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Eine gegenwärtige Analyse des Prinzen
der Philosophen Ibn Sīnā

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A Place for Thought Experiments: John Philoponus and Avicenna and the Use of Thought Experiments in Determining a Scientific Account of Place

There is no (medieval) Arabic term or phrase for ‘thought experiment’. Be that as it may, medieval philosophers and scientists working in Arabic both concretely employed thought experiments in their philosophies and discussed their merits and demerits abstractly.¹ Indeed, it would seem that thought experiments truly captured the imagination of medieval thinkers in the Muslim world, who left behind a significant body of examples and analyses of such experiments. What I propose to do in this study is to look in some detail at one of those thought experiments and its history, which can be traced back to the theory of place of the late Greek Christian and Neoplatonic philosopher, John Philoponus (490–570). Philoponus’ thought experiment in turn prompted the great medieval Islamic philosopher and scientist Avicenna (980–1037) to undertake a careful analysis of the underlying metaphysics and psychology of thought experiments more generally. To the best of my knowledge, Avicenna’s analysis is the first in-depth study of the underpinnings and value of thought experiments, and it was his analysis that would frame the use and limits of thought experiments thereafter in the medieval Islamic world.

1 Philoponus’ Thought Experiment

The philosophical and scientific issue at stake in the story I am about to tell concerns what is the right account of a thing’s *place*. That is, how do we identify *where* a thing is. This question might seem like a silly one at first, but it is far from it since physics is concerned with motion, and the primary kind of motion is change of place.² Thus, providing an account of how to track changes in where an object is and has been is fundamental to physics.

1 Studies of thought experiments in the medieval Islamic world include Knuuttila/Kukkonen 2011, Kukkonen 2014, and McGinnis forthcoming.

2 Cf. Aristotle (1936), 8.7, 260 a 20–261 b 26; Avicenna (2009), 4.9.

As is so frequently the case with philosophical stories set in the medieval Islamic world, one must begin with Aristotle (384–322 BCE) and, for our purposes, particularly his account of place (Gk. *topos*, Ar. *makān*).³ Aristotle notes that since an object can change its place, place must refer to some accidental or coincidental relation that the object has, precisely because it can *change* its place.⁴ That relation might be, on the one hand, to how the object is situated relative to its immediate surroundings, that is, how it stands to things outside of it. Or, on the other hand, the place of a thing might refer to the space that the object occupies and so a thing's place is in a sense internal, albeit not in any essential way. For Aristotle, these two options came down to this: Either place is, one, the immediately contacting surface of the surrounding body, so, for example, my place is in this room but more precisely in the air that is surrounding me; or, two, place is the extension that a thing occupies, that is, for example, wherever my innards are.⁵ In this later case, a thing's place becomes identical with the space (Gk. *diastēma*, literally, the 'extension' or 'dimension', Ar. *bu'd*) that it occupies.

For a number of reasons, Aristotle denied that place can be identified with the space that a thing occupies.⁶ Indeed, if one thinks about it, space is something of a queer entity. Space cannot be something material, for if it were material, then it would be a body. Moreover, if space were a body, then, when one body occupies some space, the one body would occupy another body, and so two bodies would interpenetrate one another, which seems odd. Furthermore, if space were a body, then it should occupy a space, and one is now on the road to an infinite regress. If, conversely, space is immaterial, then what sort of thing is it? It cannot be simply nothing, because then it is not a thing, and so does not exist. Indeed, space presumably has some extension but extension is a property of something. Again, however, it is not at all clear what this immaterial thing might be, certainly not God or an angel or a soul, so what it is it? Given the queer nature of space, Aristotle preferred to identify a thing's place with its relation to what immediately surrounds it.

It turns out that Aristotle's preferred account of place has its own set of problems, and many found those problems to be intractable, at least by the time of Philoponus.⁷ Consequently, Philoponus decided to revisit the suggestion that

3 Aristotle's own account of place proper occurs at *Physics* 4.1–5. *Physics* 4.6–9 are also closely associated with Aristotle's account of place, since they deal with the void (Gk. *kenon*, Ar. *ḥalā'*), which is empty space; void is also particularly relevant to our story since Aristotle argues against the existence of a void, whereas Philoponus allows its existence in principle. Studies of Aristotle's own account of place include Algra (1994), ch. 4 and Morrison (2002).

4 Aristotle (1936), 4.2, 209 b 21–32.

5 Ibid., 4.4, 211 b 5–212 a 21.

6 Ibid., 4.4, 211 b 19–29 & 4.8, *passim*.

7 Even Aristotle's immediate successor, Theophrastus (d. 287 BCE), found Aristotle's account of place troubling; see Sorabji (1988), ch. 11 and Morrison (2010). Additional studies on the

a thing's place is the space that it occupies and the suggestion that space might be an immaterial extension.⁸ To get us to see that space needs not be such a queer notion, Philoponus introduces the following thought experiment.⁹ He has us consider the Earth and the surrounding atmosphere, which for ancient and medieval thinkers was thought to extend to the orbit of the Moon. Philoponus now asks us to imagine that the Earth and all of its atmosphere are completely removed. What would remain? Immaterial extension, Philoponus tells us. While Philoponus is certain that removing the Earth and its atmosphere is *physically* impossible, it nonetheless exhibits what is *metaphysically* possible, he claims. That is, the idea of an immaterial extension is not contradictory or absolutely incoherent.

In fact, continues Philoponus, the thought experiment is exactly like one that Aristotle used to prove the metaphysical possibility of matter as a type of pure potentiality.¹⁰ Aristotle observes that physical objects have the potential to undertake or to possess a literal host of activities, states and properties even perhaps infinitely many; however, at any given moment, the physical body only ever has some finite number of states or properties and undergoing only a finite number of activities. According to Aristotle, what explains the actual state of a physical body at any time, as opposed to its plethora of potential states, is the body's form(s). Form is a principle or cause of whatever is presently existing or actual in a thing. Philoponus claims that Aristotle arrived at a notion of matter as pure potential through a process of imagining the systematic removal of a physical body's forms, which would involve the removal of colour, shape and ultimately location in space. At the limit of this process of removing forms and so the actuality of a thing one comes upon the idea of something that could potentially be all of those states but is not actually any of them. This pure potentiality is matter. Aristotle himself noted that in fact nothing *actually* exists as pure potential; for if it *actually* existed as such, that thing has some actuality and there would be an actuality that has no actuality, a contradiction. For Philoponus, what is good for the goose is good for the gander: If one can get to a coherent notion of matter as pure potentiality by a process of systematic removal, then, reasons Philoponus, one can get to a coherent notion of space as immaterial extension by that same process.

reception of Aristotle's account of place in both the ancient and medieval Islamic worlds include Algra (1994), ch. 5 and Lammer (2016), ch. 5.

8 See Philoponus (1888), 557,8–585,4, the “corollaries on place”. For studies of Philoponus' theory of space see Wieland (1967), Furley (1987), and Sedlely (1987).

9 Philoponus (1888), 574,13–575,20.

10 Ibid., 574,27–575,2. The Aristotelian argument that Philoponus has in mind is that of Aristotle's *Metaphysics* Z 3, where he argues that matter abstracted from all forms would not exist; cf. Aristotle (1925), 7.3, 1029 a 10–25.

2 Avicenna and the Challenge of Thought Experiments¹¹

Philoponus' *Physics* commentary in which he presents the arguments just given was translated into Arabic and, indeed by the time of Avicenna, Philoponus' commentary was second in importance only to Aristotle's own *Physics* for those working in natural philosophy. Thus, it should come as no surprise that Avicenna knows of Philoponus' thought experiment concerning the nature of place and has things to say about it. Before looking at those specific comments, we should consider Avicenna's more general remarks about thought experiments, for Avicenna recognizes that a certain dilemma lies at the very foundation of thought experiments and threatens the very usefulness of thought experiments as a tool for exploring the world in which we live.

The dilemma, which Avicenna identifies, is psychological in nature.¹² Specifically, the dilemma concerns which psychological faculty do we employ when we construct a thought experiment. Most frequently when ancient Greek thinkers suggested a thought experiment, they introduced it as a conditional statement: "If this were to happen, what would follow?" In other words, ancient Greek philosophers for the most part did not indicate which faculty is doing the proverbial work in a thought experiment.¹³ Still there are the occasional instances where Aristotle and Philoponus refer to thought experiments using terms derived from the verb 'to perceive by way of the intellect' (*noein*).¹⁴ Indeed, Philoponus fully approves of experiments 'in thought' (*kat' epinoian*) when defending the idea of an immaterial extension.

The problem with claiming that thought experiments are the product of the 'intellect' (*aql*), at least for Avicenna, is that the objects of the intellect indicate the universal essences of things as they actually exist in the physical world. In other words, the intellect gets at how things in fact are in the world, not counterfactual imaginings. Consequently, the intellect is not the right sort of psychological faculty to imagine particular non-existent states of affair and counterfactual premises.

What seems needed in these cases is something like imagination (Gk. *phantasia*, Ar. *fanṭāsīyā*, *mutaḥayyila*, *ḥayāl* or *wahm*, all of which are possible translations of the Greek), for imagination is certainly not restricted to solely what in fact is the case. Thus, imagination can conjure up images of particular non-existent states of affair and counterfactual premises in the way that a thought

11 Much of the material of this section repeats that of McGinnis forthcoming, § 2.

12 The most detailed discussion to date about the relation of thought experiments to theories of psychology developed in the medieval Arabic world is Tanelli Kukkonen's landmark 2014 article, to which this section is heavily indebted.

13 For a discussion of thought experiments in the ancient Greek world see Ierodiakonou (2005).

14 Aristotle (1936), 3.8, 208 a 14–16; and Philoponus (1888), 574,14; 575,8.10.18.

experiment requires. This very strength, however, seems to be the greatest weakness of making thought experiments the product of imagination. There simply is no check on imagination that ensures that its fantastical imaginings tell us something informative about the world. Just such a concern prompted the late Hellenistic Neoplatonist and ardent opponent of Philoponus, Simplicius (c. 490 – c. 560), to complain about putting one's faith in such fantasies.¹⁵ Thought experiments are supposed to help one understand the world better, and yet imagination is frequently linked to the real world only in the most tenuous of ways.

One is now in a position to see the special problem that Avicenna recognized about the premises used in thought experiments. If these premises are products of the faculty of intellect, then, they are restricted to a well-defined set of unvarying natural laws and fixed universal forms. In other words, premises produced by the intellect do not lend themselves to the imaginary and counterfactual scenarios that frequently are at the core of a thought experiment. Alternatively, if the premises of thought experiments are nothing more than unbridled compositions of the imagination, then there is no assurance that their content connects up with anything in the world so as to give one a deeper insight into the world. In short, for Avicenna the question is what faculty of the soul produces the premises employed in (legitimate) thought experiments as opposed to wild ravings? Intellect seems too restricted and imagination seems too unrestrained.

Avicenna's solution to this dilemma was to introduce a new internal sensory faculty called the 'estimative faculty' (*wahm*).¹⁶ According to Avicenna, the estimative faculty perceives non-sensible features or intentions (sing. *ma'nā*) within sensible particular things.¹⁷ The classic example is the sheep's recognition of the particular ferocity in a given wolf, for while ferocity is not itself something sensible it is manifested in the sensible features of the wolf, as in its sharp fangs and claws and the carnivorous odour that it exudes. In non-human animals the estimative faculty is, for Avicenna, the highest functioning psychological power, less than intellect but also more than mere imagination.¹⁸ It allows these animals to interact with the world around them in a fairly accurate way. Even in humans, according to Avicenna, it is the estimative faculty that allows us to navigate many of our day-to-day interactions.

Additionally, Avicenna appeals to the estimative faculty to explain the objects and premises of the mathematical sciences. The objects of mathematics, Avicenna tells us, are certain formal features of material objects but which can be

15 Simplicius (1894), 418,30.

16 For discussions of Avicenna's theory of the estimative faculty see Black (1993), Hasse (2000), esp. II.2, Hall (2006), and Kukkonen (2014), esp. § 3.

17 Avicenna (1959), 1.5, p. 45; 2.2, p. 60; & 4.1, p. 166.

18 Ibid., 4.1, pp. 167.

considered in the estimative faculty in some idealized way, like, for example, the universal squareness or a perfectly straight line.¹⁹ In this respect, the estimative faculty is what allows the mathematicians to consider perfect geometrical figures or numbers in the abstract even though these do not exist in the physical world around us. Likewise, the estimative faculty is the power that allows the physicists to imagine perfectly frictionless planes or a sphere's touching a two-dimensional surface at a single point, even though again in the nitty-gritty world around us none of these exists. These mathematical abstractions, Avicenna says, exist as a product of the estimative faculty. It is the estimative faculty, then, that provides mathematicians and (theoretical) physicists with an idealized picture of the world.

In this respect, the estimative faculty offers up a rough and ready guide to real physical possibilities.²⁰ Still one must be careful to distinguish between what exists as perceived in the estimative faculty and what actually exists as separate in the world.²¹ For Avicenna, if one is to move from the possibilities perceived in the estimative faculty to what actually exists, one must also have a demonstration or provide some actual instance in the world of what the estimative faculty posits.

To sum up, Avicenna develops the notion of an estimative faculty in order to explain a number of different, albeit related, phenomena. Among these phenomena are the semi-rational thoughts and cognitive processes of those higher animals that lack an intellect. Another was to show how idealizations used in mathematics, which do not actually exist separately in the world, can be informative about the world. Finally, the estimative faculty provides Avicenna with a psychological underpinning for thought experiments, which does justice to their frequently counterfactual nature while also explaining how they can have import about the world as it actually is.

3 Avicenna's Response to Philoponus' Thought Experiment

We are now in a position to consider Avicenna's response to Philoponus' thought experiment that attempted to show that an immaterial extension is not only coherent but also metaphysically possible. Avicenna critiques Philoponus' suggestion within the broader context of discussing the concept of void.²² He begins with an accurate presentation of the thought experiment. The proponents of a void or immaterial extension, Avicenna relates, have one consider some con-

19 Avicenna (1952), 1.2, pp. 12f.

20 Cf. Avicenna (2009), 2.1 [14].

21 Cf. *ibid.*, 2.9 [11].

22 Cf. *ibid.*, 2.9 [11].

tained body, whether the water in a jug or what lies between the moon's orbit around the earth. Here the contained body exists within certain limits of the containing body. Through an act of the estimative faculty, Avicenna continues, Philoponus and others have one imagine that the contained body is eliminated; however, the elimination of the contained body does not eliminate the space or extension (*bu'd*) between the limits of the containing body. What is eliminated and what is not eliminated, however, are distinct things. Thus, the thought experiment concludes, the space or extension is distinct from the body existing in it, albeit, that space or extension exists together with the body.

Avicenna's criticism of this argument is precisely to appeal to the limits of the estimative faculty's abilities and to Philoponus' failure to provide a demonstration showing that what was imagined can exist independently. To begin, Avicenna happily endorses the general method that the thought experiment employs: one uses the estimative faculty to isolate some formal feature within a body for closer scrutiny. In fact, Avicenna acknowledges that it is just this method that allows one conceptually to distinguish the form of a body from its matter. The problem in the present case comes from thinking that what is separable in thought must also be separable in reality. He clarifies by appealing to the form-matter case: were one able to remove all forms from some matter, the matter, Avicenna observes, would simply cease to exist, for the form is the principle of actualization. As for the case of the imagined void interval, he writes:

Let us grant that this interval is assumed in the estimative faculty, when a certain body or bodies are eliminated. How does one know that this act of the estimative faculty is not false [when applied to something existing separate from imagination], such that what follows upon it is absurd, and whether this assumption is, in fact, even possible, such that what follows upon it is necessary?²³

Avicenna's complaint is twofold. First, while the estimative faculty provides a rough and ready guide to whether an immaterial extension is possible, Philoponus further needs to show that no absurdity follows on the extra-mental existence of an immaterial extension. Second, Avicenna asks: Even if an immaterial extension is possible, is it a necessary part of our best explanation of the world? On both counts, Avicenna believes that Philoponus' immaterial extension fails.

To make his point Avicenna first compares Philoponus' thought experiment for an immaterial extension with the thought experiment for the conceptual distinction between form and matter. Philoponus' thought experiment is different from the form-matter case, for one can show that it is impossible for matter as pure potentiality to exist actually independent of any form. That is because if

²³ Cf. *ibid.*, 2.9 [11].

matter as pure potentiality were to exist actually without any form, and so without any principle of actualization, something that has no actualization would be actual, a contradiction. Still, Avicenna believes that he can demonstrate that matter is something necessary if we are to explain a thing's changing from certain potential states to actual states, for matter is what bears (*hāmīl*) potentiality, Avicenna argues.²⁴ In other words, the form-matter thought experiment is not intended to show that matter, as pure potentiality, is possible; matter's possibility is shown from the very fact that things change. Instead the form-matter thought experiment, Avicenna believes, is intended to show that matter must be conceptually distinct from form, even if never existing independently of form.

In contrast, Philoponus' thought experiment is intended to show that an immaterial extension is possible, even if space never exists independently of some body's occupying it. Avicenna observes that despite Philoponus' claim that space never exists independently of some body occupying it, nothing about Philoponus' argument precludes the possible existence of a 'body-free' immaterial extension. Philoponus certainly does not point to some contradiction that would follow on absolutely empty space in the way that the form-matter thought experiment did. In other words, for Avicenna, if Philoponus is correct, one should be able to assume the possible existence of an immaterial extension without any absurdity following.

4 Avicenna's New Thought Experiment against Philoponus

An absurdity, at least by Avicenna's lights, does follow upon the assumption of an absolutely infinite void. In fact, Avicenna thinks many absurdities follow upon that assumption. One of Avicenna's cases draws upon a number of principles taken straight from Philoponus as well as using a new thought experiment, so I consider it here in a little detail.

Avicenna constructs his new thought experiment in the form of an indirect proof for the impossibility of a void.²⁵ In other words, he assumes that Philoponus' immaterial extension is possible and then shows that this assumption coupled with certain other assumptions to which Philoponus is, or should be, committed, leads to an absurdity. The argument begins by imagining that an infinite void exists in which objects move. (The introduction of *infinite* is important to Avicenna's argument and while Philoponus himself would deny that space could be infinite, Avicenna maintains that there is nothing about the

24 Ibid., 3.11 [1–2]; Avicenna (2005), 4.2 [17–26]. For discussion of Avicenna's analysis see McGinnis (2012) and (2014).

25 Avicenna (2009), 2.8 [18].

character of a void such that a void must “either come to an end or be exhausted”;²⁶ rather, the characteristic of being finite is true primarily of body, maintains Avicenna.)

Next Avicenna considers the case of projectile motion in a void, for example, my shooting an arrow into empty space. When I shoot an arrow, I, by means of the bow, impart a certain motive power to the arrow. As a historical note, it was Philoponus himself, when criticizing Aristotle’s explanation of projectile motion, who introduced the idea of an imparted motive power or impetus or inclination (Gk. *rhōpē*, Ar. *mayl*).²⁷ So again, imagine I shoot an arrow into some infinite void space: Avicenna maintains that either the arrow continues in its motion unabated infinitely or it comes to a stop. That is because either the power that I imparted to the arrow remains, in which case the cause of the arrow’s motion remains moving the arrow, or the power that I imparted to the arrow cease to exist, in which case the effect, that is the motion, ceases to exist with the cessation of its cause.

On the one hand, the arrow cannot continue on infinitely, Avicenna believes, for a finite agent, and I am finite, can only ever produce a finite effect. The assumption that a finite agent cannot produce an infinite effect is one that both Avicenna and Philoponus accept. That is because if a finite agent could produce an infinite effect, there would be more in the effect, indeed infinitely more, than the finite agent has to give. By the very fact that the agent is finite, it has only a finite amount of whatever to give. A finite agent’s creating an infinite effect, then, would involve something’s coming from nothing but this is absurd, a principle that Philoponus himself accepts and exploits against Aristotle, at least with respect to natural things.²⁸ Consequently, if, when I shoot the arrow into the infinite void, the arrow continues moving without ever stopping, I would have produced an infinite effect. Thus, there is a contradiction: No finite agent can produce an infinite effect but some finite agent, me, would have produced an infinite effect.

On the other hand, if the arrow ceases to move once shot, then the privation or absence (*‘adam*) of motion must be owing to the fact that the power that I imparted to the arrow has ceased to exist. That power’s ceasing to exist, Avicenna observes, is either because ceasing to exist belongs to the power essentially, that is, on account of what it is, or because of some external cause acting upon the arrow so as to weaken the imparted power. If ceasing to exist, and so the absence of producing motion, Avicenna continues, belonged to the motive power essentially, then it would be impossible that the arrow moves at all. That is because if the essence of something were to cease to exist and so not to exist, then it

26 Ibid., [8].

27 Philoponus (1888), *ad* 4.8, 639,5–642,26. Studies include the seminal works of Pines (1938 a), (1938 b), and (1953); more recently see Wolff (1987) and Zimmerman (1987).

28 See Wildberg (1987), fragments 114–116.

essentially and so necessarily does not exist. There simply would not be any power to impart to the arrow so as to move it, which is patently false.²⁹

As for an external thing's bringing the arrow to rest, we have been asked to imagine a void. A void is literally something *devoid* of any thing, which includes causes that might arrest the arrow's motion. Thus, if there is something in the void that weakens the power that was imparted to the arrow so as to bring it to a rest, then there is something in that in which there is nothing, a contradiction. Of course, Avicenna develops each of these moments in the argument in greater detail, but almost every moment employs a thought experiment asking us to imagine how the projectile would move or come to rest in a void with every option entailing some absurdity.

Let me end this study on a bit of a whimsy with a breakneck survey of the historical background leading up to our Sir Isaac Newton's theory of inertia, for Avicenna's argument just described may have played a role, admittedly in a Byzantine way, in the evolution of our current notion of inertia and Sir Isaac Newton's *First Law of Motion*. Inertia is a property of matter by which a body continues in its existing state of rest or of moving uniformly in a straight line, unless an external force changes that state.

To appreciate Avicenna's role in the formation of the law of inertia, we must go to Paris around the time 1277. At that time, certain natural philosophers were claiming that the existence of a void is absolutely impossible and that not even God could create a void. In 1277 Stephen Tempier (d. 1279), the Bishop of Paris, condemned this position along with 218 other theologically suspect claims of certain natural philosophers.³⁰ One of the apparent results of the condemnation of this particular thesis is that it led John Buridan (1295–1363) to re-consider Avicenna's claim that if a body were to undergo projectile motion in an infinite void, it would move without ever ceasing.³¹ Again, Avicenna had argued that such an infinite effect is impossible and so the existence of a void must be impossible too; however, after the Condemnation of 1277, Buridan took the existence of a void as possible and so asked after the effect of the projectile motion in a void.³² If a void is possible, and it is assumed that it is now, a projectile would seemingly move unabated indefinitely. Buridan's thoughts on this topic in their turn

29 Here it is important to note that Avicenna is arguing against the possibility that impetus (*mayl*) can be self-expending or self-diminishing, since certain contemporary scholars believe that this claim had to await John Buridan; cf. Zupko (2014).

30 Condemnation 49, which reads: "Quod Deus non posit movere celum motu recto. Et ratio est, quia tunc relinqueret vacuum; that God cannot move the heaven rectilinearly and the reason is that then a void would be left behind" (Denifle, H./E. Châtelain (eds.), p. 546, # 49).

31 For the influence of Avicenna on Buridan's dynamics see Saylı (1984) and (1987).

32 For studies of Buridan's and later Medieval Latin dynamics see Duhem (1913), pp. 1–259 and Grant (2007), pp. 217–225.

reached Galileo Galilei (1564–1642) and influenced his thought experiments involving frictionless, infinitely long inclined planes.³³ Finally, it was Galileo's inclined plane experiments that Sir Isaac Newton developed into his *First Law of Motion*, again the law of inertia.³⁴

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