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ARTICLE

Noûs

Metaphysics of risk and luck

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Abstract

According to the modal account of luck it is a matter of luck that *p* if *p* is true at the actual world, but false in a wide-range of nearby worlds. According to the modal account of risk, it is risky that *p* if *p* is true at some close world. I argue that the modal accounts of luck and risk do not mesh well together. The views entail that *p* can be both maximally risky and maximally lucky, but there is nothing which is both maximally lucky and maximally risky. I offer a novel theory of risk that fits together with the modal account of luck and demonstrate that it is both extensionally and formally superior to extant proposals.

1 | INTRODUCTION

The notions of risk and luck have taken a central role in contemporary philosophy that engages with normative issues, such as ethics[1], epistemology[2], and legal philosophy[3]. It is therefore not surprising that luck and risk themselves have garnered the interest of philosophers. The extant theories of risk and luck can be roughly divided into three categories; probabilistic accounts[4], modal accounts[5] and lack of control-accounts[6]. Recently modal accounts of luck and risk have

[1] See Nagel (1979), Williams (1981), and Hirvelä and Lasonen-Aarnio (2021) for the role of luck in ethics. For risk, see Thomson (1986), MacAskill, Bykvist, and Ord (2020), and Rowe (2021).

[2] Regarding luck, see Zagzebski (1994), Pritchard (2005), Riggs (2007), Carter (2016), and Hirvelä (2019). For risk, see Pritchard (2016), Williamson (2009), Smith (2010, 2016), Newton (2022), Navarro (2021) and Gardiner (2020).

[3] For the role of luck in philosophy of law, see Nozick (1974), Hart (2008). For risk, see Pritchard (2018), Littlejohn (2020), Placani (2017) and Handfield and Pisciotta (2005).

[4] See Rescher (1995, 2014) Steglich-Petersen (2010), Stoutenburg (2019), Buchak (2013), and Yang (2021).

[5] See Pritchard (2005), Carter and Peterson (2017), Ebert, Smith, and Durbach (2020), and Pritchard (2015b). For a hybrid of the modal and probabilistic account of luck, see de Grefte (2020).

[6] See Coffman (2007, 2009), Riggs (2007), and Broncano-Berrocal (2015).

taken prominence over alternative approaches especially within epistemology (Ebert et al., 2020; Pritchard, 2005; Williamson, 2009). I will focus on modal accounts of luck and risk since I am attracted to the idea that luck and risk are modal notions. But how are luck and risk related, and can we understand luck in terms of risk, or vice versa?

The central idea of this essay is that luck and risk are negatively correlated with each other in that the unluckier it is that *p* the lower the risk of *p*, and the riskier it is that *p* the less it is a matter of bad luck that *p*. My main task is to formulate accounts of luck and risk that respect this idea. I argue that current modal accounts of luck and risk don't fit well together, and that they yield absurd consequences when applied simultaneously. For example, they entail that something can be both maximally risky and maximally unlucky, but that is impossible. I argue that the culprit is the modal account of risk and provide several arguments against it. For instance, I demonstrate that extant modal accounts of risk entail that risks never add up. But small risks can add up to big risks, so the extant theories must be false. More positively, I propose a novel modal account of risk that matches with the modal account of luck. I demonstrate that the new account of risk yields a quantifiable conception of risk that allows us to talk about degrees of risk with mathematical precision. I close by suggesting that we can obtain a more precise picture of the modal nature of luck by understanding it in terms of risk.

The structure of this essay is the following. In the next section I lay out the extant modal accounts of luck and risk. In the third section I argue that they don't mesh well together and that we should lay the blame on the doorstep of the modal account of risk. In the fourth section I provide a novel account of risk that succeeds where current accounts fail and show how it can be used to shed light on the nature of luck.

2 | MODAL ACCOUNTS OF LUCK AND RISK

I will use Pritchard's modal account of luck as foil in our quest to find satisfactory accounts of luck and risk. Our key desiderata is that acceptable accounts of luck and risk must fit well together. The reason why I focus on the modal account of luck, as offered by Pritchard, is two-folded. *First*, the account has been highly influential in the current literature. *Second*, although the account no doubt suffers from some problems, these problems are in my mind much less severe than the ones that competing proposals face. Without further ado, here is the modal account of luck:

> **Luck$^{\mathbf{M}}$**: "If an event is lucky, then it is an event that occurs in the actual world but which does not occur in a wide class of the nearest possible worlds where the relevant initial conditions for that event are the same as in the actual world." (Pritchard, 2005, p. 128)

A few clarificatory remarks are in order. Possible worlds are understood as sets of propositions. Luck$^{\mathrm{M}}$ quantifies over metaphysically, rather than epistemically possible worlds. The space of possible worlds is centered on the actual world, and worlds are ordered in terms of how similar they are to the actual world. The worlds most similar to the actual world lie at the center of the space of possible worlds, representing possibilities that could easily have obtained, whereas worlds further away are less similar to the actual world, representing more far-fetched possibilities that couldn't easily have obtained. The relevant initial conditions that are kept fixed across the worlds have to be such that they neither individually nor jointly determine that the event in question obtains. While this notion is vague, it is plausible that we can in most contexts grasp what the relevant initial conditions are (Pritchard, 2005, pp. 131–132).

In what follows I understand luck and risk to be primarily attributable to propositions, rather than to events or states of affairs.[7] Statements such as 'the risk of *p* is ...' are understood to be elliptical for statements of the form 'the risk that *p* obtains is ...'. There are several reasons for this. *First*, risk and luck judgments feature as inputs in Boolean operations. It makes sense to ask 'what is the risk that I'll be unemployed *or* land an unsatisfying job within the next year?', or to claim that 'It was a matter of luck that the thieves were *not* caught red-handed'. Unlike propositions, events do not serve as inputs to Boolean operations, as there are no disjunctive or negative events. *Second*, it is questionable whether there are merely possible events, but it is clear that there are risks that do not actualize. In addition to talking about how lucky or risky a given event is, we standardly describe actions and decisions as lucky or risky. I suspect when we say that a decision was lucky, we often don't mean that it was a matter of luck that we made the particular decision, but rather that it was a matter of luck that the decision had certain consequences. For present purposes I set this issue aside.

In his earlier work Pritchard held that only significant events can be lucky or unlucky, depending on whether the event was of positive or negative valance (Pritchard, 2005, p. 132). Later he has rejected the significance condition, on the grounds that the metaphysics of luck should not be concerned with properties that are relative to subject's interests, as such conditions are bound to be subjective (Pritchard, 2015a, p. 604). Since my primary interest here is to pin down the nature of chance, accidentality or possibility that luck involves I follow Pritchard in this regard although I am of the opinion that luck ascriptions apply only to significant proposition (Hirvelä 2019). Later we can dispense with this assumption.

Luck^{M} tells when it is a matter of luck that a proposition is true. For each proposition *p*, it is either a matter of luck that *p* or it is not a matter of luck that *p*. But luck comes in degrees (Carter, 2016, p. 147; Pritchard, 2015a, p. 559). What we need is a comparative notion of luck. Pritchard holds that Luck^{M} naturally gives rise to such a notion. He maintains that the wider the class of nearby possible worlds where the relevant initial conditions for the proposition hold, but the proposition is false, and the closer those worlds are to the actual world, the luckier the truth of the proposition is (Pritchard, 2005, p. 130; 2015a, p. 599). The truth of *p* is then luckier than the truth of *q* if:

(i) *p* is false in a wider range of close worlds than *q*, where the relevant initial conditions hold, and,
(ii) the relevant worlds at which *p* is false are closer to the actual world than the relevant worlds in which *q* is false.

There are a few problems with this proposal. *First*, it is not exhaustive in that it doesn't tell us how to weigh the importance of modal closeness of the worlds at which *p* is true when compared to the proportion of the worlds at which *q* is true. This means that for any two propositions, *p*, *q*, of which *p* is false at a wider range of close worlds than *q*, and *q* is false at some possible world which is closer to the actual world than any possible world at which *p* is false, we cannot tell whether it is luckier that *p* or that *q*. The proposal that I offer in section 4 remedies this shortcoming. *Second*, it is not immediately clear how the relevant initial conditions ought to be understood when making comparisons between different propositions. If the relevant initial conditions are just relative to the proposition being evaluated, then the relevant set of worlds when evaluating how lucky it is

[7] Ebert et al. (2020, p. 2) make the same move when developing their normic account of risk.

that *p* might be different than the relevant set of worlds when comparing how lucky it is that *q*. There is then a danger that we are comparing apples to oranges when making the comparative judgment. In response I suggest that the context fixes a unique set of relevant initial conditions, so that we are quantifying over a single set when comparing whether it is luckier that *p* or that *q*.

Putting these two problems aside, the informal idea is clear enough. Luck is to be understood in terms of *modal isolation*. It is maximally lucky that *p* iff, *p* is true in the actual world but false in all other relevant worlds. It is minimally lucky that *p* iff, *p* is true in all relevant worlds. The wider the class of close worlds in which *p* is true, and the closer those worlds are to the actual world, the less modally isolated *p* is, and hence the less lucky it is. Propositions that satisfy Luck^{M} pass a certain threshold and are hence conceived as being true as a matter of luck full-stop.

Supplemented with the above points, Luck^{M} yields plausible verdicts regarding a range of cases, has welcomed formal properties, and contrasts favourably with competing proposals. *First*, take a paradigm case of luck, such as a lottery win. Winning a fair lottery with long odds is lucky on Luck^{M} since one wins the lottery in the actual world, but loses it in most nearby possible worlds (Pritchard, 2007, p. 278). After all, if the odds are long one's lottery ticket is a loser in most worlds. *Second*, Luck^{M} neatly captures the idea that if one believes solely on the basis of the odds involved that one's ticket is a loser, then one's belief is at best true as a matter of luck since the world where one's belief is false is very close to the actual world (Pritchard, 2007, p. 292). Probabilistic accounts of luck, which hold that the degree to which the truth of *p* is a matter luck is a function of how improbable *p* is, struggle to deliver this verdict, since it is highly probable that one's ticket is a loser. *Third*, unlike lack-of-control accounts of luck, which hold that *p* is a matter of luck for a subject iff, the subject does not have control over whether *p*, Luck^{M} doesn't predict that the rising of the sun is a matter of luck (Latus, 2000, p. 167).[8] *Fourth*, Luck^{M} entails that disjunction introduction is not a valid pattern of inference for luck. Suppose that eight friends play a board game that cannot end in a draw and each player has an equal shot at winning. It might be a matter of luck for each player that they won if they won, but it is not a matter of luck that $x \vee y \vee z \vee \ldots$ won. The fact that a disjunction can be less lucky than its disjuncts is an extremely important feature of luck that tends to be neglected. Its importance resides in the fact that we often seek to secure a specific outcome, and hence to minimize the role of luck. One way to secure an outcome is to use a variety of methods, each of which has some marginal chance of delivering the desired outcome. It might then be that each particular way of delivering the outcome would succeed in doing so only by luck, but it need not be a matter of luck that the outcome was achieved.

If we accept a modal account of luck, then modal accounts of risk become quite appealing. This is because luck and risk seem to be systematically linked. We are often lucky in that a risk didn't materialize. If my risk of failing the test is high then it is a matter of luck that I passed the test. Similarly, if the risk that this paper is rejected is high, then it is not a matter of bad luck that it was rejected (although the particular way in which it is rejected might be a matter of luck). Unsurprisingly, modal accounts of risk have emerged to the literature in the wake of modal accounts of luck (Ebert et al., 2020, p. 13; Pritchard, 2015b, p. 447; 2016, p. 563; Williamson, 2009, p. 18). While there are some differences between these accounts, all of them hold that risk is a function of modal closeness.[9] Hence we get:

[8] Some hold that even non-chancy propositions can be lucky (Levy, 2011, pp. 33-34). Following Coffman (2014, p. 502), putative cases of non-chancy luck are in my mind better understood as cases of fortune. See Rescher (1995, pp. 28-29) for the distinction between luck and fortune.

[9] Ebert et al. (2020, p. 13) rearrange the space of possible worlds in terms of their normality, so that the most normal worlds lie at the center of the space of possible worlds. Since the actual world need not be normal it might not lie at the

> **Risk$^{\mathbf{M}}$**: The risk that *p* is greater than the risk that *q* iff, holding the relevant initial conditions for *p* and *q* fixed, the closest possible world where *p* is true is closer to the actual world than the closest possible world where *q* is true.

Whereas propositions of any valance can be lucky, only unwanted propositions can be risky. Some hold that worse propositions are *ceteris paribus* more risky than propositions that are less bad (Gardiner 2020, p. 490). Plausibly the risk of losing your house on a fair coin flip is higher than the risk of losing 10 € on the same coin flip.[10] For now I put this complication aside and assume that risk does not increase with disutility since I am primarily interested in the nature of chance, accidentality or possibility that risk involves. When developing my own view I show how it can be made to accommodate the idea that risk increases with disutility (footnote 23).

Risk^{M} has a number of welcomed properties. Risk^{M} is a comparative definition of risk. A proposition *p* counts as risky full-stop iff the closest world at which *p* is true is close enough to the actual world. Risk^{M} makes correct predictions regarding a range of cases. Unlike a probabilistic account of risk, which holds that risk is solely a function of how probable the proposition in question is, Risk^{M} entails that the risk of being shot is high when playing a single round of Russian roulette, since even though the probability of being shot is only 1/6, the possible world where one is shot is extremely close to the actual world. Risk^{M} provides guidance for risk management. If Risk^{M} is true, then good risk management practices involve taking measures that push modally close unwanted possibilities further away from the actual world. We seek to eliminate the easy possibilities and are less concerned with the more farfetched possibilities of misfortune.

Finally, Risk^{M} and Luck^{M} do have some synergy. If one boards a rickety plane, then there is a high risk of a plane crash. If one emerges unscathed after an extremely dangerous flight, then one was lucky that the plane did not crash (Pritchard, 2016, p. 560). This example points towards two distinct ideas. *First*, it indicates that risk ascriptions are forwards looking, in that when we talk about the risk of an event we are looking at the event from the past towards the future. In contrast, luck ascriptions tend to be backwards looking, in that we evaluate the luckiness of an event after it has happened, that is from the present towards the past. This is the lesson that Pritchard (2016, p. 560) draws from the example attributing it to Navarro.[11] However, we need to tread carefully here. The fact that risk assessments tend to be forwards looking does not mean that the proposition (or event) would obtain in the future. When renovating a house built in the 80's in Germany it is sensible to wonder what is the risk that the wall contains asbestos (Ebert et al. 2020, p. 2). When you are contemplating this, you are not thinking about whether the wall will contain asbestos in

center of the space of possible worlds. Moreover there might not be a unique most normal world and hence the system is weakly, rather than strongly centered (Lewis, 1973, section 1.7). Nevertheless, most of the critical remarks that I offer apply directly to their account as well. I highlight in footnotes how to amend the arguments in order to undermine their proposal. It is worth to note that Ebert et al. (2019) endorse risk pluralism, according to which risk is a function of either normality or probability. However, they don't offer any principle on the basis of which we could determine whether the risk of a proposition is a function of normality or probability in a given case. Without such a principle the predictions of risk pluralism are radically indeterminate. For this reason I will focus only on the normality-side of their view in what follows. Williamson (2009, p. 18) suggests also another alternative, according to which risk is a function of the proportion of worlds where the proposition is true. He doesn't commit himself to either the proportional or the closeness-based conception.

[10] For an argument against the view that risk increases with disutility, see Ebert et al. (2020, pp. 3, ft. 2).

[11] Navarro (2019, p. 69) states that this isn't quite what he had in mind. Instead of talking about events or propositions, Navarro focuses on *situations*, which are states of affairs that serve as starting and endpoints of temporally extended events. He holds that when we judge that a situation is lucky, we are evaluating how the situation transpired. When we judge that a situation is risky, we are evaluating how the situation might evolve in the future.

the future, but whether it contains asbestos right now. *Second*, the example suggests the attractive idea that luck and risk are negatively correlated:

Negative Correlation$^{\text{Bad Luck}}$:

The more it is a matter of bad luck that p, the lower the risk of p is.

The higher the risk that p is, the less it is a matter of bad luck that p.[12]

Because only detrimental propositions can be risky, while lucky propositions can be of either negative or positive valance, this principle holds only between risk and bad luck. However, in cases in which p is of negative valance, and $\neg p$ is of positive valance, good luck and risk are negatively correlated. Consider for instance Pritchard's case of boarding a rickety plane. There is a high risk that the plane will crash. One is highly luck that it did *not* crash. Hence good luck and risk seem to be correlated negatively as well:

Negative Correlation$^{\text{Good Luck}}$

The higher the risk of p, the more it is a matter of good luck that $\neg p$.

The lower the risk of p is, the less it is a matter of good luck that $\neg p$.[13]

One way to think about the above is that risk is the mirror-image of luck. We should expect certain kind of systematic dependency relations between luck and risk. We noted earlier that disjunctions tend to be less lucky than the individual disjuncts. We should expect the opposite to be true of risk. Disjunctions tend to be more risky than their riskiest disjunct. Interestingly, Risk^{M} and Luck^{M}, when taken together, cannot accommodate the idea that luck and risk are negatively correlated. The reason for this is that while Luck^{M} holds that luck is a function of both the modal closeness and proportion of the possible worlds where the proposition under evaluation is true, Risk^{M} holds that risk is solely a function of the modal closeness of the closest world at which the proposition under evaluation is true. This entails that Risk^{M} and Luck^{M} don't pair well. In the next section I demonstrate that we cannot accept both of them and that we should reject Risk^{M}, rather than Luck^{M}. The discussion that follows will focus on the negative correlation between risk and bad luck. I will return to consider the relationship between good luck and risk at the end of section 4.

3 | RISK^{M} IS DEAD, LONG LIVE LUCK^{M}!

In this section I argue that Luck^{M} and Risk^{M} don't fit well together and that Risk^{M} has disastrous consequences. Hence we should reject Risk^{M} and try to formulate a new account of risk that is compatible with the plausible Luck^{M}.

According to Luck^{M} the degree to which it is lucky that p is a function of how modally isolated p is. If p is true only at the actual world then it is maximally lucky. If p is true at all possible worlds,

[12] Note that the negative correlation is not perfect since it can be lucky that p only if p is true, whereas there might be a risk that p even if p is false.

[13] As stated above, this principle applies only in cases in which p is of negative significance and $\neg p$ is of positive significance. I would like to thank an anonymous reviewer at *Nous* for encouraging me to consider the relationship between good luck and risk.

it is not lucky at all. According to Risk^M the risk of *p* is solely a function of the modal closeness of the closest possible world where *p* is true. Now suppose that *p* is a detrimental proposition that obtains only in the actual world. Luck^M entails that it is maximally unlucky that *p* is true since *p* is completely modally isolated. I think this is the right verdict. But note that since the actual world is closest to itself *p* is also maximally risky! I think this is the wrong verdict. How could the risk of *p* have been maximal if *p* is the case only at the actual world? Surely the risk of *p* would have been greater if *p* was true in a wider range of worlds![14,15]

Could proponents of Risk^M reply that risk ascriptions are sensitive to time and hence claim that we should be talking about cases, that is worlds that are centered on a particular time (Lewis, 1979, p. 531), rather than complete possible worlds?[16] The idea behind the objection is that the modal distance between cases might differ from one time to the other, and that this could be used to block the argument above. Sadly, this move is a non-starter. This is because at any time each case is still closest to itself even if the modal distances that the case bears to other cases might vary with time. Hence it's impossible to block the above argument by quantifying over time-centered worlds.

What we have here is not a mere problem in the extension of Risk^M, although I think that the extensional inadequacy of Risk^M is a serious issue. Rather, the more fundamental problem has to do with the fact that someone who endorses both Luck^M and Risk^M must reject the idea that luck and risk are negatively correlated. They must embrace the possibility that a single proposition can be both maximally unlucky and maximally risky. But note how awkward such as position is. It is absurd to state that 'I know that the risk of failing is extremely high, but if we do fail, it's very unlucky'. It is hard to see why this statement is nonsensical if there could be propositions that are maximally risky and maximally unlucky.

In addition to being incompatible with the idea that luck and risk are negatively correlated, Luck^M and Risk^M are not in balance with respect to each other. When applied to epistemology, they entail that it is epistemically much worse if one's belief is true as a matter of luck, than that one's true belief had a high risk of being false. This is because a belief is true as a matter of luck only if the belief is false in *most* close worlds where it is formed in the same way. In contrast a true belief is highly risky even if there is only a *single* close world where it is formed in the same way, and it is false. But why should it be worse to have a luckily true belief than to have a true belief that had a high risk of being false? This is doubly puzzling since Pritchard (2016, p. 563) holds that "our interest in excluding luck is usually to be explained by our interest in excluding

[14] In order to apply this argument to the account of risk offered in Ebert et al. (2020) stipulate that *p* is true only at the actual world, and that the actual world is among the most normal worlds. Since there is no world which is more normal than the world at which *p* is true, the risk that *p* is maximal on their account. Hence *p* is both maximally unlucky and maximally risky.

[15] Note that denying that a detrimental proposition *p* which is true solely in the actual world is not maximally risky does not entail denying that *p* could have a relatively high risk value. Consider Pritchard's (2016, p. 562) 'Hunger Games' scenario in which a subject has one ticket to a fair lottery with an extremely detrimental prize. The subject is clearly very unlucky if they 'win' the lottery, and maybe the risk that they win it is also relatively high. However, the risk is not maximally high since it would have been higher if the subject had more than one ticket. The unified theory of risk that I propose in section 4 is able to accommodate the intuition that the risk that the subject wins the lottery is relatively high, even if they win the lottery solely in the actual world. This can be done in two ways. First, we could give the actual world a significantly greater weight in determining risk values of worlds. Second, we could subscribe to the idea that more detrimental propositions are *ceteris paribus* riskier than less detrimental ones. Since the 'prize' of winning the Hunger Games lottery is extremely detrimental the risk that one wins the lottery is relatively high. I outline how the idea that more detrimental propositions are *ceteris paribus* riskier than less detrimental ones can be incoropated to the unified theory of risk in footnote 23. I would like to thank an anonymous reviewer of *Nous* for giving me an opportunity to consider this issue.

[16] Thanks to Maria Lasonen-Aarnio for pressing this objection.

risk, rather than *vice versa*.” But if luckily true beliefs are epistemically worse than risky true beliefs, how can our interest in excluding luck be explained in terms of our interest to exclude risk? Due to this imbalance the transition from anti-luck epistemology to anti-risk epistemology that Pritchard (2007, 2016) has advocated seems to have been deceptively smooth. If we accept both Luck^{M} and Risk^{M}, and make a seemingly easy transition from anti-luck epistemology to anti-risk epistemology, we sweep normatively significant things under the rug.

So we cannot accept both Luck^{M} and Risk^{M} and hence we have to reject at least one of them. I think Risk^{M} is the account that gives the wrong verdict here, but it would be too hasty to reject it on the basis of a single case. I now argue that the failings of Risk^{M} are not confined to the above kind of case.

First, risks can add up but Risk^{M} entails that they cannot. It is easy to see that risks can add up. Suppose that a fair 20-sided die is cast. On a result of ‘2’ you will lose 5 €. If the die lands on a result greater than ‘1’ I will lose 5 €. As a matter fact the result is ‘1’ and we both get to keep our money. It is clear that I am at a greater risk of losing 5 € than you are. Risk^{M}, however, cannot vindicate this result. The reason for this is that the closest possible world where a ‘2’ is thrown is just as close to the actual world as the closest possible world where a ‘2’ or a ‘3’, or a ‘4’, or a … ‘20’ is thrown. After all, the disjunction holds in all, and only in those worlds where some of its disjuncts hold, and since the dice is fair, the world where a ‘2’ is thrown is just as close to the actual world as the world in which say a ‘3’ is thrown. Risk^{M} entails that the risk of a disjunction is always equal to the risk of its most risky disjunct. Therefore, on Risk^{M} risks never add up. But risks can add up so Risk^{M} must be false.[17,18]

Second, Risk^{M} entails that we cannot compare the riskiness of two unwanted propositions that are actually true. This is because if *p* is actually the case then it is maximally risky on Risk^{M}. But risks that actualize can differ in how risky they are. Some risks are almost bound to occur, and hence there is a high risk that they will obtain, whereas others are highly unlikely. Suppose that you and I have bought lottery tickets to a lottery with very long odds. Your ticket is in fact a loser, and intuitively the risk that you would lose was high. Reflecting on the long odds I form the belief that my ticket is a loser. As it turns out my belief is false since I won the lottery. Risk^{M} entails that your losing the lottery was maximally risky, and me falsely believing that my ticket is a loser was maximally risky. But it is clear that the risk that you would lose the lottery was greater than the risk that I would falsely believe that I lost the lottery! True propositions can and do differ in terms of how risky they are. Risk^{M} cannot accommodate this, so it must be false.[19,20]

[17] To apply this argument to the account of risk offered by Ebert et al. (2020) make the plausible assumption that any result of the die is equally normal.

[18] Note that it is not just the case that there are more distinct risks involved for me in the case at hand because there are several different ways in which I could end up losing 5 €. In the world where I lose 5 € due to the fact that the die landed on a ‘2’ and in the world where I lose 5 € due to the fact that the die landed on a ‘3’, I still end up losing 5 €. [I lose 5 €] is the risk that we are interested. The proposition [I lose 5 €] can be true in many different worlds. Risks can add up because the very same risk can obtain in many different worlds. I would like to thank an anonymous reviewer of *Nous* for raising this objection.

[19] Assuming that the world where you lose the lottery and I win it, but believe on the basis of the odds that I lost it, is among the most normal worlds, the view offered by Ebert et al. (2020) entails that the risk that my belief is false is the same as the risk that you would lose the lottery.

[20] An anonymous reviewer of *Nous* objects that since it is on balance beneficial to falsely believe that one has lost the lottery, there is no risk that one falsely believes that one has lost the lottery. This objection assumes that we can pool together the negative epistemic value of having a false belief and the positive practical value of winning the lottery to calculate an all-things-considered value for the relevant proposition. To avoid this objection it suffices to stipulate that the practical value of winning the lottery is so small that it does not outweigh the negative epistemic value of having a false

Third, Risk^M entails that propositions that are actually true are always risker than propositions that are merely possibly true. But sometimes the risk that *p* is greater than the risk that *q*, even though *q* ends up being true and *p* false. Suppose that Yen and Triss are participating in a fair lottery with 1000 000 tickets. Yen has bought 999 999 tickets to the lottery. Intuitively the risk that she loses the lottery is small. Triss has bought the one remaining ticket to the lottery. Intuitively the risk that Triss loses is very high. As it happens Yen loses the lottery and Triss consequently wins it. Since Yen actually loses the lottery Risk^M entails that the risk that Yen would lose the lottery was higher than the risk that Triss would lose the lottery. But it is clear that the risk that Triss would lose the lottery was higher.[21] Moreover, note that Risk^M entails that by buying more tickets to the lottery Yen did not decrease the risk that she would lose the lottery. But it is obvious that Yen decreased the risk of losing the lottery by buying more than one ticket.

I take it that the arguments above give us a compelling reason to reject Risk^M rather than Luck^M. Of course I have not established the truth of Luck^M, and that is not a task I will undertake here. Although it might not match our intuitions in every case, the problems it faces are not as severe as the problems that Risk^M faces, and I hope that what I have said so far, and will say in the next section, alleviate some of the concerns the reader might have regarding Luck^M.[22] For present purposes I assume that Luck^M at least roughly captures the structural properties of luck, and that we can use these properties and the idea that luck and risk are negatively correlated to shed light on the nature of risk. In the next section I offer a new modal account of risk that fits together with Luck^M. I demonstrate that the new account does not suffer from any of the problems that Risk^M suffers from.

4 | A NEW THEORY OF RISK

In order to develop the new theory of risk, consider the connections between luck and risk. The first thing to note is that the guiding idea behind Luck^M is that luck is a function of modal isolation. It is lucky that *p* iff *p* is actually true, but false in a wide range of worlds where the relevant initial conditions for *p* remain the same. The smaller the range of relevant close worlds where *p* is true the luckier it is that *p* (*ceteris paribus*). If luck and risk are negatively correlated we should expect that the opposite is true of risk. The wider the range of relevant close worlds at which *p* is true the higher the risk of *p* is (*ceteris paribus*).

belief. In that case falsely believing that your lottery ticket is a loser will on balance be detrimental. An alternative way to reply to this objection would be to say that we can distinguish between epistemic and practical risks in terms of what is at stake. My belief that I lost the lottery is epistemically risky because my belief could have been false, and having a false belief is of negative epistemic value (Pritchard 2022, p. 14). You are at *practical* risk of losing the lottery because you could lose out on practical value. If we take onboard this distinction, Risk^M entails that the *epistemic* risk that I falsely believe that I lost the lottery is just as high as the *practical* risk that you will lose the lottery.

[21] The view offered by Ebert et al. (2020) yields similar counterintuitive results. Take the conjunction of the propositions that is true at world *w* which belongs to the set of the most normal worlds *W*, and compare the riskiness of that conjunction with the riskiness of the proposition [everything is not maximally normal right now].This proposition is not true in any of the most normal worlds, but intuitively the risk that everything is not maximally normal right now is much higher than the risk of an arbitrarily long conjunction of normal propositions. Sometimes what is true at a world which belongs to the set of the most normal worlds is less risky than that which it is true only at those worlds that are not normal.

[22] Lackey's (2008, p. 261) 'buried treasure' case is probably the most influential counterexample to Luck^M. For what I find to be a successful reply, see Carter and Peterson (2017, pp. 2182-2183).

The second thing to note, is that modally close possible worlds where *p* is true carry more weight than worlds that are further away when it comes to determining how lucky it is that *p*. This fits well with the metaphor of modal isolation. *Ceteris paribus*, you are more isolated if your closest neighbor lives 6 kilometers from you than if they live 5 kilometers from you. If luck and risk are negatively correlated the reverse should be true regarding risk. Hence we get a second *ceteris paribus*-clause. *Ceteris paribus*, if the closest world where *p* is false is further away from the actual world, than the closest world where *q* is false, then the risk that *p* is greater than the risk that *q*. I propose that these two *ceteris paribus* clauses taken together capture what risk is. Here is then the unified theory of risk:

> **Risk^{U}**: The riskiness of a detrimental proposition *p* is a function of both the range of possible worlds where *p* is true, and the closeness of the worlds where *p* is true.

It should already be clear that Risk^{U} doesn't share the shortcomings of Risk^{M}. Risk^{U} entails that risks can add up, since a disjunction can be true in a wider range of worlds than any single disjunct that it comprises of. Risk^{U} allows for the possibility that two propositions that are true in the actual world differ in how risky they are. After all, the modal spread of the propositions might be different, and hence the propositions can differ in their riskiness. Finally, Risk^{U} doesn't entail that propositions that are true are always more risky than contingent false propositions. Although true propositions are *ceteris paribus* riskier than contingent false propositions, this doesn't entail contingent false propositions couldn't be more risky. Indeed, a completely modally isolated proposition, which is true only at the actual world but false at all other possible worlds, is far less risky than the negation of that proposition. And this fits perfectly with Luck^{M}. After all, such a proposition would be highly unlucky, and given the negative correlation between luck and risk we ought to expect this. Finally, there is no reason to think that it would be epistemically worse if one's true belief was true as a matter of luck, than if there was a high risk that one's true belief would have been false. Risk of false belief and epistemic luck (luckily believing the truth) might be equally detrimental for epistemic goods such as knowledge.

But it would be nice to be able to demonstrate these points in a more precise manner and tell how the two *ceteris paribus* clauses combine. To that end I introduce a model in which risks of propositions can be calculated and show how we can define luck in terms of risk once that model is in place.

First, we introduce a frame, which consists of an ordered pair, $<W, A>$, where *W* is a set and *A* is a binary relation between members of *W*. Informally *W* is to be conceived as the set of possible worlds and *A* as the accessibility relation between members of *W*. Possible worlds are individuated by the propositions that are true at the worlds and hence for the purposes of the model they are understood as sets of propositions. Since we are interested in evaluating the riskiness of propositions given certain relevant initial conditions, we assume that the accessibility relation holds between worlds where the relevant initial conditions apply. That is, $A(w, w^{i})$ if the relevant initial conditions hold at *w* and w^{i}.

Second, we add a similarity measure \$ to the frame, which is a function from order-pairs of members of *W* to the half open unit interval (0,1]. Informally \$ tells the relative similarity between members of *W*. The greater the value of $\$(w, w^{i})$ the more similar w^{i} is from the perspective of *w*. The reason the values of \$ fall within the half open unit interval (0, 1] and not the closed unit interval is that while worlds can be maximally similar to each other $\$(w, w) = 1$, worlds cannot be maximally dissimilar to each other. Everything bears some similarity to everything else

(Goodman, 1972, p. 443). Hence there is no pair of worlds, w, w^{i}, for which $\$$ would give 0 as a value.

Third, we add a set of functions R to the frame which maps values of $\$$ to the half open unit interval (0, 1] from the perspective of an evaluation world as follows: $R_w = x / \sum_{y \in \$w} y$, where x is the similarity value of some world from the perspective of the evaluation world, and $\$_w$ is a multiset of all the similarity values from the perspective of the evaluation world. R_w gives the *risk values* of worlds from the perspective of the evaluation world w.

In less abstract terms, here is what R and $\$$ do. First, the similarity function $\$$ gives a similarity value for each world-pair. Once the similarity values have been obtained we pick an evaluation world, which in our case will usually be the actual world, and add the similarity values from the perspective of that world up. Then, for each similarity value from the perspective of that world we divide it with the sum of all of the similarity values from the perspective of that world. This operation gives a new value for each world which is directly proportional to the world's similarity value from the perspective of the evaluation world, and all of these values add up to exactly 1. These values represent the risk values of individual worlds from the perspective of an evaluation world. From these risk values we can calculate how risky a given proposition is at the evaluation world. The risk of a proposition is just the sum of the risk values of the worlds at which it is derivable. Call this the *risk score* of a proposition.[23]

The risk score 1 is the highest possible risk score, and 0 the lowest. These risk scores give a cardinal, rather than a merely ordinal ranking of risks. That is, the relative differences between risk scores of different propositions not only tell us which proposition is riskier than the other, but also how much more risky one proposition is when compared to another. This is an extremely important feature, since only a cardinal ranking will provide enough information for decision-making under risk.

Now that we have a clear grasp of Risk^{U} let us examine some of its formal properties. *First*, note that since the risk values of all accessible worlds add up to exactly 1, and the risk score of a proposition is simply the sum of the risk values of the worlds in which it obtains, Risk^{U} entails that an unwanted proposition that is true in all possible worlds is maximally risky. This is a welcomed result and fits well with the idea that risk and luck are negatively correlated. Unlike Risk^{M}, Risk^{U} does not entail that propositions that are true at the actual world are trivially maximally risky.

Second, unlike Risk^{M}, Risk^{U} entails that risks can add up. To demonstrate this suppose that the risk score of p is 0.2 and the risk score of q is 0.3. Suppose further that there is no world in which p and q obtain. To calculate the risk score of $p \vee q$ we must add up the risk values of the worlds in which $p \vee q$ is derivable. The disjunction $p \vee q$ is derivable in all, and only those worlds in which either p is derivable or in which q is derivable. Since there are no p & q worlds, $p \vee q$ is derivable only in worlds in which $p \,\&\, \neg q$ or $\neg p \,\&\, q$ is derivable. Each p world is an $p \,\&\, \neg q$ world. The sum of the risk values of the p worlds is 0.2. Each q world is an $\neg p \,\&\, q$ world. The sum of the risk values of the q worlds is 0.3. Since $p \vee q$ is derivable in all of the p-worlds and in all of the q-worlds, the risk score of $p \vee q$ is 0.5. Hence a disjunction can be risker than its disjuncts.

[23] To accommodate the idea that the risk of a proposition increases with its disutility we need to proceed as follows.

1. Determine the risk values of all worlds in the manner above.
2. Add a function £ that assigns a disutility value for each world on the half-open unit interval (0, 1].
3. For each world multiply its risk value with its disutility value.
4. For each product, divide it with the sum of all the products to obtain the *disutility weighted risk values* for each world.
5. The *disutility weighted risk score* of a proposition is the sum of the disutility weighted risk values of the worlds in which the proposition is derivable.

The fact that Risk^{U} entails that risks can add up matches well with the idea that luck and risk are negatively correlated. Just as disjunctions tend to be riskier than their individual disjuncts on Risk^{U}, disjunctions tend to be less lucky than their individual disjuncts on Luck^{M}. A similar point holds for conjunctions. If a conjunction of propositions is true at the actual world then that conjunction tends to be luckier than its conjuncts on Luck^{M}, since conjunctions tend to be false in a wider range of worlds than the individual conjunts they comprises of. The reverse is true of risk on Risk^{U}, just as we should expect. A conjunction tends to be less risky than the individual conjunts it comprises of, since conjunctions tend to be true in narrower range of worlds than the conjuncts they comprise of.

Third, unlike Risk^{M}, Risk^{U} does not allow for the possibility when coupled with Luck^{M} that there could be a proposition which is both maximally unlucky and maximally risky. As we noted earlier, maximally unlucky propositions are true only at the actual world. Such propositions cannot be maximally risky unless the actual world is the only possible world in the domain. If the actual world is the only possible world in the domain, then the propositions that are actually true are not lucky at all, since they are true at all the possible worlds. Supposing that the actual world is not the only possible world in the domain, propositions that are true at the actual world are still quite risky. This is, in my mind, the correct result. It is not sensible to say that there was no risk that the pipes would burst if they did burst. Freak accidents do happen and they must have had some risk of happening. Risk^{U}, unlike Risk^{M}, correctly predicts that if a proposition is true only at the actual world then its risk score is smaller than the risk score of any proposition which is true both in the actual world and in some relevant possible world. Propositions that are true only at the actual world are minimally risky given that they are actually true (though even this minimal risk can be quite high), and this fits neatly with the idea that risk is the mirror-image of luck.

Thus far I have demonstrated that Risk^{U} has plausible formal properties and that it meshes well with Luck^{M}. Given how intimate the relationship between Risk^{U} and Luck^{M} is, one can hope that they could be defined in terms of each other, and in particular that the cardinal ranking of risk scores that Risk^{U} delivers could be carried over to Luck^{M} to yield a cardinal ranking for how lucky different events are. If we accept, as we should, the idea that luck and risk are negatively correlated this is an easy task to accomplish. For any actually true detrimental proposition p, the degree to which it is unlucky that p is $1 - R(p)$, where $R(p)$ is the risk score of p. Assuming that good luck and bad luck differ only in terms of their valance (Pritchard 2005, p. 132), the modal properties of good and bad luck should be the same. Hence if we have uncovered the modal nature of bad luck, we have also unveiled the modal nature of luck in general.

If I have correctly captured the modal nature of risk, and risk and luck are negatively correlated, then the structural properties of risk outlined here give us a firmer grasp of how to understand Luck^{M}. Luck^{M} did not specify how we should weigh the importance of the modal closeness and the proportion of the possible worlds at which the target proposition is true. With the help of the model developed here this can be done, though I lack the space to do it.

5 | CONCLUDING REMARKS

I demonstrated that Risk^{M} is extensionally and formally inadequate and that it does not fit together with Luck^{M}. More positively, I provided a novel account of risk which doesn't suffer from any of the shortcomings of Risk^{M}. According to the new theory, which I call the unified theory of risk, the risk of a proposition is a function of the proportion and closeness of the possible worlds where it obtains. By combining this view with the modal account of luck we end up with the idea that whereas luck is a kind of modal isolation, risk is a kind of modal robustness. They are the mirror-images of each other. I hope to be able to apply these theories to a wide range of topics in future work.

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