SPECIAL ISSUE: THOUGHT EXPERIMENTS IN THE HISTORY OF PHILOSOPHY OF SCIENCE

MOTIVATING THE HISTORY OF THE PHILOSOPHY OF THOUGHT EXPERIMENTS

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The literature on thought experiments has been steadily expanding since 1986. And yet, it appears that several aspects of the philosophical conversation have recently stalled. We claim that the current philosophical literature has much to gain by a reappraisal of its origins: by identifying the historical contingencies that caused the contemporary discussion to take the shape it has, we will be in a better position to entertain other directions the current debate could go, identify and eliminate mistaken dogma, and revive forgotten insights. This special issue of HOPOS is an attempt to start such a conversation, and we hope it might inspire similar pursuits in the history of the philosophy of other scientific methods like modeling, experiment, and computer simulation.

By any measure, the literature on thought experiments is thriving. Since 1988, we count at least 13 monographs, seven collected editions, and eight journal issues dedicated to thought experiments.[1] In 2020, the thought experiments

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1. Monographs: Wilkes (1988), Sorensen (1992), Buschlinger (1993), Häggqvist (1996), Genz (1999), Gendler (2000), Behmel (2001), Kühne (2005), Rescher (2005), Cohnitz (2006), Swirski (2007), Buzzoni (2008), and Brown (2011). Collected editions: Horowitz and Massey (1991), Macho and Wuenschel (2004), Ierodiakonou and Roux (2011), Frappier et al. (2013), Borstner and Gartner (2017), Stuart

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section of PhilPapers (http://www.philpapers.org; currently moderated by Magdalena Balcerak Jackson) has 476 entries, which is more than the semantic view of theories (124), inference to the best explanation (198), scientific representation (203), structural realism (280), and incommensurability in science (406), and is equal to the discussion of natural selection as a whole (476). Obviously, it is a lively and ongoing discussion. And yet, there is still a lot of work to do.

Concerning the class of scientific thought experiments, the majority of papers either focus on specific scientific cases (Schrödinger's cat is a case in point, with 55 entries on PhilPapers), the thought experiments of a specific scientist (with Einstein and Galileo attracting most of the attention), or the epistemology of scientific thought experiments in general.[2] Lacking, however, are historical accounts of the philosophical discussion of scientific thought experiments. There are notable exceptions, but more work seems necessary for at least two reasons.[3]

The first is that the current philosophical literature has much to gain by a reappraisal of its origins (or so we claim). The notion that there is a single "pure origin" of any debate is dubious (see Foucault 1977). Nevertheless, by identifying the historical contingencies that caused the ongoing debate to take the shape it has, we will be in a better position to entertain other directions the current debate could go, identify and eliminate mistaken dogma, and revive forgotten insights. With reference to the articles that constitute this special issue, we will now discuss several tentative steps through which progress might be made.

Charlene Brecevic revisits Ernst Mach's writings on thought experiments. Mach is a prominent figure in the history of philosophical inquiry into thought experiments. Indeed, the importance of Mach's *Knowledge and Error* (1905/1976) for the evolution of philosophical thinking about thought experiments can hardly be overstated. He set out many of the terms, examples, and ideas that would inspire future writers. This in itself is a historically intriguing fact, because it wasn't him but Hans Christian Ørsted who introduced the notion of thought experiments into the philosophical discussion in 1811, with a very different agenda. And yet, well into the 1990s it is Mach who is mistakenly cited often

et al. (2018a), and Bornmüller et al. (2019). Journal issues: *Berichte zur Wissenschaftsgeschichte*, vol. 38, no. 1; *Croatian Journal of Philosophy*, vol. 7, nos. 1 and 2; *Deutsche Zeitschrift für Philosophie*, vol. 59, no. 1; *Topoi*, vol. 38, no. 4; *Philosophica*, vol. 72; *Perspectives on Science*, vol. 22, no. 2; and *HOPOS*, this issue.

2. On Einstein, see, e.g., Norton (1991, 1993) and Kühne (2005, 225–79). On Galileo, see, e.g., Palmieri (2003, 2018). On the epistemology of scientific thought experiments in general, see Miščević (1992), Nersessian (1992), Sorensen (1992), Häggqvist (1996), Norton (1996, 2004), Buzzoni (2008), and Brown (2011).

3. See, e.g., Kühne (2005), Moue et al. (2006), Buzzoni (2008, 2018), Fehige and Stuart (2014), and Stuart et al. (2018b).

as the originator of the term "thought experiment." (Marco Buzzoni and Yiftach Fehige both touch on this fact in their contributions, with each offering differing explanations for it.)

Brecevic reevaluates Ernst Mach's seminal and formative contribution from the perspective of Mach's writings on imagination. The article begins by noting an interesting tension. Within the literature on thought experiments, Mach is seen as an early champion of the topic, but outside the literature, Mach has been interpreted as a phenomenological reductionist or subjective idealist whose "principle of economy" would, in the words of Planck, "lame" the imagination. The idea is that Mach requires all models, theories, and concepts to be grounded in "elements of sensation" (colors, sounds, pressures, temperatures, smells, etc.). Without allowing scientists to imagine how the world might be, independent of sensory elements, Mach severely limits the power of imagination in science.

This tension comes out clearly, as Brecevic contrasts Mach's praise of thought experiments in *Knowledge and Error* with his negative claims about imagination made in connection with his criticism of Newton's bucket thought experiment. On the one hand, Brecevic reminds us that for Mach, "every explanation, proof and deduction" is the result of a thought experiment (Mach 1905/1976, 144). Yet, on the other hand, Mach claims that Newton's bucket thought experiment deals only with "the arbitrary fictions of our imagination" (1883/1919, 232). Claims about absolute space, time, or motion are "pure things of thought, pure mental constructs, that cannot be produced in experience" (229). Brecevic diffuses this tension by focusing on the evolutionary nature of science. According to Mach, there can be no quantum leaps: everything must build on and be continuous with previous experience. Newton violates this maxim by trying to use imagination to establish facts that could never be confirmed by experience. Brecevic points out that this criticism of Newton is consistent with Mach, holding that imagination can play other (important or even necessary) roles in science, such as via thought experiments. To this end, Brecevic introduces an important distinction between poetic and simulative imagination, which helps to explain the roles Mach sees for imagination in science.

Given the importance of Mach for the literature on thought experiments, this historical reinterpretation is very welcome, especially as Brecevic connects it with discussions of the role of imagination in science, the view that thought experiments are mental models, and the relation between memory and imagination. For instance, scholars are now (re)examining the specific epistemic role that imagination plays in thought experiments (Arcangeli 2010, 2021; McAllister 2013; Meynell 2014, 2018; Stuart 2017, 2021; Camp 2020; Salis and Frigg 2020). This discussion would profit from taking earlier ideas into account, including the distinctions Brecevic draws between kinds of imagination in Mach.

This is especially true as we begin to realize that our current concept of "scientific imagination" is something that developed over centuries (McLeish 2019, 317).

Until the 1980s, the most important single paper on thought experiments (after Mach [1905/1976]) must be Kuhn's (1964). In that paper, Kuhn offers a discussion of Jean Piaget, that "brilliant Swiss child psychologist," to motivate his own account of the role of thought experiments in scientific progress. Buzzoni, in his contribution to this special issue, pulls hard on this thread. His paper asks intriguing questions about Piaget's own position on thought experiments. As it turns out, Piaget had a lot to say about mathematical thought experiments, and he also drew on the work of Mach. Specifically, Piaget characterized at least two kinds of thought experiment: one was Machian (a mental variation of variables), while the second was "logically reversible" (i.e., mathematical). An important source of inspiration for Piaget was the French logician and philosopher of science Edmond Goblot. Buzzoni argues that Piaget wrongly interpreted Goblot, who anticipated Piaget's distinction between empirical and mathematical thought experiments. Goblot also discusses why the graphic, visual, or iconic character of mathematical thought experiments is so important. This is still a significant topic of discussion today. Buzzoni also draws attention to Goblot's account of how thought experiments play justificatory roles in mathematics, and discusses his noteworthy ideas concerning the relation between logic and psychology.

Another oddity in the history of the philosophical discussion about thought experiments concerns Paul Feyerabend. He was a powerful influence (whether positive or negative) on the course of the history and philosophy of science, and he wrote quite a lot about the epistemological functions of Galileo's thought experiments. Specifically, he defended the importance of "counterinduction" (where we try to find evidence for a hypothesis that contradicts theoretical claims we believe to be true) as a way of examining our most fundamental assumptions, or "natural interpretations." And for Feyerabend, counterinduction was pursued perhaps most powerfully in science through the use of thought experiments. More than anyone else at the time, it was Feyerabend who protested against philosophical accounts of science that excluded thought experiments and other vehicles of scientific imagination as epistemologically uninteresting. And yet, while references to Mach, Kuhn, Popper, and to a lesser extent, Lakatos are frequent in the current literature on thought experiments, Feyerabend has been almost forgotten. In order to draw out Feyerabend's considered views on the topic, Mike Stuart interprets the account of Galilean thought experiments we find in Feyerabend's most well-known work, *Against Method*, through the lens of Feyerabend's later writing on the epistemology of drama, stories, and myths. In his article,

Stuart argues that for Feyerabend, thought experiments are a special kind of story that can be used to demolish a dominant myth (in science or elsewhere) and instigate a new myth through the use of propaganda to change our habits. Thought experiments do this by appealing to our sense of what is interesting, appealing, revealing, comprehensible, coherent, and surprising.

Stuart also puts Feyerabend into dialogue with current accounts that emphasize the importance of reconstructing thought experiments into logical arguments. One upshot of Feyerabend's account, if correct, is that the epistemological power of a thought experiment cannot be determined without reference to features of the audience, and so accounts that try to portray this power purely in terms of acontextual logic are missing an important part of the story. Feyerabend's account also contradicts the widely held belief that reconstructing thought arguments into logical arguments, even if not necessary, is helpful. The idea is that logical reconstruction clarifies the premises and inferences that are central to a thought experiment, and thereby facilitates epistemological appraisal. Feyerabend suggests otherwise: "clarification" is merely a license for the widespread philosophical bias against emotion and desire. Clarification strips thought experiments of life by forcing their rich narratives and metaphors into logical boxes. Moving in the other direction, Feyerabend suggests an anthropological approach, according to which we examine how thought experiments are actually used, rather than thinking we know better than the scientists who use them (Feyerabend 1995, 142). We should leave thought experiments as the stories they are (including their appeals to emotion and use of imagination and open-endedness) and analyze them accordingly. Stuart ends with considerations about the ethics of scientific storytelling and the effects of storytelling on the scientific imagination.

The contribution by Fehige takes us almost to the present. One of the most discussed problems about thought experiments in the current literature is how thought experiments are able to lead to new knowledge or understanding, despite not requiring new experience. James R. Brown's answer is that performing a thought experiment produces a new phenomenon in the mind. This phenomenon can serve as "fairly conclusive" evidence for a theory (Brown 2011, 43). John D. Norton has been Brown's main foil. He argues that thought experiments are nothing but arguments (see Norton 1996). We gain new knowledge from thought experiments only by rearranging or logically extending existing knowledge. For Norton, all thought experiments succeed or fail only insofar as they instantiate logically good arguments. Without an understanding of how and why this dialectic emerged historically, it is difficult to pinpoint the hidden biases and generatively entrenched structures inside it. And without this, it is difficult to see other (perhaps more fruitful) ways the debate might have evolved and might still

evolve. For example, Fehige points out that the shape of the disagreement between Brown and Norton is partially due to certain philosophical undercurrents at work in the 1980s, including the ongoing reaction to Kuhnian views, as "a great deal of historical scholarship and analytic spadework" had "moved" the "understanding of the processes of scientific rationality and scientific change considerably beyond the point where Kuhn left it" (Laudan 1984, xii). The literature in the 1990s shows resistance against Brown and Norton setting the terms of the investigation, and the drive to find a middle ground between these two positions is best explained (according to Fehige) by examining the philosophical undercurrents present at the time, including a push toward scientific pluralism and more detailed case studies. Grand epistemological claims along the lines of the traditional empiricism-rationalism divide, Fehige argues, became heuristically questionable, and this partially explains the trajectory of the modern debate.

To summarize, the first reason it is worthwhile to look back at the history of philosophical discussions about scientific thought experiments is that (we believe) there continues to be great value in the pursuit of integrated history and philosophy of science (HPS). Philosophy requires history, and history requires philosophy. So far, in the discussion on thought experiments there has been excellent philosophy and excellent history, but not as much history of philosophy, and that element is crucial for integrated HPS. Of course, the other direction of interaction is also important: philosophy of history. The fifth contribution in this special issue, by Catherine Greene, helps to fill this gap. Greene argues that counterfactual analysis in history is a form of thought experimentation, and she charts the history of the philosophy of that practice. She then analyzes the justification attributed to that practice by philosophers like David Lewis and James Woodward, and historians like Max Weber, Johannes Bulhoff, Niall Ferguson, Richard Lebow, Yuen Foon Khong, Richard Evans, Philip Tetlock, and Aaron Belkin. She argues that imagination can play a positive epistemic role in the evaluation of historical counterfactuals, especially once we reconceive the purpose of counterfactuals in history. That purpose is not always to find out "What would have happened if . . ." but rather "How contingent was this or that event?" Greene's article might be the first to chart the history of the philosophy of counterfactuals, which is surprising, given the centrality of counterfactuals in modal epistemology and the importance of counterfactuals for the method of history. But also, and perhaps even more importantly, Greene argues for a new account of how history is and should be done, and what roles imagination should play in that process.

A second reason why we think that it is worthwhile to look back at the history of the philosophy of scientific thought experiments is that most of the

existing historical work on thought experiments has focused on individual thought experiments or individual accounts of thought experiments. We might call this microlevel history. What we do not see is macrolevel history, that is, historical discussions of the interaction between different philosophers (or philosophical accounts) over time. Macrolevel history can provide insights that are invisible at the micro level. Thus, Fehige in his entry discusses the reactions of philosophers to the Brown-Norton debate in light of the surrounding philosophical context. The features of this historical trajectory only become possible objects of inquiry from this higher level of analysis. That is, certain explananda would not appear if we looked only synchronically at the accounts of individual philosophers. Likewise, Buzzoni's article allows us to see what Edmund Goblot got right about mathematical thought experiments via an analysis of Piaget's misinterpretation of his views. Greene finds resonance, development, and conflict between the accounts of counterfactual reasoning given by philosophers and historians, which inform her positive proposals. Stuart contrasts two very different philosophers: the early and later Feyerabend. By reading the former in terms of the latter, we gain insights not explicitly provided by either. Of course, any good macrolevel history will rely on microlevel work, and each of our authors either draws on such work or performs it themselves in the course of their analyses.

We hope this special issue brings to light the importance of the history of the philosophy of thought experiments, and also that it inspires other subfields of philosophy of science to look again at their history. For instance, there is not much macrolevel historical work on the philosophy of scientific modeling, experiment, analogy, narrative, metaphor, or computer simulation. We think such explorations could be useful for illuminating and advancing discussions in those subfields. After all, many of those cognitive tools are devices of imagination. And it was only very recently that philosophy has rediscovered the important role that the imagination plays in our cognitive lives. Historical work is extremely important in such cases. We should never allow the youth of a philosophical discussion to fool us into thinking that the past holds no relevant lessons for the present.

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