WHO'S AFRAID OF UNDERMINING?

Why the Principal Principle need not contradict Humean Supervenience

Abstract. The Principal Principle (PP) says that, for any proposition A, given any admissible evidence and the proposition that the chance of A is x%, one's conditional credence in A should be x%. Humean Supervenience (HS) claims that, among possible worlds like ours, no two differ without differing in the spacetime-point-by-spacetime-point arrangement of local properties. David Lewis (1986b, 1994) has argued that PP contradicts HS, and his argument has been accepted by Bigelow, Collins, and Pargetter (1993), Thau (1994), Hall (1994), Strevens (1995), Ismael (1996), and Hoefer (1997). Against this consensus, I argue that PP need not contradict HS.

1. Introduction.[1]

Behold: a uranium atom! Some physicists would claim that *this* uranium atom has a 50% chance of decaying within the next 6.5 billion years or so if left alone. Now I don't profess to fully understand what (objective) chance is, but at least I think I know this much: if I were certain that these physicists are right and I knew nothing else about this uranium atom, then I should, on pain of some kind of irrationality, be 50% confident that this atom will decay within the next 6.5 billion years or so if left alone. In other words, I adopt a *chance-credence principle*: a principle relating chance (objective probability) and credence (subjective probability, degree of belief). This principle, unfortunately, is elementary and rough. Can we say something more sophisticated? Can we be more precise?

Yes, we can. Or so several philosophers seem to think. A prominent example is Lewis (1980), whose widely discussed 'Principal Principle' (PP) is a chance-credence principle with considerable intuitive appeal. The crux of PP is a distinction between 'admissible' and 'inadmissible' evidence. Suppose I have a crystal ball which on numerous occasions has reliably predicted the spontaneous decay times of uranium atoms. If my crystal ball predicts that this uranium atom will spontaneously decay within the next three minutes, then I should no longer be so confident that this atom will stay around for billions of years if left alone. The crystal ball evidence would be *inadmissible*: it would break the link between chance and credence. *Admissible* evidence, on the contrary, preserves the link. Irrelevant evidence is always admissible: a storm in the antipodes can hardly affect this uranium atom. But some relevant evidence is also admissible; for instance, evidence that this atom was created three billion years ago. So we have an intuitive grasp of admissibility. Now PP roughly says that, for any proposition A, given any admissible evidence and the proposition that the chance of A is x%, one's conditional credence in A should be x% (details in §2). Is PP, as

[1] This section presents the issues in a simplified and slightly imprecise way, eschewing formalism and omitting details. Rigour is introduced in later sections.

Lewis (1994: 489) claims, 'the key to our concept of chance'?

Lewis was apparently happy with PP until he came to believe (1986b) that PP contradicts his cherished metaphysical thesis of 'Humean Supervenience' (HS). Take a dot matrix picture. Its global properties (e.g., symmetry) supervene on the point-by-point arrangement of dots: no two pictures differ without differing in the arrangement of dots. Similarly, HS claims that, among possible worlds like ours, no two differ without differing in the spacetime-point-by-spacetime-point arrangement of local properties. HS is inspired by Hume, the great denier of necessary connections: 'all there is to the world is a vast mosaic of particular fact, just one little thing and then another' (Lewis 1986b: ix; details in §3). But how on earth is HS supposed to contradict PP? Not directly, but in two steps, which I will now examine in order.

First step. If HS is true, then the configuration of present chances in our world is determined by the total (past, present, and future) arrangement of local properties in our world. Now every possible but nonactual future, in combination with the actual present and past, constitutes a total arrangement of local properties and thus (given HS) determines a possible configuration of present chances, a configuration in general different from the actual one. Suppose that one such future (to repeat, a possible but nonactual future which, in combination with the actual present and past, determines a configuration of present chances different from the actual one), call it *F*, has a positive (present, actual) chance of occurring. *F* will not occur, since it's not actual; but *could* it occur? 'Well, yes and no. It could, in the sense that there's non-zero present chance of it. It couldn't, in the sense that its coming to pass contradicts the truth about present chances' (Lewis 1994: 482; details in §4). The existence of such *undermining futures*, to which Lewis thinks that acceptance of HS commits him, is arguably (Lewis says 'certainly') very peculiar; but peculiarity is not (yet) contradiction.

Second step. To be specific, suppose that *F* has chance 60% but determines, in combination with the actual present and past, a configuration of chances that assigns chance 55% to *F*. Consider the conjunction *C* of the actual present and past with the proposition that the chance of *F* is 60%. *C* apparently contradicts *F* (because the conjunction *CF* apparently entails that the chance of *F* is both 55% and 60%), so that, given *C*, one's conditional credence in *F* should be zero. But PP says that this conditional credence should be 60%; hence the (putative) contradiction (details in §5).

Lewis is not alone in thinking that HS contradicts PP: variations on the above two-step argument have been approvingly rehearsed by Bigelow, Collins, and Pargetter (1993), Thau (1994), Hall (1994), Strevens (1995), and Hoefer (1997). Nevertheless, I beg to differ: my main thesis in this paper is that there is a flaw in the above argument. To see the flaw, go back to the beginning, namely to the definition of HS. Lewis defines HS as a thesis of *restricted* supervenience: it's not any two possible worlds whatsoever, but rather any two *among worlds like ours*, that don't differ without differing in the arrangement of local properties. What counts as a world like ours doesn't matter here; what matters is that, given Lewis's definition of HS, a total arrangement of local properties 'determines' (if HS is true) a configuration of chances only among worlds like ours. But then the conjunction of *C* with *F* in the last paragraph need not be *impossible*, false in *every* possible world; therefore, given *C*, one's conditional credence in *F* need not be zero, and no contradiction arises (details in §5). The point may look simple, but given that it goes against what seems to be a weighty consensus, I will spend some time in the body of the paper laying out the issues rigorously and addressing possible objections.

In §2, §3, and §4 I set the stage by formulating PP, HS, and undermining respectively. In §5 (the crux of the paper) I argue that HS need not contradict PP. In §6 I examine a second putative contradiction. In §7 I provide some concluding remarks.

2. The Principal Principle.

Let Cr be the credence function of a rational person (at some time instant); i.e., the function which assigns to any proposition A about which the person has a belief a number in [0, 1] which is the person's degree of belief in A (assuming, to simplify, that every belief has a degree). Let Ch be the chance function (at some time instant); i.e., the function which assigns to any proposition A that has a chance a number in [0, 1] which is the chance of A. Let $<Ch(A)=x>$ be the proposition that $Ch(A)$ is x, x being a number in [0, 1]. Let E be any proposition. Then a rough but for present purposes adequate formulation of PP is as follows (cf. Lewis 1980: 87):

(PP) If E is admissible with respect to $<Ch(A)=x>$, then: $Cr(A|E<Ch(A)=x>) = x$.

For my purposes it will be more convenient to use a consequence of PP, which I call the 'Expert Principle' (EP). Let 'f' denote *rigidly* (Kripke 1980: 77-8) a function from propositions to numbers in [0, 1]. Let T_f be the proposition that Ch is f; i.e., that (i) dom Ch = dom f and (ii) for every A in dom f, $Ch(A) = f(A)$. T_f entails propositions (like $<Ch(A)=f(A)>$) that specify the chances of various propositions. For example, if $f(A)$ is 0.3, then T_f entails the proposition that $Ch(A)$ is 0.3. Note that 'Ch' denotes the chance function *nonrigidly* (cf. Lewis 1980: 89). If T_f in the above example is true, then $Ch(A)$ is in fact 0.3; but if the chance of A had been 0.5, then $Ch(A)$ would have been 0.5 (whereas $f(A)$ would still have been 0.3, so that T_f would have been false). Now it can be shown that PP entails EP:

(EP) For every A in dom f, if ET_f is admissible with respect to $<Ch(A)=f(A)>$, then: $Cr(A|ET_f)=f(A)$.

EP corresponds to Lewis's 'reformulation' of PP (1980: 97).[2]

3. Humean Supervenience.

Lewis calls 'Humean Supervenience' (HS) 'the doctrine that all there is to the world is a vast mosaic of local matters

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[2] I borrow the term 'expert' from Gaifman (1988: 192-3) and from van Fraassen (1989: 198-9, 201-2). EP is similar to Skyrms's 'Generalized Miller' principle (1980: 124). Here is how EP follows from PP. If ET_f is admissible with respect to $<Ch(A)=f(A)>$, then PP gives, with ET_f in the place of E and $f(A)$ in the place of x: $Cr(A|ET_f<Ch(A)=f(A)>) = f(A)$. But T_f entails $<Ch(A)=f(A)>$. So PP gives: $Cr(A|ET_f) = f(A)$.

of particular fact, just one little thing and then another' (1986b: ix). Here is an analogy (Lewis 1986a: 14):

> A dot-matrix picture has global properties – it is symmetrical, it is cluttered, and whatnot – and yet all there is to the picture is dots and non-dots at each point of the matrix. The global properties are nothing but patterns in the dots. They supervene: no two pictures could differ in their global properties without differing, somewhere, in whether there is or there isn't a dot. … [Similarly:] The world has its laws of nature, its chances and causal relationships; and yet – perhaps! – all there is to the world is point-by-point distribution of local qualitative character.

Haslanger comments: 'There is a compelling idea here, for it is plausible to think that what happens *over* time, and *over* space, depends on what happens at particular points along the way' (1994: 342).

Lewis defines *local qualities* as 'perfectly natural intrinsic properties of points, or of point-sized occupants of points', and understands an *arrangement of qualities* as a 'spatiotemporal arrangement of local qualities throughout all of history, past and present and future' (1994: 474). Then Lewis formulates HS as a thesis of restricted global supervenience: 'among *worlds like ours*, no two differ without difference in the arrangement of qualities' (1994: 474). To see why Lewis formulates HS as a thesis of *restricted* supervenience, consider an analogy with materialism: 'to be a materialist one need not deny the very possibility of spirits. Some worlds have spirits, even if ours does not. Instead we look to articulate a materialist thesis which locates our world among a special set of worlds, and postulates, e.g., that between members of this restricted set there is no mental difference without a physical difference' (Haslanger 1994: 343; cf. Lewis 1983: 362-4). Similarly, according to Lewis, some worlds differ without differing in the arrangement of qualities. Some of these worlds are not 'like ours'; e.g., 'there might be emergent natural properties of more-than-point-sized things' (1986b: x). The details of what counts as a world like ours don't matter for present purposes; what matters is that Lewis uses 'worlds like ours' rigidly and that, according to Lewis, some worlds are *not* like ours.

Lewis recognizes that HS 'is inspired by classical physics' (1994: 474), but claims that he 'wouldn't grieve' if physics itself were to teach him that HS is false (1986b: xi) (e.g., by teaching him that 'many fundamental properties are instantiated not at points but at point-tuples'), because his defence of the philosophical tenability of HS 'can doubtless be adapted to whatever better supervenience thesis may emerge from better physics' (1994: 474). Lewis's concession that the truth of HS depends on the truth of something like classical physics and is thus an 'empirical' issue (1986b: xi) will prove crucial for my argument in the sequel.

4. Undermining.

Let H be the *total history function*; i.e., the function which specifies the arrangement of qualities. Given a time instant t, let H_- and H_+ be the *pre-t* history function and the *post-t* history function respectively; i.e., the function which specifies the arrangement of qualities for time instants *not later* than t and later than t respectively. Note that 'H', 'H_-', and 'H_+' denote history functions *nonrigidly*; I will use (e.g.) 'h', 'h_-', and 'h_+' to denote *rigidly* history functions (cf. the distinction between *Ch* and *f* in §2).

Applied to chances, HS has the following consequence:

(HS_1) For any time instant *t* and for any worlds *w* and *w'* like ours, if *w* and *w'* have the same total history function, then *w* and *w'* have the same chance function at *t*.

Besides holding HS_1, Lewis (for reasons that don't matter here—see 1994: 484) *denies* HS_2:

(HS_2) There is a time instant *t* such that, for any worlds *w* and *w'* like ours, if *w* and *w'* have the same pre-*t* history function, then *w* and *w'* have the same chance function at *t*.

In Lewis's words: 'present chances supervene upon the whole of history, future as well as present and past; but not upon the past and present alone' (1994: 482).

Now accepting HS_1 while denying HS_2 has an arguably peculiar consequence. Consider a time instant *t* and suppose that HS_2 is false. Then there are worlds *w* and *w'* like ours that have the same pre-*t* history function h_- but different chance functions at *t*, *f* and *f'*. Given HS_1, *w* and *w'* have different total history functions, so they have different post-*t* history functions, h_+ and h'_+. Given again HS_1, *any* world like ours that has pre-*t* history function h_- and post-*t* history function h'_+ will have chance function *f'* at *t*; thus the conjunction (*C*) of the propositions that H_- is h_- and that H_+ is h'_+ *entails* (among worlds like ours) that *Ch* is *not f*. What makes this result arguably peculiar is that the conjunction *C* is *possible* (among worlds like ours), since *C* is true in *w'*; therefore, roughly speaking, in *w* at *t* there is a possible future whose realization would make the chances at *t* different from what they are. Lewis comments: 'It's not that if this future came about the present would change retrospectively. Rather, it would never have been what it actually is, and would always have been something different. This undermining is certainly very peculiar' (1994: 482-3).

More formally, define *undermining* as follows:

(UN) Given the proposition (T_-) that H_- is h_-, the proposition (T_+) that H_+ is h_+ *undermines* the proposition (T_f) that *Ch* is *f* exactly if (1) T_-T_f and T_-T_+ are possible among worlds like ours and (2) T_-T_+ entails among worlds like ours (T_f. (Then T_+ is an *undermining future* and T_f is *underminable*.)[3]

Note that *possibility and entailment in UN are restricted to worlds like ours*; this restriction is usually omitted in

[3] Cf.: Lewis 1994: 482; Thau 1994: 495; Hall 1994: 509; Strevens 1995: 549; Ismael 1996: 81; Hoefer 1997: 323. Usually the condition that T_-T_f be possible (among worlds like ours) is omitted from the definition of undermining, presumably because it's assumed that T_-T_f is true. Undermining can also be defined by replacing T_f with the proposition that $Ch(T_+)$ is *x* (a number in [0, 1]); this special case corresponds to what I call a 'self-undermining' future.

definitions of undermining[4] but is crucial for my argument in §5.

What I showed above (following Ismael 1996: 82) is that the conjunction of HS_1 with the denial of HS_2 has the consequence that, for any time instant *t*, there is an undermining future. Is this consequence problematic? Answering this question *in general* is beyond the scope of this paper, but I argue next that there is a flaw in a commonly adduced reasoning that purports to derive a contradiction from the conjunction of EP with the existence of undermining futures.

5. The putative contradiction and its failure.

The reasoning purporting to derive a contradiction from the conjunction of EP with the existence of undermining futures can be formulated as follows. Suppose that, given T_-, T_+ undermines T_f. Suppose also that $f(T_+)$ is positive[5] and that T_-T_f is admissible with respect to $<Ch(T_+)=f(T_+)>$. Then EP (§2), with T_+ in the place of A and T_- in the place of E, gives that $Cr(T_+|T_-T_f)$ is $f(T_+)$ and is thus positive. On the other hand, UN gives that T_-T_+ entails $(T_f$, so that $Cr(T_-T_+T_f)$, hence also $Cr(T_+|T_-T_f)$, should be zero.[6] Contradiction?

No. According to UN, T_-T_+ entails $(T_f$ *among worlds like ours* (§4). If some worlds are not like ours (§3), then one may *not* conclude that T_-T_+ entails $(T_f$ *simpliciter*. $T_-T_+T_f$ is false but need not be *impossible*. One may not conclude that $Cr(T_-T_+T_f)$ should be zero. The above reasoning is blocked.

One might grant that the above reasoning is blocked but claim that 'the inconsistency is of the probabilistic and not the logical sort' (Thau 1994: 495), in the sense that $Cr(T_-T_+T_f)$ should be zero even if $T_-T_+T_f$ is not impossible. I

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4 Of course one can define undermining as one wishes, but if one defines undermining by means of *unrestricted* entailment, then accepting HS_1 ((HS_2 gives little reason to believe that undermining futures exist.

5 Usually the condition that $f(T_+)$ be positive is included in the *definition* of undermining. Lewis (1994: 482; but contrast 1980: 130) and Ismael are exceptions: Lewis in effect claims that the positivity of $f(T_+)$ follows from the assumption that 'the differences between … alternative futures are differences in the outcomes of present or future chance events' (1994: 482), and Ismael (1996: 82 n. 6) gives a similar reasoning. I disagree: if a coin is to be tossed infinitely many times, then (under suitable assumptions) every particular infinite sequence of heads and tails has chance zero. Nevertheless, I omitted from UN the condition that $f(T_+)$ be positive partly because I didn't want to spoil the theorem (in §4) that HS_1 ((HS_2 entails, for any *t*, the existence of undermining futures.

6 This reasoning comes in several related variants. (See: Bigelow, Collins, and Pargetter 1993: 445-6; Lewis 1980: 130, 1994: 483; Thau 1994: 496; Hall 1994: 509-10; Strevens 1995: 549-50; Hoefer 1997: 325. Ismael 1996: 82 n. 6 endorses the reasoning without going through it.) A variant of the reasoning uses PP instead of EP and *self*-undermining (footnote) instead of undermining futures. This variant goes as follows (cf. §1). Let C be the proposition $<Ch(T_+)=x>$ $(x > 0)$. Suppose that T_+ is a self-undermining future with respect to T_- and C. Suppose also that T_- is admissible with respect to C. Then PP (§2) gives that $Cr(T_+|T_-C)$ is x and is thus positive; but self-undermining gives that T_-T_+ entails $(C$, so that $Cr(T_+|T_-C)$ should be zero.

will examine two arguments for the conclusion that $Cr(T_-T_+T_f)$ should be zero. For both arguments, call U the proposition that, given T_-, T_+ undermines T_f.

<u>Argument A.</u> Given UN, U entails that $T_-T_+T_f$ is false among worlds like ours, so that $Cr(UT_-T_+T_f)$ should be zero. U is noncontingent and is by assumption true; thus U is necessary, so that $Cr(U)$ should be one and $Cr(T_-T_+T_f)$ should be equal to $Cr(UT_-T_+T_f)$ and should thus be zero.

<u>My reply.</u> If the reasoning of Argument A is accepted, then the absurd conclusion follows that *every* false proposition should get credence zero and *every* true proposition should get credence one. Here is why. Take any false proposition G and call G' the proposition that G is false in our world. (I use 'our world' rigidly because, as I said in §3, Lewis uses 'worlds like ours' rigidly.) According to the reasoning of Argument A, $Cr(G'G)$ should be zero and (given that G' is noncontingent and true and is thus necessary) $Cr(G')$ should be one; then $Cr(G)$ should be equal to $Cr(G'G)$ and should thus be zero. Moreover, if G^* is any true proposition, $(G^*$ is false, so that $Cr((G^*)$ should be zero and $Cr(G^*)$ should be one. I need not take a stand here on whether this absurd conclusion should be avoided by rejecting the claim that $Cr(UT_-T_+T_f)$ (and $Cr(G'G)$) should be zero or by rejecting the principle that every necessary proposition should get credence one (or both); the fact that I have provided a *reductio* of Argument A suffices for present purposes.

<u>Argument B.</u> (1) U is a priori true.

Therefore: (2) $T_-T_+T_f$ is a priori false.

(3) Every a priori false proposition should get credence zero.

Therefore: (4) $Cr(T_-T_+T_f)$ should be zero.

<u>My reply.</u> First, a preliminary remark. Call N the principle that every necessary proposition should get credence one. If one accepts Argument B, then one should reject N. Here is why. Accepting (1) and (2) commits one to accepting: (5) $UT_-T_+T_f$ is a priori false. Accepting in addition (3) commits one to accepting: (6) $Cr(UT_-T_+T_f)$ should be zero. (The argument from (3) and (5) to (6) was implicit in Argument A, where (6) was used without explicit justification.) But my *reductio* of Argument A showed that one cannot accept both (6) and N. Given that Argument B commits one to (6), Argument B commits one to rejecting N. For some people this may be reason enough to reject Argument B. Let's proceed, however, on the assumption that N is rejected. I will argue that there are two problems with Argument B. First, (3) is questionable. Second, and more important, (1) is false.

(i) Let's see first why (3) is questionable. It's reasonable to assign credence in (0, 1) to provable mathematical propositions for which no proof is currently available. But provable mathematical propositions are generally considered to be a priori true. There are thus putative counterexamples to (3).

One might respond by amending Argument B. (3) refers to a priori false propositions; i.e., to propositions *knowable* a priori to be false. Replace (3) with: (3*) every proposition *known* a priori to be false should get credence zero. The amended argument circumvents the above putative counterexamples.

I reply that even (3*) is dubious. Suppose that Fermat's Last Theorem is known a priori to be true by those mathematicians who have carefully checked Wiles's proof (Singh and Ribet 1997). Nevertheless, the proof is so complicated that it seems reasonable for those mathematicians to keep an open mind and assign positive credence to the negation of the theorem.

(This reply may fail when a *simple* proof is available. For example, since U entails that $T_-T_+T_f$ is false among worlds like ours, it's simple to prove that $UT_-T_+T_f$ is false. I am willing to concede—and this concession will play an important role in §6—that $Cr(UT_-T_+T_f)$ should be zero. But I see no simple proof of U, or any proof at all.)

One might respond by claiming that (3*) applies only to idealized epistemic agents (who are, presumably, infallible reasoners). I have two replies. First, if different epistemic principles apply to idealized and to real agents, then the fact (if it is a fact) that EP does not apply to idealized agents fails to show that EP does not apply to real agents. Second, and more important, why do even idealized agents know U a priori? In fact, I will now argue that U is not even *knowable* a priori.

(ii) Let's see, then, why (1) is false. Recall from §3 that the truth of HS depends on the truth of something like classical physics. But it is not a priori knowable whether something like classical physics is true. Therefore, as Lewis himself concedes, the truth of HS is an 'empirical' issue; i.e., HS is not a priori knowable. Similarly for HS_1, which U presupposes. Therefore, U is not a priori knowable. Note also that, even if HS_1 were a priori knowable, (1) would not follow, because HS_1 says only that chances supervene on arrangements of qualities, whereas (1) presupposes that *the specific way* in which chances supervene on arrangements of qualities is a priori knowable.

I conclude that the putative contradiction fails.

6. A second putative contradiction.

In my reply to Argument B (§5) I parenthetically conceded that $Cr(UT_-T_+T_f)$ should be zero. One might exploit this concession by modifying as follows the reasoning that led to the putative contradiction. Suppose that UT_-T_f (rather than just T_-T_f) is admissible with respect to $<Ch(T_+)=f(T_+)>$. Then EP gives that $Cr(T_+|UT_-T_f)$ is $f(T_+)$ and is thus positive. But I have conceded that $Cr(UT_-T_+T_f)$, hence also $Cr(T_+|UT_-T_f)$, should be zero. Contradiction!

Though closely related to the first, this second putative contradiction is nowhere to be found in the literature. With good reason: as I will argue, it has a much less dramatic consequence than the consequence which Lewis drew from the first putative contradiction.

Consider first a range of *possible* reactions to the two putative contradictions. One could reject HS_1 (hence also HS, since HS entails HS_1). One could accept HS_2. One could accept HS_1 ((HS_2 but deny the existence of *strongly* undermining futures; i.e., of undermining futures with $f(T_+) > 0$. One could accept the existence of strongly undermining futures but deny that any of these futures corresponds to T_- and T_f such that T_-T_f (for the first putative contradiction) or UT_-T_f (for the second putative contradiction) is admissible with respect to $<Ch(T_+)=f(T_+)>$. Or, one could reject EP (hence also PP, since PP entails EP).

Reacting to the first putative contradiction, Lewis chose to reject PP. Here is his reasoning. If HS_1 ((HS_2 holds, i.e., 'if chancemaking patterns extend into the future, then *any* use of the Principal Principle is fallacious. For *any* proposition that bears information about present chances thereby bears information about future history' (1994: 485). Lewis, however, needs (but does not give) an argument for his claim that 'information about present chances is inadmissible, *because* it reveals future history' (1994: 486, emphasis added).[7] *Some* information about the future is clearly inadmissible: witness the crystal ball evidence in §1. But some information about the future may be admissible: a solar eclipse next year can hardly affect an imminent coin toss (Strevens 1995: 551). Is Lewis's reaction to the first putative contradiction an overreaction? Rather than rejecting the admissibility of *every* proposition about present chances, one might reject *only* the admissibility (with respect to $<Ch(T_+)=f(T_+)>$) of T_-T_f, whenever T_- and T_f correspond to a strongly undermining future T_+.

Lewis might reply that he sees no principled reason for denying the admissibility of T_-T_f while maintaining the admissibility of ordinary propositions about present chances. Such a reply, however, is not available when one wonders what is the proper reaction to the *second* putative contradiction. There *is* a principled reason for denying *specifically* the admissibility of UT_-T_f: similarly to the way in which crystal ball evidence is inadmissible, UT_-T_f is inadmissible because UT_-T_f says directly that the undermining future T_+ will not come about. Therefore, even if the reality of the second putative contradiction is granted, proponents of HS need not thereby reject PP: they need only reject the admissibility of UT_-T_f, and they can do so with good reason.

7. Conclusion: against imperfectionism.

PP is so intuitive that it cannot be lightly discarded. In fact, Lewis's rejection of PP apparently left him feeling uneasy. In the concluding section (entitled 'Against perfectionism') of his 1994 paper, Lewis wrote: 'A feature of

[7] One might think that such an argument can be easily constructed: 'if we know that nine out of the next ten tosses of a fair coin will land heads, we will not set our subjective probability that the very next toss lands tails to one half. … But on a frequency account of chance, *all* information about probabilities is information, in part, about future frequencies. So information about probabilities is itself inadmissible' (Strevens 1995: 554). I would think, however, that on a (crude) frequentist account, saying that the chance of tails is one half amounts roughly to saying that the proportion of tails in tosses of the coin over all eternity is one half, and *this* proposition doesn't look inadmissible (assuming that the tosses go on forever), even if it's partly about the future.

Reality deserves the name of chance to the extent that it occupies the definitive role of chance; and occupying the role means obeying the [Principal] Principle … Because of undermining, nothing perfectly occupies the role, so *nothing perfectly deserves the name*. But … an imperfect candidate may deserve the name quite well enough' (1994: 489, emphasis added; cf. Hoefer 1997: 334). If my argument in this paper succeeds, we can escape this unpalatable conclusion. We need not espouse Lewis's imperfectionism. Proponents of PP need not be afraid of undermining.

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