# Chance and Actuality

Moritz Schulz

Penultimate draft. Please quote from the published version (PQ 2011).

**Abstract**

The relation between chance and actuality gives rise to the following puzzle. On the one hand, it may be a chancy matter what will actually happen. On the other hand, standard semantics for 'actually' imply that sentences beginning with 'actually' are never contingent. In order to elucidate this puzzle, a kind of objective semantic indeterminacy will be defended: in a chancy world, it may be a chancy matter which proposition is expressed by sentences containing 'actually'. As an application, this thesis is brought to bear on certain counterexamples to the Principal Principle recently proposed by Hawthorne & Lasonen-Aarnio.

## 1 A Puzzle

In a chancy world, there are non-trivial objective chances concerning what will actually happen, or so it seems. Suppose a fair coin is tossed and that it is a genuinely chancy matter what the outcome will be. On the face of it, there is a chance that the coin will actually come up heads, and there is a chance that the coin will actually come up tails. Let HEADS be 'the coin will come up heads' and TAILS be 'the coin will come up tails'. Then, for some time $t$ in some chancy world $w$, one is tempted to say

(1) $\mathrm{Ch}_{w,t}(\text{Actually } \textsc{Heads}) > 0$ and $\mathrm{Ch}_{w,t}(\text{Actually } \textsc{Tails}) > 0$.[1]

However, this may be a bad idea. Standard semantics for 'actually' construes sentences beginning with 'actually' to be either necessarily true or necessarily false.[2] This is because 'actually' is described as an operator which rigidifies the semantic value of the embedded formula within the context of utterance: in evaluating 'Actually $p$' with respect to some world, we are always taken back to the world of the context of utterance. Consequently, 'Actually $p$' expresses a necessary truth just in case '$p$' is true in the actual world, and

[1] Here and in what follows, $\mathrm{Ch}_{w,t}$ is the chance distribution in world $w$ at time $t$. For present purpose, it would be most natural to think of $w$ as the actual world. Otherwise, it should be stressed that 'actually' is intended to be evaluated in $w$ and not with respect to some other world.

[2] See Crossley & Humberstone (1977).

it expresses a necessary falsehood just in case '$p$' is false in the actual world. Application to our example yields the following:

(2) $\neg\Diamond$(Actually HEADS) or $\neg\Diamond$(Actually TAILS).

The coin will either come up heads or tails. If it comes up tails, it will be impossible that it actually comes up heads. If it comes up heads, it will be impossible that it actually comes up tails.

Yet only contingencies have non-trivial chances of being true. If something is impossible, it never has a chance of being true; and if something is necessary, it never has a chance of being false. Let us make this explicit:

(3) Impossibilities never have a chance of being true (and necessities never have a chance of being false).

But assumptions (1) to (3) are incompatible. Given (3), we can argue from (2) to the falsity of (1). First suppose the first disjunct in (2), i.e. that it is impossible that the coin actually comes up heads. Then, by (3), the first conjunct in (1) is false. By a parallel argument, the falsity of the second conjunct in (1) follows from the truth of the second disjunct in (2). So, in any case, one of the conjuncts in (1) will be false. Which way out?

In this paper, I am interested in a solution to the puzzle which sticks to the last two assumptions and gives up the first. Let me briefly indicate why assumptions (2) and (3) are worth preserving. The last assumption, claiming that necessities and impossibilities are never assigned non-trivial objective chances, seems hardly to be disputable. Objective chance is a restricted kind of metaphysical modality. And if something is impossible in the broad metaphysical sense, it is impossible in any narrower sense. In particular, if something is metaphysically impossible, it has never an objective chance of being true. The second assumption is less obvious but strongly supported by how 'actually' embeds into contexts of objective modality as witnessed by the following examples:

(4) If he had watched less TV as a child, he would have been smarter than he <u>actually</u> is.

(5) He could have been smarter than he <u>actually</u> is.

(6) There was a chance that he would be smarter than he <u>actually</u> is.

Given the success of standard semantics for 'actually' in explaining the embedding behavior of 'actually' within constructions involving objective modals, it would be nice to explain the puzzle in accordance with this account.

Denying the first assumption raises subtle issues concerning the relation between subjective credences and objective chances. On the one hand, one will want to preserve the plausible thought that a sentence '$p$' and its 'actually'-variant 'Actually $p$' are *a priori* equivalent. On the other hand, one will need to say that they can be assigned different objective chances. This may be thought to threaten Lewis's Principal Principle.

One may doubt, though, that we are dealing with a real puzzle here.[3] After all, there are various routes to explain away the intuitive appeal of the first assumption. For a start, 'actually' can be used simply as a rhetorical marker which is semantically redundant. Hence, one may easily assign the first assumption a true interpretation by invoking a redundant reading of 'actually'.[4,5] Second, an epistemic reading of 'chance' may be available on which the first assumption comes out true. Finally, it should be pointed out that a colloquial rendering of (1) sounds somewhat stilted. So, the intuitive support of (1) may be rather weak. Taken together, isn't this an easy way out?

There remains some puzzlement. We may still ask: on the rigid interpretation of 'actually', which of 'Actually HEADS' and 'Actually TAILS' is necessary? Given that the outcome of the toss is indeterminate at $t$, that is given that there is a chance that the coin comes up heads and there is a chance that it comes up tails, a sensible response seems to be: that's indeterminate at $t$! A natural rendering of this response would be

(1′) $\mathrm{Ch}_{w,t}(\Box\text{Actually }\textsc{Heads}) > 0$ and $\mathrm{Ch}_{w,t}(\Box\text{Actually }\textsc{Tails}) > 0$.

Yet this reinstantiates a variant of our original puzzle, for one of the two embedded sentences will be impossible:

(2′) $\neg\Diamond(\Box\text{Actually }\textsc{Heads})$ or $\neg\Diamond(\Box\text{Actually }\textsc{Tails})$.[6]

By the same argument as above, these two assumption are seen to be incompatible. So, the question is: where can we safely locate an indeterminacy of actuality?

[3]Thanks to Richard Dietz for bringing this issue to my attention.

[4]I leave it open whether the rhetorical use of 'actually' embeds freely enough into complex syntactic constructions in order to be available in the first premise.

[5]Some philosophers have argued that there is evidence for a shifty reading of 'actually' which is not based on its rhetorical interpretation. See the postscript to Lewis (1970) and Van Inwagen (1980). However, the standard examples are in terms of the adjective 'actual' as in 'Some other world might have been actual'. It is not easy to see whether these examples can be reproduced by using the adverb 'actually' instead of the adjective. For instance, I cannot get a reading of the sample sentences (4) to (6) on which they are obviously false.

[6]This assumes a relevant instance of the S5-axiom. Even though this axiom may be disputable, it would be surprising if an account of chance and actuality were forced to deny it.

I will proceed as follows. After some stage setting, I will develop the view that the indeterminacy of actuality is best understood in a metalinguistic way: sometimes it is indeterminate which proposition is expressed by sentences containing 'actually'. Thereafter, I will show how this thesis relates to the puzzle we started with. Finally, I will look at Lewis's Principal Principle and some counterexamples to it which have recently been mentioned by Hawthorne & Lasonen-Aarnio.

## 2 Setting the Stage

An indeterministic world can be understood in terms of the objective possibilities it gives rise to. Given a world $w$, we can assume that a world $w^*$ is an objective possibility with respect to $w$ at time $t$ just in case the history of $w^*$ up to $t$ is the same as the history of $w$ and $w$ and $w^*$ are governed by the same basic laws of nature. To a world $w$ and a time $t$, let $\mathrm{HL}(w, t)$ be the set of worlds which share the history of $w$ up to and including $t$ and which are governed by the same laws of nature. It is always $w \in \mathrm{HL}(w, t)$. Every world $w^* \in \mathrm{HL}(w, t)$ will be called an *objective possibility* at $t$ in $w$.[7] Finally, in a world $w$ at time $t$ it is *determinate that* $p$ iff the proposition that $p$ is true at every world $w^* \in \mathrm{HL}(w, t)$; and it is *determinate whether* $p$ in $w$ at $t$ just in case it is either determinate that $p$ or determinate that not $p$. Accordingly, it is *indeterminate whether* $p$ iff it is not determinate whether $p$.

Thus, the objective possibilities in a world are construed as time-relative. Whether the coin will come up heads may be indeterminate at a time $t$, but at a later time, after the coin landed, it will be determinate that the coin came up heads. Quite generally, at a time $t$, statements solely about the history up to time $t$ are always determinate, since all worlds in $\mathrm{HL}(w, t)$ share their history up to time $t$. For an analogous reason, the laws of nature are always determinately true.

Within this framework, we can call a world $w$ *indeterministic* if for some time $t$, the set $\mathrm{HL}(w, t)$ contains a world $w^*$ unequal to $w$. This definition of indeterminism amounts to the idea that a world is indeterministic if the basic laws of nature together with the history up to a certain time do not always imply what happens at later times. This definition of indeterminism or indeterminacy should be kept distinct from the many other philosophical doctrines which are sometimes subsumed under these labels. For instance, it has nothing to do with the sense in which vague sentences are sometimes called 'indeterminate'.

[7] This taxonomy is close to the one in Hawthorne & Lasonen-Aarnio (*forthcoming*); an objective possibility is what they call a *branching possibility*.

More to the present point, this conception should not be conflated with certain *semantic* theories concerning future contingents. For example, various theories would assign to future contingents under certain circumstances the semantic value 'indeterminate' which means roughly the same as 'neither true nor false'. No such semantic presumptions have been built into the present definition of indeterminism; it remains a substantial question which semantics is appropriate for future contingents when the world is indeterministic in the present sense. For all that has been said, the world may be indeterministic and yet bivalence does not fail.

A note on indeterminism versus chanciness. I would not object to saying that a world is *chancy* just in case it is indeterministic because I would be happy to grant that there can only be non-trivial objective chances in a world if that world is indeterministic.[8] But since there is a debate concerning the possibility of *deterministic chance*, it may be better not to adopt a terminology which would close this debate off.[9] However, even proponents of deterministic chance can grant that there is a certain level—presumably the level of most fundamental physics—with respect to which chanciness lines up with indeterminism. When I use 'chancy' or 'chance' in what follows, a proponent of deterministic chance should take them to apply to this most fundamental level.

Since it simplifies the issue considerably, I will take propositions to be sets of possible worlds. In particular, this licenses speaking of *the* necessary truth and *the* necessary falsehood. Apart from the word 'actually', I will ignore the possible indexicality of sentences. So, I will assume that sentences express propositions relative to the world of utterance. This allows that sentences containing 'actually' express different propositions in different worlds. For instance, in a world $w$ in which the coin comes up heads, the sentence 'The coin will actually come up heads' expresses the necessary proposition, whereas in a world $w^*$ in which the coin comes up tails, this sentence expresses the impossible proposition. Expressions such as 'here', 'now', and 'I' demand a richer model of contexts; but since they are not our present concern, they can be safely ignored. Sometimes, I will speak of the propositional value of a sentence in a world $w$: this will always mean the proposition expressed by this sentence in $w$.

[8] A note of caution. A Newtonian world may be indeterministic (cp. Norton 2008) although Newtonion physics does not mention probabilities. The present use of 'chancy' should therefore not be taken to imply that the basic laws must be probabilistic.

[9] For the debate on deterministic chance, see e.g. Schaffer (2007) and Glynn (forthcoming).

## 3 The Argument

Let us focus on a particular utterance of 'The coin will actually come up heads'. Suppose in some world $w$ at some time $t$ it is indeterminate whether the coin will come up heads. Which proposition is expressed by 'The coin will actually come up heads' in $w$ at $t$? There is an objective possibility according to which the coin comes up heads, and there is an objective possibility according to which the coin comes up tails. Now, in the former case the sentence 'The coin will actually come up heads' expresses the necessary proposition, and in the latter case it expresses the impossible proposition. Hence, it will be indeterminate which proposition is expressed by 'The coin will actually come up heads' in $w$ at $t$. In a nutshell, this is the basic argument. Thus, objective indeterminacy induces a certain kind of objective semantic indeterminacy: if it is indeterminate whether $p$, it will be indeterminate which proposition is expressed by 'Actually $p$'. Let us capture this in the following schema:

> **(Objective Semantic Indeterminacy)**
> Assume that in a world $w$ at a time $t$ it is indeterminate whether $p$. Then it is in $w$ at $t$ indeterminate which proposition is expressed by 'Actually $p$'.

I am not sure whether 'objective semantic indeterminacy' is a good label, for it can probably be misunderstood in many ways. For instance, one may hear semantic indeterminacy to imply a failure of bivalence, that is a sentence would be semantically indeterminate just in case it is neither true nor false. As already indicated, this sense of semantic indeterminacy is not the one intended here. Similarly, there are notions of semantic indeterminacy which center around phenomena such as vagueness, semantic imprecision, semantic underdetermination, etc. Set those aside as well. Nevertheless, there is something genuinely semantic about the present phenomenon: it concerns objective possibilities as to which proposition a sentence at a given time expresses. I have prefixed the label with the adjective 'objective' hoping that it reminds one of objective possibilities. Another possible label would be 'semantic chanciness'. I would be happy with this label, but, as noted above, it does not square well with the idea of deterministic chance.

Let me try to give a somewhat more precise argument for the thesis of objective semantic indeterminacy so understood. For present purposes, I take 'express' to mean 'expresses in current English'. This will ensure that if we look at which propositions are expressed by a given sentence at another world, we take the sentence to mean what it actually means. In particular, the fact that there are sometimes chances that certain expressions change their meaning in English will not be described as an instance of objective semantic indeterminacy. The point of the principle above is rather that the propositional value of sentences containing 'actually' may be indeterminate even if there is no chance that these sentences change their meaning: there are objective possibilities in which 'Actually $p$' expresses different propositions but does not have a different linguistic meaning.

The stipulation that 'express' is taken to mean 'expresses in current English' makes the following principle true, which can be used to give a precise argument for the thesis of objective semantic indeterminacy:

(7) Necessarily, 'Actually $p$' expresses the necessary proposition iff $p$.[10]

In every world $w$ considered as the world of utterance in which 'Actually $p$' has its current linguistic meaning, or is evaluated as having this meaning, it expresses the necessary proposition if and only if the proposition that $p$ is true in $w$; otherwise it will express the impossible proposition.

Now, the thesis of objective semantic indeterminacy can be shown to be true by the following argument. Assume that in a world $w$ at a time $t$ it is indeterminate whether $p$. Then there is at $t$ an objective possibility $w_1$ at which it is true that $p$ and an objective possibility $w_2$ at which it is false that $p$. By (7), 'Actually $p$' expresses the necessary proposition in $w_1$ but not in $w_2$ (in $w_2$ the impossible proposition is expressed). Therefore, it is indeterminate in $w$ at $t$ which proposition is expressed by 'Actually $p$'.

To better understand the argument, contrast the present case with an example in which there is no semantic indeterminacy. Take the sentence 'The coin will come up heads' at a time $t$ at which it is still indeterminate how the coin will land, that is there is an objective possibility that the coin will come up heads and there is an objective possibility that it will come up tails. Now, the sentence 'The coin will come up heads' is—in the present sense of this expression—semantically determinate at $t$. No matter how the coin lands, the sentence will express the same proposition, namely the set of worlds at which the coin comes up heads. So, for many sentences '$p$', it is at a given time $t$ determinate which proposition they express despite it being indeterminate whether $p$.

If it is in $w$ at $t$ indeterminate which proposition a sentence of the form 'Actually $p$' expresses, does this mean that it is at $t$ somehow indeterminate

[10] Here and in what follows, instances of '$p$' are assumed to be free of indexical elements. In particular, they may not contain 'actually' itself. Otherwise the principle would be false, for 'actually' would take scope over the initial necessity operator.

which world $w$ is? The following line of thought might be possible. If it is indeterminate which proposition is expressed by 'Actually $p$', then it must be indeterminate which world the actual world is. But given that $w$ is the actual world, it would then be indeterminate which world $w$ is. However, the present thesis of semantic indeterminacy has no such consequence, for the indeterminacy in which proposition is expressed by 'Actually $p$' at $t$ in $w$ is not due to some indeterminacy concerning the identity of $w$. Rather, it is a consequence of the fact that there are certain worlds different from $w$ which are at $t$ objective possibilities and in which 'Actually $p$' expresses different propositions. This is no threat to the idea that it is always determinate which world $w$ is.[11]

A remark on what the conclusion of the argument is not meant to establish. At a world $w$ at a time $t$ it may be indeterminate whether $p$ and yet be true that $p$. It may be indeterminate at $t$ whether $p$ in virtue of there being worlds in $H(w, t)$ at which $p$ and worlds at which $\neg p$. And it may be true that $p$ in virtue of it being the case *at* $w$ that $p$. As already indicated above, this makes it clear that indeterminacy is not meant to exclude truth and falsity; it is simply a notion of what is objectively possible in a world at a given time. Applying this consideration to the present argument indicates that the obtained conclusion is rather modest. It establishes only that at a world $w$ at a given time $t$ it may be indeterminate which proposition is expressed by a sentence $s$ because at $t$ there are various objective possibilities as to which proposition $s$ might express. Still, this is compatibel with $s$ expressing a certain proposition at $w$. So, if $w$ is a world at which the coin comes up heads, it may at $t$ be indeterminate which proposition is expressed by the sentence 'Actually, the coin will come up heads' and simultaneously be the case that this sentence expresses at $w$ the necessary proposition. The conclusion of the argument does not show that there is no proposition expressed by certain 'actually'-sentences; it only shows that there are sometimes multiple possibilities as to which proposition will be expressed. Only in this latter sense, it is indeterminate which proposition is expressed.

A final observation. At any time, there is a straightforward relation between the chances of the proposition that $p$ and the chances that 'Actually $p$' expresses the necessary proposition: they are just the same. The chances of the proposition that $p$ are the chances that 'Actually $p$' expresses a true proposition. And 'Actually $p$' expresses a true proposition just in case it expresses the necessary proposition. More precisely, by (7), it is necessary that 'Actually $p$'

[11] Incidentally, we may note that if 'the actual world' is taken to refer to worlds with a complete history (as opposed to a large chunk of things whose identity is not bound to a particular history), then it will sometimes be indeterminate to which world 'the actual world' refers.

expresses the necessary proposition if and only if $p$, and necessarily equivalent propositions have at any time the same chance of being true:

(8) $\mathrm{Ch}_{w,t}(p) = \mathrm{Ch}_{w,t}$('Actually $p$' expresses the necessary proposition).

In particular, if there is a chance that the proposition that $p$ is true, there is a chance that 'Actually $p$' expresses a true proposition.

# 4 Clarifications

Semantic indeterminacy concerns objective chances as to which proposition is expressed by a sentence containing 'actually' at a certain time. Hence, this kind of semantic indeterminacy is of the same kind as objective chances are in general. Since objective chances are time-relative, semantic indeterminacy will be time-relative as well. Before the coin is tossed, it may be semantically indeterminate which proposition is expressed by 'The coin will actually come up heads'. But after the coin is tossed, it will be determinate which proposition is expressed: if the coin comes up heads, it will be determinate after the toss that the sentence expresses the necessary proposition.

This kind of objective indeterminacy concerning the propositional value of sentences containing 'actually' does not imply that such sentences do not have a constant linguistic meaning. As with indexicals in general, we need to distinguish between the linguistic meaning of a sentence and the proposition expressed in a given context. Indexical sentences have a constant linguistic meaning, but they can be used to express various propositions in different contexts. Or, to put it in Kaplan's terms, the indeterminacy concerns only the content of sentences containing 'actually' but not their character.[12]

Let me also mention a puzzling phenomenon. Consider an instance of the equivalence '$p \equiv$ Actually $p$'. Such instances can be known a priori, for we can reason a priori from it being the case that $p$ to it being actually the case that $p$ and vice versa. Despite being a priori, such instances express contingent propositions. For example, it is not necessary that kangaroos have tails if and only if they actually have tails. Part of the explanation of why we can still know something like this a priori will draw on the character of 'actually': although attaching 'actually' to a sentence may affect the proposition this sentence expresses in a given context of utterance, it never affects its truth-value. That the truth-value is never affected is partly responsible for why we can know instances of the equivalence '$p \equiv$ Actually $p$' a priori, but the fact that 'actually $p$' may express a proposition different from the one expressed by '$p$' simultaneously

[12]For the relevant distinction, see Kaplan (1989).

allows for the equivalence to be contingent. However, there is something very puzzling about some instances of this kind of a priori knowledge. For suppose that it is indeterminate whether $p$. Then it will be indeterminate which proposition is expressed by '$p \equiv$ Actually $p$' because it will either express the set of worlds at which $p$ or the set of worlds at which $\neg p$. But then it will be the case that we know at a time $t$ that $p$ if and only if actually $p$ although it is indeterminate at $t$ which proposition is expressed by '$p$ if and only if actually $p$'. In a sense, these are cases of a priori knowledge where it is indeterminate which proposition is known. The puzzlement may be eased somewhat by observing that although there is indeterminacy with respect to the *content* of knowledge, there is determinacy with respect to the *character* by which the content is given. And the character ensures that a true proposition is believed.

Semantic indeterminacy does not merely constitute a lack of knowledge. But, of course, it may have epistemic consequences. For instance, if we do not know in advance whether the coin will come up heads, we will not be in a position to know which proposition is expressed by 'The coin will actually come up heads'. For, our capacity to know whether it expresses the necessary or the impossible proposition seems to be dependent on being able to know whether the coin comes up heads or not. At first glance, this consequence may seem objectionable.[13] We seem to have the feeling that we know what is said when we encounter an utterance of a sentence containing 'actually'. But this feeling can be explained on the present account. As pointed out above, sentences containing 'actually' have a stable linguistic meaning even though there are objective chances as to which proposition they express. The stability in linguistic meaning can serve to explain why we feel that we know what is said: we know the linguistic meaning of the relevant sentences. Note also that there is always, by disquotation, a weak sense in which we know which proposition is expressed: we can know that a sentence of the form 'Actually $p$' expresses the proposition that actually $p$.

The conception of propositions as sets of possible worlds is not essential. Take any conception of propositions which is such that a proposition is either true or false with respect to a possible world. Then a proposition will always determine a set of possible worlds, namely the set of worlds at which the proposition is true. It follows then that if it is indeterminate which set of possible worlds is expressed by a sentence, it will be indeterminate which more fine grained proposition is expressed by this sentence. However, if one has a conception of propositions which comes closer to the linguistic meaning of a sentence,

[13] Many thanks to Dylan Dodd for drawing my attention to this problem.

then, as was indicated above, it may well be determinate which proposition is expressed. For instance, if Kaplanian characters are labelled "propoposition", then this will generally be so.

The proposed kind of semantic indeterminacy is a rare phenomenon. It occurs with respect to sentences containing 'actually', and, as will be important later on, certain other sentences which contain expressions whose referents are fixed according to a presently indeterminate condition. So, for instance, I may now introduce the term 'winner' to name next year's Wimbledon champion. Then there may be objective chances concerning which proposition is now expressed by 'Winner is swiss'. But since natural language contains only few such expressions, the phenomenon of objective semantic indeterminacy is not widespread. In particular, most sentences about the future have presently a determinate propositional value. Take, for example, the sentence 'There will be a sea battle tomorrow'. Even though it may presently be indeterminate whether there will be a sea battle tomorrow, this does not imply that this sentence's propositional value is presently indeterminate. It stably expresses the set of possible worlds at which there is a sea battle tomorrow.

It is an interesting question how the present account interacts with various semantics for future contingents. Clearest is the relation to the classical account. So, suppose there is something like a "thin red line": there are various objective possibilities, but one of them is privileged in representing what will actually happen.[14] This proposal allows for a bivalent semantics for future contingents. In particular, the following comes out as a consistent schema: it is true that $p$, but there is an objective possibility (or chance) that not $p$. This is so because the first conjunct may hold in virtue of '$p$' being true at the privileged actual world and the second conjunct may hold in virtue of '$p$' being false at one of the non-actualized possibilities. Combining this view with the present proposal would result in the following claim: there is always a proposition expressed by sentences containing 'actually', but there are various chances as to which proposition that is. So, a sentence of the form 'Actually $p$' will express the necessary proposition if '$p$' is true at the privileged branch, and it will express the impossible proposition otherwise. However, there may be an objective chance that 'Actually $p$' expresses a proposition different from the one it actually expresses because the truth-value of '$p$' at some of the non-actual possibilities differs from its truth-value at the actual branch. The "thin red line"-view of future contingents allows to say that even in cases in which it is indeterminate which proposition is expressed by 'Actually $p$', there is always a

[14]The expression "thin red line" in the present context comes from Belnap & Green (1994).

proposition expressed.

It is less clear how the present account would combine with non-classical semantics for future contingents. *Prima facie*, it may seem that whatever a given non-classical account says about indeterminacy could be carried over to the thesis of objective semantic indeterminacy. For instance, a supervaluationist may say that on a given occasion it is neither supertrue nor superfalse that an 'actually'-sentence expresses, say, the necessary proposition. Something similar could also be said within a relativist framework. However, there is a hidden problem. It is unclear to which extent non-classical theories of future contingents can take over the standard semantics for 'actually'.[15] But if a non-classical theory of future contingents needs to make use of a non-standard account of 'actually', it is an open question what will happen to the present thesis of objective semantic indeterminacy which relies on the rigidifying effect of 'actually' within standard semantics. I have to leave a thorough discussion of this issue for another occasion.

# 5 Taking a Look Back

Let us take a look back at the original puzzle. On the one hand, there is the claim that it is indeterminate whether the coin actually comes up heads or tails:

(1) $\mathrm{Ch}_{w,t}(\text{Actually }\textsc{Heads}) > 0$ and $\mathrm{Ch}_{w,t}(\text{Actually }\textsc{Tails}) > 0$.

On the other hand, standard semantics for 'actually' delivers that one of 'Actually HEADS' and 'Actually TAILS' will be impossible:

(2) $\neg\Diamond(\text{Actually }\textsc{Heads})$ or $\neg\Diamond(\text{Actually }\textsc{Tails})$.

As we have seen, these two claims do not live happily together.

Given the account of objective semantic indeterminacy as developed in the previous sections, there is a certain kind of indeterminacy concerning the components of (1) and (2). If the coin comes up heads, the first conjunct in (1) and the second disjunct in (2) will be true whereas the second conjunct in (1) and the first disjunct in (2) will be false, for in this case 'Actually HEADS' will express the necessary proposition. But if the coin comes up tails, the situation will be reversed: the first conjunct in (1) and the second disjunct in (2) will be false while the second conjunct in (1) and the first disjunct in (2) will be true. However, even before the toss it is determinate that (1) expresses a false proposition and that (2) expresses a true proposition. No matter what the outcome will be, one of the conjuncts in (1) will be false and one of the disjuncts in

[15] See MacFarlane (2008) for more discussion and Broogard (2008) for a reply.

(2) will be true, for in any case exactly one of 'Actually HEADS' and 'Actually TAILS' will express the necessary proposition while the other will express the impossible proposition.

Interestingly, the thesis of semantic indeterminacy enables us to find a true metalinguistic variant in the immediate neighborhood of (1). By (8), the chances of the coin coming up heads equal the chances of 'The coin will actually come up heads' expressing the necessary proposition. Since a sentence governed by 'actually' either expresses the necessary or the impossible proposition, the chances of the coin coming up heads equal the chances of 'The coin will actually come up heads' expressing a true proposition. So, there is a direct correspondence between the chances of $p$ and the chances of 'Actually $p$' expressing a true proposition. So, even though there may be no chance that the coin actually comes up heads, since the coin comes up tails, there will be a chance that 'Actually the coin comes up heads' expresses a true proposition. As a variant of (1), the following statement comes out true:

(1*) $\mathrm{Ch}_{w,t}$('Actually HEADS' expresses a true proposition) $> 0$ and
$\mathrm{Ch}_{w,t}$('Actually TAILS' expresses a true proposition) $> 0$.

Normally, the chances of it being the case that $p$ and the chances of '$p$' expressing a true proposition go hand in hand. For example, the chances of the coin coming up heads and the chances of 'The coin comes up heads' expressing a true proposition are just the same. But with respect to sentences containing 'actually', these chances can come apart because the propositional value of sentences containing 'actually' depends on the future course of events. So, typically, pairs of sentences of a form similar to (1) and (1*) are equivalent, but when it comes to sentences containing 'actually', they need to be distinguished carefully.

Note that the corresponding metalinguistic variant of (2) is obviously false:

(2*) $\neg\Diamond$('Actually HEADS' expresses a true proposition) or
$\neg\Diamond$('Actually TAILS' expresses a true proposition).

Whether a true proposition is expressed by 'Actually HEADS' is a contingent matter of fact even if the linguistic meaning of this sentence is held constant: in heads-worlds it expresses the necessary proposition, but in tails-worlds it expresses the impossible proposition. Similarly for 'Actually TAILS'. Thus, both disjuncts in (2*) are false.

A worry may lurk here.[16] How do the present considerations bear on the validity of the T-schema? There are no problems for simple disquotation:

[16] Many thanks to Elia Zardini and an anonymous referee of this journal for mentioning this issue to me.

(9) 'Actually $p$' is true if and only if actually $p$.

This holds. But there is a problem with its necessitation:

(10) Necessarily, 'Actually $p$' is true if and only if actually $p$.[17]

The necessitated T-schema is invalid. At some world $w$ the sentence 'Actually, kangaroos have tails' may be false because kangaroos have no tails in $w$, but kangaroos have tails, of course, in the actual world. Isn't this a problem for the present view?

It may feel unpleasant that the necessitated T-schema does not hold for a language containing the 'actually'-operator. But in fact its invalidity has nothing to do with the present thesis of objective semantic indeterminacy. The thesis of semantic indeterminacy played no role in the way the counterexample was just constructed. The reason for the invalidity of the necessitated T-schema lies rather in the fact that it applies truth to sentences which may express different propositions when uttered in different worlds. Since 'actually kangaroos have tails' expresses a different proposition when uttered in a world in which kangaroos have no tails than when utttered in a world in which kangaroos do have tails, it is possible that 'actually kangaroos have tails' expresses a false proposition although actually kangaroos have tails. Another way of looking at this is by focussing on the fact that 'actually' is *mentioned* on the left hand side but *used* on the right side. Using 'actually' on the right hand side always makes the actual world relevant for the evaluation of the sentence governed by it. However, mentioning 'actually' on the left hand side allows the context to be shifted by the outer modal operator. So, we look at different worlds at which to evaluate 'actually'. Since the semantic contribution of 'actually' is sensitive to the world of the context of utterance, using 'actually' and simply mentioning it can make for a big difference within modal constructions.

Naturally, there are variants of the necessitated T-schema which elliminate the problems caused by the context-sensitivity of 'actually'. For instance, if truth is applied to the proposition expressed by an 'actually'-sentence rather than to the sentence itself, this will result in a valid schema:

(11) Let **Ap** be the proposition expressed by 'Actually $p$'. Necessarily, **Ap** is true if and only if actually $p$.

There are only two cases to consider: either it is true that $p$ or not. If it is true that $p$, then **Ap** is the necessary proposition which will be true if and only if actually $p$. Similarly, if it is false that $p$, then **Ap** is the impossible proposition

[17] The modal operator is supposed to have wide scope, i.e. the schema is of the form '$\Box(\ldots)$'.

for which it necessarily holds that it is true if and only if actually $p$. Thus, a necessitated version of the T-schema holds on the level of propositions.

Time to take stock. Sentences beginning with ‘actually’ never express contingent propositions. For this reason, there is no non-trivial interaction between chance ascriptions and the ‘actually’-operator. But in a chancy world, it may be a chancy matter which proposition is expressed by sentences beginning with ‘actually’. As a consequence, there are non-trivial chances concerning which sentences beginning with ‘actually’ express a true proposition. Therefore, an indeterminacy of actuality should be located at the metalinguistic level.

## 6 An Application: The Principal Principle

In his 1980 paper ‘A Subjectivist’s Guide to Objective Chance’, Lewis proposed an intimate connection between subjective probabilities and objective chances: the Principal Principle. Recently, potential counterexamples have been suggested which stem from the realm of the contingent a priori. Interestingly, the counterexamples are provided by sentences for which it is, at the time of application, indeterminate which proposition they express. In what follows, I will have a look at the potential counterexamples in order to see whether the present account of objective semantic indeterminacy can be used to shed some light on them.

The Principal Principle can partly be motivated by way of example. Suppose a fair coin is going to be tossed tomorrow. How likely should we think it to be true that it will come up heads? 1/2, of course. Why? Because its present objective chance of coming up heads is 1/2. The Principal Principle generalizes this pattern of reasoning. It states that in the absence of evidence which bears more directly on a sentence $A$, we should adjust our credence in $A$ to what we take to be the best estimate of the objective chances of $A$.

Here is the Principal Principle in quote:

> **The Principal Principle**. Let $C$ be any reasonable initial credence function. Let $t$ be any time. Let $x$ be any real number in the unit interval. Let $X$ be the proposition that the chance, at time $t$, of $A$'s holding equals $x$. Let $E$ be any proposition compatible with $X$ that is admissible at time $t$. Then
>
> $$C(A|XE) = x\,.$$[18]

Some preliminary notes of clarification. Firstly, $XE$ is the conjunction of $X$ and $E$. Secondly, $C(A|B)$ is the conditional probability of $A$ given $B$. Thirdly,

[18] Lewis (1980: p. 270).

Lewis states his view in terms of reasonable initial credence functions. These are supposed to represent reasonable epistemic states which have not taken in any empirical evidence. Finally, $E$ is the evidence which is *admissible* at the given time $t$. As a first approximation, a piece of evidence is admissible at $t$ if it is solely concerned with the history up to $t$ and with what the laws of nature are. Since the question of which propositions are admissible will not play a significant role in the discussion to follow, we can leave it here at that.[19]

Essentially, the Principal Principle comes to this: conditional on the assumption that the objective chance of $A$ at time $t$ is $x$ and conditional on the admissible evidence at $t$, one should have credence $x$ in $A$. In a way, this can be seen as a specification of the idea that subjective probabilities should track objective chances. *Prima facie*, this principle is highly plausible, and it seems to allow for correct predictions with respect to a great variety of cases.

It may seem that the present resolution of our initial puzzle is directly at odds with the Principal Principle. Consider the following line of thought. (a) We should always assign to a proposition and its 'actually'-variant the same credence, for the two propositions are a priori equivalent. (b) If the proposition expressed by 'Actually HEADS' is always assigned a trivial objective chance of either 1 and 0, and we can admissiby know what these chances are, the Principal Principle will dictate trivial credence in this proposition. (c) If this can happen in a situation in which we should still have credence 1/2 in the proposition expressed by HEADS, (b) would contradict (a), i.e. the a priori equivalence would be incompatible with the Principal Principle.

However, this argument can be resisted. For, finding out whether the objective chance of the proposition expressed by 'Actually HEADS' is 1 or 0 is tantamount to finding our whether the coin comes up heads or not. If we know that the objective chance of the proposition expressed by 'Actually HEADS' is 1, we can infer that the coin came up heads. If we know that the objective chance of the proposition expressed by 'Actually HEADS' is 0, we can infer that the coin came up tails. So, when we are in a position to know what the objective chance of the proposition expressed by 'Actually HEADS' is, we are already in a position to know whether the coin came up heads or tails. For this reason, the antecedent in the conditional in (c) should be denied: we cannot find out about the objective chances in an epistemic situation in which we should still have credence 1/2 in HEADS.

Although the present proposal is not directly at odds with the Principal Principal, it relates in an interesting way to certain counterexamples to the Prin-

[19]Some refinements of the Principal Principle are discussed in the postscript to Lewis (1980) and in Lewis (1994).

cipal Principle recently mentioned by Hawthorne & Lasonen-Aarnio.[20] They consider the following example. Suppose there is a fair lottery containing $n$ tickets. Let us fix the referent of the name 'Lucky' by stipulating that it is to refer to the winning ticket. So, 'Lucky' is not supposed to abbreviate the definite description 'The winner of the lottery'. Rather, the description is merely used to fix the referent of 'Lucky'. Now, it seems that we should be certain that Lucky wins the lottery while we should simultaneously hold that its chances of winning are $1/n$. This would be a counterexample to the Principal Principle. To see this, let **Lucky** be the proposition expressed by 'Lucky wins the lottery' and let $X$ be the proposition that the objective chance of **Lucky** is $1/n$. Then the present case would show that

(12) $C(\mathbf{Lucky}|X) = 1$

describes a rational epistemic state. Our certainty that Lucky will win the lottery is not undermined by the assumption that it has only a chance of 1 in $n$ to win the lottery. The present case treats on typical features of the contingent a priori. The counterexamples are made possible because apriority allows for certainty whereas contingency allows simultaneously for non-trivial objective chances.[21]

As noted by Hawthorne & Lasonen-Aarnio, a similar counterexample can be constructed in terms of 'actually'. We can always be certain that the coin will actually come up heads just in case it will come up heads. But the sentence

(13) (Actually $\textsc{Heads}$) $\equiv$ $\textsc{Heads}$

is necessarily equivalent either to $\textsc{Heads}$ or to not $\textsc{Heads}$ depending on whether the coin comes up heads or not. For, the following is a theorem in the logic of 'actually':

(14) $\Box[((\text{Actually } \textsc{Heads}) \equiv \textsc{Heads}) \equiv \textsc{Heads}] \vee$
$\Box[((\text{Actually } \textsc{Heads}) \equiv \textsc{Heads}) \equiv \text{Not } \textsc{Heads}]$.

Theorem (14) implies that the chances of actually $\textsc{Heads}$ if and only if $\textsc{Heads}$ are 1/2, since they equal either the chances of $\textsc{Heads}$ or the chances of not $\textsc{Heads}$, which are both 1/2. This gives us a similar counterexample to the Principal Principle ('A' stands for 'Actually'). Let $X$ be the proposition that the objective chance that (A $\textsc{Heads}$)$\equiv$$\textsc{Heads}$ is 1/2 and let AHH be the proposition that (A $\textsc{Heads}$)$\equiv$$\textsc{Heads}$. Then

[20] See Hawthorne & Lasonen-Aarnio (*forthcoming*).

[21] That Lucky will win may not be fully a priori, though, because it may not be a priori that Lucky exists and one may also need to know how the term 'Lucky' was introduced.

(15) $C(\text{AHH}|X) = 1.$

Knowledge that the objective chance of actually HEADS if and only if HEADS is 1/2 does not undermine our certainty that the coin will actually come up heads if and only if it comes up heads.[22]

Now, we may observe that the counterexamples presented involve sentences whose propositional value is indeterminate at the time of evaluation.[23] Consider the sentence 'Lucky wins' first. Before the lottery, there is for any $i$ an objective chance that 'Lucky wins' will express the set of possible worlds at which ticket $i$ wins, for there is a chance that ticket $i$ wins, and if it does, 'Lucky' will refer to ticket $i$. Similarly for the sentence containing 'actually'. Before the coin is tossed, there is a chance that the sentence 'The coin will actually come up heads just in case it will come up heads' expresses the set of worlds at which the coin comes up heads, and there is a chance that it expresses the set of worlds at which the coin comes up tails. So, the second counterexample shares a crucial property with the first one: at the time of evaluation, the propositional value of the relevant sentence is indeterminate.

If the propositional value of a sentence is indeterminate at a certain time, the chances of it expressing a true proposition and the chances of the proposition it expresses may come apart. At least to some extent, this feature explains why sentences whose propositional value is indeterminate form a potential source of counterexamples to the Principal Principle. To see this, take the lottery case again. In reflecting on whether Lucky will win, I may consider the relevant future courses of events which I take to be possible (i.e. ticket 1 wins, ticket 2 wins, etc.). I become certain that Lucky will win because I realize that in any of these scenarios 'Lucky wins' expresses a true proposition, for there is a systematic correlation between the possible futures and the proposition expressed by 'Lucky wins' which guarantees that no matter which proposition is expressed, it will be a true one. On the other hand, in evaluating the objective chances of Lucky winning the lottery, I take any of the propositions it may express and see what its chances of being true are. Since all of them have an objective chance of $1/n$, I conclude that the objective chance of Lucky winning is only $1/n$. For such a case to arise, it seems crucial that the relevant sentence

[22] Williamson (2006) observes that contexts of objective chances are not hyper-intensional, whereas contexts of subjective probability are. This may be a structural fact on the basis of which it can be explained (a) why our credence in 'The coin comes up heads' should not always equal our credence in 'The coin comes up heads if and only if it actually comes up heads' when both statements are in fact necessarily equivalent and (b) why the two statements should nevertheless in this case be assigned the same objective chances.

[23] A similar point is made by Hawthorne & Lasonen-Aarnio: in different branches, different singular propositions are believed under the guise of 'Lucky wins'.

has an indeterminate propositional value.

Let us also note that other instances of the contingent a priori do not seem to cause trouble for the Principal Principle. Take, for example, the Cartesian truth that I exist. Assuming that there is a chance that I do not exist always seems to be incompatible with my evidence that I do exist. Hence, the Principal Principle will not apply. Something similar holds for 'I am here now'. In order to challenge the Principal Principle, the sentences have to be in a certain way about the future. But when they are, the present kind of semantic indeterminacy seems to accompany non-trivial objective chances. Thus, we may conjecture that the phenomenon of objective semantic indeterminacy characterises the class of potential counterexamples to the Principal Principle.

Should the potential counterexamples be accepted as genuine? In what follows, I will sketch two ways to deal with them, the first expressing a dismissive attitude aiming to resist the counterexamples, the second embracing the counterexamples as genuine. On the latter view, the concept of semantic indeterminacy may be used to find an adequate restriction of the Principal Principle.

It is important to note that the Principal Principle is formulated on the level of propositions conceived as sets of possible worlds. According to Lewis (1980), credences as well as objective chances attach primarily to propositions so conceived. The question then arises which set of possible worlds is to be associated with the sentence 'Lucky wins'. Assume for the sake of argument that Lucky is in fact ticket 1. The first and perhaps most natural option would be to associate 'Lucky wins' to be the set of worlds at which ticket 1 wins. This proposition does in fact have an objective chance of $1/n$. However, a possible response might go, we cannot be certain at the relevant time that this proposition is true, since we cannot rule out in advance worlds at which some other ticket different from ticket 1 wins. So, if the sentence 'Lucky wins' is associated with the set of worlds at which ticket 1 wins, no counterexample needs to be granted. Alternatively, one may associate 'Lucky wins' with the set of words in which the winning ticket wins. This will be the set of worlds at which some ticket or other wins. We can be certain in advance that this proposition is true, for in order to know this proposition we do not need to rule out any world in which a particular ticket wins. However, this proposition does not have an objective chance of $1/n$ but rather an objective chance of 1. Hence, we should have credence 0 that the objective chance of this proposition is $1/n$ and so the conditional probability on this assumption would not even be well defined. Again, no counterexample seems to arise. So, no matter which set of worlds is associated with 'Lucky wins', a case can be made that the Principal

Principle is not violated.[24]

This line of response can be underpinned by facilitating the framework of two-dimensional semantics. A sentence $\phi$ is associated with two sets of possible worlds, the proposition $[\![\phi]\!]_1$ *1-expressed* by $\phi$ and the proposition $[\![\phi]\!]_2$ *2-expressed* by $\phi$. The first dimension can be thought of as describing the *modal profile* of the sentence under consideration whereas the second dimension is perhaps best seen as describing its *epistemic profile*.[25]

Let us illustrate this with our two main examples. Take the sentence 'Lucky wins' first. Sticking with the assumption that Lucky is in fact ticket 1, this sentences 1-expresses the set of worlds at which ticket 1 wins and it 2-expresses the set of worlds at which some ticket or other wins. In terms of the proposition 1-expressed by 'Lucky wins', it is explained how this sentence can be associated with an objective chance of $1/n$; and in terms of the proposition 2-expressed, it can be explained how it gains its epistemic status of certainty. A fairly similar line can be pursued with respect to 'actually'. This operator is taken to change the modal profile of a sentence but to leave the epistemic profile of it intact. Thus, the proposition $[\![\phi]\!]_1$ 1-expressed by $\phi$ may be quite different from the proposition 1-expressed by $[\![A\phi]\!]_1$: the first proposition may be contingent whereas the second proposition may be the necessary proposition. In contrast, the two sentences always 2-express the same proposition. The latter fact is invoked to explain why sentences and their 'actually'-counterparts seem to enjoy the same epistemic status. In particular, this allows to explain in which sense it is a priori that $p$ if and only if actually $p$, for the proposition 2-expressed by '$p \equiv Ap$' is always the necessary proposition.

Now, the idea suggests itself that contexts of subjective probability are sensitive to the proposition 2-expressed by a sentence whereas contexts of objective chance are sensitive to the proposition 1-expressed by a sentence. This idea is perhaps best explained by way of example. Consider the sentence

(16) The subjective probability that Lucky wins is 1.

Suppose our semantics provides for a subjective probability function $C$. Then the whole sentence will be taken to be true just in case the following holds:

(17) $C([\![$ 'Lucky wins' $]\!]_2)=1$.

Thus, when a sentence occurs in the scope of an operator of subjective probability, the proposition 2-expressed is selected.

[24]Thanks to Benjamin Schnieder, Wolfgang Schwarz, and two anonymous referees of this journal for helping me to see this option more clearly.

[25]Of course, there are many quite different variants of two-dimensional semantics. I am sketching here what I hope is a fairly prominent version of it. Cp. Chalmers (2006).

In contrast, consider now the sentence

(18) The objective chance that Lucky wins is $1/n$.

Similarly, suppose our semantics provides for an objective chance function $P$. Then the whole sentence will be assigned the following truth conditions:

(19) $P(\llbracket$ 'Lucky wins' $\rrbracket_1)$=1/n.

In the scope of an operator of objective chance, the proposition 1-expressed by 'Lucky wins' would be selected. Although the same sentence occurs in the two statements of probability, two different propositions are relevant on the semantic level.

Based on the present idea, the apparent counterexamples can be explained away as occuring merely on the sentential level. When we assume that Lucky has an objective chance of $1/n$, we make an assumption corresponding to (19), that is the concept of objective chance in our assumption operates on the proposition 1-expressed by 'Lucky wins'. But since contexts of subjective probability are sensitive to the proposition 2-expressed by a sentence, the statement that we are certain that Lucky wins (even on the assumption that Lucky's objective chance of winning is only $1/n$) can be true simultaneously. For here the proposition 2-expressed by 'Lucky wins' will matter. Thus, there will be counterexamples on the sentential level, but since different propositions are associated with the two occurrences of the relevant sentence in our semantics, the counterexamples do not carry over to the level of propositions.[26]

It may be a problem for the two-dimensional strategy that many if not most sentences 1-express a proposition which differs from the proposition 2-expressed. Usually, sentences containing proper names or indexical elements are asscociated with two different propositions. Yet it seems that for many such sentences the Principal Principle is still in command. To illustrate, consider the sentence

(20) Hesperus will collide with Jupiter in 2220.

On a typical two-dimensional view, this sentence 1-expresses a proposition different from the proposition 2-expressed. Let us assume that there is a small objective chance that Hesperus will collide with Jupiter in 2220. It seems that we should have on this assumption a small subjective probability that Hesperus will collide with Jupiter in 2220. However, if the Principal Principle is not to be

[26]An alternative explanation of the same broad kind may be inspired by Evans (1979) who holds that pairs of sentences of the form '$p$' and 'Actually $p$' express the same Fregean thought but embed differently into modal contexts.

applied in the cases constituting the potential counterexamples, the Principal Principle cannot be applied in this case either. For again, the objective chances would operate on the proposition 1-expressed by 'Hesperus will collide with Jupiter in 2220' whereas the subjective probabilities would be taken to attach to the proposition 2-expressed. Since these propositions are non-identical, the Principle Principal would not be applicable according to the strategy employed to resist the counterexamples. Yet one may feel that this case is as good an application of the Principal Principle as any. Thus, the worry might be that the present strategy is overprotective. It does not allow to apply the Principal Principle in many cases in which it seems to apply. Note that the sentence 'Hesperus will collide with Jupiter in 2220' is not semantically indeterminate at the time of application: there are no non-trivial objective chances as to which proposition it expresses.[27]

One may also not want to buy into the strategy I have sketched to resist the counterexamples for more general reasons. For instance, one may want to insist that sentences should generally be associated with only one proposition. One may doubt that sentences express different propositions in the scope of objective and subjective probability operators. Instead, one may opt for an alternative semantic picture. There are many options. One may want to embrace a conception of propositions which is much more fine grained than sets of possible worlds (think, for instance, of Fregean thoughts). Alternatively, one may also add to a fairly coarse grained conception of propositions the idea that epistemic attitudes attach to propositions only under the guise of a sentence. On such views, one may be tempted to accept the counterexamples as genuine and look for an adequate restriction of the Principal Principle. In what follows, I will sketch one such strategy.

As indicated above, the counterexamples to the Principal Principle seem to involve precisely the sentences which are semantically indeterminate at the relevant time. If one takes this fact to be at the heart of the problem, then the problem is to be located at the sentential level. Hence, one will somehow need to specify the relevant sentences in a proper restriction of the Principal Principle. It strikes me that the simplest way to do this would be to reformulate the Principal Principle on the level of sentences and then look for an adequate way to exclude the trouble making sentences from its domain of application. Formulating the Principal Principle with sentences instead of propositions does not necessarily mean that subjective probabilities are taken to attach primarily to sentences (although this is one of the options). To a certain extent, the

[27]I have been using and will continue to use 'proposition' to mean what would be on the two-dimensional picture the proposition 1-expressed.

proposal can simply be seen as a model which allows for various interpretations. For instance, one can take the sentence to specify the guise under which the proposition they express in a given context is evaluated. Or, alternatively, they may be taken to represent corresponding sentences in the language of thought. Further options seem to be possible as well.[28]

A minimally invasive modification of the Principal Principle would be to restrict it to sentences whose propositional value is determinate at the relevant time $t$. This would exclude the counterexamples. Moreover, if the story above is approximately correct, there is some evidence that this will indeed capture the crucial feature of the counterexamples. Then we would get

**PP***  Let $A$ be a sentence which has a determinate propositional value at $t$ and let $E$ be a sentence expressing only admissible evidence. Moreover, let $X$ be a sentence consistent with $E$ expressing that the objective chance of $A$ at $t$ is $x$. Finally, let $C$ be a reasonable initial credence function. Then

$$C(A|E \,\&\, X) = x.$$

A note of clarification. How is the phrase 'the objective chance of $A$' to be understood? Since $A$ is a sentence, objective chances appear to be taken to attach to sentences. This is not what I have in mind. I would like to understand the phrase in a disquoted way. So, if $A$ is the sentence '$p$', the phrase 'the objective chance of $A$ at $t$ is $x$' should be taken to mean *the objective chance that $p$ at $t$ is $x$*. To illustrate, take $A$ to be the sentence 'Lucky will win'. Then the sentence $X$ expressing the assumption about the objective chances can be taken to be the sentence 'The objective chance at $t$ *that Lucky will win* is $x$'. In the chance ascription, the relevant sentence 'Lucky will win' is thus not mentioned but used.

It is important to distinguish this understanding from an alternative metalinguistic interpretation. On this way of spelling things out, one would mean by the objective chance of 'Lucky will win' the objective chance that the sentence 'Lucky will win' is true. As noted above, these two interpretations can differ greatly. The objective chance that Lucky will win may be $1/n$, whereas

[28]The basic question here is: what are the objects of credences? This is a familiar problem. It is well known that standard bayesianism cannot easily assign non-trivial credences to mathematical statements, logical truths, or statements expressed by sentences such as 'Hesperus is Phosphorus'. Cp. e.g. Stalnaker (1984: ch. 4), who adopts a metalinguistic approach to such problems: Stalnaker introduces metalinguistic truths such as the proposition *that 'Hesperus is Phospherus' expresses the necessary proposition* with respect to which we can have non-trivial credences. He also considers to take more abstract structures than the sentence itself. This proposal differs somewhat from the present suggestion but clearly shares the metalinguistic aspect of it.

the objective chance that the sentence 'Lucky will win' is true may instead be 1. Notably, it seems that on the latter understanding one would not need to restrict the Principal Principle, for the objective chances of the sentences being true seem to comply with the corresponding subjective probabilities. However, the assumption we make about the objective chances would always be metalinguistic. But in paradigmatic situations in which the Principal Principle seems to be in command, no metalinguistic assumptions are made. For instance, we typically start our reasoning with the assumption that the objective chance of the coin landing heads is 1/2. This assumption seems to command a credence of 1/2 that the coin will land heads. On the basis of the alternative metalinguistic principle, this could not be explained, for it would only tell us what to think on the assumption that the objective chance that the sentence 'The coin will land heads' is true is 1/2. Thus, such a principle would directly apply only in the rare situations in which we make assumptions about the objective chances of sentences being true. Of course, one could supplement such a principle with an account of the conditions under which one can move back and forth between the objective chances of '$p$' being true and the objective chances that $p$. I reckon that such an account would need to impose the same kind of restrictions on the transitions between metalingustic chance ascriptions and their corresponding non-metalinguistic variants which I suggest to impose directly on the Principal Principle. Ultimately, then, there would not be much of a difference.

Back to PP$^*$. Unfortunately, the present version of the Principal Principle would be too simple. The problem is that the chance hypothesis in the Principal Principle does not need to be true. The Principal Principle is supposed to tell us what to think on the assumption of various hypotheses about the objective chances some of which may well be false. With this in mind, consider the lottery case again. Suppose that the admissible evidence $E$ leaves it open when the lottery will be held. Now, take $t$ to be a time after the lottery and consider the chance hypothesis that the chance at $t$ of Lucky winning is $1/n$. This hypothesis is false, since the lottery was already held at $t$, but the hypothesis is consistent with the admissible evidence $E$. As a matter of fact, it is at $t$ determinate which proposition is expressed by 'Lucky wins'. Thus, the proviso in PP$^*$ is satisfied and PP$^*$ would—on the assumption of $E$ and the chance hypothesis—require a credence of $1/n$ that Lucky will win. This seems wrong. Even on these assumptions, one can be certain that Lucky will win.

The problem with this example seems to be that the propositional value of the relevant sentence is in fact determinate despite the fact that for all the evidence $E$ says, it may still be indeterminate. However, one would not want to require the evidence $E$ to provide metalinguistic information, for in most applications of the Principal Principle no metalinguistic evidence seems to be needed. We can relax the present suggestion by requiring only that $E$ together with general information concerning the linguistic meaning of $A$ implies that $A$ has a determinate propositional value:

**PP**$^{**}$ Let $E$ be a sentence expressing only admissible evidence *which implies together with facts concerning solely the linguistic meaning of a sentence $A$ that $A$ has a determinate propositional value at $t$*. Moreover, let $X$ be a sentence consistent with $E$ expressing that the objective chance of $A$ at $t$ is $x$. Finally, let $C$ be a reasonable initial credence function. Then

$$C(A|E \,\&\, X) = x.$$

Given this modification, the restricted principle makes predictions similar to Lewis's original principle with respect to most cases. For in most cases, no evidence which goes beyond general linguistic knowledge is needed to rule out that a sentence has an indeterminate propositional value. For instance, no evidence is needed in addition to knowledge of the linguistic meaning of 'The coin lands heads' in order to see that it has a determinate propositional value. Thus, pure information of the objective chance of HEADS is indeed sufficient to adjust the credence in HEADS to 1/2 in the example above.

Back to Lucky. This is a case where more than linguistic information is needed to rule out that 'Lucky wins' has an indeterminate propositional value at $t$. In addition, one needs to know that the lottery was already held before $t$, because 'Lucky wins' receives a determinate propositional value only after the lottery. But once it is known that the lottery was held before $t$, it can be known that the chance of Lucky winning is either 1 or 0 at $t$. In fact, given that it is known that Lucky wins, the only live option is that the chance is 1. Obviously, this epistemic state does not cause any trouble for the Principal Principle.

The present suggestion aims at a minimal restriction of the Principal Principle. Of course, one could think of a more radical modification: exclude all sentences from the range of the Principal Principle which have an indeterminate propositional value at some time or other.[29] Thus, a sentence such as 'The coin comes up heads' would continue to be in the range of the Principal Principle, for at all times it is determinate which proposition is expressed by this sentence. On the other hand, sentences such as 'Lucky wins the lottery' or 'The coin will actually land heads' would be excluded from the application of the Principal

[29] This may naturally combine with accounts of objective chance which make objective chances dependent on a well defined chance setup (see e.g. Hoefer (2007)). On such accounts, one may doubt that the troublemaking statements should be assigned objective chances at all.

Principle, for they have an indeterminate propositional value at certain times. Clearly, the more radical restriction is more likely to be found correct. But in the light of a less radical restriction, it would seem unnecessarily narrow. Further research would be welcome to decide between these and possible further options.[30]

[30] **Acknowledgements.** I would like to thank Dylan Dodd, Nick Haverkamp, Miguel Hoeltje, Benjamin Schnieder, Alexander Steinberg, and two anonymous referees of this journal for very helpful and substantive comments which have significantly improved the present paper. The paper has been presented at the ECAP 2008, at the inaugural Phlox workshop in Berlin 2008, and at the Arché/CSMN graduate conference in Oslo 2008. Many thanks to all the participants for valuable discussions. Research for this paper has been made possible through the generous support of the Deutsche Forschungsgemeinschaft.

## References


[1] Almog, J. & Perry, J. & Wettstein, H. (1989): *Themes from Kaplan*, Oxford: Oxford University Press.

[2] Belnap, N.D. & Green, M. (1994): "Indeterminism and the thin red line", in Tomberlin (1994: 365-388).

[3] Broogard, B. (2008): "Sea Battle Semantics", *The Philosophical Quarterly* **58**, 326-335.

[4] Chalmers, D.J. (2006): "The Foundations of Two-Dimensional Semantics", in García-Carpintero & Marcià (2006: 55-140).

[5] Crossley, J.N. & Humberstone, L. (1977): "The Logic of 'Actually'", *Reports on Mathematical Logic* **8**, 11-29.

[6] Evans, G. (1979): "Reference and Contingency", *The Monist* **62**, 161-189.

[7] García-Carpintero, M. & Marcià, J. (eds.) (2006): *Two-Dimensional Semantics*, Oxford: Oxford University Press.

[8] Glynn, L.: "Deterministic Chance", *forthcoming* in the *British Journal for the Philosophy of Science.*

[9] Hawthorne, J. & Lasonen-Aarnio, M. : "Knowledge and Objective Chance", forthcoming in *Williamson on Knowledge* at Oxford University Press. Available at URL
www.philosophy.ox.ac.uk/__data/assets/pdf_file/0009/1161/Knowledge_and_Chance.pdf

[10] Hoefer, C. (2007): "The Third Way on Objective Probability: A Sceptic's Guide to Objective Chance", *Mind* **116**, 549-596.

[11] Jeffrey, R.J. (ed.) (1980): *Studies in Inductive Logic and Probability*, Vol. II, Berkeley and Los Angeles: University of California Press.

[12] Kaplan, D. (1989): "Demonstratives", in Almog & Perry & Wettstein (1989: 481-563).

[13] Kölbel, M. and García-Carpintero, M. (eds.) (2008): *Relative Truth*, Oxford: Oxford University Press.

[14] Lewis, D. (1970): "Anselm and Actuality", *Noûs* **4**, 175-180. Reprinted with postscript in Lewis (1983: 10-25).

[15] Lewis, D. (1980): "A Subjectivist's Guide to Objective Chance", in (1980). Reprinted with postscripts in Lewis (1986: 83-132).

[16] Lewis, D. (1983): *Philosophical Papers*, Vol. I, Oxford: Oxford University Press.

[17] Lewis, D. (1986): *Philosophical Papers*, Vol. II, Oxford: Oxford University Press.

[18] Lewis, D. (1994): "Humean Supervenience Debugged", *Mind* **412**, 473-490.

[19] MacFarlane, J. (2008): "Truth in the Garden of Forking Paths", in Kölbel & García-Carpintero (2008: 81–102).

[20] Norton, J.D. (2008): "The Dome: An Unexpectedly Simple Failure of Determinism", *Philosophy of Science* **75**, 786–798.

[21] Schaffer, J. (2007): "Deterministic Chance?", *The British Journal for the Philosophy of Science* **51** 113-140.

[22] Sosa, E. & Villanueva, E. (eds.) (2006): *Philosophical Issues* **16**: *Philosophy of Language*, Oxford: Blackwell.

[23] Stalnaker, R. (1984): *Inquiry*, Cambridge (Massachusetts): The MIT Press.

[24] Tomberlin, J. (ed.) (1994): *Philosophical Perspectives* **8**: *Logic and Language*, Atascadero: Ridgeview Publishing,

[25] Van Inwagen, P. (1980): "Indexicality and Actuality", *The Philosophical Review* **89**, 403-426.

[26] Williamson, T. (2006): "Indicative versus subjunctive conditionals, congruential versus non-hyperintensional contexts", in Sosa & Villanueva (2006: 310-333).