Multiverses and Fine-Tuning

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Questions.

How similar are the two views really? Are there shared underlying philosophical principles behind the two?

Main claim

Each can be motivated using a notion of fine-tuning.

Introduction

Physical fine-tuning

Mathematical fine-tuning

Conclusions

- The idea that there are multiple universes of physics is often linked to the idea of fine-tuning.

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- The constants and initial conditions that govern our physical universe seem fine-tuned for life.

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- **Constants.** e.g. The strength of gravity compared to the the strength of electromagnetism seems fine-tuned for life. (If gravity had been substantially weaker, galaxies, stars, and planets would not have formed. Much stronger, and stars would be too short-lived.)

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- These can even be 'unnatural' (e.g. mass of the Higgs Boson and cosmological constant, cf. [Friederich, 2019]).

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  - (c) the fine-tuning is illusory (it will eventually be explained away).

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Mysticism

The idea that the universe is fine-tuned for life either by luck or design is fundamentally mysterious.

The Physical Multiverse View

There is not just one physical universe (ours) with the relevant initial conditions and constants, but rather many (no one of which contains all the concreta).

- We can, in addition, supplement this view with a **Richness Principle:** the idea that any consistent set of initial conditions/constants is realised in some universe in this "multiverse".

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- We can then formulate an abductive and/or probabilistic argument for the physical multiverse hypothesis.
- The existence of a universe supporting life is very unlikely (almost to the point of mysticism) under the universe hypothesis), but overwhelmingly probable (and totally non-mystical) under a suitably rich multiverse hypothesis.

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- **Large** literature here with a lot of ways of tweaking the examples.

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- As many will be aware, the Continuum Hypothesis (the statement that $2^{\aleph_0} = \aleph_1$) is independent from the axioms of our "standard" set theory (ZFC).
- But this goes for a huge number of statements.

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The Set-Theoretic Multiverse View

There is not just one set-theoretic universe, but rather many (no one of which contains all the abstracta).

- Again, we may want to supplement the Set-Theoretic Multiverse View with the following.

Balaguer's Principle

(Extracted from [Balaguer, 1998]) Every consistent set theory T is instantiated in a (at least one) corresponding universe of sets.

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- One is about *abstracta* and the other *concreta*.
- However, I want to argue that there is something like a fine-tuning argument available to the advocate of the set-theoretic multiverse.

- In 1917, Mirimanoff was careful to distinguish between the "ordinary" and "extraordinary" sets (what we'd now call "ill-founded" and "well-founded" sets) and left it open whether all sets are ordinary (i.e. well-founded).

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- There were a multiplicity of ways of proceeding compatible with Mirimanoff's thought.
- We're now in a similar situation with many different ways of enriching our concept of set to yield different axiom systems.[2]

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- As [Hamkins, 2012] puts it: "Set theorists build models to order".
- For ZFC + ϕ (for some ϕ independent ϕ we take to be true), the universe seems fine-tuned to our theory.
- Particularly so when we note that we may go on to accept more axioms.

One way of responding to this fine-tuning problem:

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(Often (mis)attributed to Gödel) We have some quasi-mystical perceptual ability that allows us to "perceive" set-theoretic truths.

Similar problems to the physical multiverse case (also with luck).

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- **Descriptivism.** Our reference to set-theoretic reality is mediated by the descriptions we provide.
- If multiversism is true, we're guaranteed to be speaking truly when we utter $\mathsf{ZFC} + \phi$, whereas it's mysterious under universism.

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- One response for the physical multiverse: Since there is an **observer selection bias** (observers don't exist at worlds inhospitable to life) we don't commit the fallacy (see Bradley's vs. Landsman on urns).

- What about the inverse gambler's fallacy charge?
- One response for the physical multiverse: Since there is an **observer selection bias** (observers don't exist at worlds inhospitable to life) we don't commit the fallacy (see Bradley's vs. Landsman on urns).
- [Friederich, 2019] has argued that these responses are only good insofar as one already holds some multiverse-style position, since you really need it to be the case that you could have ended up sampling a different universe.

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- If there's time: Compare with the categoricity arguments for the universe position.

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Philosophical conjecture.

The kind of descriptivism provided will affect the validity of fine-tuning.

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- But there's still a lot to be done.
- In particular, properly formalising the fine-tuning argument and inverse gambler's fallacy charge in the set-theoretic case.

Thanks for listening!

References I

Balaguer, M. (1998).
Platonism and Anti-Platonism in Mathematics.
Oxford University Press.

Barton, N. (2022).
Structural Relativity and Informal Rigour, pages 133–174.
Springer International Publishing, Cham.

Ewald, W. B., editor (1996).
From Kant to Hilbert. A Source Book in the Foundations of Mathematics, volume I.
Oxford University Press.

Friederich, S. (2019).
Reconsidering the inverse gambler's fallacy charge against the fine-tuning argument for the multiverse.
Journal for General Philosophy of Science, 50(1):29–41.

Friederich, S. (2022).
Fine-Tuning.
In Zalta, E. N., editor, The Stanford Encyclopedia of Philosophy. Metaphysics Research Lab, Stanford University, Summer 2022 edition.

Hamkins, J. D. (2012).
The set-theoretic multiverse.
The Review of Symbolic Logic, 5(3):416–449.

References II

Maddy, P. (1988a).
Believing the axioms. I.
The Journal of Symbolic Logic, 53(2):481–511.

Maddy, P. (1988b).
Believing the axioms II.
The Journal of Symbolic Logic, 53(3):736–764.

Woodin, W. H. (2011).
The continuum hypothesis, the generic-multiverse of sets, and the Ω-conjecture, page 13–42.
Lecture Notes in Logic. Cambridge University Press.

Zermelo, E. (1930).
On boundary numbers and domains of sets.
In [Ewald, 1996], volume 2, pages 1208–1233. Oxford University Press.