *will in fact* generate a lower expected return than following EDT, it is not true, on any particular occasion, that you *could have* done better than the CDT-approved strategy of taking two boxes. If you take both boxes you will always certainly end up with $1K more than you *would have got* if you *had* taken only one box. So in Newcomb’s problem, the option that CDT recommends is at least counterfactually superior to the alternative.

 But in the Insurance Problem, CDT is liable to lead you into a sequence that does not even have the merit of counterfactual optimality. CDT recommends O1P1 (i.e. smoking and betting) to anyone with the right combination of initial beliefs and attitude to sequential choice. But O1P1 certainly is counterfactually suboptimal. If you take O1P1 you will lose 50¢. So you are 50¢ worse off than you *would have been* if you *had* taken the alternative O2P2, which has a guaranteed net return of zero.

 I believe that these two differences between them make the Insurance Problem a far more serious difficulty for CDT than Newcomb’s problem. I think that the Insurance Problem constitutes decisive grounds for rejecting CDT. In the next section I’ll deal with some objections to this line of thought, before saying, in section 7, what it is *about* CDT that invites this form of exploitation.

**6. Objections**

I’ll consider eight objections. These are: (i) that the presence of a second stage in the problem nullifies the evidential significance of what you do at the first stage; (ii) that I have ignored time-slice rationality; (iii) that I have ignored the difference between normal-form and extensive-form representations of the problem; (iv) that I have ignored the possibility of mixed strategies; (v) that modifications of CDT evade the difficulties that this paper raises for standard versions; (vi) that I have ignored resolute choice; (vii) that the example is pathological because it involves a change in beliefs or a change in desires; (viii) that what I am proposing is a diachronic Dutch Book argument and so shares the weaknesses common to other such arguments.

*6.1 Evidential significance*

The standard cases where Causal and Evidential Decision Theory come apart are those where the agent must make a *single* decision whose issue is evidentially relevant but causally irrelevant to some state of the world that matters to her. For instance, her taking just one box in the Newcomb problem is evidence that the predictor has put $1M in that box, but this ‘one-boxing’ does nothing to bring about that prior act. Similarly, your smoking is evidence that you have a pre-existing defect that makes smoking harmful.

 But even if some one-off decisions *do* have evidential but non-causal bearing on states of interest, it doesn’t follow that the evidential bearing persists in *extended* cases where that decision is embedded in some non-trivial *sequence* of decisions.

 That raises a problem for my argument that CDT leads any myopic or sophisticated agent with the right Cr1 (D) to smoke and then to bet in the Insurance Problem. That argument presupposed that such an agent will take his smoking *in the Insurance Problem* as a sign that he got the defect. My ground for this presupposition, at least as I presented the story in section 1, was the observed correlation between smoking and the presence of the defect. That is, it was the observed correlation between the *isolated* decision to smoke and the pre-existence of the defect. When I said ‘more than 75% of smokers have the defect and fewer than 25% of non-smokers have it’, I meant amongst those who face the decision to smoke quite generally, *not* exclusively those who are subsequently offered the bet P1. With what right am I assuming that smoking in the Insurance Problem has the same evidential significance as it does in the truncated version of that problem, of which Table 1 describes the entirety?[[9]](#footnote-9)

 There is no doubt that this raises a serious difficulty for the Insurance Problem as described. At least, it seems likely to dash my hopes of using that case to show what I meant it to show. But I think there are plausibly modified back-stories that would get around this difficulty. These are cases where it would be legitimate to think that the decision to smoke (or what stands in for it) has the same evidential bearing on the presence of the defect, whether or not one then has the opportunity to bet on this correlation. It is plausible *either* because it is something that we stipulate (as in the ‘N-version’ below), *or* (as in the ‘L-version’ and ‘G-version’ below) because the ‘predictive’ mechanism is likely to work in a wide range of situations, and so in particular in the first stage of a two-stage sequential problem like the Insurance Problem.

 One simple but science-fictional way of doing that would be to redescribe the problem in terms of a Newcomb-style *predictor*. This, we are imagining, is either an alien being with supernatural powers, or some tried-and-tested psychological algorithm. In either case, it has a proven track record of being able to predict one’s responses in problems like the following.

 At *Stage 1*, there is in front of you a console on which you can see a blue button and a red button. You must press just one of them. If you press the blue button then certainly nothing happens. If the predictor predicted that you would press the red button, it has arranged that pressing it will cause $1 to be credited to your bank account. If the predictor predicted that you would press the blue button then it arranged that pressing the red button would cause $1 to be *debited* from your account. You cannot check your account until after *Stage 2*, at which you must choose whether or not to bet $1.50, at odds of 1:3, that the predictor made the correct prediction concerning your action at Stage 1. The predictor neither learns nor cares about what happens at Stage 2.[[10]](#footnote-10) Call this the *N-version* of the Insurance Problem.

 In the N-version of the problem, the payoffs at each stage, and the net payoffs, correspond exactly to those in the original Insurance Problem itself. In particular, suppose that in Tables 1-3 we replace the Stage 1 options of smoking and not smoking with the options of pressing the red button and pressing the blue button respectively. Suppose we replace the states of your having and not having the defect with the states of the prediction having been that you would press the red button and its having been that you would press the blue button, respectively. And suppose we replace the state T with the state of the predictor’s having got you right at Stage 1. Then the resulting payoff matrices are the stage-wise and overall payoff matrices for the N-version of the Insurance Problem.

 And it should be clear that this version of the problem raises no difficulties with taking your choice at Stage 1 to be evidence of the prediction, even given that that choice is embedded within a larger sequential problem. For we are free to stipulate that the predictor is very good at telling whether or not somebody will press the red button, even in the context where the specified bet is available at Stage 2. In that case, the correlation between pressing either button and having been predicted to press it remains positive; and there is nothing to stop us from setting it above 75%. The argument that CDT loses 50¢ in the N-version of the Insurance Problem therefore survives this objection to the original version of the problem.

 There *are* legitimate concerns about the realism of cases involving predictors with powers that are as amazing as those just stipulated. The fact that CDT loses money in science-fictional scenarios of this sort might not seem a very strong reason for rejecting CDT.[[11]](#footnote-11) But more realistic versions of the story serve equally well.

One of these—call it the L-version of the Insurance Problem—involves replacing the predictor with a Libet-style apparatus: electrodes attached to your skull that make EEG recordings of your cerebral activity and which can predict your conscious decision some 350-400 milliseconds before it occurs.[[12]](#footnote-12) We might then connect the apparatus to the red button in such a way that the red button becomes wired to debit or to credit $1 to or from your account on pressing, just before you choose to press it or the blue button respectively.

A less expensive if less vivid realization of the case would be *game*-theoretic. Suppose that at Stage 1 of this *G-version* of the Insurance Problem, you and Bob must *each* press a red or a blue button simultaneously and (causally) independently. Your joint payoffs depend on your joint actions in the following manner:

|  |  |  |
| --- | --- | --- |
|  | **Bob presses red** | **Bob presses blue** |
| **You press red** | (-1, -1) | (1, 0) |
| **You press blue** | (0, 1) | (0, 0) |

*Table 5: G-version Stage 1 payoffs: (payoff to you, payoff to Bob)*

At Stage 2, you must each, again independently and simultaneously, choose to bet whether you made the *same* choice at Stage 1. You can each choose ‘Yes’ to bet or ‘No’ not to bet.

|  |  |  |
| --- | --- | --- |
|  | **Same choice at Stage 1** | **Different choices at Stage 1** |
|  | **Bob: yes** | **Bob: no** | **Bob: yes** | **Bob: no** |
| **You: yes** | (0.5, 0.5) | (0.5, 0) | (-1.5, -1.5) | (-1.5, 0) |
| **You: no** | (0, 0.5) | (0, 0) | (0, -1.5) | (0, 0) |

*Table 6: G-version Stage 2 payoffs*

Each player is facing a version of the Insurance Problem; at least this is so if both you and Bob have an initial confidence exceeding 0.75 that you will both come to same conclusions about what to do in the first stage of it. And this would be a reasonable thing to believe if you thought that you and Bob were psychologically similar (it need not be perfect similarity: it might just be, for instance, the fact that you are confident that you agree in endorsing CDT). In fact if you have *any* level of confidence >0.5 that you and Bob will choose the same in the G-version of the Insurance Problem, it is possible to adjust the payoffs so that CDT leads both sophisticated and myopic agents with the right initial credences into certain loss. This follows from the argument at Appendix B.[[13]](#footnote-13)

 To summarize the point: it is true that as I initially presented it, the Insurance Problem involved an assumption that I did not there defend, namely that the evidential correlation between smoking and the presence of the defect survives the knowledge that one can later make a bet on it. But there are analogues of the Insurance Problem that could easily make the same point, and in which the assumption is harder to question. Some of these cases are even realistic.

*6.2 Time-slice rationality*

The second objection is as follows. My claim is that if you are a sophisticated agent who follows CDT and you have Cr1 (D) ≥ 0.5, then in the Insurance Problem you are prepared to make a sequence of decisions that results in a certain loss that was avoidable *ex ante*. But if we think of the two decisions as being made by separate time slices of your self, it is hard to see why *either* stage is acting irrationally, given what it knows about what the other stage will do.[[14]](#footnote-14) Your earlier time-slice, which smokes at Stage 1, is doing the best that it can, given what it knows that your later time-slice is doing. Your later time-slice, which bets at Stage 2, is also doing the best that it can, given that it knows what your earlier time-slice is doing. It’s too bad that both slices end up worse off than either would have been had they both acted differently. But neither time-slice is acting *irrationally*. So Causal Decision Theory is not leading anyone into irrational action.

 According to this response, the situation is therefore somewhat analogous to the Prisoners’ Dilemma, for which the payoff matrix is as follows:

|  |  |  |
| --- | --- | --- |
|  | **Bob co-operates** | **Bob defects** |
| **Alice co-operates** | (1, 1) | (-1, 2) |
| **Alice defects** | (2, -1) | (0, 0) |

*Table 7: Prisoners’ Dilemma*

If both players defect then both players do worse than either would have done if both had co-operated. And yet it is rational for Alice to defect and it is rational for Bob to defect, since defection is best for each player if the other defects, and also if the other co-operates. So we end up with a Pareto inefficient outcome despite both players’ acting rationally.

 If you are sophisticated and follow CDT, we can similarly represent the Insurance Problem as a game between your earlier and your later time slices, in which the payoffs to each extended action for each time-slice correspond to the (causal expected) utility that that slice assigns to the corresponding outcome. For instance, suppose we set Cr1 (D) = 0.6 and Cr1 (T) = Cr2 (T) = Cr1 (D⎪O1) = Cr1 (¬D⎪O2) = 0.8 (where T = O1 ↔ D). Then the payoff matrix looks like this:

|  |  |  |
| --- | --- | --- |
|  | **P1: Slice 2 bets** | **P2: Slice 2 doesn’t** |
| **O1: Slice 1 smokes** | (-0.5, -0.5) | (-0.2, -0.6) |
| **O2: Slice 1 doesn’t** | (-0.7, 0.1) | (0, 0) |

*Table 8: Insurance Problem as an intrapersonal game for CDT*

The players in this game (‘Slice 1’ and ‘Slice 2’) correspond to your time slice at Stage 1 and your time slice at Stage 2. To see how the entries were derived, consider e.g. the bottom left entry. For Slice 1, Cr1 (D) = 0.6, so U1 (O2) = 0.6 V (O2P1D) + 0.4 V (O2P1¬D) = -0.7. Similarly for Slice 2, Cr2 (T) = 0.8, so U2 (P1) = 0.8 V (O2P1T) + 0.2 V (O2P1¬T) = 0.1. The argument for the other three entries is similar.

 For Slice 2, betting dominates not betting and so betting is what Slice 2 does, *whatever* Slice 1 does. Knowing this, Slice 1 prefers smoking to not smoking, and so the unique Nash equilibrium of this game is O1P1, which is Pareto inefficient since both parties are better off at O2P2. But just as in Prisoners’ Dilemma, this needn’t impugn the rationality of either party: Slice 1 is doing the best it can given what Slice 2 is doing, and Slice 2 is doing the best it can given what Slice 1 is doing.[[15]](#footnote-15) Since P1 and O1 are therefore both rational, CDT is not recommending any irrational action to *either* actor.

 The first thing to say in response is that calling O1 a *rational* act in this context is simply begging the question. Since the agent who follows EDT will choose O2 and then P1, the whole issue between EDT and CDT is over whether it *is* rational to smoke in the first stage of the Insurance Problem. A better way to put the objection would be to say that by smoking at Stage 1, Slice 1 is doing exactly what CDT recommends that it do; and that by insuring at Stage 2, Slice 2 is likewise following CDT. But we knew that already.

 Does this mean that the debate is simply deadlocked? Not if we can point to reasons why it would be fair to criticize CDT on the basis of the outcomes that it generates. And there seem to me to be two such reasons, both of which survive the reformulation of the problem as an intrapersonal game between your temporal slices.

 The first is that CDT appears to generate *gratuitous* *mal-coordination* between your temporal slices. This is particularly vivid in the case where you forget at Stage 2 what you did at Stage 1, so that Cr1 = Cr2. Notice that in this case both temporal slices *agree* on *all* of the following: (a) the ranking of final outcomes; (b) the likelihood that D is true; (c) the likelihood that T is true; (d) the causal structure of the situation. But in spite of all of this agreement, CDT still renders them unable to act in concert: in Table 8, which is consistent with your being forgetful, slice 1 and slice 2 simply disagree over the relative rankings of the joint actions that they are jointly able to perform.[[16]](#footnote-16) This makes the situation worse than in inter- or intrapersonal Prisoners’ Dilemma, where the divergence of the players’ rankings of their joint actions can be traced to their having divergent preferences over final outcomes: Alice prefers the final outcome where Alice defects and Bob cooperates to the outcome where Alice cooperates and Bob defects, whereas for Bob it is the other way around.

 And it also makes the situation worse than it is for Evidential Decision Theory. For that theory, intrapersonal agreement on the relevant likelihoods and preferences *guarantees* that your two slices will act in concert, in the sense that both agree on their relative rankings of joint actions and so both agree which one is best, in which therefore they both willingly acquiesce. We can see this from the following representation of the Insurance Problem as an intra-personal game with payoffs corresponding to the V-scores, for each player, of their respective joint actions. In it, we retain the assumption that Cr1 (T) = Cr2 (T) = Cr1 (D⎪O1) = Cr1 (¬D⎪O2) = 0.8.

|  |  |  |
| --- | --- | --- |
|  | **P1: Slice 2 bets** | **P2: Slice 2 doesn’t** |
| **O1: Slice 1 smokes** | (-0.5, -0.5) | (-0.6, -0.6) |
| **O2: Slice 1 doesn’t**  | (0.1, 0.1) | (0, 0) |

*Table 9: Insurance Problem as an intrapersonal game for EDT*

In this game the unique Nash equilibrium is O2P1, and this is also the joint action that both parties consider optimal.

 The second point is more simpleminded. Let us just drop the contested notion of *rationality*, and focus instead on the less contentious issue of *exploitability*. The fact is that whether or not you get to be called ‘rational’, you will, if you follow CDT, inevitably and gratuitously be losing things that you value. In the original Insurance Problem you are losing value at a rate equivalent to 50¢ per game. In the G-version, the follower of CDT is inevitably losing actual money at that rate; and it would be a simple matter to construct a single-player version in which you really do lose 50¢ on every go. And this ex hypothesi is something that matters to you, or can be stipulated to matter to you, more than ‘being rational’.

 Causal Decision Theorists are often keen to assert that real-life Newcomb-type cases are perfectly realistic.[[17]](#footnote-17) If they are right, then everything that the Newcomb case entails is also perfectly realistic. In particular, it is realistic that there are states of the world that are evidentially but not causally dependent on one’s actions in a given situation. (In the original Newcomb problem, this would correspond to the state of there being $1M in the opaque box.) If such a case existed it would be a simple matter to arrange payments in a way that mimics Tables 1-3. And it would be worthwhile to do this too, because by repeatedly offering the resulting game to followers of CDT, we could be quite certain of making unlimited wealth entirely at their expense.[[18]](#footnote-18) This remains true whether we think of our victims as enduring persons or as time-slices, in which latter case it would be literally as well as figuratively true to say that there is one born every minute.

*6.3 Normal Form v. Extensive Form*

Note that Causal Decision Theory does *not* lead to disaster if we represent the problem in normal form: that is, if we think of the agent as making a once-and-for-all choice between the four possible *sequences* O1P1, O1P2, O2P1, O2P2. Looking at Table 3 and interpreting it now as representing one four-way choice, we see that both O1P1 and O2P1 are dominated relative to a partition {D, ¬D} that is causally independent of anything that you do. Therefore Causal Decision Theory cannot recommend those sequences: instead it must recommend either O1P2 or O2P2, of which the causal utilities will be as specified in (21) and (23). Either way, CDT does *not* generate a guaranteed loss of 50¢.

 The point is correct but does nothing to help CDT in the situation that I have envisaged. I am free to stipulate that you do not make a once-and-for-all choice between four sequences but must *first* choose whether to smoke and *then* choose whether to bet. I am free to stipulate this because anyone is free to create such a situation, by withholding the offer of the bet until you have either committed yourself to smoking, or passed up the opportunity to smoke. And it does not matter that you can foresee that you will get the opportunity to bet. The argument, that CDT leads you to O1P1, takes into account that you foresee at Stage 1 that you will get the offer at Stage 2, and even—in the sophisticated case—that you foresee how you will respond to it and adjust your Stage 1 choices accordingly.

 Nor does it matter that at Stage 1 you will see that the sequence O1P1 is dominated and leads to a certain loss of 50¢. You may then *hope* that you don’t end up going down that route. But if you follow CDT and have the appropriate initial credence function, then that *is* what you *will* do. In particular, whatever you may hope at Stage 1 that you do at Stage 2, it is simply an unalterable fact that your decision at Stage 2 is one that you can make at, and only at, Stage 2. No amount of hoping and willing at Stage 1 that you won’t bet at Stage 2 can stop it from being a matter for your *future* free choice whether or not you actually do.[[19]](#footnote-19)

 That the extensive form and normal form representations of a decision problem can diverge is not in itself a new point. It is known that similar issues arise for decision theory based on unsharp credences[[20]](#footnote-20) and for decision theory without the axiom of independence[[21]](#footnote-21). The Insurance Problem shows that the divergence also arises for CDT, but its interest resides not so much in that fact as in the strictly stronger point that it leads followers of CDT into certain monetary loss.

 *Game* theory gives rise to a divergence between normal and extensive form that seems to have more immediate bearing. What I have in mind are cases in which some Nash equilibrium involves an incredible threat. Suppose that you and I each start with $1. I have a choice between (A) taking $1 from you and (B) not taking it; if I do take it, you then have the option to set off a bomb that kills both of us. Here is a normal form representation of this game:

|  |  |  |
| --- | --- | --- |
|  | **C: Bomb if A** | **D: No bomb** |
| **A: Take**  | (-2, -2) | (2, 0) |
| **B: Leave**  | (1, 1) | (1, 1) |

*Table 10: Incredible threat*

In this game there are two Nash equilibria i.e. AD and BC. But the normal form representation misses out what the extensive form reveal clearly reveal: BC is an impossible equilibrium because it is based on an idle threat on your part. If I do take the $1 then I know that you won’t detonate the bomb, because I know that from your own perspective it is better to acquiesce in an unfair arrangement than it is to kill both of us.[[22]](#footnote-22) It would therefore be wrong for someone to recommend that you play C, even though my best response to C has a better payoff for you than my best response to D, because I have no reason to believe that you will carry through on C if I play A. By the same token, it would be wrong for anyone to criticize your playing D (and so losing $1 if I play A), because there is no credible alternative.

 Now it may look similarly wrong for me to criticize CDT for leading to O1P1 in the Insurance Problem. My grounds for criticizing it were that it leads to a certain loss when it was possible to avoid any loss i.e. by taking O2P2, which is in effect the option of walking away from the whole arrangement. But, we might now say, O2P2 is an *incredible* strategy, because it involves the option P2, which you know in advance that you are not going to realize because the bet that the alternative P1 represents is clearly rationally optimal. (Recall, P1 is the option of betting at odds of 1:3 on a proposition, T, in which your confidence throughout the procedure exceeds 75%, in an environment of constant marginal utility for money.)

 But rejecting a strategy on the grounds that another strategy dominates it does *not* depend on the rationality, or credibility, of the *dominating* strategy. If a strategy is dominated then that rules out the strategy altogether, whether or not it is rational to play the strategy by which t is dominated. For instance, suppose that you have three options: to bet $1 on a proposition X at odds of 1:1 (Bet 1), to bet $2 on X at odds of 1:4 (Bet 2), or not to bet at all (No bet). See Table 11.

|  |  |  |
| --- | --- | --- |
|  | **X** | **¬X** |
| **Bet 1** | 1 | -1 |
| **Bet 2** | 0.5 | -2 |
| **No bet** | 0 | 0 |

*Table 11*

On the assumption that X is both stochastically and causally independent of your choice, we can immediately rule out Bet 2 as irrational, without knowing or caring which of the other options is rational. This is because it suffices for the irrationality of Bet 2 that Bet 1 dominates it. That is true whatever your confidence that X is true and whatever your attitude towards risk, so it is true even if the dominant Bet 1 is *also* irrational. Similarly, we can rule out O1P1 as irrational simply on the grounds that it is dominated by O2P2, quite consistently with also rejecting O2P2 as irrational on the grounds that P1 represents a bet that is definitely worth taking.

 There might still seem to be a problem. After all, the intuition behind rejection of dominated strategies goes something like this. ‘Suppose A dominates B with respect to an appropriate partition. Then whatever the state of the world, you could do better by doing B than by doing A. So you should certainly not do A, because B would certainly be better.’ This intuitive argument relies on the premise that whatever the state of the world, you *could* do better by doing B than by doing A. But if B is something that you *can’t* do, then it looks as though this premise is false, and dominance loses its intuitive force.

 But this is to confuse *incredible* strategies with *impossible* strategies. In what sense ‘can’t’ you realize O2P2? It is true that you *won’t* realize it. But there is nothing *stopping* you: in fact you are at (negative) liberty to realize any of the four available sequences. O2P2 does represent a genuinely available sequence of real options (for you). The only thing that ‘stops’ you from carrying it out is your own decision theory. But it doesn’t follow that you *can’t* realize O2P2 in any sense that disables the dominance argument. Otherwise, we could very easily defend following EDT in Newcomb’s problem, on the grounds that since EDT ‘makes’ you take only the opaque box, you can’t take both boxes, so one-boxing is not dominated in any very damaging sense after all. Of course I do myself think that one-boxing is rationally defensible; but the defence certainly does not come as cheaply as that.

 Finally, my argument in this section has a slight wrinkle that is worth ironing out. My argument was that O1P1 is irrational because O2P2 dominates it. I do not recommend O2P2 but rather follow EDT in recommending O2P1, which looks best to that decision theory at *both* stages of the Insurance Problem. But O2P1 is *itself* dominated, by O1P2. (If you *have* got the defect then O1P2 returns 50¢ more than O2P1, and if you have *not* got the defect then O1P2 returns 50¢ more than O2P1.) So how can I reject a strategy on grounds that would also rule out the one that I endorse?

 There are two responses to that. First, note that the plausibility of dominance arguments in *decision* theory (as opposed to game theory) are sensitive to the partition with respect to which the dominance obtains.[[23]](#footnote-23) In particular: (a) from the fact that an act A1 dominates an act A2 relative to a partition that is causally dependent on the choice between A1 and A2, nothing follows about whether A1 is rationally superior to A2: to think otherwise is the fallacy of fatalism. Furthermore, (b) if A1 dominates A2 relative to a partition that is causally but not evidentially independent of the choice between A1 and A2, then *Causal* Decision Theory must reckon A1 superior to A2, though *Evidential* Decision Theory need not: this is the whole point of Newcomb’s Problem. Finally, (c) if A1 dominates A2 with respect to a partition that is *both* causally *and* evidentially independent of the choice between them, then CDT and EDT, and presumably everyone else, should agree that A1 is the rationally superior of the two.

 Now in the Insurance Problem we are in case (b): whether or not you have the defect is *causally* but not *evidentially* independent of what you do at Stage 1 and Stage 2. And we know that if you have got the defect, O2P2 does better than O1P1, and if you have *not* got the defect, O2P2 does better than O1P1. So Causal Decision Theory leads you into a suboptimal sequence of choices that is suboptimal *by its own lights*. To point that out, which is essentially what the present argument does, should be enough to cast doubt on Causal Decision Theory, *whether or not* one agrees with CDT over the normative bearing of the three kinds of dominance that I have distinguished.

 The second response is that the situation with regards to O1P1 and O2P2 is not *simply* that O2P2 dominates O1P1 with respect to the partition {D, ¬D}. What actually obtains is the stronger condition that O2P2 dominates O1P1 with respect to *any* partition of the event space; equivalently, the *worst* possible outcome of O2P2 is better than the *best* possible outcome of O1P1. Call this relation *superdominance*. It seems clear that a superdominated act or sequence of acts is bad; also that we can rule them out even if we do not endorse any of the options or sequences that superdominates it.

For instance, consider the following choice of ‘bets’ on a proposition X:

|  |  |  |
| --- | --- | --- |
|  | **X** | **¬X** |
| **Bet 3** | 2 | -2 |
| **Bet 4** | -0.5 | 0.5 |
| **Bet 5** | -1 | -1 |

*Table 12: Superdominance*

Bet 4 superdominates Bet 5. So we can rule out Bet 5 however likely or unlikely we take X to be, whatever our attitude towards risk, and in fact regardless even of whether X is causally or stochastically dependent on one’s choice. It is certainly *never* wise to take Bet 5 from Table 12, for *any* X; and this is consistent with holding that Bet 3, which does not even dominate Bet 5, is the only rational option in Table 12.

 Returning to the Insurance Problem, we see that O2P2 *super*dominates O1P1, and so we can reject O1P1 out of hand and consistently with endorsing O2P1, which nothing superdominates. This is because rejecting O1P1 on these grounds is consistent with any view at all about the normative significance of ‘mere’ dominance.

 Let me summarize the overall response to the initial concern regarding incredible threats. I accept the point that its involving an incredible threat (or promise) should raise doubts about the feasibility of a set of strategies in a game, even if it constitutes a Nash equilibrium for that game. I accept the analogous point for the Insurance Problem, which is that there is something wrong with *endorsing* the sequence of options O2P2 if you know in advance of the decision that you will not play P2 at Stage 2. But I deny that this creates a problem for the position defended here, which does *not* endorse O2P2 but only rejects O1P1 on the grounds that O2P2 dominates it. Finally, to the worry that I ought not to endorse the dominated sequence O2P1 if I reject the dominated sequence O1P1, I reply: first, that whatever *my* attitude towards dominance is or should be, the one that CDT endorses is enough to rule out the sequence O1P1 into which CDT itself is liable to lead you. And second, even if we should not reject O1P1 on the grounds that it is dominated, we should in any case reject that sequence on the grounds that it is *super*dominated.

*6.4 Mixed strategies*

Suppose that as well as your ‘pure’ options at Stage 1, namely smoking and not smoking, you also have a ‘randomizing’ option, in which you let some randomizing device settle what happens at that stage. For, instance you can pre-commit to smoking at Stage 1 if and only if this chancy coin lands heads. One way to do this might be to sign a contract with some other person to pay her $1M if you do not abide by the coin. Does this make a difference?

 It looks as though it does. Most obviously, what it means is that whether you abide by EDT or CDT, you have no reason to bet on T at Stage 2 if you randomize at Stage 1, since randomizing smoking breaks the connection between smoking and the presence of the defect. At least that is true if we stipulate, as I hereby do, that in this version T says that *you smoke either at the outset or in response to the random process* if and only if you have the defect, rather than that you *take O1 at the outset* if and only if you have the defect. But then randomization leaves open the possibility that you do *not* bet at Stage 2 and so that you avoid a sure loss of 50¢. So randomization appears to be a possible way for Causal Decision Theory to avoid a sure loss.

 A boring but apparently effective reply would be simply to amend the rules of the problem so that randomization was heavily penalized. In that case you certainly would not randomize, and so things would remain just as they were.[[24]](#footnote-24)

 But even if we *allow* an option to randomize, there are feasible circumstances in which the causalist agent would not take it, and there are feasible situations in which the causalist agent *would* take it and the resulting sequence would be irrational. To see this, suppose we expand your set of options at Stage 1 to include an additional option Oπ, 0 < π < 1, this being the option to pre-commit to smoking at Stage 1 if a coin that has chance π of landing heads does so at its next toss, and to not smoking if it lands tails. Then your decision situation is as in Figure 2.

**Figure 2**

(Note that in this diagram, ‘H’ and ‘T’ refer to the possible outcomes of the coin toss following Oπ.)

How does CDT approach this problem?

 Consider first the myopic approach, according to which you select at Stage 1 whichever sequence looks best to you and then realize the currently available segment of that sequence. In that case the U-scores of the two original options O1 and O2 are as at (20)-(23). In addition we have:

1. U1 (OπP1) = π U1 (O1P1) + (1-π) U1 (O2P1)
2. U1 (OπP2) = π U1 (O1P2) + (1-π) U1 (O2P2)

Since 0 < π < 1, it follows immediately from (20)-(23), (40) and (41) that the myopic follower of CDT *rules out* Oπ at Stage 1 *unless* he satisfies the knife-edge condition that Cr1 (D) = 0.5. So unless that condition holds, the option of randomization makes no difference to you if you are myopic and follow CDT.

 Suppose then that Cr1 (D) = 0.5 and you take Oπ at Stage 1. Then assuming that at Stage 2 you remember what you did at Stage 1, the U-scores of the options P1 and P2 can be calculated as follows. If the coin landed heads then you smoke. But you have no special reason to think that T is true i.e. in effect that the defect is present, since the intervention of a random process has broken the correlation between smoking and the presence of the defect. In this case your Cr2 (T) = Cr1 (D), so:

1. U2 (P1⎪Oπ ∧ smoke) = -0.5
2. U2 (P2⎪Oπ ∧ smoke) = 1-2Cr1 (D) = 0

Similarly, if the coin landed tails then you smoke. But again, you have no special reason to think that T is true. So again your Cr2 (T) = Cr1 (¬D) = 0.5. So:

1. U2 (P1⎪Oπ ∧ ¬smoke) = 0.5 - 2Cr1 (D) = -0.5
2. U2 (P2⎪Oπ ∧ ¬smoke) = 0

So however the coin lands, you *decline* the bet at Stage 2 for an expected net loss of zero.

 But as I just emphasized, the reasoning that led to this conclusion required that Cr1 (D) = 0.5. And in that case, although CDT will permit you, if you are myopic, to take Oπ at Stage 1, it does not *demand* that you do so. It follows from (20)-(23), (40) and (41) that if Cr1 (D) = 0.5 then:

1. U1 (O1P2) = U1 (OπP2) = U1 (O2P2)
2. U1 (O1P2) > U1 (O1P1) = U1 (OπP1) = U1 (O2P1)

So at Stage 1, the options that are available at Stage 1 (i.e. O1, Oπ, O2) are *all* CDT-permissible if you are myopic, because all three options are initial steps in a sequence that at Stage 1 you consider optimal. In particular then, you *might* *still* take O1 at Stage 1, and since in that case nothing disrupts the correlation between smoking and the defect, you *will* then accept the bet at Stage 2.

 So even if the option to randomize is available to you, there is no guarantee that you will take it, if you are myopic. If your initial Cr1 (D) is not exactly 0.5 then you will not take it. Even if your initial Cr1 (D) does take that value, it is still CDT-permissible for you not to take it, and in fact permissible for you to start down a route that again ends with an inevitable loss of 50¢.

 Let us now suppose that you are a sophisticated follower of CDT, so that your choice at Stage 1 depends on what you then think you would choose at Stage 2, if you made this or that choice at Stage 1. Start by thinking about Stage 2. If you take O1 or O2 at Stage 1 then the reasoning that you take P1 at Stage 2 proceeds as at section 3. But what will you do at Stage 2 if you take Oπ at Stage 1?

To answer this we can apply (42)-(45) again, only now without any assumption about the value of Cr1 (D). The upshot is that what you will do if you take Oπ at Stage 1 depends on two things: (a) whether the coin lands heads (smoking) or tails (no smoking); and (b) the value of your Cr1 (D), your initial confidence that you have got the defect. The upshot is as stated in the following table:

|  |  |  |
| --- | --- | --- |
| **Value of Cr1 (D)** | **Action at Stage 1**  | **Action at Stage 2** |
| 0 ≤ Cr1 (D) < 0.25 | Smoke | P2 |
| Not | P1 |
| Cr1 (D) = 0.25 | Smoke | P2 |
| Not | P1 *or* P2 |
| 0.25 < Cr1 (D) < 0.75 | Smoke | P2 |
| Not | P2 |
| Cr1 (D) = 0.75 | Smoke | P1 *or* P2 |
| Not | P2 |
| 0.75 < Cr1 (D) ≤ 1 | Smoke | P1 |
| Not | P2 |

*Table 13: Stage 2 acts for sophisticated CDT after Oπ*

Now go back to Stage 1. You know that if you *deliberately* smoke at Stage 1 then you will bet at Stage 2, for a certain payoff of -0.5. You know that if you deliberately refrain from smoking at Stage 1 then you will bet at Stage 2, for an expected payoff, as it now seems to you, of 0.5-2Cr1 (D) (see (34)). Finally, you know that if you randomize at Stage 1, then you will bet or not at Stage 2, depending on Table 13. Now, at Stage 1, the payoff to randomization is therefore a (π, 1-π) gamble between the expected payoffs of (a) smoking and what you will do at Stage 2 if the coin lands heads and (b) not smoking and what you will do at Stage 2 if the coin lands tails. Suppose for simplicity that if at Stage 2 you are indifferent between betting and not betting (as will happen if you realize rows 4 or 7 of Table 13), you will *not* bet at Stage 2. Then by Table 13, the expected utility of randomizing at Stage 1 is:

1. U1 (Oπ) = π U1 (O1P2) + (1-π) U1 (O2P1) if 0 ≤ Cr1 (D) < 0.25
2. U1 (Oπ) = π U1 (O1P2) + (1-π) U1 (O2P2) if 0.25 ≤ Cr1 (D) ≤ 0.75
3. U1 (Oπ) = π U1 (O1P1) + (1-π) U1 (O2P2) if 0.75 < Cr1 (D) ≤ 1

Calculating the U-values on the right-hand sides:

1. U1 (Oπ) = π (1-2Cr1 (D)) + (1-π) (0.5 – 2Cr1 (D)) = 0.5 + π/2, if 0 ≤ Cr1 (D) < 0.25
2. U1 (Oπ) = π (1-2Cr1 (D)), if 0.25 ≤ Cr1 (D) ≤ 0.75
3. U1 (Oπ) = -0.5π, if 0.75 < π ≤ 1

So now we know the initial U1-scores for each of O1, Oπ and O2. In all cases U1 (O1) = -0.5 and U1 (O2) = 1-2Cr1 (D); and U1 (Oπ) is as at (51)-(53). So taking to order them by these U1-scores, their relative rankings depend on Cr1 (D) as follows:

|  |  |  |
| --- | --- | --- |
| **Value of Cr1 (D)** | **U1 (Oπ)** | **Ranking** |
| 0 < Cr1 (D) < 0.25 | 0.5+π/2 | Oπ O2 O1 |
| 0.25 ≤ Cr1 (D) < 0.5 | π (1-2Cr1 (D)) | Oπ O2 O1 |
| Cr1 (D) = 0.5 | π (1-2Cr1 (D)) | Oπ O2 ~ O1 |
| 0.5 < Cr1 (D) ≤ 0.75 | π(1-2Cr1 (D)) | Oπ O1 O2 |
| 0.75 < Cr1 (D) ≤ 1 | -0.5π | Oπ O1 O2 |

*Table 14: Stage 1 ranking for sophisticated CDT*

As we can see from the final column of Table 14, you will therefore *always* choose to randomize at Stage 1 if you are sophisticated. Note that this does not depend on the value of π: the only thing that these calculations assumed was that 0 < π < 1 i.e. that the coin was genuinely chancy, not necessarily that it was fair.

 So we seem here to have a way out for the sophisticated follower of CDT. If it is possible to make one’s smoking or not the result of some chance process, then you will if you are sophisticated always do so. So you will in all cases avoid the combination O1P1 that led to a loss of 50¢ in the original Insurance Problem. This seems to be a good response on behalf of CDT—at least it is, *if* we could somehow rule out the stipulation that randomization is severely punished.

 But even then there remains a problem for sophisticated CDT when Cr1 (D) exceeds 0.75. In that case you will, as Table 14 implies, randomize at Stage 1. But it is also true that you will take the bet at Stage 2 if the coin lands heads and you smoke. There is a chance of π that this will happen; if it does not happen then you will not bet, for a certain net payoff of zero. So if Cr1 (D) > 0.75 and you are a sophisticated follower of CDT, you are committing yourself to a gamble that *loses* 50¢ with a probability of π and wins zero with a probability 1-π. That is, you are committed to a gamble in which you *can* lose but *cannot* win. This seems wrong, given that there was available to you *ex ante* a gamble (O2P2) in which you cannot win *or* lose. You are taking a gamble that another available gamble stochastically dominates.

 To see how bad this is, recall that nothing in the foregoing argument depended on the precise value of π. We only require that 0 < π < 1. So choose π = 1-2-n for n as large as you like. You will, if you are a sophisticated follower of CDT with Cr1 (D) > 0.75, accept this gamble i.e. one that is arbitrarily likely to lose 50¢ and will certainly not win anything. You will accept this gamble even though you could *ex ante* have simply avoided any gamble at all by taking O2P2. This looks just as irrational, and is almost certainly as disastrous, as taking O1P1 in the original Insurance Problem.[[25]](#footnote-25)

 So there are two objections to randomization. First, there is the very crude objection that if randomization is an option, then we can simply amend the payoffs in the Insurance Problem in a way that penalizes it. I see no obvious way around this objection. But even if one exists, randomization does not help followers of CDT. It does not help myopic followers of CDT because in the only case where randomization makes a difference, it still permits the disastrous sequence O1P1. And it does not help sophisticated followers of CDT, because although such persons will always randomize, there are still cases where doing so involves a gamble that can be made arbitrarily likely to have the *same effect* as the disastrous sequence.

 The reason that the ‘mixed strategy’ approach faces the initial, crude objection and this second, more complex one, is that it sought to add randomization as an *additional option* at Stage 1. But there is a *stochastic* interpretation of mixed strategies that arises most obviously in a *game*-theoretic context, and this avoids both difficulties. According to it, no third *option* of randomization is available, but rather the ‘mixture’ corresponds to epistemic uncertainty about what each player will do in the mind of her opponent. Let us see whether this version of the approach offers any comfort to CDT.

To see how it might apply in the Insurance Problem, suppose that you and Bob are playing the two-stage G-version of the problem as set out in Tables 5 and 6. Each of you presses the red button at Stage 1 on a proportion π of the occasions that you meet, and each of you presses the blue button at Stage 1 in the remaining proportion 1-π of your meetings. So each of you has a strategy that is mixed, not in the sense that either of you ever chooses to act on the basis of a coin-toss etc., but in the sense that each of you has mixed beliefs over the other player’s choice at Stage 1.[[26]](#footnote-26)

Your Stage 1 choices on any play of the G-version are *causally* independent. In order to capture the *evidential* dependence between them, let us suppose that you both believe that some random process causally determines your *deliberate choices* at Stage 1, but that the processes are correlated, so that about 75% of the time you and Bob end up playing the same move.[[27]](#footnote-27)

If both you and Bob follow CDT, is there then some non-trivial value of π, i.e. some π ∈ (0, 1), such that this situation is sustainable? The answer is yes if and only if, for some such value of π, CDT is *indifferent* at Stage 1 between pressing the red button and pressing the blue button. If that were not the case, then for any π ∈ (0, 1), each of you would press the strictly preferred button on every occasion, in which case π would have to be 1 (if the preferred button is red) or 0 (if the preferred button is blue).

Now consider the situation from your point of view. From that perspective, Bob’s pressing the red button is equivalent to your having the defect in the original Insurance Problem. So x is a satisfactory value for π just in case Cr1 (D) = x makes CDT indifferent between O1 at Stage 1 and O2 at Stage 1. We can therefore see from Table 4, and similarly from Table 14, that there is exactly one value of π for which this mixed equilibrium holds, namely π = 0.5. This is the only value of Cr1 (D) on which CDT (sophisticated *or* myopic) is indifferent between O1 and O2 at Stage 1.

So CDT is consistent with the following situation: you and Bob repeatedly play the G-version of the Insurance Problem. Each of you is indifferent at Stage 1 between pressing the red button and pressing the blue button. Each of you presses the red button at Stage 1 on 50% of all plays. But although your button-pressings are causally independent, they are correlated, so that in fact you each press the same button 75% of the time, regardless of which button you press. Knowing this, both of you always bet at Stage 2. This means that 50% of the time, each one of you is playing a strategy that will certainly lose 50¢ when you could have avoided all loss for certain (by pressing the blue button and declining to bet). In this scenario you each make an average *loss* of 25¢ per game.[[28]](#footnote-28)

By way of contrast, *Evidential* Decision Theory permits only *one* long run equilibrium, namely the pure one in which you both press the blue button at Stage 1 and both bet at Stage 2 every time you play together. (This is evident from Table 4, which shows that for any agent with any initial beliefs, EDT endorses O2P1 and nothing else.) So both players win and lose nothing at Stage 1 and both players make 50¢ at Stage 2, for an average *profit* of 50¢ per game.

 So in the iterated G-version of the Insurance Problem, EDT outperforms CDT. But this is not very interesting—we were already aware of a variety of scenarios in which EDT is guaranteed to outperform CDT in the long run.[[29]](#footnote-29) What the example shows is rather that even on this epistemic interpretation of ‘mixed strategy’, Causal Decision Theory cannot avoid permitting agents to spend half of their time on sequences of moves that lead to a guaranteed loss that another available sequence would certainly have avoided. This more statistical interpretation of mixed equilibrium is therefore of no help to CDT in the Insurance Problem.

*6.5 Robustness*

Even if I am right that the Insurance Problem poses a serious difficulty for Causal Decision Theory, we might wonder whether the difficulty also faces small perturbations of the theory that preserve its essential spirit. Causal Decision Theory as I have presented it assumes two things that are extraneous to that spirit. First, it assumes that you have perfectly precise credences over the states that are of interest. Second, it assumes that you act, at Stage 1 or at Stage 2, without taking into account the information about what you will do that your CDT-guided inclinations would give you. What happens if we decline one or other of these idealizations?

*6.5.1 Unsharp credences*

Settling on a particular numerical credence in a proposition can sometimes seem to be doing more than the evidence warrants. For instance, suppose that the weather forecaster says that the chance of rain tomorrow is between 40% and 60%. Would it be sensible, on this basis alone, to adopt a credence of *exactly* 0.5 (or 0.54287163, or 0.48739285) that it will rain tomorrow? But the assumption of precise numerical credences implies that you *must* now have some completely precise confidence in this proposition.

 Anyone who finds this example compelling should perhaps rather represent belief states of rational agents as numerical *intervals*: so that, for instance, your confidence that it will rain tomorrow is not some number in the interval [0.4, 0.6] but that whole interval itself. Of course this raises the question of what it *means* to adopt interval-valued credences. I won’t here say what interval-valued credences are because (a) I don’t know and (b) it doesn’t matter: what matters is how CDT tells you to act on them.

 There are many possible answers to that question, of which I only have space to consider the two most obvious. The first and probably *most* obvious is the mid-point rule: if your credences in the action-relevant propositions A, B, … are the intervals [a1, a2], [b1, b2], … then to accord with CDT is to follow the advice that CDT gives to an agent with the same preferences but with *precise* credences Cr (A) = (a1 + a2)/2, Cr (B) = (b1 + b2)/2…

 It is quite plausible that an agent with interval-valued credences who applies CDT in accordance with the mid-point rule should still run into difficulties with the Insurance Problem. For instance, if a sophisticated agent has Cr1 (D) = [d1, d2], Cr1 (D⎪O1) = [e1, e2] and Cr1 (D⎪O2) = [f1, f2], then it *suffices* for the difficulty to arise that:

1. d1 + d2 ≥ 1
2. e1 + e2 > 1.5
3. f1 + f2 < 0.5

These conditions are easily met. Suppose, for instance, your initial confidence that you have got the defect to be representable by the interval [0.4, 0.6]. And suppose that you think that at least 80% of people who smoke have got the defect, and at least 80% of people who do not smoke lack the defect. Then d1 + d2 = 1, e1 + e2 ≥ 1.6 and f1 + f2 ≤ 0.4, so (54)-(56) are satisfied. In that case, CDT together with the midpoint rule will advise you to smoke and will then advise you to bet, for a certain loss of 50¢. Similarly, for the myopic agent it suffices for CDT to make a certain loss of 50¢ that (54) is *false* and (55) and (56) are true. This too is a fairly light condition on one’s initial states of belief when these are representable by interval subsets of [0, 1].

 An alternative rule is MaxMin Expected Utility (MMEU).[[30]](#footnote-30) To apply this rule, we assume first that the interval-values for, for instance, Cr1 (D⎪O1) and Cr2 (D) arise from an underlying convex set of probability distributions. That is, your overall belief-states at Stage 1 and Stage 2 are representable as sets CR1, CR2 of probability distributions satisfying the condition that for any probability functions π1, π2 ∈ CR1, the probability function λπ1 + (1-λ)π2 is also in CR1 whenever 0 < λ < 1. So we have, for any proposition X:

1. Cr1 (X) = {π (X)⎪π ∈ CR1}
2. Cr2 (X) = {π (X)⎪π ∈ CR2}

The convexity condition on CR1 and CR2 implies that for any X, Cr1 (X) and Cr2 (X) are each either interval or singleton subsets of [0, 1].

 MMEU then recommends the following procedure. For each π ∈ CR1 ∪ CR2 there is an associated utility function Uπ (O) for each option O, given by calculating the regular U-score for O on the assumption that π is your credence function. The MEU-score for O is then given by:

1. MEU1 (O) = Inf. {Uπ (O)⎪π ∈ CR1}
2. MEU2 (O) = Inf. {Uπ (O)⎪π ∈ CR2}

The agent should then take whatever option maximizes MEU amongst the available options i.e. whichever option has maximal MEU1 at Stage 1 and whichever option has maximal MEU2 at Stage 2.

 Let us see how this works in detail for the sophisticated follower of CDT. Beginning at Stage 2, let us first suppose that you are such an agent and that you remember *smoking* at Stage 1. Since you remember that you have smoked at Stage 1, we can assume that the elements of CR2 are just those probability functions that one gets by updating on this information. In that case, we have:

1. MEU2 (P1⎪O1) = -0.5
2. MEU2 (P2⎪O1) = Inf. {1 – 2π (D⎪O1) ⎪π ∈ CR1}

Now suppose that you remember not smoking at Stage 1. Then by similar reasoning we have:

1. MEU2 (P1⎪O2) = Inf. {0.5 – 2π (D⎪O2)⎪π ∈ CR1}
2. MEU2 (P2⎪O2) = 0

It follows from (57) and (59)-(64) that causalist MMEU endorses betting at Stage 2, *whatever* you did at Stage 1, if and only if the following conditions hold:

1. e1 ≥ 0.75
2. f2 ≤ 0.25

Suppose that these conditions do hold and turn to Stage 1, at which we may now also suppose you to know that whatever you now do, you will bet at Stage 2. Since you are sophisticated, you take this fact into account at Stage 1. The MEU-scores for the options are therefore:

1. MEU1 (O1⎪P2) = -0.5
2. MEU1 (O2⎪P1) = Inf. {0.5 – 2π (D)⎪π ∈ CR1}

It follows that if you are sophisticated, causalist MEU endorses your smoking at Stage 1 if and only if the following condition holds:

1. d2 ≥ 0.5

Putting together (65), (66) and (69): MMEU advises the sophisticated causalist with interval-valued credences to smoke and then to bet so long as: (a) the upper limit of his initial confidence that he has the defect is *at least* 0.5, *and* (b) the lower limit of his conditional confidence in T (= D ↔ O1), given that he smokes or given that he does not smoke, is *at least* 0.75. These conditions are consistent and not demanding. It follows that MMEU, like the midpoint rule, does nothing to stop the Insurance Problem from threatening a sophisticated causalist agent with interval-valued credences from a certain loss of 50¢.

It is also straightforward to see that (i) a similar argument raises similar problems for a *myopic* causalist MEU-maximizer whose credences are interval-valued; (ii) the Insurance Problem raises no such difficulty for the (sophisticated or myopic) *evidentialist* MEU-maximizer whose credences are interval-valued; and (iii) the Insurance Problem raises no such difficulty for any evidentialist follower of the *mid-point* rule whose credences are interval-valued.[[31]](#footnote-31) I conclude that at least on these two ways of acting on the basis of interval-valued credences, these small departures from classical CDT face the same prospects of disaster as those that I highlighted at section 5.

*6.5.2 Deliberational equilibria*

The argument up to this point has ignored the possibility of epistemic feedback between provisional judgments about what to do and your opinion about the state of the world. And it seems that this is a mistake. After all, your own inclinations at Stage 1 of the Insurance Problem are telling you something about whether you have got the defect, and it would be wrong to act before taking this into account, for the simple reason that it is wrong not to act on *all* of the available information.[[32]](#footnote-32)

As an illustration of how this might make a difference, consider Stage 1 of the Insurance Problem in isolation, with payoffs as in Table 1 (i.e. the basic smoking case). Suppose you start out with a high credence that you have got the defect. Then CDT advises you not to smoke. Rather than immediately *acting* on this advice, you just *raise your confidence* that you will not smoke. But the effect of this is to raise your confidence that you have *not* got the defect. This follows from the fact that:

1. Cr1 (D) = Cr1 (D⎪O1) Cr1 (O1) + Cr1 (D⎪O2) Cr1 (O2)

—for, given that Cr1 (D⎪O1) > Cr1 (D⎪O2) and these values are fixed, it must be the case that Cr1 (D) falls as Cr1 (O2) rises. But this now motivates you *to* smoke.

 *Deliberational* Causal Decision Theory (DCDT) is the doctrine that a rational agent’s confidence that he will realize an option O is his credence in O at some equilibrium of this feedback process. An equilibrium is a point where his credential distribution over the options, and over the relevant states of nature, makes him indifferent between all of the options that he has non-zero confidence that he will realize. Under fairly light assumptions, at least one such equilibrium is guaranteed to exist for roughly the same, essentially topological, reasons that a mixed Nash equilibrium is guaranteed to exist in a wide range of n-player games.[[33]](#footnote-33)

 Applying this to the basic smoking problem (i.e. Stage 1 of the Insurance Problem, considered in isolation), we have from (10) and (11) that the follower of CDT is indifferent between smoking and not just at the point Cr1 (D) = 0.5. So whatever his initial confidence that he has the defect, the rational agent will terminate deliberation at the point where he is as confident that he has got it as that he has not. Exactly how confident he is that he will smoke at that point depends on his Cr1 (D⎪O1) and Cr1 (¬D⎪O2): if we set both equal to one another but not equal to 0.5, for instance, then in equilibrium we must have Cr1 (O1) = Cr1 (O2) = 0.5.

 For another example, consider Newcomb’s Problem. In this case, as the agent—who is assumed to be a causalist—becomes more and more confident that he will take both boxes, he becomes more and more confident that there is nothing in the opaque box. But this doesn’t motivate him to change his mind: the reasons for taking both boxes are as good as they ever were, whatever is in the opaque box. So in the only equilibrium, the agent is confident that there is nothing in the opaque box and certain that he takes both boxes; and this means that he always takes both boxes.

 What about the full-scale Insurance Problem? Let us start once more at Stage 2. Whatever you did at Stage 1, CDT advises you to bet at Stage 2, since you are being offered odds of 1:3 to bet on a proposition in which your confidence exceeds 75%. Note also that at Stage 2 your inclination to bet has no relevance to whether the bet is winning i.e. to whether T is true. So in this case there is no interesting feedback, just as in the Newcomb Problem: in equilibrium you will be certain that you bet i.e. Cr2 (P1) = 1; and this means that you will always bet.

 Let us now suppose that you are myopic and consider your position at Stage 1. There are four possible sequences with payoffs as at (20)-(23). Looking at (20)-(23), we see that *ex ante* only O1P2 and O2P2 have a chance of seeming optimal. So your confidence in those two options will increase. Now as you become more confident that you will take O1 at Stage 1, your Cr1 (D) will increase, so by (21) your U1 (O1P2) will fall; similarly as you become more confident that you will not smoke, your U1 (O1P2) will rise. The only equilibrium is therefore one in which you have confidence 0.5 that you have got the defect. As with Stage 1 considered in isolation, the exact values of Cr1 (O1) and Cr1 (O2) will depend on the exact values of Cr1 (D⎪O1) and Cr1 (D⎪O2); setting the latter two quantities equal to one another and distinct from 0.5 ensures that Cr1 (O1) = Cr1 (O2) = 0.5.

 If you are myopic and follow DCDT you must therefore find it *permissible* to smoke at Stage 1 of the Insurance Problem; sometimes you will do this, and sometimes you will not, but in any case you will then go on to bet at Stage 2. Myopic DCDT therefore faces the objection that in the Insurance Problem it at least *permits* a sequence that leads to a certain loss of 50¢.

 Things are no better for *sophisticated* DCDT. You know that you will bet at Stage 2: so if you are sophisticated your decision whether or not to smoke at Stage 1 depends on your relative evaluation of O1P1 and O2P1 at Stage 1. Inspection of (33) and (34) now reveals the following. First, whatever you think about the presence or the absence of the defect, your expected causal utility for O1P1 remains fixed at -0.5. Second, your expected causal utility for O2P1 is given by 0.5-2Cr1(D). So as you become more confident that you have the defect, not smoking at Stage 1 becomes less attractive to you. In this case the feedback is *positive*: as you become more convinced that you *will* smoke at Stage 1, you become more convinced that you *should* smoke at Stage 1.

 But the converse is also true, since there is also positive feedback for non-smokers. That is, as you become more and more convinced that you will *not* smoke at Stage 1 you become more and more convinced that you lack the defect and so also (given that you will bet at Stage 2) that you *should* not smoke at Stage 1.

 Formally, the upshot is that sophisticated DCDT allows *three* equilibria in this situation: (a) one where you are convinced that you will smoke and Cr1 (D) > 0.5; (b) one where you are convinced that you will not smoke and Cr1 (D) < 0.5; (c) one where you are not sure what you will do, but where your Cr1 (D) = 0.5. Since DCDT allows the first of these situations as a rationally permissible terminus of deliberation, it regards it as at least permissible to smoke at Stage 1; since any sophisticated agent also bets at Stage 2, this is a situation that leads you into a certain loss of 50¢.

 Suppose that we tried to add the following rider to DCDT: if there are many equilibria then choose the equilibrium that has maximal causal utility. In the present case, the utility scores of the three equilibria are: -0.5 in (a), 1 -2Cr1 (D) > 0 in (b), and 0 in (c). Of these the best is clearly (b), so you should *not* smoke at Stage 1. That would seem to get sophisticated DCDT to the same outcome as does EDT: not smoking at Stage 1 and betting at Stage 2.

 The trouble with this proposal is that although all three equilibria mark points where causalist deliberation comes to rest, they do not all mark resting-points that are available to any agent, *whatever* her initial credences. If you start out with Cr1 (D) > 0.5 then causalist reasoning *cannot* make you less likely to smoke than before you engaged in it. If you are more confident that you have the defect than that you do not, and if you know that you will bet at Stage 2, then CDT unambiguously recommends smoking at Stage 1. Not smoking at Stage 1 would indeed be rationally preferable according to the Evidential theory, but DCDT cannot simply impose this solution on somebody with these credences without doing the very thing for which causalists constantly scold evidentialists, namely ignoring the fact that the presence or absence of the defect is causally independent of anything that you do now or at Stage 2. In short, if you start out with Cr1 (D) > 0.5 then DCDT can only push you into smoking at Stage 1, even though this leads inevitably to a loss of 50¢.

 Similarly, if at the outset you satisfy the knife-edge condition that Cr1 (D) = 0.5, then you have U1 (O1P1) = U1 (O2P1), and so causalist deliberation can do nothing to increase *or* decrease your confidence that you will smoke. At the point Cr1 (D) = 0.5, CDT is indifferent between smoking and not smoking, so CDT-guided deliberation is already at rest. At this point both smoking and non-smoking will seem permissible from the perspective of CDT. So at that point DCDT cannot avoid permitting smoking, even though again this leads to a certain loss of 50¢.

 So sophisticated DCDT is in exactly the same position as sophisticated CDT, as outlined in Table 4. If your initial credences about the case make you at least 50% confident that you have got the defect, then the theory always endorses a course of action that guarantees a loss of 50¢ when you might, by refusing to smoke and refusing to bet, have guaranteed a loss of zero.

*6.6 Resolute choice*

The argument so far has considered only whether CDT makes sensible recommendations when combined with either (a) a myopic or (b) a sophisticated approach to sequential choice. Readers will notice that I have so far ignored a third approach: *resolute choice*. The resolute agent makes a plan at the outset and then sticks to it, even if doing so would seem ill advised to him during its execution, had he not already planned to do so.[[34]](#footnote-34)

 For instance, the resolute agent’s approach to the Insurance Problem is in effect to treat it as a single decision between the four sequences in Table 3. At Stage 1 he will ask which of these sequences seems best to him then; having settled on one, he will then proceed to follow it through, whatever his subsequent feelings about it.

 Causal Decision Theory does not give bad advice to the resolute chooser. At least, it does not lead that person into the disastrous combination O1P1. Writing ‘A B’ for ¬(B A), (20)-(23) imply that at Stage 1 CDT reckons:

1. 0 ≤ Cr1 (D) < 0.25 → O1P2 1 O2P1 1 O2P2 1 O1P1
2. 0.25 ≤ Cr1 (D) < 0.5 → O1P2 1 O2P2 1 O1P2 O1P1
3. 0.5 ≤ Cr1 (D) < 0.75 → O2P2 1 O1P2 1 O1P1 1 O2P1
4. 0.75 ≤ Cr1 (D) ≤ 1 → O2P2 1 O1P1 1 O1P2 1 O2P1

So in any case the *resolute* follower of CDT will settle upon and then execute either O1P2 or O2P2. This person will therefore certainly not bet at Stage 2, and so is immune to the difficulties attending the smoking-and-betting option that section 5 highlighted. So it looks as though my argument does not refute CDT as such, but only shows that Causal Decision Theorists must take a resolute attitude towards sequential choice.

 But it is hard to see how resolute choice could possibly be rational at Stage 2. As we have just seen, resolution recommends that you *not* bet at that stage, *whatever* your initial beliefs Cr1. But whatever those beliefs were, and so whatever happened at Stage 1, it remains the case that at Stage 2 you have the chance to bet $1.50 at odds of 1:3 on a proposition T (= O1 ↔ D) in which your confidence *at the time* exceeds 0.75. This is a proposition to which the act of betting itself is both causally and evidentially irrelevant. How *could* it be rational not to accept that bet at those odds?

 Of course it is true that your beliefs at Stage 2 might make your earlier decision at Stage 1 seem foolhardy. For instance, in case (72) you will if you are resolute smoke at Stage 1, because you then think it relatively unlikely that you have got the defect. But at Stage 2 you will think that this was a mistake, since your Cr2 (D) = Cr1 (D⏐O1) > 0.75, so probably you have the defect. That’s too bad. But at least you have got the chance to make amends, by insuring, at what now seems a low premium, against your having the defect. Just because you probably made a mistake at Stage 1, why compound the error now?

 The fact that you *made* *a plan* not to bet cannot by itself be a reason to stick to it: there is no more reason a priori not to break plans than there is not to break mirrors.[[35]](#footnote-35) One reason to stick to the plan might be that you *happen* to attach some value to consistency, to following through on what you started. But if you do then the utilities in Tables 2 and 3 should reflect this, in which case we have a *different decision problem*. But the question was why anyone should be resolute at Stage 2 of the problem as it was initially described.

Another reason to stick to the plan is that you have raised the cost of deviating from it, for instance by placing an initial side bet that you will stick to any plan that you make at Stage 1. But again, a sequential problem in which such self-binding is available at the outset is a different problem from the insurance problem.[[36]](#footnote-36) What we still haven’t found, and what I see no prospect of finding, is any reason why the Causal Decision Theorist, or for that matter why anyone, should, as resoluteness demands, pass up a bet on terms that are as obviously advantageous as those actually specified in Stage 2 of this problem.[[37]](#footnote-37)

*6.7 The case involves a change in beliefs or desires*

Cases of sequential choice in which your act at an earlier stage affects your choice-relevant beliefs at a later stage can raise problems even for a sensible decision rule. But in this case the solution is not to drop the decision rule but to see the case as pathological because it involves an irrational change in your beliefs.

 Consider: you must choose at Stage 1 whether to take this legal and performance-enhancing but mildly unpleasant drug. You must choose at Stage 2 whether to enter a race that you have every chance of winning if and only if you have taken the drug. But the drug impairs your judgment—if you take it at Stage 1 then at Stage 2 you’ll *think* that you won’t win.

A sensible decision rule D might well endorse your taking the drug at Stage 1 but then not entering the race at Stage 2, leaving you definitely worse off, whatever happens, than if you’d either (i) refused the drug or (ii) entered the race. But it’s arguable that this doesn’t refute D. All it reveals (you might think) is that even sensible decision theories go wrong in pathological sequences where your earlier actions distort your later beliefs.

I doubt that, but set it aside. The main point is that the Insurance Problem is *not* like this. As Table 2 makes clear, you are at Stage 2 choosing whether to bet on the proposition T, that you have the defect if and only if you smoked. The *only* belief that does or should make any difference to this is your Cr2 (T). But your confidence in T does not even *change* between Stage 1 and Stage 2; at any rate, it does not change in any decision-relevant way, since we have both Cr1 (T) > 0.75 and Cr2 (T) > 0.75.[[38]](#footnote-38) Far from involving a pathological or irrational change of belief that makes the whole case moot, the step from Stage 1 to Stage 2 does not involve *any* action-relevant changes in belief at all.

Analogous suspicions might arise about sequential cases in which one’s basic *desires* (i.e. preferences over outcomes) change from one state to the next. It may just be a fact of life that such problem cases exist: for instance, our temporal preferences (desire for future pleasures and indifference to past pains; or hyperbolic discounting of future consumption) arguably lead to foreseeable certain losses for any agent following decision rules that are otherwise sensible. And it is perhaps plausible that in *these* cases all blame should lie with the temporal bias and not with whatever decision rule was complicit in the result.[[39]](#footnote-39)

Be that as it may, it is irrelevant to the Insurance Problem. Both the payoff structure and your attitude towards it—i.e. caring only about your terminal wealth—remain constant throughout the sequence. The paradox is that in spite of this fact and your clear-eyed appreciation of it, CDT enjoins throwing away 50¢ for nothing. The blame for *this* fact rests with CDT alone.

*6.8 Diachronic Dutch Book Arguments*

There is some justice in a comparison between the present argument and the ‘Dutch Book Arguments’ (DBAs) that philosophers sometimes advance against agents whose beliefs or belief-changes are inconsistent with some favoured rule or paradigm. There are two kinds of DBA: synchronic and diachronic. *Synchronic* DBAs attempt to show that given a fixed set of beliefs, preferences etc., all and only non-conforming agents will accept a *package* of bets that incur a certain loss. *Diachronic* DBAs attempt to show that non-conforming agents will accept a *sequence* of bets that incur a certain loss. In both cases the moral that we are supposed to draw is that conformity is best.

The standard example of a synchronic DBA is Ramsey’s argument for probabilism, the doctrine that the measure of your beliefs should be a probability function.[[40]](#footnote-40) Recent examples of diachronic DBAs include van Fraassen’s argument for what he calls ‘Reflection’[[41]](#footnote-41) and Lewis’s argument for updating by conditionalization[[42]](#footnote-42).

The present argument resembles a diachronic DBA in that it faces the Causal Decision Theorist with a sequence of bets that guarantee a 50¢ loss, on which basis it rejects Causal Decision Theory. This raises the concern that it may be vulnerable to criticisms that seem to undermine both types of DBA indifferently, and to criticisms that face diachronic DBAs in particular.

One problem for both types of DBA is that they are too pragmatic. For instance, it seems that the synchronic DBA for probabilism doesn’t reveal any *epistemic* incoherence in beliefs that are not probability measures but only a *pragmatic* one. For all that it says, there might be nothing wrong with *having* beliefs that are not probability measures (for instance, in being more confident in P than in P ∨ Q for some propositions P, Q) as long as you don’t *act* on them.[[43]](#footnote-43) Whatever its justice against Ramsey et al., this argument has no relevance in the present context, in which the target is not a pattern of beliefs but a precept for action. It is *enough* that the Insurance Problem reveals a ‘merely’ pragmatic difficulty for Causal Decision Theory. If it is unwise to *act* on CDT then CDT is false.[[44]](#footnote-44)

A second issue for both types of DBA is their presupposition that if an agent prefers each one of a sequence or package of bets to not betting at all, then she prefers the combination of them to not betting at all. There is no obvious reason to think that rational agents are like that. Just because you would accept (b1) a $1 bet on some proposition P at odds of 1:2, and (b2) a $1 bet on ¬P at the same odds, it doesn’t follow that you would accept *either* bet, *given* that you had already taken on the other.[[45]](#footnote-45) Similarly, a diachronic bettor, who sees that taking b1 will inevitably lead to her taking b2 tomorrow, will refuse to take the first step on this path to certain loss, even though she might have accepted b1 had b2 not been in the offing tomorrow.[[46]](#footnote-46)

 But again, the difficulty does not arise in the present context. For in the Insurance Problem, you know that you *will* bet at Stage 2 *whatever* you do at Stage 1. So from the Stage 1 perspective of a sophisticated follower of CDT for whom Cr1 (D) > 0.5, taking O1 at Stage 1 is not the first step down the primrose path to ruin. It is doing the best that you now can to mitigate your future folly. (And the myopic agent won’t care about her future decisions in any case.)

A more specific objection to some diachronic DBAs is that constructing the damaging sequence of bets requires detailed knowledge of the target’s doxastic schedule. For instance, in order to extract money from an agent whose updating policy violates conditionalization, it is not enough to know *that* she violates conditionalization. Nor is it enough to know that for some specified P, Q, her degree of belief in Q on learning P *somehow* fails to match her prior conditional credence in Q given P. We need to know specifically *how* she updates her beliefs about Q on learning that P i.e. we need to know the precise level of her *ex post* confidence in Q. But the agent might well lack this highly specific knowledge about *herself*. If so, the argument shows only that someone who knows something that she does not is in a position to exploit her. But *that* is unsurprising and has no bearing on the rationality or otherwise of her updating policy.[[47]](#footnote-47)

True enough, but no such difficulty attends the present argument against CDT. It is true that in constructing the Insurance Problem I relied on foreknowledge that you would be confident, at Stage 2, that you smoked iff you have the defect (that your Cr2 (T) > 0.75). But the supposition that *you* also know this is completely straightforward. For you can reasonably be supposed to know at Stage 1 that you are then confident of T. And you know in advance that *nothing* is going to happen during the sequence that affects your evidence for T. The fact that CDT makes a sure loss for people who meet this undemanding standard of self-knowledge is enough to damn the theory, notwithstanding that when more self-ignorant persons run into similar trouble we cannot draw this conclusion.

 Finally, one might object to a diachronic DBA that even if it shows that a certain kind of policy or attitude leads to a certain loss, it doesn’t show that the policy or attitude itself is irrational, because its application at each stage of the sequence is manifestly rational.[[48]](#footnote-48) In the present case, O1 can seem inescapably rational at Stage 1 and P1 can seem inescapably rational at Stage 2. For instance, at Stage 1, if you know in advance that you will bet at Stage 2 and are very confident that you have the defect, then you are already very likely to lose either 50¢ if you smoke, or $1.50 if you don’t (see Table 3). So of course O1 is the only thing you can rationally do at this stage. And everyone agrees that P1 is right at Stage 2. But if CDT really is irrational then it must be going wrong at *one* of these stages. And yet it does not seem to be going wrong at *either* stage.

Much of what I said at section 6.2 is also applicable here. But let me add that in my view CDT *is* going wrong, at Stage 1. However confident you are that you have the defect, it is always irrational to smoke at Stage 1. But what shows this is not just consideration of Stage 1 by itself, holding fixed what happens at Stage 2. What shows it is the fact that rational agents who must make certain *further* choices will go wrong by smoking at Stage 1. For it shows that any agent who smokes at Stage 1 *and* (rationally) bets at Stage 2 will make a loss that he *could* have certainly avoided.

This shows that it is impossible to *embed* smoking at Stage 1 into a sequence of choices that are altogether rational. And that is reason for rejecting CDT: it shows that it is impossible to expand CDT into a rational theory of sequential choice, assuming that we have ruled out the resolute approach to sequential choice.

The only way to preserve CDT would be to insist (a) that it applies *only* to what Savage called ‘small world’ decisions, that is, decisions made bearing in mind only those future contingencies and decisions that one can feasibly take into account; *and* (b) that in the Insurance Problem, the decision whether to smoke at Stage 1 must for this reason be considered in isolation, so that when making that decision in light of whether you will smoke at Stage 2 one ceases to operate in a small world.[[49]](#footnote-49) But whilst (a) is certainly interpretable as a form of pragmatic modesty about one’s own intellectual limitations, (b) is ludicrous. The Insurance Problem is an extremely simple problem of sequential choice, and it is not only practically possible but also perfectly sensible to measure a decision theory against the payoff to its repeated application to such a case.

**7. Diagnosis**

It is easy enough to see the cause of the difficulty. At Stage 1, smoking is *causally* irrelevant to the truth of D. And CDT simply ignores whatever *evidential* bearing smoking has on the truth of D. This is because smoking is an option for you at Stage 1, and the point of CDT is to ignore the evidential bearing of an option on what state obtains in so far as it outruns the *causal* bearing of that option on what state obtains.

But at Stage 2, smoking is no longer optional: either you have already chosen to smoke or you have already chosen not to smoke. So from this new perspective, your smoking or your non-smoking is not a live option but a ‘dead’ fact, whose evidential bearing on the state of interest *is* now relevant to your new choice. And although this evidential bearing itself remains unchanged, the new perspective on its relevance entails a shift in your ranking of the four possible sequences, halfway through implementing one of them.

So whilst you do not suffer any changes in your action-relevant *beliefs* between Stage 1 and Stage 2 (Cr1 (T) and Cr2 (T) both exceeding 0.75), you will, if you follow CDT, act *as if* you had changed the relevant credences between two opportunities to take bets: that is why you are effectively open to a Dutch Book. And the same problem will arise for *any* persisting agent who, *because* he persists, is supposed to regard the *same* option from one perspective at the time when it is live, and from another perspective after he has settled the matter.

 By contrast, EDT does *not* enforce any shift in perspective between Stage 1 and Stage 2. It treats the evidential bearing of smoking on the presence of the defect as practically relevant at Stage 1 *and* at Stage 2. So it always recommends not smoking at Stage 1. And in consequence it does not recommend the disastrous sequence O1P1 to anyone. As Table 4 makes clear, it always recommends O2P1 i.e. not smoking at Stage 1 and betting at Stage 2. This policy does not make a certain loss. On the contrary, the *ex ante* expected return to O2P1 is -1.5 Cr1 (D⏐O2P1) + 0.5 Cr1 (¬D⏐O2P1) > 0; in fact this quantity exceeds the *ex ante* expectation of any alternative sequence.[[50]](#footnote-50)

 Could any recognizably causal version of decision theory avoid the catastrophic result? No, because the shift in perspective that is the source of the problem is supposed by its advocates to be the fundamental philosophical *insight* behind CDT. The whole point of CDT is that when you are choosing what to do, the evidential bearing of choosing an option on its non-effects *should* be irrelevant to its assessment as an option. For instance, Lewis writes:

It is essential to define [causal] utility as we did using the unconditional credences Cr (D) and Cr (¬D) of [causal] dependency hypotheses, not their conditional credences Cr (D⏐O1P1) etc. If the two differ, any difference expresses exactly that news-bearing aspect of the options that we meant to suppress.[[51]](#footnote-51)

Pearl makes the same point in a poem: ‘Whatever evidence an act may provide / On facts that preceded the act / Should never be used to help one decide / On whether to choose that same act’.[[52]](#footnote-52) For both writers, the insistence on a special agential perspective on the evidence is what *makes* CDT right.

 It follows from this diagnosis that Causal Decision Theory needn’t be the only theory to face the difficulty. *Any* theory that distinguishes, for practical purposes, between an agent’s perspective on some event, and an observer’s perspective on it, will face the same trouble with sequential choice. This is because one and the same agent must at different times view the event in these different ways.

Thus consider the doctrine of Ramsey’s, recently endorsed by Price, that my currently contemplated act cannot *for me, now*, have any *evidential* bearing on any past state of the world, although it might have that bearing for me at a later date.[[53]](#footnote-53) This form of two-perspectivism is different from the one that I associated with CDT, because on this new version the evidential bearing of choosing smoking itself, and not only the pragmatic relevance of that choice, changes between Stage 1 and Stage 2 of the Insurance Problem. In particular, CDT is compatible with the stipulated conditional probabilities (26) and (27) in virtue of which smoking is evidentially relevant to the presence of the defect at Stage 1. The Price-Ramsey doctrine cannot even allow this. On the contrary it has:

1. Cr1 (D⏐O1P1) = Cr1 (D⏐O2P1) = Cr1 (D)
2. Cr1 (D⏐O1P2) = Cr1 (D⏐O2P2) = Cr1 (D)

But in spite of this difference in the *way* that it cashes out the agent’s perspective, the Price-Ramsey doctrine runs into the same trouble with the Insurance Problem simply by virtue of distinguishing that perspective in the first place. In particular, consider a sophisticated chooser facing the insurance problem who (a) grants the Price-Ramsey doctrine and (b) has Cr1 (D) > 0.5. If this person follows Causal Decision Theory then (b) gets this person into trouble anyway, as we have already seen. But if he follows *Evidential* Decision Theory then the *Price-Ramsey doctrine* gets him into trouble.

To see this, note that (a) implies that at Stage 1 he treats smoking as *evidentially* irrelevant to whether or not he has the defect. But at Stage 2, smoking is *no longer* a currently contemplated option. So the evidential bearing of smoking is restored. So whatever happens at Stage 1, he has Cr2 (T) > 0.75. So he will certainly bet at Stage 2, and he can foresee this at Stage 1. It follows from (b), (75) and (76), that *this* sophisticated follower of EDT will choose to smoke at Stage 1. This is because the Price-Ramsey doctrine, in effect and via (75) and (76), forces EDT to emulate CDT at Stage 1. This person will therefore end up with O1P1 for a certain loss of 50¢. So when combined with EDT, the Price-Ramsey doctrine runs into trouble for the same basic reason that CDT does. It postulates a pragmatically relevant distinction between the agent’s perspective and the observer’s perspective on any option that the former is presently contemplating.

Although both Causal Decision Theory and the Price-Ramsey doctrine are relatively precise and relatively modern realizations of it, the distinction itself has deeper and older philosophical roots. It goes back at least as far as the Kantian idea that a rational agent who is deliberating whether or not to smoke simply cannot *whilst deliberating* regard his choice as being subject to external influences to which it is evidentially relevant for instance, the presence of a defect.[[54]](#footnote-54) But opposition to it is also traditional. Thus Hume seems to argue that although whilst deliberating somebody might *think* that what he eventually does is causally unconstrained by, and so evidentially irrelevant to, any past state of his, this is simply a mistake and not something that his *being* the agent somehow puts him in any special position to get right.[[55]](#footnote-55) In so far as it has any bearing upon them, the present argument raises a practical objection to the Kantian but not to the Humean line.

 But my purpose was not even to describe, let alone to criticize, all of the ways in which you might explicate, or in which philosophers actually have explicated, the notion that an agent has *some* special perspective upon her acts that the observer lacks. Certainly the present argument leaves many such ideas untouched.

 For instance, it has nothing to do with the thought that *whilst* you are doing something you have a *way* *of knowing* about it, at least under the description in which it is intentional, that is different from the way in which anyone knows about it who is not doing it.[[56]](#footnote-56) For all I’ve said, that may be true, just as it is true that whilst you are seeing something you know about it in a way that is different from the way in which anyone knows about it who is not seeing it. And the explanation, in the case of action, is presumably neurological: perhaps, that when we act we are directly aware not of the movements themselves, but of some pre-motor process that is associated with them.[[57]](#footnote-57) *Perhaps* it will turn out that *all* of the philosophical fuss about the ‘agent’s perspective’ condenses into this drop of neuropsychology.

 Whether or not it does, my point in mentioning that fuss was not at all to show that it is groundless. Rather this section has tried to make the following point about Causal Decision Theory: what leads *it* into disaster, the essential feature that it shares with the Price-Ramsey doctrine, is not some arbitrary epicycle that its advocates just made up, but in fact one fairly natural outgrowth of an intellectual tradition. But natural or not, and whatever your feelings about that tradition, I hope you agree with me that the outgrowth itself is a pathology that rational choice is better off without.

**Appendix A**

This appendix establishes four claims about the Insurance Problem that section 3 made without proof: (i) that if you *don’t* smoke at Stage 1 and remember this then CDT will advise you to bet at Stage 2; (ii) that if you *forget* what you do at Stage 1 then CDT will advise you to bet at Stage 2; (iii) that if you remember what you did at Stage 1 then EDT will advise you to bet at Stage 2 whatever you did at Stage 1; (iv) that if you forget what you did at Stage 1, then EDT will advise you to bet at Stage 2.

 (i) If you don’t smoke at Stage 1 and remember this at Stage 2 then the utilities of your options at Stage 2 are as follows:

(A1) U2 (P1) = V2 (O2P1D) Cr2 (D) + V (O2P1¬D) Cr2 (¬D)

(A2) U2 (P2) = V2 (O2P2D) Cr2 (D) + V (O2P2¬D) Cr2 (¬D)

We know from Table 3 that

(A3) V2 (O2P1D) = -1.5

(A4) V2 (O2P1¬D) = 0.5

(A5) V2 (O2P2D) = V2 (O2P2¬D) = 0

Since you remember that you smoked at Stage 1, the assumption that you update by conditional probability gives:

(A6) Cr2 (D) = Cr1 (D⎪O2) < 0.25

Substituting (A3) and (A4) into (A1), and (A5) into (A2), gives:

(A7) U2 (P1) = -1.5Cr2 (D) + 0.5Cr2 (¬D) = 0.5-2Cr2 (D)

(A8) U2 (P2) = 0

It follows from (A6), (A7) and (A8) that U2 (P1) > U2 (P2) i.e. CDT recommends betting at Stage 2.

 (ii) If you have forgotten at the outset of Stage 2 what you did at Stage 1 then the utilities of your options at Stage 2 are:

(A9) U2 (P1) = -0.5 Cr2 (O1) – 1.5 Cr2 (O2D) + 0.5 Cr2 (O2¬D)

(A10) U2 (P2) = -Cr2 (O1D) + Cr2 (O1¬D)

Let us write α =def. min (Cr2 (D⎪O1), Cr2 (¬D⎪O2)). Since you have forgotten what you did at Stage 1, we have Cr2 (O1), Cr2 (O2) > 0. It follows from (A9) and (A10) that:

(A11) U2 (P1) ≥ -0.5 Cr2 (O1) + (2α – 1.5) Cr2 (O2)

(A12) U2 (P2) ≤ (1-2α) Cr2 (O1)

It follows that U2 (P1) > U2 (P2) if:

(A13) (2α - 1.5) Cr2 (O2) > (1.5 - 2α) Cr2 (O1)

But Cr2 (O2) > 0; and since your belief in the correlation between smoking and the defect is the same at Stage 2 as it was at Stage 1, it follows from (1) and (4) that α > 0.75. Hence (A13) is true and so U2 (P1) > U2 (P2) i.e. CDT recommends taking the bet at Stage 2.

 (iii) First suppose that you smoke at Stage 1 and remember this at Stage 2. Then:

(A14) V2 (P1) = V2 (P1O1D) Cr2 (D⎪P1) + V2 (P1O1¬D) Cr2 (¬D⎪P1)

(A15) V2 (P2) = V2 (P2O1D) Cr2 (D⎪P2) + V2 (P2O1¬D) Cr2 (¬D⎪P2)

Table 3 and the probability calculus simplify these equations to:

(A16) V2 (P1) = -0.5

(A17) V2 (P2) = 1 - 2Cr2 (D⎪P2)

Now for any X in the algebra, Cr2 (X) = Cr1 (X⎪O1), since what you have learnt at Stage 2 is just that you smoke at Stage 1. And nothing that you do at Stage 2 has any further evidential bearing on whether you have got the defect, given that you have smoked. So:

(A18) Cr2 (D⎪P2) = Cr1 (D⎪O1)

It follows from (1), (A16), (A17) and (A18) that V2 (P1) > V2 (P2). So EDT recommends that you bet at Stage 2.

 Now suppose that you abstain at Stage 1 and remember this at Stage 2. Then:

(A19) V2 (P1) = V2 (P1O2D) Cr2 (D⎪P1) + V2 (P1O2¬D) Cr2 (¬D⎪P1)

(A20) V2 (P2) = V2 (P2O2D) Cr2 (D⎪P2) + V2 (P2O2¬D) Cr2 (¬D⎪P2)

These can be simplified as follows:

(A21) V2 (P1) = 0.5 - 2Cr2 (D⎪P1)

(A22) V2 (P2) = 0

And by similar reasoning to that behind (A18) we have:

(A23) Cr2 (D⎪P1) = Cr1 (D⎪O2)

It follows from (3), (A21), (A22) and (A23) that V2 (P1) > V2 (P2) i.e. EDT again recommends betting at Stage 2.

 (iv) Finally, consider what EDT recommends if you do not remember what you did at Stage 1. In this case we need to assume that what you do at Stage 2 has no evidential bearing *either* on whether you have the defect *or* on what you did at Stage 1 *or* on any joint specification of these matters. This assumption is plausible; at any rate it is consistent with all of the other assumptions that I have made about this case.

 In this case the relevant V-scores are as follows:

(A24) V2 (P1) = -0.5Cr2 (O1⎪P1) – 1.5Cr2 (O2D⎪P1) + 0.5Cr2 (O2¬D⎪P1)

(A25) V2 (P2) = -Cr2 (O1D⎪P2) + Cr2 (O1¬D⎪P2)

By our assumption about the evidential irrelevance of Stage 2, we may assume that:

(A26) Cr2 (O1⎪P1) = Cr2 (O1)

(A27) Cr2 (O2D⎪P1) = Cr2 (O2D)

(A28) Cr2 (O2¬D⎪P1) = Cr2 (O2¬D)

(A29) Cr2 (O1D⎪P2) = Cr2 (O1D)

(A30) Cr2 (O1¬D⎪P2) = Cr2 (O1¬D)

Substituting (A26)-(A30) into (A24) and (A25) gives

(A31) V2 (P1) = -0.5 Cr2 (O1) – 1.5 Cr2 (O2D) + 0.5 Cr2 (O2¬D)

(A32) V2 (P2) = -Cr2 (O1D) + Cr2 (O1¬D)

The right hand sides of (A31) and (A32) are identical to the right hand sides of (A9) and (A10) respectively. So by the same reasoning as at (ii) we may infer that V2 (P1) > V2 (P2) i.e. that EDT recommends betting at Stage 2.

 It’s worth briefly commenting on the assumption of evidential irrelevance that we needed for the reasoning in part (iv). There is no harm that I can see in simply stipulating that it holds in the Insurance Problem. But we can certainly imagine variations on the Insurance Problem in which that assumption fails. For instance, suppose that it is known (A) that forgetful people who bet at Stage 2 are very likely to have smoked at Stage 1, and also very likely to have the defect; (B) that forgetful people who do not bet at Stage 2 are very likely not to have smoked at Stage 1, and also very likely not to have the defect. Then the forgetful evidentialist will choose not to smoke at Stage 1 and not to bet at Stage 2, so in this version of the problem my claim that everyone will bet at Stage 2 is simply false.

But even on this version of the problem, the recommendation of O1P1 holds for the forgetful Causal Decision Theorist who knows that he follows CDT at Stage 2, since by (ii) this person knows at Stage 1 that he bets at Stage 2. And it also holds for the *un*forgetful Causal Decision Theorist who doesn’t know whether he follows CDT or EDT at Stage 2, since by combining (i) and (iii) this person can also know at Stage 1 that he bets at Stage 2. So in this variant case the forgetful follower of EDT loses (or makes) 0¢ for sure, whereas any sort of Causal Decision Theorist with the right Cr1 loses 50¢ for sure. This follows from the argument at section 4.

**Appendix B**

This appendix establishes the following claim about the Insurance Problem, made without proof in section 5. *If* you think that there is *some* act O and state S such that (i) O makes S more likely than not, (ii) ¬O makes ¬S more likely than not, (iii) O is causally irrelevant to S; *then* it is possible to construct an example that generates a certain loss for CDT.

We are supposing that:

(B1) Learning O makes S more likely than not

(B2) Learning ¬O makes ¬S more likely than not

(B3) O is causally irrelevant to S

Now suppose that for some choice between O and ¬O we write π1 =def. Cr1 (S⏐O) and π2 =def. Cr1 (¬S⏐¬O). By (B1) and (B2) there is some ε>0 s.t.:

(B4) min (π1, π2) - ε > 0.5

(B5) min (π1, π2) - ε > Cr1 (S) > 1 – (min (π1, π2) - ε)

Choose some such ε and write π =def. min (π1, π2) - ε. Now for real numbers k, Δ > 0 define I (Δ, k) to be a version of the Insurance Problem with the following two stages. At Stage 1 the payoffs are:

|  |  |  |
| --- | --- | --- |
|  | **S** | **¬S** |
| **O** | -k(1 – π) - Δ | kπ - Δ |
| **¬O** | 0 | 0 |

*Table 15: I (Δ, k) Stage 1*

At Stage 2 you have a choice between betting (P) and not betting (¬P) with payoffs as follows:

|  |  |  |
| --- | --- | --- |
|  | **O ↔ S** | **O ↔ ¬S** |
| **P** | k(1 – π) | -kπ |
| **¬P** | 0 | 0 |

*Table 16: I (Δ, k) Stage 2*

So the overall payoffs are:

|  |  |  |
| --- | --- | --- |
|  | **S** | **¬S** |
| **OP** | -Δ | -Δ |
| **O¬P** | -k(1 – π) - Δ | kπ - Δ |
| **¬OP** | -kπ | k(1-π) |
| **¬O¬P** | 0 | 0 |

*Table 17: I (Δ, k) overall payoffs*

In this problem insuring at Stage 2 will seem rationally mandatory to every unforgetful agent at Stage 2 iff:

(B6) -Δ > -kπ1(1-π) – π1Δ + (1-π1)(kπ - Δ)

(B7) -(1-π2)kπ + π2k(1-π) > 0

Since k > 0, condition (B6) holds because π1 > π and condition (B7) holds because π2 > π.

 If you have forgotten what you did at Stage 1 then the utilities of insuring and not insuring are:

(B8) U2 (P) = -ΔCr2 (O) - kπCr2 (¬OS) + kπCr2 (¬O¬S)

(B9) U2 (¬P) = (-k(1-π)-Δ)Cr2 (OS) + (kπ-Δ)Cr2 (O¬S)

Now we know that your confidence in the correlation is the same as at Stage 1; so:

(B10) U2 (P) ≥ -ΔCr2 (O) – kπ(1-π)Cr2 (¬O) +kπ2Cr2 (¬O)

(B11) U2 (¬P) ≤ (-k(1-π)-Δ)πCr2 (O) + (kπ-Δ)(1-π)Cr2 (O)

Comparing the right hand sides of (B10) and (B11), a little manipulation gives the following sufficient condition for U2 (P) > U2 (¬P):

(B11) kπ2Cr2 (¬O) > (kπ - kπ2)Cr2 (¬O)

Since the agent is forgetful Cr2 (¬O) > 0; since k > 0 and 1 > π > 0, it follows that U2 (P) > U2 (¬P) if π/(1-π) > 1. It therefore follows from (B4) that U2 (P) > U2 (¬P). So CDT recommends insuring to the forgetful as well as the unforgetful agent at Stage 2 of I (Δ, k).

So writing ‘A B’ for ¬(B A), myopic CDT will endorse OP iff it entails: O¬P 1 ¬OP and O¬P 1 ¬O¬P, since in that case the agent will choose O at Stage 1, and then (as we have just seen) P at Stage 2. By (B3), this will happen if and only if:

(B12) –Cr1 (S)(k(1-π) + Δ) + Cr1 (¬S)(kπ - Δ) ≥ -Cr1 (S)kπ + Cr1 (¬S)k(1-π)

(B13) –Cr1 (S)(k(1-π) + Δ) + Cr1 (¬S)(kπ - Δ) ≥ 0

Conditions (B12) and (B13) hold if and only if:

(B14) π ≥ 1/2 + Δ/2k

(B15) π ≥ Cr1 (S) + Δ/k

By (B4) and (B5), it is always possible to find k, Δ > 0 such that (B14) and (B15) hold: in such an I (Δ, k) myopic CDT endorses a policy (OP) that is certain to lose $Δ both in absolute terms and relative to ¬O¬P.

Sophisticated CDT endorses OP in I (Δ, k) iff it entails OP 1 ¬OP. By (B3), this holds iff:

(B16) -Δ ≥ -Cr1 (S)kπ + Cr1 (¬S)k(1-π); that is:

(B17) Cr1 (S) ≥ 1-π + Δ/k

By (B5), it is always possible to find a k, Δ > 0 such that (B17) holds: in such an I (Δ, k), sophisticated CDT also endorses a policy (OP) that is certain to lose $Δ in absolute and in relative terms.

Finally, it is evident from (B14), (B15) and (B17) that if there are Δ, k > 0 that satisfy any of these then there are Δ, k > 0 that satisfy all three simultaneously. In such an I (Δ, k), CDT leads both the myopic and the sophisticated agent into a sure loss of $Δ.

**References**

Ahmed, A. and H. Price. 2012. Arntzenius on ‘Why ain’cha rich?’ *Erkenntnis* 77: 15-30.

Allison, H. E. 1990. *Kant’s Theory of Freedom*. Cambridge: CUP.

Anscombe, G. E. M. 1957. *Intention*. Oxford: Blackwell.

Arntzenius, F. 2008. No regrets, or: Edith Piaf revamps decision theory. *Erkenntnis* 68: 277-97.

———, A. Elga and J. Hawthorne. 2004. Bayesianism, infinite decisions and binding. *Mind* 113: 251-83.

Bermudez, J.-L. 2013. Prisoner’s dilemma and Newcomb’s problem: why Lewis’s argument fails. *Analysis* 73: 423-9.

Bernartzi, S. and D. H. Thaler. 1999. Risk aversion or myopia? Choices in repeated gambles and retirement investments. *Management Science* 45: 364-81.

Broome, J. 1992. Review of McClennen 1990. *Ethics* 102: 666-8.

Buchak, L. 2013. *Risk and Rationality*. Oxford: OUP.

Cartwright, N. 1979. Causal laws and effective strategies. *Noûs* 13: 419-37.

Christensen, D. 2004. *Putting Logic in its Place*. Oxford: OUP.

Dougherty, T. 2011. On whether to prefer pain to pass. *Ethics* 121: 521-37.

Dummett, M. A. E. 1986. Causal loops. In R. Flood and M. Lockwood (ed.), *The Nature of Time*. Oxford: Blackwell: 135-69. Reprinted in his *Seas of Languag*e. Oxford: OUP 1993: 349-75.

Egan, A. 2007. Some counterexamples to Causal Decision Theory. *Phil*. *Rev*. 116: 93-114.

Elga, A. 2010. Subjective probabilities should be sharp. *Philosophers’ Imprint* 10 no. 5.

Gärdenfors, P. and N.-E. Sahlin. 1982. Unreliable probabilities, risk taking and decision making. *Synthese* 53: 361-86.

Gibbard, A. 1992. Weakly self-ratifying strategies: comments on McClennen. *Phil*. *Stud*. 65: 217-25.

——— and W. L. Harper 1978. Counterfactuals and two kinds of expected utility. In C. Hooker, J. Leach and E. McClennen (ed.), *Foundations and Applications of Decision Theory*. Dordrecht: Riedel: 125-62. Reprinted in P. Gärdenfors, and N.-E. Sahlin (ed.), *Decision, Probability and Utility*. Cambridge: CUP 1988: 341-76.

Gilboa, I. and D. Schmeidler. 1989. Maxmin expected utility with a non-unique prior. *Journal of Mathematical Economics* 18: 141-53.

Haggard, P. 2003. Conscious awareness of intention and action. In Roessler, J. and N. Eilan (ed.), *Agency and Self-Awareness*. Oxford: OUP: 111-127.

Harsanyi, J. 1992. Game solutions and the normal form. In C. Bicchieri and M. Della Chiara (ed.), *Knowledge, Belief and Strategic Interaction*. Cambridge: CUP: 355-76.

——— and R. Selten. 1988. *A General Theory of Equilibrium Selection in Games*. Cambridge, Mass.: MIT Press.

Hedden, B. 2013. Options and diachronic tragedy. *Philosophy and Phenomenological Research*. Published online at:

 <http://onlinelibrary.wiley.com/doi/10.1111/phpr.12048/pdf>

Hume, D. 1949 [1738]. *Treatise of Human Nature*. London: J. M. Dent.

Joyce, J. 1999. *Foundations of Causal Decision Theory*. Cambridge: CUP.

———. 2012. Regret and instability in causal decision theory. *Synthese* 187: 123-45.

Kant, I. 1964. [1785]. *Groundwork of the Metaphysics of Morals*. Tr. H. J. Paton. New York: Harper and Row.

———. 2000 [1781/7]. *Critique of Pure Reason*. Ed. and tr. P. Guyer and A. W. Wood. Cambridge: CUP.

Lewis, D. 1973. *Counterfactuals*. Oxford: Blackwell.

———. 1979. Prisoners’ Dilemma is a Newcomb Problem. *Philosophy and Public Affairs* 8: 235-40. Reprinted in his *Philosophical Papers Vol. II*. Oxford: OUP 1986: 299-304.

———. 1981. Causal decision theory. *AJP* 59: 5-30. Reprinted in his *Philosophical Papers Vol. II*. Oxford: OUP 1986: 305-339.

———. 1999. Why conditionalize? In his *Papers in Metaphysics and Epistemology*. Cambridge CUP: 403-7. Reprinted in A. Eagle (ed.), *Philosophy of Probability: Contemporary Readings*. Abingdon and New York: Routledge 2011: 132-4.

McClennen, E. F. 1990. *Rationality and Dynamic Choice: Foundational Explorations*. Cambridge: CUP.

Maher, P. 1990. Symptomatic acts and the value of evidence in Causal Decision Theory. *Philosophy of Science* 57: 479-98.

———. 1992. Diachronic rationality. *Philosophy of Science* 59: 120-41.

———. 1993. *Betting on Theories*. Cambridge: CUP.

Meacham, C. 2010. Binding and its consequences. *Philosophical Studies* 149: 49-71.

Mellor, D. H. 1983. Objective decision making. *Social Theory and Practice* 9: 289-309

———. 1990. Introduction. In D. H. Mellor (ed.), *F. P. Ramsey: Philosophical Papers*. Cambridge: CUP: xi-xxv.

———. 2005. What does subjective decision theory tell us? In H. Lillehammer and D. H. Mellor (ed.), *Ramsey’s Legacy*. Oxford: OUP: 137-148.

Moss, S. Forthcoming. Time-slice epistemology and action under indeterminacy. *Oxford Studies in Epistemology*.

Mulligan, C. B. 1996. A logical economist’s argument against hyperbolic discounting. Department of economics, University of Chicago. Published online at: <http://www.spc.uchicago.edu/~wwwcbm4/>

Nozick, R. 1970. Newcomb’s problem and two principles of choice. In N. Rescher (ed.), *Essays in Honor of Carl G. Hempel*. Dordrecht: D. Reidel: 114-46. Reprinted in P. Moser (ed.), *Rationality in Action: Contemporary Approaches*. Cambridge: CUP 1990: 207-34.

O’Shaughnessy, B. 2008. *The Will: A Dual Aspect Theory*. 2d ed. 2 vols. Cambridge: CUP.

Pearl, J. 2000. *Causality*. Cambridge: CUP.

Price, H. 1993. The direction of causation: Ramsey’s ultimate contingency. *PSA vol. 2*: 253-67.

———. 2012. Causation, chance, and the rational significance of supernatural evidence. *Phil*. *Rev*. 121: 483-538.

Radner, R. and R. W. Rosenthal. 1982. Private information and pure-strategy equilibria. *Mathematics of Operations Research* 7: 401-9.

Ramsey, F. P. 1990 [1926]. Truth and probability. In his *Philosophical Papers*, ed. D. H. Mellor. Cambridge: CUP: 52-94.

———. 1990 [1929]. General propositions and causality. In *ibid*. : 145-63.

Rosenthal, R. W. 1979. Sequences of games with varying opponents. *Econometrica* 47: 1353-66.

Rubinstein, A. 1991. Comments on the interpretation of game theory. *Econometrica* 59: 909-24.

Savage, L. J. 1972. *The Foundations of Statistics*. 2nd ed. New York: Dover.

Sen, A. 1983. Liberty and Social Choice. *Journal of Philosophy* 80: 5-28. Reprinted in his *Rationality and Freedom*. Cambridge, Mass.: Harvard University Press 2003: 381-407.

Seidenfeld, T. 1988. Decision theory without ‘independence’ or without ‘ordering’: what is the difference? *Economics and Philosophy* 4: 267-90.

———. 1994. When normal and extensive form decisions differ. In D. Prawitz, B. Skyrms and D. Westerthal (ed.), *Logic, Methodology and Philosophy of Science IX*. Boston: Elsevier: 451-463.

Shafir, E. and A. Tversky. 1992. Thinking through uncertainty: nonconsequential reasoning and choice. *Cognitive Psychology* 24: 449-74.

Skyrms, B. 1980. *Causal Necessity*. New Haven: Yale UP.

Slezak, P. 2013. Realizing Newcomb’s Problem. Available online from philsci-archive.pitt.edu

Strotz, R. H. 1955. Myopia and inconsistency in dynamic utility maximization. *Review of Economic Studies* 23: 165-80.

Van Fraassen, B. 1984. Belief and the will. *Journal of Philosophy* 81: 235-56. Reprinted in A. Eagle (ed.), *Philosophy of Probability: Contemporary Readings*. Abingdon and New York: Routledge 2011: 150-65.

Walker, M. T. 2014. The real reason why the prisoner’s dilemma is not a Newcomb problem. *Philosophia* online. DOI: 10.1007/s11406-014-9516-z

Wegner, D. 2002. *The Illusion of Conscious Will*. Cambridge, MA: MIT Press.

1. Advocates of CDT who treat it this way include Gibbard and Harper (1978), Lewis (1981) and Joyce (1999). Not everyone agrees. (1) Ramsey seems to have thought that subjective decision theory admits only a descriptive interpretation (Mellor 1990: xviii). (2) Mellor (1983, 2005) and Cartwright (1979, on which see Lewis 1981: 325n. 15) both advocate prescriptive but *objective* versions of CDT. [↑](#footnote-ref-1)
2. Gibbard 1992: 218. [↑](#footnote-ref-2)
3. Egan 2007: 96ff. [↑](#footnote-ref-3)
4. Strotz 1955: 168-71. We might alternatively reserve ‘myopic’ for (a) choice that only cares about the payoffs to the *present* choice and so treats Stage 1 as an isolated problem (following Bernartzi and Thaler 1999: 380), and use the term ‘naïve’ for (b) choice that is myopic in the sense being used here (following Buchak 2013: 176, 219n. 18). I’ll ignore ‘myopia’ in sense (a) because it quite clearly delivers the same results as sense (b): CDT allows (a)-type myopic agents to smoke at Stage 1 iff Cr1 (D) ≤ 0.5 whereas EDT always recommends non-smoking to them. [↑](#footnote-ref-4)
5. For instance Maher (1990: 482-4) argues that CDT should evaluate the immediately available options (not sequences) at the current stage by taking into account their effects on one’s choices at later stages. Suppose we take counterfactual dependence to be the measure of these effects. Then in (say) a two-stage problem with option sets **O** at Stage 1, **P** at Stage 2 and a set **S** of relevant possible states of the world, the relevant stage-1 evaluations apply to any o ∈ **O** as follows:

U1 (o) = Σp ∈ **P** Σ s ∈ **S** Cr1 (o → ps) V1 (ops)

(Here, → is the counterfactual conditional.) If you now know that at Stage 2 you *would* realize some p\* ∈ **P** whatever you were to do at Stage 1, you have Cr1 (o → p\*) = 1 for any o ∈ **O**. Given your rationality and a logic of counterfactuals as strong as Lewis’s **VC** (Lewis 1973: 132), (i) then reduces to:

U1 (o) = Σ s ∈ **S** Cr1 (op\* → s) V1 (op\*s)

And (ii) in effect applies CDT to a one-off choice from amongst {op\*⏐o ∈ **O**}, which is what the sophisticated approach recommends.

 Joyce (1999: 60-1) takes the immediately available options at any stage in sequential choice to be *resolutions*: whether or not your present self can influence your future choices, it is entirely up to your present self what sequence it now *resolves* to actualize. But again, when CDT chooses from amongst resolutions, it should take into account the causal effect that a present resolution to realize (say) p\* at Stage 2 will actually have on what you do at that future time. If you know in advance that it has no effect (because you know that at Stage 2 you will realize p\* come what may) then you should simply treat your future choice as just another unalterable fact about the state of the world. So Joyce is committed to the sophisticated approach.

 Similarly, Arntzenius, Elga and Hawthorne (2004: 267) argue that if your present choice has no causal influence over your future choice then it is rational to evaluate one’s present options whilst keeping one’s future actions fixed, just as sophistication requires. (That paper covers countably *infinite* choice sequences. But nothing in their discussion gives any reason to restrict *this* point to the infinite case). [↑](#footnote-ref-5)
6. For details see Nozick 1970: 207-8. [↑](#footnote-ref-6)
7. Gibbard and Harper (1978: 371) describe but do not endorse the argument. Dummett (1986: 374-5) appears to endorse it. [↑](#footnote-ref-7)
8. Lewis 1981: 310. [↑](#footnote-ref-8)
9. To see just one particularly serious way in which this threat might arise, consider Stage 1 of the Insurance Problem, taken in isolation as a one-off choice with payoffs as in Table 1—call this the *Truncated Problem*. And suppose that you are a *sophisticated agent who follows CDT*. Then by inspection of Table 1 and Table 4 we see that you prefer to smoke in the Truncated Problem iff your initial credence that you have the defect satisfies Cr1 (D) < 0.5; but you prefer to smoke in the Insurance Problem iff your initial credence that you have the defect satisfies Cr1 (D) > 0.5. Finally, suppose that the defect increases your propensity to smoking by *reducing your confidence that you have got the defect*. In that case, it looks as though the evidential significance of smoking is actually *reversed* when the decision to smoke is embedded within the two-stage Insurance Problem. But then it would be wise for the follower of CDT *not* to bet at Stage 2 of this problem. So my argument for (35) would be self-undermining. [↑](#footnote-ref-9)
10. So it would be misleading to describe this situation as a game played between you and the predictor. Certainly we can assume that the predictor has no interest in making money out of you, or in your losing any gamble that you enter into at Stage 2. The only thing that matters to him, or it, is that the wiring of the red button depends on the prediction as described. [↑](#footnote-ref-10)
11. Cf. Lewis 1981: 310. On the other hand, there is empirical evidence that people will readily believe that some psychological algorithm has these predictive powers: see Shafir and Tversky 1992: 461ff. [↑](#footnote-ref-11)
12. Wegner 2002: 52-6. For application to Newcomb’s original problem see Slezak 2013: 16-17. [↑](#footnote-ref-12)
13. This device is analogous to that in Lewis 1979, where he argues that in a Prisoners’ Dilemma in which both parties consider themselves psychologically alike, both players are facing a Newcomb problem. For arguments that Prisoners’ Dilemma is not a Newcomb Problem, see Bermudez 2013 and Walker 2014. These arguments do not, however, show that Prisoners’ Dilemma is not a decision-theoretic problem from the perspective of each player. Similarly, they could not show that the G-version of the Insurance Problem does not on its own account raise the possibility of certain loss for CDT, even if, as I in any case doubt, there are significant differences between the original Insurance Problem and the G-version. [↑](#footnote-ref-13)
14. See e.g. Hedden 2013 and Moss forthcoming. [↑](#footnote-ref-14)
15. Note however that Table 8 is not a Prisoners’ Dilemma because Slice 1 doesn’t have a dominant strategy. It *is* a variant on Sen’s illustration of the impossibility of a Paretian liberal: Slice 1 and Slice 2 freely choose to smoke and to bet respectively, but that outcome is Pareto-inferior to O2P2. Cf. Sen 1983: 400-1. [↑](#footnote-ref-15)
16. For instance, it is clear from Table 8 that slice 1 ranks O1P1 over O1P2 but slice 2 reverses this, and similarly for the pairs of joint actions O1P1/O2P1 and O1P2/O2P1. This does not contradict the fact (a) that they agree on the ranking of *final* outcomes that is implicit in Table 3. That is, they agree on: O1P2¬D O2P1¬D O2P2D ~ O2P2¬D O1P1D ~ O1P1¬D O1P2D O2P1D, here writing ~ for indifference. [↑](#footnote-ref-16)
17. See e.g. Lewis 1981: 310-11; Joyce 1999: 147-9. [↑](#footnote-ref-17)
18. Lewis objects to the ‘exploitation’ interpretation of Dutch Book Arguments for probabilism (and Bayesian conditionalization) on the grounds that (i) there are no such exploiters around; (ii) if you saw one coming you could simply avoid him (1999: 133). Whatever their merits in that context, neither such move can save Causal Decision Theorists from exploitation in the Insurance Problem. In connection with (i): there were no such exploiters around because the exploitative mechanism is not public; but now that it is we might expect them to arise wherever Newcomb-type scenarios are feasible. (And if the latter are nowhere feasible then this undermines the whole motivation for preferring CDT to EDT in the first place.) Certainly *I* am prepared to exploit them; and if my argument is sound, then I am confident of being able to raise the capital to finance the operation. In reply to (ii): the option of walking away is *already built in* to the scenario; and we have already seen that causalists will reject it. Specifically, imagine the following situation: here is an accurate predictor of your actions. I offer you the chance to bet $1 at odds of 1:1 that he predicted that you would not take this bet. Whether or not you accept it, I later offer you the chance to bet $1.50 at odds of 1:3 that his earlier prediction was correct. At both stages you *can* choose to walk away: the walking away options correspond to O2 and P2 in the Insurance Problem. But we have already seen that any Causal Decision Theorists with initial beliefs lying within a perfectly sane and plausible range will *choose* not to walk away and yet will certainly lose 50¢ to me. [↑](#footnote-ref-18)
19. Cf. Seidenfeld 1988: 279-81. This point holds at least for myopic and sophisticated approaches to sequential choice. It does not so clearly apply to what is called the resolute approach, but I deny that resoluteness is even feasible. See section 6.6. [↑](#footnote-ref-19)
20. Seidenfeld 1994: 457ff. [↑](#footnote-ref-20)
21. Seidenfeld 1988. [↑](#footnote-ref-21)
22. Table 10 adapts an example from Harsanyi and Selten 1988: 16-17. For further discussion see Seidenfeld 1994: 452-4 and Harsanyi 1992: 357-9. [↑](#footnote-ref-22)
23. A1 *strictly* dominates act A2 with respect to a partition P = {P1, P2, …Pn} of the event space if A1Pi A2Pi for 1 ≤ i ≤ n. A1 *weakly* dominates A2 with respect to P if A1Pi A2Pi for all 1 ≤ i ≤ n and, for some j such that 1 ≤ j ≤ n, A1Pj A2Pj. ‘Dominance’ means strict dominance unless stated otherwise. A partition is causally (evidentially) independent of a choice if *which* element of the partition actually obtains is causally (evidentially) independent of that choice. [↑](#footnote-ref-23)
24. Nozick makes a similar stipulation in the Newcomb Problem (1970: 208 n.1). [↑](#footnote-ref-24)
25. You might wonder at this point whether it is really plausible that Cr1 (D) > 0.75. After all, if you think that your smoking is a sign of the presence of the defect then your Cr1 (D) must be constrained by your opinion about what you will do. But in fact it is not smoking as such, but smoking without first having randomized, i.e. O1, that is supposed to be a sign of the defect. If you are confident that you will take Oπ at Stage 1 then you will reject any evidential connection between your actually smoking and your having the defect. In that case there are no constraints on Cr1 (D) other than your prior evidence. And we could easily suppose that in the absence of whatever evidence your deliberately choosing O1 or O2 would constitute, what evidence you do have makes you confident that the defect is present. [↑](#footnote-ref-25)
26. We can understand this approach as applying either of two interpretations of mixed strategies that have been proposed in the literature. On the one hand there is the ‘population’ model (Rosenthal 1979): one’s opponent is drawn from a population in which a proportion π always presses the red button at Stage 1, only here we are thinking of the population as a collection of time slices of Bob rather than as a population of distinct persons. On the other hand there is the ‘purification’ model (Radner and Rosenthal 1982), in which each player chooses which button to press on the basis of private information that does not affect payoffs and concerning which the other player has confidence π that it will motivate pressing the red button. For criticism of both approaches see Rubinstein 1991 section 3. [↑](#footnote-ref-26)
27. I should emphasize that this is not the same thing as each of you deliberately choosing a third, randomizing option. The only options are O1 and O2 i.e. deliberately pressing the red button and deliberately pressing the blue button. But can an external random process causally determine deliberate choice itself? It can, if you think with many compatibilists that the prior causal determination of the will is irrelevant to whether it is free. [↑](#footnote-ref-27)
28. On the 50% of plays when you press the red button at Stage 1 (and bet at Stage 2, which you always do), you make a sure loss of -50¢. On the 50% of plays when you press the blue button at Stage 1, you win the Stage 2 bet 75% of the time for a profit of 50¢, and you lose the Stage 2 bet 25% of the time for a loss of $1.50. So your overall average profit is 0.5×(-50¢) + 0.5×0.75×50¢ + 0.5×0.25×(-$1.50) = -25¢. [↑](#footnote-ref-28)
29. Newcomb’s problem is an example of this: see the discussion of ‘Why Ain’cha Rich?’ at section 5. So too is its game-theoretic counterpart: Prisoners’ Dilemma in a setting where players’ choices are correlated but causally independent (Lewis 1979). Arntzenius (2008: 289-90) discusses cases where EDT seems to do worse in the long run than CDT. For an argument against Arntzenius see Ahmed and Price 2012. [↑](#footnote-ref-29)
30. Gärdenfors and Sahlin 1982; Gilboa and Schmeidler 1989. [↑](#footnote-ref-30)
31. Briefly to argue for these points: (i) the myopic causalist MEU maximizer is prepared to bet at Stage 2 if (65) and (66) are true, and will also be prepared to smoke at Stage 1 if, consistently with this, d2 ≤ 0.5. (ii) The sophisticated evidentialist who maximizes MMEU will bet at Stage 2 if (65) and (66) are true but will *not* smoke at Stage 1 if f2 < 0.5; since (66) guarantees this, EDT *never* advises O1P1 to this person. The myopic evidentialist who maximizes MEU will smoke at Stage 1 only if e2 ≤ 0.5 and bet at Stage 2 only if e1 ≥ 0.75; these conditions are inconsistent. (iii) It follows from Table 4 that any sort of evidentialist who follows the mid-point rule will not smoke at Stage 1. [↑](#footnote-ref-31)
32. See for instance Joyce’s requirement of full information (Joyce 2012: 127). The following comments on what I am calling DCDT apply equally to Joyce’s approach as set out in that paper. [↑](#footnote-ref-32)
33. For more details and further references see Arntzenius 2008: 292ff. [↑](#footnote-ref-33)
34. McClennen 1990: 12-13. [↑](#footnote-ref-34)
35. I owe this pithy formulation to Elga (2010: 9). For further references to the literature on resolute choice, see Elga 2010: 9n. 25. [↑](#footnote-ref-35)
36. Meacham 2010: 67. [↑](#footnote-ref-36)
37. This criticism of resoluteness applies a general point from Broome 1992: 668. There Broome endorses the sophisticated approach to sequential choice. [↑](#footnote-ref-37)
38. To see that Cr1 (T) > 0.75, note that since T = O1D v O2¬D, we have Cr1 (T) = Cr1 (T⏐O1) Cr1 (O1) + Cr1 (T⏐O2) Cr1 (O2) ≥ Cr1 (O1D⏐O1) Cr1 (O1) + Cr1 (O2¬D⏐O2) Cr1 (O2) = Cr1 (D⏐O1) Cr1 (O1) + Cr1 (¬D⏐O2) Cr1 (O2). By (1) and (4) it follows that Cr1 (T) > 0.75 Cr1 (O1) + 0.75 Cr1 (O2) = 0.75. Of course Cr2 (T) > 0.75 follows from (1), (4) and Bayesian updating. [↑](#footnote-ref-38)
39. For an argument against the past-future asymmetry see Dougherty 2011. For an argument against hyperbolic discounting see Mulligan 1996. [↑](#footnote-ref-39)
40. Ramsey 1990 [1926]: 78. [↑](#footnote-ref-40)
41. Van Fraassen 1984: 152-5. [↑](#footnote-ref-41)
42. Lewis 1999. [↑](#footnote-ref-42)
43. Christensen 2004: 110. [↑](#footnote-ref-43)
44. Skyrms (1980: 119-20) argues that Ramsey’s real concern is not that the wrong degrees of beliefs leave you open to certain loss, but the more ‘intellectual’ point that they involve inconsistent evaluations of the same uncertain prospect when it is presented in different ways. That makes it less clear that the present objection applies to Ramsey’s DBA, although Christensen (2004: 112-5) argues that it still does. But it doesn’t make the objection any more applicable to *my* argument. [↑](#footnote-ref-44)
45. Maher 1993: 96. [↑](#footnote-ref-45)
46. Maher 1992: 124-5. [↑](#footnote-ref-46)
47. Lewis (1999: 134n3) attributes this criticism to D. Kaplan and G. Harman. [↑](#footnote-ref-47)
48. This is my own development of a point due to Maher (1993: 110-13). [↑](#footnote-ref-48)
49. Savage 1972: 15-17. [↑](#footnote-ref-49)
50. I should perhaps repeat here a point from the section 6.3: of course it is true that O1P2 dominates O2P1 with respect to the partition {D, ¬D}: if D is true then O1P2 does better than O2P1, and if D is false then O1P2 does better than O2P1. But defenders of EDT won’t mind that—we already knew (from Newcomb’s Problem) that EDT sometimes recommends acts that are dominated with respect to a causally independent partition of states. Let me also repeat that O2P2 *super*dominates the (CDT-favoured) sequence O1P1: not only does O2P2 do better than O1P1 on either hypothesis about D, but also *any* possible outcome of O2P2 beats *any* possible outcome of O1P1. [↑](#footnote-ref-50)
51. Lewis 1981: 314. I have changed Lewis’s words to make them fit my example, but the point is unaltered. [↑](#footnote-ref-51)
52. Pearl 2000: 109. [↑](#footnote-ref-52)
53. Ramsey 1990 [1929]: 158; Price 1993: 261; Price 2012: 527. Price’s view actually differs from Ramsey’s, in that he (Price) allows that a contemplated act has evidential bearing on any past state on which it has retrocausal bearing. This difference is irrelevant in the context of the Insurance Problem, since nobody in his right mind could think that smoking now causes you *to have had* the defect all along. [↑](#footnote-ref-53)
54. See Kant 2000 [1781/7]: A542/B570-A557/B585 on the ‘transcendental idea of freedom’, the point of which is to constitute ‘a model of deliberative rationality which includes, as an ineliminable component, the thought of practical spontaneity… [T]he basic idea is simply that it is a condition of the possibility of taking oneself as a rational agent, that is, a being for whom reason is practical, that one attribute such spontaneity to oneself’ (Allison 1990: 45). See also Kant 1964 [1785]: 124-6 (Ak. 4: 456-8) on the ‘two standpoints’. [↑](#footnote-ref-54)
55. ‘Though in reflecting on human actions we seldom feel such a looseness or indifference, yet it very commonly happens, that in performing the actions themselves we are sensible of something like it… We *feel* that our actions are subject to our will on most occasions, and *imagine we feel* that the will itself is subject to nothing; because when by a denial of it we are provoked to try, we feel that it moves easily every way, and produces an image of itself even on that side, on which it did not settle… But these efforts are all in vain; and whatever capricious and irregular actions we may perform; as the desire of showing our liberty is the sole motive of our actions; we can never free ourselves from the bonds of necessity. We may imagine we feel a liberty within ourselves; but a spectator can commonly infer our actions from our motives and character; and even where he cannot, he concludes in general, that he might, were he perfectly acquainted with every circumstance of our situation and temper, and the most secret springs of our complexion and disposition.’ Hume 1949 [1738]: II.iii.2. Here Hume appeals to the spectator’s vision as a *corrective* to the agent’s, thus rejecting the idea that when my seeing my actions as uncaused arises from a different *perspective* on those acts from that of a spectator (who may be myself at a later date). [↑](#footnote-ref-55)
56. Anscombe 1957: sections 8, 28-32. Also and especially O’Shaughnessy 2008: ch. 9. [↑](#footnote-ref-56)
57. Haggard 2003: 119-124. [↑](#footnote-ref-57)