

## 1. *Précis of Thought Experiments*

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Imagination is associated with escapism, free association, and unfettered thought. Yet thought experiments intertwine with all sorts of reasoning and even in the appraisal of argument. Typically, the validity of an argument is first tested by trying to imagine a situation in which the premises are true and the conclusion false. For example, George Simmel invalidated Nietzsche's argument for the eternal return by envisaging a universe containing three wheels on a single axle spinning endlessly at rates  $n$ ,  $2n$ , and  $\pi/n$ . (The incommensurability introduced by the irrational number  $\pi$  ensures that the wheels never re-align.) Enthymemes are reconstructed with a curious crew of fictions: the devil's advocate, the reasonable man, the ideal thinker, etc. Definitions are refuted by (often highly) hypothetical counterexamples: Russell's five minute hypothesis, the Ship of Theseus, Aquinas' cannibals. Imagination also figures prominently in less understood acts of clarification such as idealization.

True, logicians often try to break free of any reliance on imagination. The formal strategy is to disinterpret an argument into inert symbols and let the proof proceed by purely syntactic means. But this two dimensional symbol manipulation only applies to arguments that have been *translated* into the calculus. Thought experiment is well-represented at this interface between informal and formal logic because the translator must test the faithfulness of the translation by trying to imagine whether the statement could be true while its translation is false. Crucial logical points have themselves been made by thought experiment. Recall Lewis Carroll's debate between Achilles and the Tortoise, Quine's radical translator, and Wittgenstein's woodcutters. Hypotheticals have enriched our logical vocabulary with 'grue', 'tonk', and 'quus'.

Nevertheless, methodical sorts who demand clear reasoning from clear sources of evidence are apt to be suspicious. Thought experiments seem to give you something for nothing. The thought experimenter starts out ignorant. Then he sits in his armchair. Instead of looking, smelling, listening, and so forth, he blocks out empirical data and uses his imagination. He then rises with the answer. What, short of parapsychology, could account for this cognitive transformation?

The skeptic challenges the presupposition that the thought experiment proves something. He grants that the thought experiment might be relevant to the context of discovery (like a dream) but not the context of justification. My main response in *Thought Experiments* is to present a variety of scientific thought experiments that are acknowledged as proof by scientists. I then rely on meta-

philosophical gradualism (the view that science and philosophy differ in degree, not kind) to extend lessons about scientific thought experiments to philosophical ones.

Some of the scientific thought experiments are conceptual but others deliver empirical answers. Hence these cases show that we cannot explain their success as just the deduction of tautologies or as an appeal to ordinary language.

Einstein's mentor, Ernst Mach, suggested that the empirical reliability of thought experiment is due to the generate and eliminate mechanism of natural selection. Proto-human beings who had a more accurate feel for what could not happen had an edge on predicting and controlling nature and each other. This sense of the absurd has been refined into a touchstone of truth. For we can eliminate an hypothesis by showing that it has an absurd consequence.

I defend Mach's evolutionary strategy as basically sound. I update Mach's biology and put his epistemology in a reliabilist framework. A fully general account, one that can handle all thought experiments from Aesthetics to Zoology, must explain how non-perceptual processes enhance epistemic authority.

There are a number of models of armchair inquiry that seem sensible and enlightening: recollection, transformation, homuncular, rearrangement, and one I call the cleansing model. Psychology is too young to allow much development of the first four. However, a special case of the cleansing model lets me lean on standard logic and offers a way of domesticating some of Thomas Kuhn's wild insights about thought experiments. In particular, I argue that each thought experiment can be regimented so that it fits one of two schemas. One is based on the refutation of necessities and the other targets possibilities.

Under this approach, thought experiments are devices to expose and eliminate inconsistency. Each thought experiment can be represented as a stylized *paradox*, that is, a small set of individually plausible but jointly inconsistent propositions. The official aim of the thought experiment is to refute the source statement but the thought experimenter can pursue a richer agenda through indirect means just as conversationalists can perform lots of trick bounces off of the official Gricean maxims of conversation. So although my model is artificially rigid, it is intended to support highly flexible uses of thought experiment.

The paradox model is also intended to work for regular experiments. One of the themes of the book is that thought experiment is (a limiting case of) experiment. I argue that thought experiment evolved from experiment by an attenuation of the execution element and a consequent elaboration of its other elements. Regular experiments have the same modes of enlightenment (though in lesser degree) as thought experiments (organizing data, making subtle connections, grounding hypotheses into tests) plus the obvious mode of enlightenment: fresh information through the execution of the experiment. So lessons learned about thought experiment enrich our understanding of ordinary experiments just as the recent growth in understanding of ordinary experiments helps us better understand thought experiments. These lessons are applied in the final chapter centering on fallacies in thought experiment. I conclude that although thought experiments are susceptible to various sorts of misuse and

abuse, they are generally reliable when used as part of a wide portfolio of techniques.

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