COUNTERPARTS AND COUNTERPOSSIBLES; IMPOSSIBILITY WITHOUT IMPOSSIBLE WORLDS*

Would ice form if water had a different molecular structure? Since water is essentially H_2O, this question invites countermetaphysical supposition: it is metaphysically impossible for water to have had a different molecular structure. There's a tradition going back to[1] of taking countermetaphysical conditionals like these to be trivial. But that tradition is under increasing pressure. On the standard view, if water had a different molecular structure, ice would still form; but also, if water had a different molecular structure, ice would not form. Something about this seems strange.

Here, I'll review three recent discussions of counterpossible counterfactuals. First, Peter Tan[2] has argued that many cases of scientific modelling require counterpossible conditionals. Some of Tan's examples are cases in which properties are counterfactually considered to behave in ways in which they couldn't possibly behave. Second, grounding theorists who see metaphysical explanations as structurally similar to causal explanations need counterpossibles to explicate grounding-dependence relations. Third, Humeans hold that laws of nature metaphysically supervene on particular matters of fact. But many authors have pointed out that we can counterfactually consider what the same situation would be like under different scientific laws. If the Humean is correct, at most one of these suppositions is metaphysically possible, and any other suppositions are countermetaphysicals. I'll examine these three cases in more detail in my opening (§I).

These three examples of counterpossible counterfactuals have a unifying feature: properties which are grounded or nonfundamental in the actual world either have a different grounding base in a merely possible

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[1] David K. Lewis. *Counterfactuals.* Blackwell, 1973.

[2] Peter Tan. "Counterpossible Non-Vacuity in Scientific Practice". In: *Journal of Philosophy* 103.1 (2019), pp. 32–60.

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world, or are ungrounded in that world. I'll present a possible worlds model which allows properties to be differently grounded in counterfactual scenarios. This model is a version of property counterpart theory; whether a property at one world is the same property as a property at another world depends on a counterpart relation. I'll discuss this solution in §II, and In §II.2 I directly address the problem cases (though in the interest of brevity I leave a detailed discussion of the counterpart-theoretic semantics to the appendix).

But counterpart theory can't get us out of the woods on its own. For the views above to carry philosophical water, there must be a meaningful distinction between metaphysical possibility and impossibility. I'll propose two strategies to deal with this issue in §III.1, and argue that on either strategy the counterfactuals in question are truly counterpossibles. I'll conclude with some brief remarks comparing my proposal to similar accounts relying on impossible worlds.

I. THREE USES FOR COUNTERPOSSIBLES

Standard semantics for counterfactuals take a counterfactuals $A \boxright B$ to be true if and only if the consequent (B) is true at all the *closest* possible worlds at which the antecedent (A) is true. Closeness is typically understood as a sort of similarity: in evaluating the counterfactual, we ask what the world would be like if it were changed as little as possible to accommodate the antecedent[3]. If A is impossible, then there are no A-worlds and so no closest A world. Trivially, then, the consequent is true at every closest A world and the counterfactual is trivially true. This is counterpossible triviality[4]. Recently, though, a number of interesting applications of counterpossible reasoning have cropped up. Here are three:

I.1. Nontrivial Scientific Impossibilities. Scientific modelling often requires us to idealize away features of the actual world we don't want to focus on, or consider simplified counterfactual models in which systems have properties they are known not to have. Such models are useful for a variety of reasons: they enable us to employ mathematical methods that are well-understood and they allow us to focus on the features of the actual system that matter for our explanatory or predictive purposes without being distracted by those features which do not.

[3] There is, of course, much to be said about how possibilities manage to be closer than one another—but I need not say that here.

[4] It's worth noting that there is nothing conversationally illicit about stating explicit counterpossibles. Consider this sentence from (Paul T. Corballis. *Pub Signs.* CLennard Publishing, 1988): "If pub signs could be easily categorized (which they can't because there are just too many categories to make any easy sense), you could say that two very large groups would be patriotic and religious signs."

Tan[5] considers a variety of such counterfactuals. He argues compellingly that these counterfactuals have impossible antecedents but are nonetheless scientifically interesting and nonvacuous. Tan considers counterfactuals whose antecedents are impossible because they violate the essential nature of nonfundamental kinds, such as

> "W: If water were a continuous, incompressible medium, then it would behave as the Navier-Stokes equations describe. In other words, the wave behavior of actual water closely approximates how water would behave, if it really were continuous. When put to their proper purpose, these models are quite successful..." (Tan, 2019: p. 46).

To accommodate examples like this, we should consider scientific possibilities that are metaphysical impossibilities. I'd like to highlight Tan's claim that the behavior of actual water closely approximates that of an incompressible fluid. This similarity of behavior will be a key component of my positive view: the incompressible fluid is a counterpart of water just because its behavior is similar.

Tan's example isn't isolated; for similar examples see McLoone[6] and Jenny.[7] Can we accommodate those models without nontrivial counterpossibles? I doubt it. As Alisa Bokulich[8] points out, idealized models are often explanatory because they mirror the counterfactual dependencies that exist in the actual-world systems they represent. But many of the idealizations and approximations Bokulich considers (such as the Bohr atom or frictionless planes, continuous fluids, or zero-dimensional point particles) are metaphysically impossible ways for the target system to be. If the system were as described, its composition, origins, or other metaphysically essential features would be different. If countermetaphysicals like W are trivial, these models cannot both represent their target system and mirror that system's counterfactuals dependencies. So if these models are going to meet Bokulich's criteria for explanation, the counterpossibles here must be nontrivial.

Similarly, Bhogal,[9] Tan,[10] and Loew[11] all note that by examining counterpossible counterfactual worlds we gain information about the role

[5] Tan, "Counterpossible Non-Vacuity in Scientific Practice".

[6] Brian McLoone. "Calculus and Counterpossibles in Science". In: *Synthese* (forthcoming). DOI: 10.1007/s11229-020-02855-1.

[7] Matthias Jenny. "Counterpossibles in Science: The Case of Relative Computability". In: *Noûs* 52.3 (2018), pp. 530–560. DOI: 10.1111/nous.12177.

[8] Alisa Bokulich. "How Scientific Models Can Explain". In: *Synthese* 180.1 (2011), pp. 33–45. DOI: 10.1007/s11229-009-9565-1.

[9] Harjit Bhogal. "Nomothetic Explanation and Humeanism About Laws of Nature". In: *Oxford Studies in Metaphysics* (Forthcoming).

[10] Tan, "Counterpossible Non-Vacuity in Scientific Practice".

[11] Christian Loew and Siegfried Jaag. "Humean Laws and (Nested) Counterfactuals". In: *Philosophical Quarterly* 70.278 (2020), pp. 93–113. DOI: 10.1093/pq/pqz037.

certain factors play in the actual world, even if those could not be completely removed. So when we consider how something would act if there were no air resistance or friction, we can thereby evaluate what role air resistance and friction play when making predictions in the actual world, and figure out when it can safely be ignored.

I.2. Grounding and Nontrivial Counterpossibles. Alastair Wilson[12] and Jonathan Schaffer[13] both argue that grounding should be modelled using the structural equations framework, which enjoys increasing success in accounting for causal phenomena. In causal models, these equations are taken to represent counterfactual dependencies: if a causal model connects a variable R, representing the throwing of a rock, to a variable B, representing the breaking of a window, the framework interprets this to mean that *if the rock had not been thrown, the window would not have broken.* Or more precisely, if an intervention had set the value of R to $\neg r$, representing that the rock is not thrown, then the value of B would have been $\neg b$, indicating that the window did not break.

Wilson and Schaffer argue that we should extend this framework to understand non-causal dependence relations. Because the structural equations framework models rely on counterfactual dependence relations, and since non-causal dependence concerns not just the way things are, but also the way things must be, Schaffer and Wilson argue that this requires some counterfactuals with metaphysically impossible antecedents to be true, and others to be false. For example Wilson considers the following two counterfactuals, dealing with Socrates and his singleton set—the set that contains only Socrates:

> CF1. If an intervention had prevented Socrates from existing, then Singleton Socrates would not have existed. — True [...]
> CF3. If an intervention had prevented Singleton Socrates from existing, then Socrates would not have existed. — False[14]

On an initial reading, it's very tempting to think that CF3 is true, rather than false. This is because, given the necessary connection between sets and their members, the closest world (in fact every world) without Singleton Socrates is a world without Socrates. But these close worlds are the wrong ones to look at, because the antecedent doesn't just stipulate that Singleton Socrates fails to exist—it says that Singleton Socrates fails to exist because of an intervention. An intervention is defined (roughly speaking) as a change in the target variable (Singleton's

[12] Alastair Wilson. "Grounding Entails Counterpossible NonTriviality". In: *Philosophy and Phenomenological Research* 92.3 (2016), pp. 716–728. DOI: 10.1111/phpr.12305.

[13] Jonathan Schaffer. "Grounding in the Image of Causation". In: *Philosophical Studies* 173.1 (2016), pp. 49–100. DOI: 10.1007/s11098-014-0438-1.

[14] Wilson, "Grounding Entails Counterpossible NonTriviality", p. 722.

existence) that doesn't directly change any other nodes in our grounding structure, including whether Socrates exists. So while the simplest, and only possible way, to remove Singleton is by removing Socrates, the stipulation that Singleton is intervened upon requires us to look at worlds which change the abstract object—Singleton—without changing the concrete object—Socrates. Because this impossible intervention would, by stipulation, not alter Socrates' existence, CF3 is false.

Taken together, these two counterfactuals illustrate the asymmetric dependence relation between Socrates and Singleton Socrates. Singleton Socrates depends on Socrates for its existence; Socrates does not depend on Singleton Socrates for his existence.

Schaffer and Wilson argue that using interventionist counterfactuals to understand grounding has a numerous advantages. It allows us to provide a unified account of the dependence relations that back scientific and metaphysical explanation. It also allows us to use the same epistemic framework we use in scientific and causal reasoning to uncover the world's metaphysical structure[15] . Since grounding relations, like scientific theories, are *a posteriori*, it's reasonable to assume that the same strategies can be used to discover them. For example, when asking whether heat is a substance or instead mean kinetic energy, one strategy is to consider how it would behave if it were a substance, and see whether it behaves that way. This strategy requires counterpossible nontriviality: if counterpossibles were trivial, if heat were a substance it would behave in any way you like, and no observations would be incompatible with it.

I.3. Laws of Nature. Humeans account for laws of nature like this: the laws summarize the non-modal matters of fact. A summary is good when it summarizes concisely, and it is good when it summarizes a lot. So, the laws should be both concise and informative. This is the Best Systems Account (BSA): the laws of nature are those generalizations which best balance simplicity and informational strength concerning the facts of the world[16].

The problem for the Humean is that one world or situation can be modelled by different systems of laws, and considering what would happen in that situation under different systems of laws is a scientifically

[15] For a view which denies that these counterfactuals need to be nontrivial, see Emmerson (Nick Emmerson. "Counterpossibles, Counterpossibles Everywhere, and Not a Dropto Drink, or: Towards an Interventionist Treatment of GroundingWithout Ubiquitous Counterpossibles." In: [MS]).

[16] Contemporary Humeans hold to the spirit of the Best System without confining themselves to the letter of it. For my own views on the matter, see (Michael Townsen Hicks. "Dynamic Humeanism". In: *British Journal for the Philosophy of Science* 69.4 [2017], pp. 983–1007. DOI: 10.1093/bjps/axx006)

fruitful activity. This objection was first clearly expressed by John Carroll;[17] for a good discussion of the problem, see Loew and Jaag.[18]

A compelling example can be found in Maudlin:[19] since the actual laws of gravity are those of General Relativity (GR)[20], scientists might consider what *would* happen at a world without massive objects, using GR as a guide. But a world without masses would have a much simpler, but still highly informative description, one which does not mention mass or the way massive bodies bend spacetime. The much simpler Special Relativity (SR) would be an elegant and informative description of this world. So, considering what counterfactuals are true at that world on the supposition that the laws there are the laws of General Relativity violates the BSA, according to which the laws would be the simplest description of the world.

Let's call these counterfactuals SIMPLEGR:

> SIMPLEGR$_1$: If you added a mass to an empty spacetime governed by the laws of General Relativity, that spacetime would curve.
> SIMPLEGR$_2$: If you added a mass to an empty spacetime governed by the laws of General Relativity, that spacetime would remain static.

SIMPLEGR$_1$ is true and SIMPLEGR$_2$ is false. But if Humeanism is true they both have a metaphysically impossible antecedent, since no empty spacetime has the laws of GR in its best system. So Humeanism seems to entail that some important nontrivial counterfactuals—ones which appear to be implied by our best scientific theory—are countermetaphysicals.

Similar worries arise for nomic necessitarians and dispositional essentialists in a wide range of circumstances. While Humeans cannot make sense of simple worlds governed by complex laws, necessitarians along the lines of Wilson[21] and Kimpton-Nye[22] don't allow for any worlds with any laws but the actual laws. For these necessitarians, all counternomics are counterpossibles, and so, on the standard semantics, trivially true. Things are also problematic for dispositionalists of

[17] John W. Carroll. *Laws of Nature*. Cambridge University Press, 1994.
[18] Christian Loew and Siegfried Jaag. "Humean Laws and (Nested) Counterfactuals". In: *Philosophical Quarterly* 70.278 (2019), pp. 93–113. DOI: 10.1093/pq/pqz037.
[19] Tim Maudlin. *The Metaphysics Within Physics*. Oxford University Press, 2007, p. 67.
[20] Or whatever theory of quantum gravity replaces General Relativity, a complication which need not concern us here.
[21] Alastair Wilson. *The Nature of Contingency: Quantum Physics as Modal Realism*. Oxford, UK: Oxford University Press, 2020.
[22] Samuel Kimpton-Nye. "Necessary Laws and the Problem of Counterlegals". In: *Philosophy of Science* 87.3 (2020), pp. 518–535. DOI: 10.1086/708710.

the stripe of Bird[23] or Vetter[24] who take properties to have fairly fragile modal profiles: any change to Coulomb's constant, for example, would result in a world without charge (that world would instead have a completely different charge-like property). On such views, idealizations which involve even slight counterfactual changes to the laws governing, say, an electron are counterpossibles, at least insofar as they are counterfactual suppositions about particular actual-world particle types.

Why do we care about counterfactuals concerning different laws? One answer is that doing so is a vital part of the way we confirm our actual theories. Chris Dorst[25] notes that we often use counterfactuals to evaluate evidence for a theory. By determining what would happen if a theory were true, we can compare that counterfactual behavior to the actual behavior of physical systems.[26]

For example, in order to show that the progression of the perihelion of mercury is a counterexample to Newtonian gravitational theory, we first show that, if the solar system was Newtonian and only contained the sun and Mercury, the perihelion would advance 43 seconds less than it actually does. We then argue that the gravitational influence of other planets isn't sufficient to account for this discrepancy, by showing that even if the Newtonian model included those planets, the perihelion would not progress the additional 43 arc seconds. We then conclude that these counterfactuals have a false antecedent: the actual world is not Newtonian. On Humean, dispositionalist, and necessitarian views, these are countermetaphysicals. Giving up on these nontrivial countermetaphysicals would require us to give up on these important tools for discovering the structure of the actual world.

II. IMPOSSIBLE COUNTERPARTS

I think that a properly developed property counterpart theory can handle these cases, and can do so in a way that makes sense of the idea that these are really *counterpossibles*. And I think this strategy has an advantage: it doesn't require us to introduce impossible worlds of the sort

[23] Alexander Bird. *Nature's Metaphysics*. Oxford University Press, 2007.

[24] Barbara Vetter. "Counterpossibles (Not Only) for Dispositionalists". In: *Philosophical Studies* 173.10 (2016), pp. 2681–2700. DOI: 10.1007/s11098-016-0671-x.

[25] Chris Dorst. "Why Do the Laws Support Counterfactuals?" In: *Erkenntnis* (forthcoming), pp. 1–22. DOI: 10.1007/s10670-019-00207-1.

[26] Though see Sam Fletcher (Samuel C. Fletcher. "Counterfactual Reasoning Within Physical Theories". In: *Synthese* [forthcoming], pp. 1–22. DOI: 10.1007/s11229-019-02085-0) for an alternative understanding of these counterfactuals.

advocated by Nolan,[27] Brogaard,[28] Bernstein,[29] or Priest.[30] This account builds on the application of first-order counterpart theory to counteridentical counterfactuals by Kocurek[31] and Wilhelm.[32]

For this strategy to be successful requires me to complete two tasks: first, I need to show how the strategy provides worlds and counterparts for the problematic counterpossible counterfactuals. Second, I need to show that these are really impossibilities. I'll explain the model in §II.1, and give more details about the formal model in the appendix. Then, in §II.2, I'll show how property counterpart theory handles the problem cases. To make good on the claim that these counterfactuals are counterpossibles, I need to show that these are, in a meaningful sense, impossibilities. Given that I deny that they are incomplete or contain contradictions, this is a tricky task; in §III.1 I'll argue that some counterpart relations are metaphysically privileged, and that the metaphysical possibilities are those which correspond to these counterpart relations.

The approach I advocate here works well for countermetaphysical counterfactuals. But it does not obviously extend to countermathematical or counterlogical counterfactuals. I take this to be a feature, not a bug: the countermetaphysicals discussed in §I help us to elucidate real-world dependence relations: relations of metaphysical dependence or grounding. Like causal or counternomic counterfactuals, these dependence relations are typically *a posteriori* and inferred via inference to the best explanation. They are also strongly world-dependent: they are features not of our representations or abstract objects, but on the structure of the actual world. In this way, they are unlike countermathematical or counterlogical counterfactuals. Nonetheless, as the example of Singleton Socrates suggests, there is some hope for extending the program to countermathematical and other counterpossibles. I discuss my reasons for focusing on countermetaphysicals and the prospects and challenges of extending the program in §III.2.[33]

[27] Daniel Nolan. "Impossible Worlds: A Modest Approach". In: *Notre Dame Journal of Formal Logic* 38.4 (1997), pp. 535–572. DOI: 10.1305/ndjfl/1039540769.

[28] Berit Brogaard and Joe Salerno. "Remarks on Counterpossibles". In: *Synthese* 190.4 (2013), pp. 639–660. DOI: 10.1007/s11229-012-0196-6.

[29] Sara Bernstein. "Omission Impossible". In: *Philosophical Studies* 173.10 (2016), pp. 2575–2589. DOI: 10.1007/s11098-016-0672-9.

[30] Graham Priest. "Thinking the Impossible". In: *Philosophical Studies* 173.10 (2016), pp. 2649–2662. DOI: 10.1007/s11098-016-0668-5.

[31] Alexander W. Kocurek. "Counteridenticals". In: *The Philosophical Review* 127.3 (2018), pp. 323–369. DOI: 10.1215/00318108-6718783.

[32] Isaac Wilhelm. "The Counteridentical Account of Explanatory Identities". In: *Journal of Philosophy* (2020).

[33] Here's an objection to this distinction: any countermetaphysical counterfactual can be replaced with a counterlogical counterfactual by adding a complete description of the

II.1. Property Counterpart Theory. The strategy I present for handling the problem cases follows Heller[34] in employing a higher-order counterpart theory. In first-order modal counterpart theory, we take each individual to be represented at different possibilities by a *modal counterpart*: a stand-in who is similar in some respect to the actual individual. If I could have been a contender, it's because there's some possible individual who is very like me in some contextually salient way, and who contends.

Traditionally, counterpart theory has been associated with Lewis's[35] thesis of modal realism. Because Lewis held that each world was as real as the actual world, he understood individuals at other worlds to be distinct from actual individuals. He therefore needed to explain how anyone has nontrivial *de re* modal properties. Modal counterparts filled that gap.

But counterpart theory should not be tied to any particular modal metaphysics. As Jennifer Wang[36] has argued, counterpart theory is useful for modal ersatzists, and Wolfgang Schwarz[37] has pointed out that counterpart theory is useful even when we accept that individuals can be identical to themselves across worlds or points of evaluation. Schwarz argues that counterparts are primarily a tool for modelling shifts in reference in modal contexts. Finally, Kocurek[38] and Wilhelm[39] show how first-order counterpart theory can handle counteridenticals, an interesting subset of the countermetaphysicals I address here.

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kind in question to the antecedent. On my view, this could change a nontrivial or false counterfactual into a trivially true one. For example, if we add the nature of water to the antecedent of W, we convert our countermetaphysical into the following counterlogical W*: "if water were a continuous, incompressible molecule composed of hydrogen and oxygen, then it would obey the Navier-Stokes equation." On the view I present here, W* is trivially true. I think my view is correct. When evaluate countermetaphysicals like W, we must change the nature of the property or relation in question. Building that nature into the antecedent prevents us from doing so, without explicit contradiction. Consequently we should evaluate countermetaphysicals like W differently from the way we evaluate counterlogicals like W*. Thanks to an anonymous referee for raising this point.

[34] Mark Heller. "Property Counterparts in Ersatz Worlds". In: *Journal of Philosophy* 95.6 (1998), pp. 293–316. DOI: jphil199895612.

[35] David K. Lewis. *On the Plurality of Worlds.* Wiley-Blackwell, 1986.

[36] Jennifer Wang. "Actualist Counterpart Theory". In: *Journal of Philosophy* 112.8 (2015), pp. 417–441. DOI: 10.5840/jphil2015112826.

[37] Wolfgang Schwarz. "Counterpart Theory and the Paradox of Occasional Identity". In: *Mind* 123.492 (2014), pp. 1057–1094. DOI: 10.1093/mind/fzu143.

[38] Kocurek, "Counteridenticals".

[39] Wilhelm, "The Counteridentical Account of Explanatory Identities".

Higher-order counterpart theory (as in Heller[40]) makes the same move as first-order counterpart theory but applies it to properties[41]. Properties, like individuals, have *property counterparts* at other words: properties which are similar enough to the actual world property to stand in for them at that world. So if water could have frozen at 40°, there is a world at which some property, which is sufficiently similar to water, is such that things which have that property freeze at 40°. This property is the property counterpart to water. Just as first-order counterpart theory (according to Schwarz[42]) requires no assumptions about the trans-world identity of individuals, I will make no assumptions about the trans-world identity of properties. In §III.1 I will show how we can account for the impossibility of, for example, water being XYZ on both an account which presupposes trans-world identity of objects and properties, and an account which does not (these strategies are formally modelled in §A.2).

The counterpart relation between individuals is typically taken to be a relation of similarity: if I have a counterpart who is a contender, this contender had better be similar to me in some contextually salient way. Perhaps they have my beliefs, my parentage, or perhaps they have a similar natural athletic ability to mine[43].

Property counterparts must also be similar to one another. Similarity between individuals is often cashed out in terms of shared properties; to define similarity this way for properties we would have to invoke a potentially infinite chain of higher-order properties. Fortunately, that's not necessary. In discussing the problem cases in §II.2, I employ two ways in which properties can be similar to one another: they can feature in the same (or a similar) Ramsey sentence as one another, and they can have the same (or nearly the same) extension.

The first dimension of similarity follows Heller[44] in taking property similarity to be structural. On Heller's view, two properties are similar just in case they feature in the same or sufficiently similar Ramsey sentences. Since each property features in multiple Ramsey sentences, different counterpart relations can be constructed on the basis of these different profiles; these different counterpart relations will highlight different roles the property plays. Importantly, not just any Ramsey sentence will do: the relevant Ramsey sentences need to specify the nomic

[40] Heller, "Property Counterparts in Ersatz Worlds".

[41] This move is also suggested by Lewis (David K. Lewis. "Counterparts of States of Affairs". In: *A Companion to David Lewis.* Ed. by Barry Loewer and Jonathan Schaffer. John Wiley & Sons, Ltd, 2015, pp. 15–17, p.16).

[42] Schwarz, "Counterpart Theory and the Paradox of Occasional Identity".

[43] Probably not.

[44] Heller, "Property Counterparts in Ersatz Worlds".

or causal role played by the property. This is similar to, but importantly distinct from, causal essentialism about properties (see e.g. John Hawthorne[45] and Antony Eagle[46]). Rather than holding that some particular Ramsey sentence gives the nature of a property, and so is essential to it, higher-order counterpart theory allows different Ramsey sentences to be the basis of different counterpart relations, and allows for counterpart relations to be based on the similarity of the causal role a property plays even when that role is different in some way.

Heller advertises property counterpart theory as a neat way to capture many of the intuitions we have about the modal structure of properties without relying on *quiddities*, or ungrounded facts about trans-world property identity (a strategy suggested by Lewis[47]). Like essentialist views, a property counterpart account based on the Ramsey sentence of properties captures the idea that whatever plays the role of mass in our theories is mass. Unlike essentialist views, though, property counterpart theory captures the intuitive fact that some fundamental properties, e.g. charge, could have played a *slightly* different role in the laws of nature than they in fact do, if for example the constants governing them had been slightly different. Similarly, property counterpart theorists don't have to decide whether Newtonian mass is essentially gravitational, inertial, or both—there are counterpart relations corresponding to each role. Essentialists, on the other hand, are committed to choosing one of these as giving the essence of Newtonian mass.

I'll take advantage of this feature later to make the distinction between metaphysical and nomological counterparts of a property: some Ramsey sentences explicate the grounding or metaphysical structure of a property, while others give its nomic role. In both cases, finding the counterpart of a property relies on our identifying counterparts of other properties. For example, if the nomological counterparts of gravitational mass are all connected to instantiations of gravitational force, then in order to find the counterparts of mass at a world, we also need to find a counterpart for force. If the metaphysical counterparts of water are all composites of hydrogen and oxygen, then we need to locate counterparts of these properties at a world in order to find a counterpart of water which matches its metaphysical Ramsey sentence. (As I've

[45] John Hawthorne. "Causal Structuralism". In: *Metaphysics*. Ed. by James Tomberlin. Blackwell, 2001, pp. 361–78.

[46] Antony Eagle. "Causal Structuralism, Dispositional Actualism, and Counterfactual Conditionals". In: *Dispositions and Causes*. Ed. by Toby Handfield. Oxford University Press, 2009, pp. 65–99.

[47] David K. Lewis. "Ramseyan Humility". In: *Conceptual Analysis and Philosophical Naturalism*. Ed. by David Braddon-Mitchell and Robert Nola. MIT Press, 2009, pp. 203–222, p. 211.

indicated, it's open to defenders of property counterpart theory to take at least some of these properties to be the very same as the properties in the actual world, if they are leery of Heller's wholesale rejection of quiddities.)

I'll also consider property counterparts which are similar to the actual-world property they represent by having the same or a similar extension. This might generate the following worry: first-order counterpart theory bases its counterpart relation for objects on their shared properties. If those shared properties' counterparts are determined by which objects instantiate the properties at a world, we are in too tight a circle. Fortunately, things are not so closely tied together. Just as identifying a Ramsey sentence for a property requires us to find counterparts of *other* properties, we can identify our objects by finding the other properties they share, and then use these objects to find the counterpart of the property they instantiate. In these cases I'll assume that the objects in the extension of the property are picked out by the other properties the object has.

An illustration will make this less abstract. Suppose we're discussing sports at David Lewis High School (DLHS). After a discussion of the popular basketball program and its players, I might say "if it were colder here, basketball would have been hockey." Depending on what's going on in our interests and shared background knowledge, I might mean that hockey would have played the same role in the social life of students at DLHS that basketball in fact plays. But I might also mean that the specific students who play basketball would have instead played hockey. If I mean this latter thing, the counterparts of the students will be picked out by a similarity relation that does not include which sport they play—they will be counterparts of the actual students because they go to the same classes, eat in the same cafeteria, and have the same parents. The property of playing hockey will be the counterpart of the property of playing basketball in this world because the students who play it are counterparts of the actual-world basketball players. But their counterparthood is based on the sharing of properties other than playing basketball. The sharing of these other properties determines the counterparts of individuals; the fact that these individuals are in the actual extension of basketball-playing makes the sport they counterfactually play—hockey—the counterfactual counterpart of basketball. In general, whether one property is similar enough to another to be its counterpart will depend on the counterparts of other properties and individuals; in this way, property counterpart relations are often determined holistically[48].

On both first-order and higher-order counterpart theory, the same world can represent multiple possibilities by being examined under distinct counterpart relations. Following Lewis,[49] I will call worlds examined under a specific counterpart relation "possibilities". It is possibilities, rather than possible worlds, which feature in modal and counterfactual discourse.

The standard semantics for counterfactuals holds that if the consequent is true at that the most similar world which satisfies the antecedent, then the counterfactual is true; otherwise, it is false. But on a counterpart-theoretic approach, the counterfactual will take us to the closest *possibility* which satisfies the antecedent, rather than the closest world. Since a possibility comprises both a world and a counterpart relation, how similar each possibility is to the actual world will depend not just on how similar the world is, but also on how similar the counterparts are. This means we need to be careful about how we understand the similarity metric, and also constraints on that metric like strong centering: the actual world is closest to itself when examined under the trivial counterpart relation of identity, but not under nontrivial counterpart relations. And while the counterpart relations I discuss in the next section do not always bring us to the most similar counterparts full stop of the relevant properties, they do bring us to the counterpart which is most similar while satisfying the counterfactual antecedent. Hence, I will claim that, though the world or counterpart relation might be quite far from actuality, these are nonetheless the closest possibility satisfying the counterfactual antecedent.

II.2. Handling the Problem Cases. Let's turn to the problem cases from §I. The task here is simple: in order to show that property counterpart theory provides a possibility which satisfies the antecedent of these conditionals, I need to show that (a) there is a consistent world where some property satisfies the antecedent, and (b) this property is connected to the relevant actual-world property by some reasonable counterpart relation. Since counterpart relations are reasonable just if they are based on the satisfaction of similar Ramsey sentences, or the similarity of their extension, I will show that the relevant properties play one or both of these roles.

[48] Things are slightly easier if we generate our impossibilities using the *grafting* strategy discussed in §III.1; then we can take advantage of trans-world identities for most properties and individuals to find non-trivial counterparts for a few that are of interest to us.

[49] Lewis, *On the Plurality of Worlds*, p. 23.

It's worth noting here that my goal in this section is to model the problem cases; I'm relying on previous arguments that these counterfactuals *are* nontrivial (both in §I and in Tan,[50] Wilson,[51] and Bhogal[52]). Here, I aim to show that, assuming that these are nontrivially true or false, the best way to make sense of this is via property counterpart theory. So even if you are not convinced by all three of these cases, I aim to convince you that property counterpart theory provides a nontrivial semantic account of them. Another caveat: counterpart relations are by their nature context-dependent. Consequently my aim here is to establish that there are counterpart relations available which will make these nontrivial in some contexts, not to show that they are nontrivial in all contexts. Contexts shift and counterpart relations shift with them; while I think these counterpart relations capture similarity relevant to some contexts, it would be extremely surprising if they were operative in all contexts.

Now that the ground is clear, let's consider Tan's example W:

(1) "W: If water were a continuous, incompressible medium, then it would behave as the Navier-Stokes equations describe."[53]

Accommodating W in the property counterpart model requires us to find a consistent world in which there is a continuous, incompressible medium which is similar to water in its behavior[54]. In the actual world, water is a fluid which flows in rivers and pipes, pools, and takes the shape of its container. Continuous counterparts of water will also play these roles and exhibit typical watery behaviors[55] , such as floating boats and wetting whistles. If the closest such counterpart obeys

[50] Tan, "Counterpossible Non-Vacuity in Scientific Practice".

[51] Wilson, "Grounding Entails Counterpossible NonTriviality".

[52] Bhogal, "Nomothetic Explanation and Humeanism About Laws of Nature".

[53] Tan, "Counterpossible Non-Vacuity in Scientific Practice".

[54] Isaac Wilhelm (Wilhelm, "The Counteridentical Account of Explanatory Identities") suggests we treat sentences like W using a first-order counterpart theory, by taking "water" to be a singular term. I think that "water" functions in "water is H_2O" as a generally quantified property like "sharks" in "If sharks ate lettuce they'd have the biggest salads" and I take my property-counterpart treatment here and in the appendix to be an extension of Wilhelm's discussion in a richer language. See also Céspedes (Esteban Céspedes. "Laws of Nature and Counterparts". In: *Kritike* 5.2 [2011], pp. 185–196), who argues that Humeans can use first-order counterpart theory to accommodate dispositional essentialist intuitions.

[55] In personal correspondence, Tan suggests that continuity is a counterpart of a property water actually has, namely, approximate continuity. I tend to think that instead water has a continuous counterpart in virtue of water's instances being nearly continuous, whereas its counterpart's instancees have the similar property of being continuous.

the Navier-Stokes equation, then W is true. In fact it does—the Navier-Stokes equation can be derived from assumptions including continuity and incompressibility, so since the worlds we consider in property counterpart theory are consistent, water's incompressible continuous counterpart will precisely obey the Navier-Stokes equation and W will be true[56].

In order for water to have a continuous, incompressible counterpart, water must have at least one counterpart that is not H_2O, since composites of H_2O molecules are not continuous or incompressible. If water is essentially H_2O, then water could not be this incompressible medium. This counterpart, then, is an *impossible* counterpart of water. The antecedent is impossible, not because it takes us to an impossible world, but because the property-counterpart of water is a property that could not be water (I discuss this in more detail in §III.1)[57].

Now to grounding counterfactuals. I'll focus on CF3, since property counterpart theory agrees with standard counterfactual semantics in taking CF1 to be true.

(2) "CF3. If an intervention had prevented Singleton Socrates from existing, then Socrates would not have existed. — False"[58]

Dealing with grounding counterfactuals like CF3 is somewhat trickier. It requires us to find counterparts of Socrates, Singleton Socrates, and the set membership relation, such that Socrates' counterpart does not bear the membership relations' counterpart to Singleton Socrates' counterpart. This is because an intervention on Singleton Socrates must leave Socrates unchanged, and sever the set membership relations which are "upstream" from Singleton Socrates. Consequently, the closest possibility must be one in which Singleton Socrates fails to exist, but not because of any difference in its grounding base – otherwise, the lack of Singleton Socrates would not be due to an intervention.

As in the case above, this world is self consistent. But the objects and relations in the world, which stand as the counterparts of Socrates,

[56] Note that this argument requires conditional proof; I show in Appendix A.3 that conditional proof holds on counterpart-theoretic semantics for $\Box\!\!\rightarrow$. I take this to be an advantage over impossible worlds approaches, which don't generically validate conditional proof.

[57] It's worth noting here that this requires continuous fluids to be genuine metaphysical possibilities; although most views of metaphysical possibility accept this, some nomic necessitarians, like (Wilson, *The Nature of Contingency: Quantum Physics as Modal Realism*) or (Kimpton-Nye, "Necessary Laws and the Problem of Counterlegals") might not. Thanks to Sam Kimpton-Nye and Alastair Wilson for discussion of this point.

[58] Wilson, "Grounding Entails Counterpossible NonTriviality".

Singleton Socrates, and the set membership relation, could not possibly be Socrates, Singleton Socrates, or membership—since necessarily, Socrates is a member of Singleton Socrates. How then can they be counterparts to Socrates, Singleton Socrates, and the grounding relation?

Call the counterpart of the membership relation at this world the "membership*" relation, and the counterparts of Socrates and Singleton Socrates "Socrates*" and "Singleton*". One way for the membership* relation to be sufficiently similar to the membership relation to count as its counterpart is for it to relate every counterpart of an individual to the counterpart of that individual's singleton, with the sole exception of Socrates* and Singleton*. The membership* relation nearly matches the membership relation in both Ramsey sentence and extension. The membership* is a strict subrelation of the membership relation, differing from it in only one instance. Such a relation would be similar enough to the membership relation to be one of its counterparts at this world.

It might seem strange to imagine a possibility where set abstraction doesn't apply to just this one instance. While I agree that, if Socrates has a singleton set, he necessarily has one, I don't think membership* is so different from membership. For note that we cannot assume that every collection of objects has a set containing it without invoking paradox. (Actual) set membership is like membership* in failing to apply to some collections; membership* just differs in that there is one particularly small finite collection which it doesn't have a set. Since the antecedent requires us to find a possibility—that is, a combination of counterparts together with a world—on which Socrates has no Singleton, this counterfactual will take us to the possibility where membership* (rather than membership) is the counterpart of the membership relation. Of course, the membership relation also exists at that world, and there is a distinct possibility according to which membership, rather than membership*, is the counterpart of membership that world[59]. But this possibility is not the closest possibility where the intervention has been performed, because it simply is not a possibility where the intervention has been performed; even though membership* is less similar to membership than membership is to itself, it is the most similar counterpart which satisfies the antecedent of the counterfactual.

[59] It may well be our own world! Since our world contains the membership relation, it also contains membership's strict subrelations. So there is possibility which consists of our world in which membership stands for itself, and another which also consists of our world, but in which the relevant counterpart relation takes us to one of membership's subrelations.

The single exception to the membership* relation at this world looks quite a bit like one of Lewis's "tiny miracles" for typical counterfactuals[60].[61] On Lewis's view, counterfactual antecedents typically take us to worlds which precisely resemble our world in the past, and precisely obey our laws in the future. But to satisfy the counterfactual antecedent, there is a very small violation of the laws in the present. On many views of metaphysical dependence, these cases are close parallels. On views which regard grounding relations as governed by metaphysical laws, such as that of Tobias Wilsch[62] or Jonathan Schaffer,[63] they are both cases of law-breaking to satisfy the counterfactual antecedent. (This analogy connects well to the legislating strategy of §III.1).

Finally, how should Humeans and nomic necessitarians deal with apparent worlds in which the laws are metaphysically impossible–for example, the empty spacetime world with general relativistic laws?

(3) SIMPLEGR$_2$: If you added a mass to an empty spacetime governed by the laws of General Relativity, that spacetime would remain flat.

Property counterpart theory provides an easy solution for Humeans in cases like this. Although there is only one world with an empty spacetime, that single world can be considered under different counterpart relations for the property of being a law. Consequently, that single world gives us two possibilities. One of these properties is similar to the actual-world lawfulness property because it has the same extension: the same regularities, those of GR, have that property. The other property is similar to the actual-world property of lawhood by having the same grounding base: it is had by the regularities, those of SR, which are in the best systematization of that world.

Things are a little complicated here because the Humean must choose what has the property of being a law: is it patterns, regularities, or propositions? I'll assume that lawfulness is a property of regularities, where a regularity is the collection of a law's instances, but I don't think anything hangs on that choice. Non-Humeans hold that this property is basic; Humeans hold that it is grounded in global facts about what best summarizes the Humean mosaic.

[60] David Lewis. "Counterfactual Dependence and Time's Arrow". In: *Noûs* 13.4 (1979), pp. 455–476.
[61] David Lewis. "Are We Free to Break the Laws?" In: *Theoria* 47.3 (1981), pp. 113–21. DOI: 10.1111/j.1755-2567.1981.tb00473.x.
[62] Tobias Wilsch. "The Nomological Account of Ground". In: *Philosophical Studies* 172.12 (2015), pp. 3293–3312. DOI: 10.1007/s11098-015-0470-9.
[63] Jonathan Schaffer. "Laws for Metaphysical Explanation". In: *Philosophical Issues* 27.1 (2017), pp. 302–321. DOI: 10.1111/phis.12111.

At simple worlds, multiple law-systems have exactly the same instances, and so multiple distinct regularities wholly overlap. This is similar to the mereological overlap of objects, like the statue and lump of clay that forms it, and I think that we can appeal to the same sort of counterpart-theoretic solution that Lewis[64] applies in that case. One particle moving inertially is an instance of Newtonian gravitational mechanics, but also of a law stating that all objects move inertially; an empty spacetime is an instance of GR, as well as SR. The counterpart relation determines which of these overlapping instances—being a regularity of GR or being a regularity of SR—is an instance of a law.

Because (according to Humeanism) *being a law* is a property a regularity has in virtue of fitting into the Best System, it's metaphysically impossible for a regularity to be a law without fitting into that system (correspondingly, on necessitarianism, *being a law* is had necessarily if at all). Nonetheless, regularities that are laws at one world can have law-counterparts at worlds where they are not the best system; these counterparts are similar in virtue of having the same content, or being the same regularity, rather than in virtue of fitting into the best system. The property is similar to *being a law* because it has the same extension—it applies to the same regularities it does in the actual world—even though it does not have the same grounding structure. SIMPLEGR$_2$ takes us to such a possibility.

This concludes my treatment of the problem cases. I'd like to highlight that in this section I've drawn strategies from both the literature on ordinary counterfactuals (as when I suggested that countermetaphysicals can involve isolated violations of metaphysical laws) and the literature on first-order counterpart theory (as when I noted the similarity between a regularity being an instance of two laws and the standard counterpart-theoretic resolution of mereological co-location).

In all three cases, the relevant worlds are internally consistent, but the counterpart relation relates objects or properties to things which they could not be. Although these things are similar in some respects to one another—similar enough for there to be a counterpart relation linking them—there is a strong sense in which, for example, water simply could not be an incompressible continuous material, $\in$ could not fail to connect Socrates and {Socrates}, and the laws must be the axioms of the Best System.

[64] David K. Lewis. "Counterparts of Persons and Their Bodies". In: *Journal of Philosophy* 68.7 (1971), pp. 203–211. DOI: 10.2307/2024902.

III. MODELLING IMPOSSIBILITIES

III.1. Impossible Counterparts. The counterpart relations involved in counterpossible counterfactuals are weird. They link individuals and properties with things which they could not be. But given that *what it is* for something to possibly be some way, according to modal counterpart theory, *just is* for it to have a counterpart that is that way, it's hard to see in what sense the antecedents are impossible, or why we judge that, e.g., water could not be an incompressible continuous material.

Collapsing this distinction may matter little for the counterpossibles discussed in Tan,[65] but it would amount to a pyrrhic victory for the Humean, the necessitarian, or the grounding theorist. If the Humean and nonHumean both think that there could be laws which aren't elements of the best deductive system of facts that world, but disagree only on what label we should give those possibilities, then their disagreement doesn't seem substantive.

There is a similar difficulty for the proponent of interventionist grounding models. If grounding relations are contingent, it's difficult to see in what sense the grounded depends on its grounds. If Socrates' Singleton could exist without Socrates, in what way does the singleton depend on its element?

We can escape this bind by showing that on the new framework, metaphysical possibility is privileged. Fortunately, a counterpart-theoretic framework has plenty of resources to accomplish this. I will here outline two strategies: the *grafting* strategy, and the *legislating* strategy.

The *grafting* strategy attaches the mechanisms of counterpart theory to an existing, well-developed metaphysical theory of possibility. Luckily, the counterpart-theoretic framework can be grafted onto any account of possible worlds without doing significant damage to its host. Recall that we did not stipulate that properties (or objects, for that matter) are world-bound. This allows philosophers with a well-developed theory of possible worlds to take the metaphysical possibilities to be those at which each property's counterpart is itself. This strategy allows us to retain the idea that the metaphysical possibilities represent the way things really could be, while nontrivial counterpart relations allow us to examine how things would have behaved if they had been something they could not have been.

The grafting strategy will work for a wide variety of theories of possible worlds. For example, philosophers who follow Stalnaker[66] or

[65] Tan, "Counterpossible Non-Vacuity in Scientific Practice".
[66] Robert Stalnaker. *Mere Possibilities: Metaphysical Foundations of Modal Semantics.* Princeton University Press, 2011.

Plantinga[67] in holding that worlds are maximal properties can take each metaphysical possibility to be one of these worlds, with each property serving as its own counterpart. The metaphysical impossibilities will *also* be these worlds, but with an expanded counterpart relation on which some properties "stand in" for others[68]. This view of worlds allows for a neat explanation of the essential nature of kinds, like water. Water is (metaphysically) necessarily H_2O because water is *in fact* H_2O, and so it is H_2O at every world where it (H_2O) represents itself. Since water's continuous counterparts are not molecular, they are not H_2O, and so must be represented by some distinct property. Since this property is not (in fact) water, these possibilities are metaphysical impossibilities. They are not impossible worlds, though—they are possible worlds examined through an impossible counterpart relation.

Similarly, philosophers who take the metaphysically possibilities to be determined by the essential natures of properties (such as Vetter[69] or Bird[70]) or the laws of nature (such as Wilson[71]) can take the metaphysical possibilities to be represented by worlds and properties which are compatible with the essences of properties or the laws of nature (respectively), while using non-trivial counterpart relations to construct metaphysical impossibilities out of these metaphysically possible worlds.

But not all philosophers have such a robust conception of metaphysical possibility; for example, some philosophers take possibilities to be abstractions from our linguistic practices, belief and cognitive states, or modal discourse itself. In the categories of Lewis,[72] these philosophers are *linguistic ersatzists* or *magical ersatzists.* And even philosophers who

[67] Alvin Plantinga. *The Nature of Necessity.* Clarendon Press, 1974.

[68] Whether first-order counterpart relations also generate metaphysical impossibilities will depend on the details of the worlds in question. If these worlds are rich enough to include individuals with trans-world identity relations, then the grafting strategy will imply that first-order counterpart relations are also metaphysically impossible (except of course for the trivial case in which the counterpart relation is identity). In this case, some of the advantages of counterpart theory, for example in dealing with mereological co-location, may be lost. But the grafting strategy is compatible with views of possible worlds on which properties, but not individuals, have quiddities or trans-world identity relations. These views of possible worlds make a principled distinction between non-trivial first-order counterparts and non-trivial higher-order counterparts. Such grafters could retain the advantages of first-order counterpart theory while holding that higher-order counterparts are impossible. As we will see, the legislating strategy (below) can retain all of the advantages of first and higher-order counterpart theory, as it permits some, but not all, non-trivial counterpart relations to represent metaphysical possibilities. Thanks to an anonymous reviewer for discussion of this point.

[69] Barbara Vetter. *Potentiality: From Dispositions to Modality.* Oxford University Press, 2015.

[70] Bird, *Nature's Metaphysics*.

[71] Wilson, *The Nature of Contingency: Quantum Physics as Modal Realism*.

[72] David Lewis. *Philosophical Papers: Volume II.* Oxford University Press, 1986.

have a robust–non-ersatzist–conception of possible worlds may lack a principled distinction between metaphysical possibility and impossibility. For these philosophers, the distinction between metaphysical possibilities and impossibilities may not flow as easily from the nature of possible worlds[73]. In that case, the distinction must be imposed on them. I advise these philosophers to distinguish metaphysical possibilities from impossibilities by *legislating*: they should hold that, as a rule or matter of principle, some counterpart relations correspond to metaphysically possible counterparts, and others do not. This is a line in the sand: on one side are metaphysically possible counterparts, on the other, impossible ones. On this view, metaphysical possibilities are a restriction on the space of possibilities, a special and privileged subclass.

To make the legislative strategy work, we need a principled way of making this distinction. One way to do this is to simply stipulate that the metaphysical possibilities are those which correspond to our intuitions about the metaphysical facts. On this view, there just are some properties which water (metaphysically) could be, others which it couldn't. The set of counterpart relations that picks out those properties is metaphysically privileged, and that's all there is to it. This mirrors the conventionalist approach of Sider.[74] Because the stipulation here is brute, this is a brutal version of the legislative strategy.

A brutal legislative strategy would leave metaphysical necessity mysterious. But laws without justification are at risk of being overturned. A better way, on my view, would be to take the metaphysical counterpart relations to be those which preserve the actual world's metaphysical structure.

Metaphysical structure includes the structure of identity relations and identity-like building relations (see Bennett[75] for an account of building relations, and Schaffer[76][77] for a defence of a law-based view of grounding). If some entity *a* is grounded in some other entity *b*, a counterpart relation which takes *a* and *b* to objects which don't bear the grounding relation to one another, or which takes *a* to some ungrounded object, is a metaphysically impossible counterpart relation[78].

[73] Although it might: for example, a Lagodonian linguistic ersatzer might identify the predicates of the language in which their worlds are constructed with the properties of the world, providing a principled account of trans-world property identity. (Thanks to an anonymous review for pointing this out.)

[74] Theodore Sider. *Writing the Book of the World*. Oxford University Press, 2011.

[75] Karen Bennett. *Making Things Up*. Oxford University Press, 2017.

[76] Schaffer, "Laws for Metaphysical Explanation".

[77] Jonathan Schaffer. "The Ground Between the Gaps". In: *Philosophers' Imprint* 17 (2017).

[78] This is, of course, too simple. For many higher-level properties are grounded by being *functionally realized* at a lower level. In these cases, it suffices that *some* realizer exist for

The counterpart relations in §II.2 do not preserve metaphysical structure. In the actual world, water is composed of hydrogen and oxygen; its continuous counterpart is not composed of any particles at all. By connecting the natural kind *water* to a property which lacks compositional structure, the counterpart relation fails to preserve metaphysical structure. Similarly the counterpart relation linking Socrates to Socrates* and Singleton Socrates to Singleton* violates the rules of set membership, and so fails to preserve metaphysical structure. Finally, worlds in which the laws are not part of the world's best system are worlds at which the laws—which are in fact grounded in the nonmodal facts about the world—are ungrounded or fundamental.

On either the grafting or the (non-brutalist) legislating strategy, metaphysical necessity is not merely stipulated or determined *a priori*. Rather, it is the grounding structure of the actual world, projected onto these possibilities, that insures the existence and nature of nonfundamental objects there. The modality is not explained by the possible world models; it is instead explained by actual-world grounding relations between fundamental and nonfundamental objects.

III.2. Impossible Counterparts or Impossible Worlds? Property counterpart theory is not the first attempt to tackle countermetaphysical counterfactuals, but it is the first that eschews the use of impossible worlds. I have no deep objection to impossible worlds, but I think property counterpart theory provides a compelling alternative that has a few advantages in handling countermetaphysicals like those I examine here. Impossible worlds approaches can be found in Berto,[79] Bjerring,[80] Vander Laan,[81] and Jago,[82] with McLoone[83] showing explicitly how an impossible worlds approach can handle countermetaphysicals like W. For a novel approach which uses fictions instead of counterparts or impossible worlds, see Kimpton-Nye[84]. Another alternative that bears some

each counterpart of the kind. Naturally, even this caveat will not capture all cases; the complexities of grounding are, alas, beyond the scope of this footnote.

[79] Francesco Berto et al. "Williamson on Counterpossibles". In: *Journal of Philosophical Logic* 47.4 (2018), pp. 693–713. DOI: 10.1007/s10992-017-9446-x.

[80] Jens Christian Bjerring. "On Counterpossibles". In: *Philosophical Studies* 168.2 (2014), pp. 327–353. DOI: 10.1007/s11098-013-0133-7.

[81] David Vander Laan. "Counterpossibles and Similarity". In: *Lewisian Themes: The Philosophy of David K. Lewis*. Ed. by Frank Jackson and Graham Priest. Oxford, UK: Clarendon Press, 2004, pp. 258–275.

[82] Mark Jago. "Impossible Worlds". In: *Noûs* 47.3 (2013), pp. 713–728. DOI: 10.1111/nous.12051.

[83] McLoone, "Calculus and Counterpossibles in Science".

[84] (Kimpton-Nye, "Necessary Laws and the Problem of Counterlegals") It is not clear to me whether fictionalist views take the antecedent to be fictionally possible, and so take the conditional to be merely fictionally non-trivial (but actually, really, trivial) or if

similarity to the present approach is that of Toby Handfield,[85] which combines a paraphrase theory with 2-dimensional semantics.[86]

First, property counterpart theory neatly mirrors our intuitive reasoning about the cases. When we reason about what water would be like, were it continuous, we are thinking of something as similar to water as possible that lacks its molecular structure. This sort of reasoning is reflected in the semantics of property counterpart theory, on which the counterfactual is made true (or false) by the most similar possible thing to water which is continuous.

Second, property counterpart theory has attractive features that the impossible worlds approach does not have. For, on property counterpart theory, the worlds—examined under a counterpart relation—are complete and consistent. Consequently, as I prove in §A.3, the consequents of these counterpossible suppositions are closed under logical entailment. So if $A \boxright B$ and $B \vDash C$, then $A \boxright C$. If $A \boxright B$ and $A \boxright C$, then $A \boxright B\&C$. Similarly, I show that on the property counterpart approach, conditional proof is valid for $\boxright$. These features are attractive, since in many of the troublesome cases, including those most useful in scientific contexts, we are interested in reasoning deductively about the consequents of counterpossible suppositions. Impossible worlds approaches can accommodate this reasoning in restricted cases, for example by claiming that at least some metaphysical impossibilities are logically consistent, and invoking a similarity ordering on which consistent worlds are closer than inconsistent ones (see

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these views aim to take the conditional to be strictly nontrivial, and true if and only if the consequent is true according to the fiction of the antecedent. If the former, I think my view has the advantage of taking our practice of evaluating these conditionals as nontrivial at face value. If the latter, it seems to me that fictionalism is not so different from linguistic ersatzism, since both involve abstract sets of claims or propositions–fictions for one, worlds for the other.

[85] Toby Handfield. "Counterlegals and Necessary Laws". In: *Philosophical Quarterly* 54.216 (2004), pp. 402–419. DOI: `10.1111/j.0031-8094.2004.00360.x`.

[86] Handfield paraphrases claims like "If water were XYZ, then ..." as "if water had turned out to be XYZ", and treats these roughly as indicative conditionals. My proposal has two primary advantages over Handfield's. The first is that my proposal is not a paraphrase theory, it is rather a semantic theory for ordinary counterfactuals. I think the charitable presumption that competent English speakers say what they mean, and are often right, inveighs against paraphrase theories and in favor of realist semantic theories. Second, my view more easily accommodates the fact that we take "If water were XYZ, then XYZ would fill our lakes and streams" to be true but "if the queen were a robot, everyone would be a robot" to be false. These are natural because the first takes us to a world where water's property counterpart is XYZ, and so XYZ plays water's role; the second takes us to a world where only the queen's counterpart is a robot, so the rest of us are humans. Handfield's account awkwardly attempts to handle these by balancing constraints which pull in the direction of taking everyone to be a robot if the queen is (see p. 418).

McLoone[87] for a compelling example of this strategy). But I think it is an advantage of the counterpart-theoretic approach that the validity of this reasoning doesn't depend on the counterfactual antecedent or the specific similarity metric.

Thirdly, property counterpart theory does not require metaphysically impossibe worlds to contain logical contradictions, as do some (but not all) impossible worlds approaches. Some impossible worlds approaches take impossible worlds to be sets of propositions, wherein "there is at least one proposition that expresses a metaphysical, logical, or mathematical impossibility, relative to what we take to be necessarily true or false at [the actual world]".[88] McLoone argues that these worlds could well be logically consistent, since they could include the impossible "water is not H_2O" but not the inconsistent "H_2O is not H_2O"[89].

But recall that Kripke's argument for the necessity of "water is H_2O" was built on the claim that "water" and "H_2O" have the same semantic value, and so contribute the same thing to the propositions they express. If Kripke is right, then "water is not H_2O" and "H_2O is not H_2O" express the same proposition, and so any impossible world which includes one includes the other. Since impossible worlds can contain contradictions, the counterpossible program can accommodate this; but it does create a challenge for the claim that the worlds are consistent. Impossible worlds theorists could reject Kripke's claims about the meaning of natural kind terms. Perhaps, as Pietroski[90] suggests, they could hold that "water is H_2O" and "H_2O is XYZ" express different propositions; maybe they would hold that the meaning of natural kind terms includes Fregean senses. But then they will need a new reason to take these worlds to be impossible, since this move would undercut Kripke's argument for the necessary identity of natural kind terms.[91]

Property counterpart theory sidesteps this issue by showing how a term can shift its reference, and so its semantic value, in modal contexts. "Bob Dylan" and "Robert Zimmerman" have the same semantic value and refer to the same man; however, in modal contexts, we can use these names to trigger different counterpart relations: "If Robert Zimmerman hadn't learned guitar, Bob Dylan wouldn't have existed." But since both counterparts are counterparts of Dylan (and so also of Zimmerman), we don't also have to add anything other than Dylan

[87] McLoone, "Calculus and Counterpossibles in Science".

[88] Ibid., p. 16.

[89] McLoone's examples are "water is XYZ" and "water is H_2O"; I've chosen these sentences instead to bring out the distinction between impossible and inconsistent.

[90] Paul Pietroski. *Conjoining Meanings.* Oxford University Press, 2018, p. 20-23.

[91] Thanks to Peter Tan and Brian McLoone for discussion of this point.

to the proposition in either the modal or nonmodal context[92]. Hence, property counterpart theory is able to avoid contradictions in metaphysically impossible worlds by avoiding Kripke's conclusion that "water = H_2O" holds in all possibilities if it holds at all. We then supplement this with a non-Kripkean account of the distinction between metaphysical possibility and impossibility, as described in §III.1.

III.3. Countermetaphysicals are not Counterlogicals . Finally, property counterpart theory draws a firm line between metaphysical impossibility and logical impossibility. It is a consequence of the semantics offered here that counterlogical counterfactuals are trivially true (although, as I will discuss shortly, there are ways to extend the sematics to avoid this). I take this firm line to be a further advantage of the view; there are good reasons for thinking that countermetaphysicals have more in common with counternomic counterfactuals than counterlogical counterfactuals. To see why, consider the following example:

> SPACE ELEVATOR: Suppose I am considering whether to attempt to construct a space elevator using steel cable. I might consider the following counterfactual: If I constructed a space elevator using steel cable, the steel cable would withstand tensions greater than $350 GPa$. After carefully considering the masses, forces, and accelerations involved in the elevator, I might conclude that this counterfactual is true, and that similar counterfactuals are false (such as the following false counterfactual: if I constructed a space elevator using steel cable, the steel cable would not be subject to tensions greater than $200 GPa$). Then, I would determine empirically whether steel is able to withstand tensions of $350 GPa$. It turns out that it is not, so it is impossible to construct a space elevator out of steel[93]. Hence the initial counterfactual was a counterpossible counterfactual.

It is not clear whether the modality involved in SPACE ELEVATOR is physical or metaphysical, since the impossibility of building a steel cable which can withstand tensions of $350 GPa$ results from the compositional structure and so metaphysically necessary features of steel, together with the dynamic laws of the actual world which govern gravitational and intermolecular forces. It is, however, clear that the counterfactual is neither counterlogical nor countermathematical: although the relations

[92] The difference in semantic value between these terms is more akin to the 'character' of indexicals than the Fregean sense of names. In different contexts, they indicate different counterparts. But both are counterparts of Dylan, and so the names contribute the same thing to the sentence—namely, Dylan himself.

[93] The hope for such an elevator created out of carbon nanotubes is greater, as they are both lighter (and so would create less tension) and have a much greater tensile strength Hamer(Trevor Hamer and Paul A. Nakroshis. "The Physics of a Space Elevator". In: *Thinking Matters Symposium Archive* 10 [2014]. https://digitalcommons.usm.maine.edu/thinking_matters/10).

and forces involved are represented mathematically, when we consider this counterfactual we consider possibilities in which the relations and forces are different, rather than situations in which they are merely represented by different mathematical operations.

The example illustrates the fact that countermetaphysical and counternomic counterfactuals have a number of commonalities: first, both sorts of counterfactuals are appealed to in scientific explanations. The explanation for the fact that attempts to build a space elevator have so far failed includes counterfactuals about the structure of available components and about the laws of nature.

Second, the counterfactuals in question are often *a posteriori*. We discover the laws of nature empirically; we similarly discover the metaphysical structure of the world empirically. Things like the molecular structure of water, the nature of heat and entropy, or grounding or supervenience base of mental processes are determined using the same scientific process that generates our physical theories.

Finally, the counterfactuals in question require violations of real-world dependence relations: either nomic dependence or metaphysical dependence relations must be broken for a steel cable to hold a space elevator.[94]

That said, some of the considerations which favour taking seriously countermetaphysical nontriviality also favour taking seriously counterlogical nontriviality. For example, mathematical explanations often rely on countermathematical counterfactuals; reasoning about logical principles often involves reductio arguments. I hold that the counterpart theoretic approach provides the most natural and plausible account of countermetaphysical reasoning, and that countermetaphysicals are more naturally grouped with counternomic counterfactuals than with counterlogicals.

But philosophers who want to hold on to countermathematical and counterlogical counterfactuals have options within the present framework: they could expand the counterpart relation to include nontrivial counterparts of the logical constants. Relations between propositions, like conjunction, disjunction, and the consequence relation could be given nontrivial counterparts, in the same way that set membership

[94] Some mathematical cases may similarly involve real-world relations and contingent or non-abstract existences, as in impure set theory. The example of Socrates and his Singleton illustrates this. Whether these cases should be grouped with countermetaphysicals seems to me to depend on the metaphysics of mathematics. If set impure theory primarily concerns concrete objects and their relations to abstracta, as (David K. Lewis. *Parts of Classes*. Blackwell, 1990) argues, then they fit best with countermetaphysicals. But of course if mathematics is just a subset of logic, as logicism holds, then they are counterlogicals. More on this below.

is given a nontrivial counterpart in §II.2. This strategy would similarly sacrifice some of the closure principles of the present approach, but plausibly in a controlled way, and it would retain the present approach's ontological parsimony. For a similar strategy, which relies on a shiftable parameter connected to conventions of inference, see Kocurek and Jerzak.[95]

IV. ANTI-HUMPHREYAN POSTSCRIPT

In closing, I'd like to fend off a worry one might have about property counterpart theory, especially a property counterpart theory built on an ersatzist understanding of possible worlds. This objection is along the lines of the Humphrey objection to first-order counterpart theory. One might think that what's possible for water should constitutively involve water in a way that water's counterparts at these worlds—whether they are linguistic entities or just other properties—just don't. When I think of the possibility that water can become Ice-9, I am not considering some non-water property and asking how much it is like water. I am thinking about a way the world could be, and what water could be like! In addition to inveighing against counterpart theory, I think that this intuition is one of the sources for support for more realist views and against ersatzist views of possible worlds. But a little thought shows that it is misguided.

On the picture I've presented here, counterpossible reasoning is useful to us primarily as a guide to real-world dependence relations, whether those are causal—as when we use metaphysically impossible idealizations to model some of a system's causal relations in isolation from others—or metaphysical—as when we engage in counterpossible suppositions to see whether they conflict with what we know about the world. In this way, the counterpossibilities stand in for or represent the actual dependence relations among real-world things.

Now, nobody really thinks that representations have to be the of same sort as the thing they represent. Nobody thinks that if a mountain is made out of rocks you can't map it using paper, or that for a feeling to be captured by a song that feeling must be made out of sound waves. And thoughts and sentences are themselves very different from the things they represent, both in substance and structure.

When we provide models of content, we are creating metarepresentations. If we've accepted the obvious fact that representations can be wildly different in substance from the thing they represent, there is no

[95] Alexander W. Kocurek and Ethan J. Jerzak. "Counterlogicals as Counterconventionals". In: *Journal of Philosophical Logic* 50.4 (2021), pp. 673–704. DOI: 10.1007/s10992-020-09581-6.

good reason to require higher-order representations to be metaphysically like the target of their representation. Our models of possibility can be whatever we want them to be, so long as the way in which they represent the content of our thoughts and sentences is clear. My aim in this paper has been to show how we use things that aren't water—things that water couldn't possibly be—as a guide to what water's actual structure is.

V. CONCLUSION

Scientific practice and metaphysical modelling posit a variety of nontrivial counterpossible counterfactuals. But these counterpossibles don't fit neatly into our current models of counterfactuals, even those which posit impossible worlds. Here, I've argued that a model based on property counterpart theory can handle many of the problem cases, while making sense of the idea that these counterfactuals have impossible antecedents.

APPENDIX A. THE COUNTERPART-THEORETIC MODEL

Here I will sketch a higher-order counterpart-theoretic model for counterfactuals[96] . The semantics is loosely based on that of Kocurek[97] and Kracht and Kutz's[98] counterpart frames; it extends both to include a higher-order counterpart relation, but simplifies other parts of the semantics to focus on this difference. Useful resources on the semantics of counterpart theory can be found in Kracht and Kutz,[99] Russell,[100] and Schwarz.[101]

A.1. Counterpart Models.

- Language: we will use the standard language of first-order predicate logic without constant terms, as in Kracht and Kutz.[102]

D1 STRUCTURE: A *structure* is a tuple $S = \langle W, D, d, \mathcal{I} \rangle$, where W is a set of worlds, D a set of objects disjoint from W, and d a function from worlds to subsets of D ($d : W \longrightarrow \wp(D)$). Intuitively, D contains all possible objects and d tells us which objects exist at each world. For each $w \in W$, we will write $D_w = d(w)$[103].

D1.1 INTENSION: An *Intension* is a function $I^n : W \longrightarrow \wp(D)^n$ from worlds to sets of elements of D^n (where D^n is the set of n-tuples of elements of D).

D1.2 The *extension of I at w* is the set I^n assigns to w. We will write this as $E_w = I(w)$. We require $E_w \subset D_w$. [104]

D2.2 We will call the set of intensions $\mathcal{I}$. Note that we do not require $\mathcal{I} = W \times \wp(D)$: intuitively, intensions may be sparse.

D2 COUNTERPART RELATION: A COUNTERPART RELATION is a function $C \subset ((D \times W)^2 \cup (\mathcal{I} \times W)^2)$. That is, it relates object-world pairs to one another and intension-world pairs to one another. (This is the primary departure from Kracht and Kutz,[105] to accommodate

[96] Thanks especially to Alexander Roberts and Salvatore Florio for comments on this appendix.

[97] Kocurek, "Counteridenticals".

[98] Marcus Kracht and Oliver Kutz. "The Semantics of Modal Predicate Logic II. Modal Individuals Revisited". In: *Intensionality: Lecture Notes on Logic 22*. Ed. by Reinhard Kahle. A. K. Peters, Ltd., 2005, pp. 60–96, p.71.

[99] Marcus Kracht and Oliver Kutz. "The Semantics of Modal Predicate Logic I. Counterpart-Frames". In: *Advances in Modal Logic, Volume 3*. Ed. by Frank Wolter et al. CSLI Publications, 2002, pp. 299–320.

[100] Jeffrey Sanford Russell. "Actuality for Counterpart Theorists". In: *Mind* 122.485 (2013), pp. 85–134. DOI: 10.1093/mind/fzt037.

[101] Schwarz, "Counterpart Theory and the Paradox of Occasional Identity".

[102] Kracht and Kutz, "The Semantics of Modal Predicate Logic II. Modal Individuals Revisited".

[103] We will not require that objects are worldbound, that is, we will not require that each object exists at only one world.

[104] If properties are worldbound, in the sense of Heller (Heller, "Property Counterparts in Ersatz Worlds"), then $E_w = I(w) = I$.

[105] Kracht and Kutz, "The Semantics of Modal Predicate Logic II. Modal Individuals Revisited".

higher-order counterparts). I also stipulate here that C delivers at most one counterpart at each world; note in the following that a model contains a set of counterpart relations and so objects can have multiple counterparts at a world, each under a different counterpart relation.

D3 COUNTERPART FRAME: A *counterpart frame* $\mathcal{F}$ is a tuple $\mathcal{F} = \langle S, \mathcal{C} \rangle$ consisting of a structure and a set $\mathcal{C}$ of counterpart relations.

D4 COUNTERPART STRUCTURE: A *counterpart structure* is a pair $\langle \mathcal{F}, \mathcal{N} \rangle$ where $\mathcal{F}$ is a counterpart frame and $\mathcal{N}$ is an interpretation.

D4.1 INTERPRETATION: An *interpretation* $\mathcal{N}$ is a function which assigns to each n-ary predicate an intension $I^n \in \mathcal{I}$. We will call the extension at w, E_w, of the intension $\mathcal{N}$ assigns to the n-ary predicate P^n "$\mathcal{N}_w(P^n)$".

D5 POSSIBILITY: A *possibility* on a frame is a pair $\langle w, C \rangle$ where $w \in W$ and $C \in \mathcal{C}$. We will write this w_C.

– We will call the set of possibilities on a frame $Pos(\mathcal{F})$.

D6 SELECTION FUNCTION: A *selection function on* $\mathcal{F}$ is a function f : $[\wp(Pos(\mathcal{F})) \times W] \longrightarrow Pos(\mathcal{F})$. That is, it takes us from a set of possibilities (intuitively, a proposition) and a world to a possibility.

– To recover Lewis's full logic of counterfactuals[106] we would need to further constrain the selection function, and allow it to take us to sets of possibilities rather than a unique possibility, but for simplicity I omit these complications.

D7 COUNTERPART MODEL: A *counterpart model* is a quadruple $\mathcal{M} = \langle \mathcal{F}, \mathcal{N}, \eta, f \rangle$ where $\mathcal{F}$ is a counterpart frame, $\mathcal{N}$ is an interpretation, η is a variable assignment, and f is a selection function on $\mathcal{F}$.

D7.1 VARIABLE ASSIGNMENT: A *variable assignment* η is a function which assigns to every $w \in W$ and every variable an element from the domain D (thought that object need not be in D_w).

D7.2 INTERPRETATION FROM A POSSIBILITY: An *interpretation from* w_C is a function which assigns to each world v and n-ary predicate P^n the counterpart which C assigns at v of the intension which $\mathcal{N}$ assigns to P^n at w. We will write this as $\mathcal{N}^{w_C}$, where $\mathcal{N}^{w_C}_v(P^n) = I(v)$ iff $\langle \mathcal{N}(P^n), w \rangle C \langle I, v \rangle$.

D7.3 ASSIGNMENT COUNTERPARTS: We will define a relation between variable assignments $\xrightarrow{C}$ where, given a counterpart relation $C \in \mathcal{C}$ and worlds v and w, $\eta \xrightarrow{C} \tilde{\eta}$ if and only if $\langle \langle \eta_v(x), v \rangle \langle \tilde{\eta}_w(x), w \rangle \rangle \in C$.

D7.4 LOCAL x–VARIANT: We will say that $\tilde{\eta}$ is a *local x-variant at v* of η if and only if $\tilde{\eta}$ is a valuation that differs from η at most in the value it assigns to x at v. We will write this as $\tilde{\eta} \simeq^v_x \eta$.

D8 TRUTH IN A MODEL: Let $\phi(\vec{x})$ and $\psi(\vec{y})$ be modal formulae with free variables $x_1, ..., x_n$ and $y_1, ..., y_n$ respectively, P^n be an n-ary predicate, $\mathcal{M} = \langle \mathcal{F}, \mathcal{N}, \eta, f \rangle$ be a counterpart model, and $w \in W$.

[106] Lewis, *Counterfactuals*.

We can now recursively define satisfaction $\vDash$ at w_C in $\mathcal{M}$.

D8.1 $\mathcal{M}, w \vDash P^n(\vec{x})$ iff $\langle \eta(x_1), \ldots \eta(x_n) \rangle \in \mathcal{N}_w(P^n)$.

D8.2 $\mathcal{M}, w \vDash x_i = x_j$ iff $\eta(x_i) = \eta(x_j)$, where $\eta(x_i), \eta(x_j) \in D(w)$.

D8.3 $\mathcal{M}, w \vDash \phi \& \psi$ iff $\mathcal{M}, w \vDash \phi$ and $\mathcal{M}, w \vDash \psi$.

D8.4 $\mathcal{M}, w \vDash \neg\phi$ iff it's not the case that $\mathcal{M}, w \vDash \phi$.

D8.5 $\mathcal{M}, w \vDash \diamond\phi$ iff there is some possibility $v_C \in Pos(\mathcal{F})$ such that $\langle \mathcal{F}, \mathcal{N}^{w_C}, \tilde{\eta}, f \rangle, v \vDash \phi$, where $\eta \xrightarrow{C} \tilde{\eta}$ and $\mathcal{N}^{w_C}$ is the interpretation of $\mathcal{N}$ from w_C.

D8.6 $\mathcal{M}, w \vDash \exists x \phi(x)$ iff there is some $\tilde{\eta} \simeq^w_x \eta$ such that $\langle \mathcal{F}, \mathcal{N}, \tilde{\eta}, f \rangle, w \vDash \phi(x)$.

D8.7 $\mathcal{M}, w \vDash \phi \mathrel{\Box\!\!\rightarrow} \psi$ iff for all possibilities v_C such that $f(\llbracket \phi \rrbracket_w, w) = v_C$, $\langle \mathcal{F}, \mathcal{N}^{w_C}, \tilde{\eta}, f \rangle, v \vDash \psi$,

– where $\eta \xrightarrow{C} \tilde{\eta}$, and $\mathcal{N}^{w_C}$ assigns to every predicate the extension which at every world is the C counterpart of what $\mathcal{N}$ assigns at w (see D7.2), and$\llbracket \phi \rrbracket_w \subseteq Pos(\mathcal{F})$ is the set of all possibilities $u_{C\dagger}$ such that $\langle \mathcal{F}, \mathcal{N}^{w_{C\dagger}}, \tilde{\eta\dagger}, f \rangle, u \vDash \phi$.

We will take the other logical constants ($\Box, \forall, \vee, \supset$) to be defined in terms of those in D8 as usual. When $\mathcal{M}, w \vDash \phi$ for all $w \in W$, we will say that $\mathcal{M} \vDash \phi$, or ϕ is true on the model. If a formula ψ is true at every world w such that $\mathcal{M}, w \vDash \phi$, we may write $\mathcal{M}, \phi \vDash \psi$. If every model $\mathcal{M}$ is such that $\mathcal{M} \vDash \phi$, then ϕ is a theorem of the counterpart-theoretic system, or $\vDash \phi$. We will call such formulas "$C - valid$". If $\mathcal{M}, \phi \vDash \psi$ for every model $\mathcal{M}$, we may write $\phi \vDash \psi$.

A.2. Extensions. The present semantics validates the following: $\Box\neg\phi \vDash \phi \mathrel{\Box\!\!\rightarrow} \psi$ for any ϕ and ψ. This, of course, is counterpossible triviality, exactly the thing we were trying to avoid. What's gone wrong? Our definition of $\diamond$ (D8.5) used the full range of possibilities provided by our counterpart relation, but, as I argued in §III.1, some counterpart relations provide us with metaphysical impossibilities. To represent this, we can modify D8.5 in one of two ways, corresponding to the two options for defining metaphysical possibility I alluded to in §III.1: grafting and legislating.

Grafting: The *grafting* strategy uses the counterpart relation to build impossibilities out of a prior set of metaphysically possible worlds. On this strategy, the worlds represent metaphysical possibilities all by themselves, and counterpart relations are added to the worlds to generate nontrivial counterpossible conditionals. The natural way to modify D8.5 to represent this is to define possibility in terms of worlds, rather than in terms of possibilities.

D8.5$_G$ $\mathcal{M}, w \vDash \diamond\phi$ iff there is some world $v \in W$ such that $\mathcal{M}, v \vDash \phi$.

When a model $\mathcal{M}$ and world w satisfies a formula ϕ given definitions D8.1-4, D8.5$_G$, D8.6-7, we will say $\mathcal{M}, w \vDash_G \phi$.

(Serious grafters may want to add an accessibility relation to their models; to keep things simple I have omitted this as that work is mostly done in my models by the counterpart relation). With D8.5$_G$ replacing D8.5 we can construct a counterexample to $\Box\neg\phi \vDash_G \phi \;\Box\!\!\rightarrow \psi$.

The model consists of:

- A structure S consisting of: two worlds $W = \{w, v\}$ and one object $D = \{a\}$ which exists at both worlds $d = \{\langle w, a\rangle, \langle v, a\rangle\}$, and two intensions: $\mathcal{I} = \{I_1, I_2\}$ where $I_1 = \{\langle w, \varnothing\rangle, \langle v, \varnothing\rangle\}$ and $I_2 = \{\langle w, \{a\}\rangle, \langle v, \{a\}\rangle\}$.
- A set of counterpart relations with one relation: $\mathcal{C} = \{C\}$, where $C = \{\langle\langle w, a\rangle, \langle v, a\rangle\rangle, \langle\langle w, I_1\rangle, \langle v, I_2\rangle\rangle\}$, relating a at w to itself at v and relating I_1 at w to I_2 at v.
- An interpretation $\mathcal{N}$ such that $\mathcal{N}(P)_w = \mathcal{N}(P)_v = I_1$ and $\mathcal{N}(Q)_w = \mathcal{N}(Q)_v = I_2$.
- A variable assignment η such that $\eta(\langle w, x\rangle) = a$ and $\eta(\langle v, x\rangle) = a$.
- A selection function f such that $f(\langle\{v_C\}, w\rangle) = v_C$.

This model is a counterexample to $\Box\neg\phi \vDash_G \phi \;\Box\!\!\rightarrow \psi$, where ϕ is $\exists x P(x)$ and $\psi = \neg\exists x P(x)$. Because I_1 is empty at each world, $\mathcal{M}, w \vDash_G \Box\neg\exists x P(x)$. There is no world where any object is in the intension of P. But since C relates I_1 at w to I_2 at v, $\mathcal{N}_v^{w_C}(P) = I_2$. Hence $\langle\mathcal{F}, \mathcal{N}^{w_C}, \tilde{\eta}, f\rangle, v \vDash_G \exists x P(x)$ but it is not the case that $\langle\mathcal{F}, \mathcal{N}^{w_C}, \tilde{\eta}, f\rangle, v \vDash_G \neg\exists x P(x)$. Given D8.7, this implies that $\mathcal{M}, w \nvDash_G \exists x P(x) \;\Box\!\!\rightarrow \neg(\exists x P(x))$.
This means that $\Box\neg\exists x P(x) \nvDash_G \exists x P(x) \;\Box\!\!\rightarrow \neg(\exists x P(x))$ which is an instance of $\Box\neg\phi \nvDash_G \phi \;\Box\!\!\rightarrow \psi$.

Legislating: The *legislating* strategy identifies some subset of the counterpart relations as representing metaphysical possibilities, effectively ruling some possibilities metaphysically possible and others metaphysically impossible. To represent this in our framework we identify a subset of the counterpart relations $\mathcal{C}_m \subset \mathcal{C}$. We will use the subscript m to mark those counterpart relations $C_m \in \mathcal{C}_m$ and possibilities v_{C_m}. Intuitively, the relations in $\mathcal{C}_m$ are those which hold fixed certain actual-world dependence relations or obey the laws of grounding.

D8.5$_L$ $\mathcal{M}, w \vDash \Diamond\phi$ iff there is some metaphysical possibility $v_{C_m} \in Pos(\mathcal{F})$ such that $\langle\mathcal{F}, \mathcal{N}^{w_{C_m}}, \tilde{\eta}, f\rangle, v \vDash \phi$, where $\eta \xrightarrow{C_m} \tilde{\eta}$ and $\mathcal{N}^{w_{C_m}}$ is the interpretation of $\mathcal{N}$ from w_{C_m}.

D8.5$_L$ will validate the same formulas as D8.5$_G$ in the limiting case where $\langle x, w\rangle C_m \langle y, v\rangle$ if and only if $x = y$. Consequently the model discussed above will also serve as a counterexample to $\Box\neg\phi \nvDash_L \phi \;\Box\!\!\rightarrow \psi$ with C_m taken to be the identity relation (this exercise is left to interested readers).

Note that on both the grafting and legislating strategies, the only change to the semantics is in D8.5. Hence counterfactuals can appeal to nontrivial or metaphysically impossible counterpart relations, even when embedded under a possibility or necessity operator. The possibility operator restricts us to metaphysical possibilities, but (given definition D8.7) there are nontrivial countermetaphysical counterfactuals true at metaphysically possibilities. $\diamond(\phi \mathrel{\Box\!\!\rightarrow} \psi)$ does not entail $\diamond\phi$. However, possibility and necessity embedded in counterfactual contexts will be shifted by the change in the interpretation required by the conditional's counterpart relation. "If water were steel, then it would necessarily be steel" may well be true if steel is necessarily steel.

A.3. Proofs. I will now show that the above logic has some desirable properties. Specifically it secures multi-premise consequent closure and conditional proof, which only hold under special conditions in impossible worlds approaches. I omit proofs of other nice properties, like necessitation and the K-axiom, for reasons of space.

Multi-premise consequent closure: Nolan[107] points out that, on an impossible worlds approach, we cannot infer $\mathcal{M}, w \vDash \phi \mathrel{\Box\!\!\rightarrow} \psi$ from $\mathcal{M}, w \vDash \phi \mathrel{\Box\!\!\rightarrow} \nu$, $\mathcal{M}, w \vDash \phi \mathrel{\Box\!\!\rightarrow} \mu$ and $\nu, \mu \vDash \psi$. This inference is valid on the counterpart theoretic model.

- Suppose $\mathcal{M}, w \vDash \phi \mathrel{\Box\!\!\rightarrow} \nu$ and $\mathcal{M}, w \vDash \phi \mathrel{\Box\!\!\rightarrow} \mu$. Then (by D8.7) for all possibilities v_C such that $f([\![\phi]\!]_w, w) = v_C$, $\langle \mathcal{F}, \mathcal{N}^{w_C}, \tilde{\eta}, f\rangle, v \vDash \nu$ and $\langle \mathcal{F}, \mathcal{N}^{w_C}, \tilde{\eta}, f\rangle, v \vDash \mu$.
- Suppose $\nu, \mu \vDash \psi$. Then every model $\mathcal{M}^*$ is such that, for any world w where $\mathcal{M}^*, w \vDash \nu$ and $\mathcal{M}^*, w \vDash \mu$, $\mathcal{M}^*, w \vDash \psi$.
- This implies that every interpretation $\mathcal{N}^*$ and variable assignment η^* is such that, for every world v at which $\langle \mathcal{F}, \mathcal{N}^*, \eta^*, f\rangle, v \vDash \nu$ and $\langle \mathcal{F}, \mathcal{N}^*, \eta^*, f\rangle, v \vDash \mu$, $\langle \mathcal{F}, \mathcal{N}^*, \eta^*, f\rangle, v \vDash \psi$.
- Since $\mathcal{N}^{w_C}$ and $\tilde{\eta}$ are an interpretation and variable assignment, respectively, this implies that any world v at which $\langle \mathcal{F}, \mathcal{N}^{w_C}, \tilde{\eta}, f\rangle, v \vDash \nu$ and $\langle \mathcal{F}, \mathcal{N}^{w_C}, \tilde{\eta}, f\rangle, v \vDash \mu$, $\langle \mathcal{F}, \mathcal{N}^{w_C}, \tilde{\eta}, f\rangle, v \vDash \psi$. Hence all possibilities v_C such that $f([\![\phi]\!]_w, w) = v_C$, $\langle \mathcal{F}, \mathcal{N}^{w_C}, \tilde{\eta}, f\rangle, v \vDash \psi$.
- Hence, by D8.7, $\mathcal{M}, w \vDash \phi \mathrel{\Box\!\!\rightarrow} \psi$, which is what we wanted.

Conditional Proof: Nolan[108] again argues this fails on the impossible worlds approach. We want to show that if $\phi \vDash \psi$ then $\vDash \phi \mathrel{\Box\!\!\rightarrow} \psi$. Suppose $\phi \vDash \psi$. Then every world w and model $\mathcal{M}$ is such that if $\mathcal{M}, w \vDash \phi$ then $\mathcal{M}, w \vDash \psi$. Then at each world, the closest possibility v_C which is such that $\langle \mathcal{F}, \mathcal{N}^{w_C}, \tilde{\eta}, f\rangle, v \vDash \phi$ will also be such that $\langle \mathcal{F}, \mathcal{N}^{w_C}, \tilde{\eta}, f\rangle, v \vDash \psi$ (again, recall that $\langle \mathcal{F}, \mathcal{N}^{w_C}, \tilde{\eta}, f\rangle$ is a model, which differs from $\mathcal{M}$ by replacing

[107] Nolan, "Impossible Worlds: A Modest Approach", p. 551.
[108] Ibid., p. 549.

$\mathcal{N}$ with $\mathcal{N}^{w_C}$ and η with $\tilde{\eta}$). Hence (by 8.7) at each world $\phi \mathbin{\Box\!\!\rightarrow} \psi$. Hence $\vDash \phi \mathbin{\Box\!\!\rightarrow} \psi$.

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