

Counterpossible Reasoning in Physics

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Overview

- Does physics oblige us to assign non-trivial truth-values to counterfactuals with physically impossible antecedents?
- Standard answer: yes, to evaluate consequences of false theories.
 - I shall argue against this standard answer.
- Deeper answer: yes, to capture objective dependence structure.
 - I shall argue that mainstream conceptions of causal structure and of grounding structure incur commitment to non-trivial counterpossibles.



Plan

- **Modal necessitarianism about laws of nature.**
 - (and why you should believe it.)
- **Do we need non-trivial counterpossibles to make sense of:**
 - **our practices of inquiry** into different physical theories? (no)
 - **the causal structure** posited by physical theories? (apparently yes)
 - **the grounding structure** posited by physical theories? (apparently yes)
- **Conclusion: counterpossible reasoning is your problem too.**



Modal Necessitarianism



Varieties of necessitarianism

- Schaffer (2005) distinguishes three grades of necessitarianism:
 - **Nomic necessitarianism:**
Properties obey the same laws of nature in every world in which they exist.
 - **Causal necessitarianism:**
Properties obey the same causal laws in every world in which they exist.
 - **Modal necessitarianism:**
The laws of the actual world are the laws of all possible worlds.
- I will focus on modal necessitarianism (MN) in this talk.
 - MN, as the strongest form, faces the biggest threat from counterfactuals.



Modal necessitarianism and state space

- Modal necessitarianism (MN) identifies physical modality and metaphysical modality.
 - The space of objective metaphysical possibilities is just the state space of the true fundamental physical theory.
- The possible worlds relevant to counterfactual evaluation are just the histories permitted by the fundamental dynamical laws, as applied to some range of possible boundary conditions.
 - Strong modal necessitarianism: only one boundary condition is possible.



Motivating modal necessitarianism

- Argument from the rational relevance of laws (Wilson 2013)
 - MN explains why we care about laws of nature.
- Argument from supporting counterfactuals (Wilson 2013)
 - MN explains why laws are held fixed in counterfactual deliberations.
- Argument from modal epistemology (Wilson 2013)
 - MN folds modal epistemology into ordinary scientific epistemology.
- Argument from quantum modal realism (Wilson 2020)
 - MN falls out of an attractive theory of the nature of metaphysical modality.



The Argument from Physical Theorizing



Counternomic theory evaluation

- Suppose some string-theory model of quantum gravity is correct.
- Then MN makes these counterfactuals into counterpossibles:
 1. If spacetime were Newtonian, it would have a Euclidean geometry. [T]
 2. If GR were complete and correct, gravity would be quantized. [F]
 3. If loop quantum gravity were correct, there would be no spin foams. [F]
- Reasoned evaluation of the theories in question seems to require us to ascribe these counterfactuals non-trivial truth-values.



The Argument from Physical Theorizing

1. Evaluating Newtonian mechanics/general relativity/loop quantum gravity involves assessing the truth or falsity of counterfactuals such as A/B/C.
2. We can and do evaluate Newtonian mechanics/general relativity/loop quantum gravity in our physical theorizing.
3. A/B/C are counterfactuals with physically impossible antecedents.
4. We assess the truth or falsity of counterfactuals with physically impossible antecedents in our physical theorizing. (From 1, 2, 3.)

Contingentists can accept the conclusion, but modal necessitarians cannot.



Necessitarian responses to the argument

- There are two main ways modal necessitarians can respond:
 - *Inflationary approach*: Appeal to physically (hence metaphysically) impossible worlds to give truth-conditions to counterfactuals.
 - *Deflationary approach*: Give an explanation of the apparent epistemic role of counterfactuals in physical theorizing that is compatible with their having trivial truth conditions.
- I favour the latter approach, since it retains this core principle:
 - *Counterfactual aboutness*: Counterfactuals are about how things stand with respect to genuine alternative possibilities.



The Two-Dimensionalist Response

- One way to go is to evaluate counterfactuals as subjunctive, but as embedded in indicative conditionals (Handfield 2004).
 1. If contingentism is correct, then if spacetime were Newtonian, it would have a Euclidean geometry. [T]
 2. If contingentism is correct, then if GR were complete and correct, gravity would be quantized. [F]
- But this strategy complicates the semantics, creates potential embedding problems, and makes the evaluation of counterfactuals parasitic on a false metaphysical theory.



The Metalinguistic Response

- Another way to go is to embrace the triviality of counternomics, and to deny that our physical theorizing needs them after all.
- Perhaps counternomic evaluation can be replaced by direct theorizing about models:
 1. If spacetime were Newtonian, it would have a Euclidean geometry.
becomes
 2. Models of Newtonian spacetime assign it a Euclidean geometry.
- This is unattractive: it does too much damage to logical form.
 - (and what if we do not know whether some claim is a counternomic?)



The Error Theory Response

- A variant on the metalinguistic response is to say that we do reason in terms of counterfactuals, but erroneously. However:
- However, the relevant metalinguistic fact about models explains why we succeed in our theoretical goals regardless.
- I think this is a more attractive approach, but sub-optimal for the same reasons that error theories in general are unattractive.
- General charity principle: if we can understand ourselves as non-confused, we should!



The Fictionalist Response (1)

- On this response, we make and evaluate counternomic counterfactuals within the context of a pretence.
 - This is fictionalism about counternomics in the make-believe version of Walton (1990), not in the fictional-operator version of Rosen (1990).
- When we evaluate some counternomic, we pretend that the antecedent is physically possible, and then evaluate the counterfactual within that pretence.
 - For example, within the pretence that Newtonian mechanics is physically possible, competent users of the theory will be willing to assert 1).



The Fictionalist Response (2)

- The fictionalist approach complements a natural approach to *reductio* proofs within mathematics.
 - When doing reductio proofs, we pretend that something not known true is true, in order to derive a contradiction.
 - When doing counterpossible reasoning, we pretend that something not known possible is possible, in order to derive nomic consequences.
- In each case the pretence may or may not be true/possible; but we don't need to know whether it does in order to engage in it.
- I want to leave open here whether the conditionals one assesses from within the pretence are indicative or subjunctive.



Summary

- Rejecting counterfactual aboutness allows a modal necessitarian account of counterlegals in terms of impossible worlds.
- If we wish to retain counterfactual aboutness, this doesn't work.
- Various deflationary accounts of the epistemic role of counterpossibles in physical theorizing are available.
- These accounts remain compatible with counterfactual aboutness.



The Argument from Causal Structure



Impossible Causal Interventions

- Counternomic counterfactuals are entailed by causal structure.
 - *Interventionists* about causation analyse causal claims in terms of the counterfactual consequences of interventions.
 - Such interventions can be physically impossible (Woodward 2003).
 - If the intervention counterfactuals trivialize, then we lack the differences in truth-value to support non-trivial causal structure.
- The problem also afflicts realist and reductionist views of causation which are intended to entail the relevant interventionist counterfactuals.



Conservation-Violating Interventions

- A first problematic kind of impossible intervention is a conservation-violating intervention.
 - If the Sun were removed from the solar system by an intervention, the Earth would cease to move in an ellipse.
 - So the presence of the Sun is the cause of the Earth's elliptical motion.
 - Making sense of this requires an intervention to remove the Sun.
- The Sun cannot simply be deleted from reality: this would violate conservation of energy and angular momentum.



Structural Interventions:

- Another problematic class of impossible interventions involve changing the background structure of the physical world.
 - If an intervention were to adjust the number of spatial dimensions to four, then the orbits of the planets would be unstable.
 - So, the three-dimensionality of space is the cause of the stable orbits of the planets.
 - Making sense of this requires an intervention to alter the number of spatial dimensions.
- Intervening on the dimensionality of space is physically impossible.



Summary: A Problem for MN

- It looks like the objectivity of causal claims is in tension with Counterfactual Aboutness, given MN.
 - A two-dimensionalist approach makes causal claims true only relative to the supposition that contingentism is correct,
 - A metalinguistic approach captures only causal dependencies between models, not causal dependencies in reality.
 - An error-theory approach leads to an error theory of the causal claims.
 - A fictionalist approach leads to fictionalism about the causal claims.
- The challenge from causal structure is a serious problem for MN.



The Argument from Grounding Structure



Grounding and Impossible Interventions

- Grounding claims entail non-trivial counterpossibles (Wilson 2018)
- The structural similarity between grounding and causation suggests that the asymmetry of grounding is reflected in an asymmetry of consequences of interventions.
 - If we intervene to change the grounding fact, the grounded fact changes.
 - If we intervene to change the grounded fact, the grounding fact does not change.



Constitutive Interventions

- Consider the claim that the **pressure** of a gas is grounded in the **average linear momentum** of the gas molecules.
 - If an (impossible) intervention were to ground an increased average momentum, the pressure would also be higher.
 - But if an (impossible) intervention were to ground a higher pressure, the average momentum of the molecules would be unchanged.
 - Making sense of this requires interventions that violate grounding principles linking molecular motion with pressure.
- The counterfactuals that we need are countermetaphysicals.



Summary: a problem for everyone

- It now looks like the objectivity of grounding claims is in tension with Counterfactual Aboutness, given either MN or contingentism.
 - A two-dimensionalist approach makes grounding claims true only relative to the supposition that contingentism about metaphysics is correct.
 - A metalinguistic approach captures only grounding dependencies between models, not grounding dependencies in reality.
 - An error-theory approach leads to an error theory of the grounding claims.
 - A fictionalist approach leads to fictionalism about the grounding claims.
- The challenge from grounding structure is a problem for everyone.



Conclusion



Conclusions

- Modal necessitarianism has various reasonable-looking options for responding to the challenge from physical theorizing.
- However, these responses do not work for the challenge from causal structure, which presents a serious problem for MN.
- An analogous challenge from grounding structure faces everyone!
- Two potential ways out of the challenge from grounding structure:
 - An account of countermetaphysicals in terms of impossible worlds, or;
 - An eliminativist/reductionist/conventionalist/instrumentalist/nihilist denial of objective grounding structure in the physical world.



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Countermathematicals & counterlogicals

- Contingentists face challenges analogous to the argument from physical theorizing – in mathematics and in metaphysics.
 - Contingentists can retain Counterfactual Aboutness for counternomics, but they still have to deny it for countermetaphysicals, countermathematicals and counterlogicals.
- Ideological equity between contingentism and MN results:
 - Everyone who takes metaphysical modality seriously needs two boxes, one for counterfactuals with metaphysically possible antecedents and one for counterpossibles.
 - Modal necessitarians just put more counterfactuals into the latter box.



Impractical Interventions

- A first-pass way in which interventions might be impossible is for them to be practically impossible.
 - If an intervention were to cause a Maxwell's demon to operate, the second law of Thermodynamics would be violated.
 - So the lack of any Maxwell's demon is a cause of the monotonic increase of entropy in a closed system.
 - Making sense of this requires an intervention to create a Maxwell's demon.
- However, as long as the interventions are physically possible (even if practically impossible) there is no problem here for MN.

