ARISTOTLE AND THOUGHT EXPERIMENTS

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Aristotle, as far as we know, has no conception of thought experiments. He does not discuss them in his works, and his writings do not show signs that he has identified a distinctive mode of pointing out something, philosophically or otherwise, that could plausibly be described in terms of what we call thought experiments. Aristotle does not even have a word for “thought experiment.” And it is not difficult to see why this is so. To start with, for our conception of “thought experiment” to make the specific sense it has (however vague it might be), it requires a context in which the concept of “experimentation” has some currency among a relevant community of thinkers. But in Aristotle’s time, there is no scientific community to which the conception of “thought experiment” could, as it were, speak: the notion relies on a specifically post-Aristotelian conception of experimentation, according to which experimenters contrive repeatable physical events, by means of which they demonstrate some correlation between physical states or events that are usually not available to immediate experience. An important aspect of this is that the experimenter produces her demonstration through exerting control over the relevant parameters (typically, with the aid of technical instruments) so as to isolate the occurrence of the phenomenon about which she wishes to demonstrate her point. The basic idea is that she, by wilfully manipulating the parameters, makes available to repeatable experience a regularity in nature that was previously not evident to her scientific community. According to this conception, experimentation is an artificial means to make available to repeatable experience hitherto unobservable facts about nature or, shorter still, a means to provide such data in otherwise unobservable natural terrain. Our notion of thought experiment depends on some such ideas of empirical experimentation. The difference is of course that thought experiments are not confined to physical facts, which is also why they do not require artificial production of physical events; what makes them experiments of thought is that repeatable imagined scenarios are used instead. But, notwithstanding this difference, our notion of thought experiments seems to preserve what is basic for the early modern idea of empirical experimentation: they are imagined scenarios, wilfully contrived through manipulations of relevant parameters and with the
purpose of isolating, and thus disclosing to experience, some previously non-evident fact; only that thought experiments, instead of providing us with experiences in an unqualified sense, provide us with what Ernst Mach calls a Gedankenerfahrung, an experience in thought (Mach 1905, 186).

There is of course no trace of this in Aristotle. But could there have been? It seems to me that the absence of a conception of thought experimentation in Aristotle’s works is not a matter of mere contingency. Aristotle, unlike early modern experimenters, does not attach much methodological weight to empirical experimentation as a means to the discovery of facts. Notoriously, his natural science relies much more on the observation of what is there and plain to see for the philosophically acute, yet instrumentally unaided, observer rather than on artificial extraction of hidden facts. Indeed, his views on the status of scientific data in empirical sciences seem to be at odds with our more engineer-like attitude towards nature. According to Aristotle’s conception, empirical science divides labour between the collection of the relevant facts, on the one hand, and the scientific explanation of these facts, on the other. The former he calls by the name of “the that (to hoti),” or the “the phenomena (ta phainomena),” or sometimes simply “experience (empeiria)” of a science, whereas he refers to the latter as the “on account of which” or “the because of which (to dihoti)” these facts obtain. Zoological science, for instance, is a twofold enterprise, consisting of the collection of relevant facts about animals and the statement of reasons for these facts. On that picture, engaging in the explanatory task of stating the reasons requires the collection of facts to be more or less completed. Aristotelian sciences are in this sense holistic: their explanations are meant to exhaustively capture the relevant explanatory order that structures their respective domains as a whole. To us, by contrast, the thought that the empirical observation of facts in a given domain is completed would not occur too easily. We tend to think of natural inquiry as an open-ended task. And it looks as if the reason for why we think that way has to do precisely with the incredible success of the post-Aristotelian method of extracting data from nature by the way of technical artifice. For that success story strongly suggests both that our ability to collect data and thus to extend the ambit of our experience beyond what is plain to see is more or less a function of our technical abilities, and that there is no obvious limit to these abilities. From a historicizing and progress-oriented standpoint such as ours, then, it is not without irony when Aristotle calls the collections of “the” observable data of a given scientific domain “experience.” But however that may be, a philosopher who thinks about natural science in the way Aristotle does is not likely to regard the discovery of new data as the scientist’s main occupation. Rather, he will be inclined to think of it as a very important and necessary, yet manageable, prerequisite for the proper business of scientific investigation, which is the explanation of the facts. And as there is little reason for such a philosopher to attach great methodological weight to experimentation as a means to the discovery of facts, there is even less reason for him to do so for thought experimentation.

This, to be sure, is not to say that there is no place for empirical experimentation in Aristotle’s conception of science. There is no particular reason why he should have regarded experimentation as in any way problematic or illegitimate: experimentation just does not form a vital part of his understanding of what empirical science is all about. This, it seems to me, is certainly — and perhaps also trivially — true of Aristotle. In this regard our engineer-like manner of doing science is simply very different.
there is also another element in our very concept of thought experiment that probably would have struck Aristotle as alien. For talk of experiments “in thought” somehow trades on the idea that the results of mere thoughts and the results of “genuine” experiments conducted by natural scientists can have similar epistemic value. What makes this parallel potentially alien to Aristotle is that it often comes with the additional idea that having an equal or similar epistemic value as empirical science somehow legitimates, or perhaps even rehabilitates, mere thoughts as a method of scientific discovery. That, however, would be a strange line of thought for a philosopher who precedes the modern divide between science and philosophy and who, apart from firmly believing in the dignity and purpose of the human capacity of reason, is ignorant of the discredit into which the (largely Aristotelian) “philosophy-schooles” fell in early modern times.7 There is reason, therefore, to doubt that Aristotle would have regarded appeal to empirical experimentation as a selling point.

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In spite of this absence of a positive conception of thought experimentation in his thinking, Aristotle undoubtedly makes abundant use of what we call thought experiments. His works, especially the ones on natural philosophy, virtually bristle with them.8 And it is not difficult to see why this is so either. Aristotle is, after all, a philosopher. What I mean by this is that, even on our by comparison very narrow conception of philosophy, he is concerned with questions that we would classify as philosophical questions, as, e.g., on the nature of value, meaning, modality, life, god, and so on. If we are to believe Aristotle’s own line of reasoning, these philosophical topics are superbly difficult precisely in virtue of the fact that they concern unobservable matters.9 And since thought experimentation, according to the minimal characterization just given, is a means of providing data in otherwise unobservable terrain, it seems to have a natural affinity with the treatment of these philosophical questions. Qua being a philosopher who is concerned with unobservable and otherwise epistemically difficult matters, this seems true of Aristotle as well. He too uses imagined hypothetical scenarios when he has reasons to do so. So the same functional account seems to apply: Aristotle uses thought experiments in order to compensate for a lack of available data in epistemically difficult terrain. However, I should add here that his conception of philosophy extends further than ours. For Aristotle, as is well known, all knowledge that we pursue for its own sake counts as philosophical knowledge, including natural science. I should also add that Aristotle’s usage of thought experiments in “epistemically difficult terrain” should be understood broadly as well. He uses thought experiments not only in cases where it would be impossible or exceedingly difficult to carry out physical experiments, but also, as we will see, in cases where it would be relatively easy to perform the corresponding physical experiments. This holds in particular for a number of thought experiments in his philosophical psychology. But this is not to say that these experiments occur in readily accessible epistemic terrain. Rather, in these cases the epistemic difficulty is located on the receiver’s end: they typically concern claims that in one way or another conflict with widespread or otherwise deeply ingrained intuitions. One such claim is the widespread view that flesh is the organ of touch (see 4.1 below). Aristotle attacks this view by way a thought experiment that could easily be performed as an actual experiment.
But in such a case we may still regard the thought experiment as a device for providing data in epistemically difficult terrain, because the data that it does provide us with are counterintuitive, i.e. they contradict common views and would not occur easily in ordinary thought. Finally, a clarification. For the purposes of this chapter, I would like to distinguish thought experiments from imagined scenarios that merely exemplify or illustrate a point, such as the following illustration of the thesis that the constitution of a living body is best preserved in an environment akin to it:

For example, if nature were to constitute a thing of wax or of ice, she would not preserve it by putting it in a hot place, for the opposing quality would quickly destroy it, seeing that heat dissolves that which cold congeals. Again, a thing composed of salt or nitre would not be taken and placed in water, for fluid dissolves that of which the consistency is due to the dry.

(De Juv. 477a18–23, transl. G.R.T. Ross)

I would not classify this as a thought experiment because in this case Aristotle is not doing anything with the imagined scenario. He is not generating evidence on the basis of which he is going to make a point, but merely illustrates a general point he made previously in the text. The scenarios I will discuss as thought experiments in what follows, by contrast, somehow generate data by having these data in one way or the other follow from the imagined parameters, so that we can experience them as happening. On the minimalistic functional perspective I am suggesting on Aristotle’s behalf, then, thought experiments are a means to compensate for a lack of data in epistemically difficult terrain, by somehow generating data from imagined scenarios. This, at any rate, is the somewhat pedestrian perspective under which I shall present a small number of examples of thought experiments. My guiding principle in choosing the examples is to illustrate some of the variety in the ways he uses them. But I should warn the reader that I make no claim towards a representative selection of examples, and let alone towards an exhaustive typology. I end this chapter with a brief discussion of what Aristotle might himself have thought about his own usages of thought experimentation.

Note on the examples

Aristotle is known to most of us as an author of densely written philosophical treatises. These are his so-called esoteric writings, which were intended to be read only by a small elite of technically skilled philosophical insiders. He is less known for his published philosophical works. These works, the so-called exoteric writings, were intended for a wider audience of philosophically interested non-experts. Today, unfortunately, we possess these writings only in a comparatively small number of fragments. Many of these writings were philosophical dialogues. As far as we know, they very much resembled the dialogues of Aristotle’s teacher Plato, not only in literary style but apparently also – and astoundingly – in their philosophical doctrine. There is, for instance, a cave analogy also in Aristotle (see below), and even arguments for the immortality of the soul, a doctrine that Aristotle appears to contradict in his esoteric works. Naturally, in the literally setting of a Platonic dialogue, the style of reasoning will be more colourful than that in the mostly terse esoteric
writings. In order to illustrate this aspect of Aristotle’s usage of thought experiments, I shall briefly present one example from his exoteric writings. All other examples are taken from his esoteric works.

1 Dialogues

1.1 The cave

We know of this thought experiment from a report by Cicero. He says:

Thus Aristotle brilliantly remarks:

Suppose there were men who had always lived underground, in good and well-lighted dwellings, adorned with statues and pictures, and furnished with everything in which those who are thought happy abound. Suppose, however, that they had never gone above ground, but had learned by report and hearsay that there was a divine spirit and power. Suppose that then, at some time, the jaws of the earth opened, and they were able to escape and make their way from those hidden dwellings into these regions which we inhabit. When they suddenly saw earth and seas and skies, when they learned the grandeur of clouds and the power of winds, when they saw the sun and realized not only its grandeur and beauty but also its power, by which it fills the sky with light and makes the day; when, again, night darkened the lands and they saw the whole sky picked out and adorned with stars, and the varying light of the moon as it waxes and wanes, and the risings and settings of all these bodies, and their courses settled and immutable to all eternity; when they saw those things, most certainly would they have judged both that there are gods and that these great works are the works of gods.

Thus far Aristotle.

(Cicero, *De natura deorum* II, xxxvii 95, Fragment 12 Rose3: transl. Barnes/Lawrence)

Aristotle invites us to imagine people who, apart from living in underground dwellings without knowledge of the existence of outside world, live in circumstances similar to ours; they have everything they need, as well as some vague stories from hearsay about the existence of a divine power. Next he invites us to imagine that “the jaws of the earth opened” so as to expose the cave-dwellers to the sight of the stars and their regular motions. On that basis, he argues that the cave-dwellers, overwhelmed by the sight, would “most certainly” come to believe there to be gods, who, as only gods could, have created this marvelous universe. We do not know in which context Aristotle originally made use of this thought experiment, but it certainly is remarkable for its poetic force. Aristotle tries to, as it were, alienate us from our own macroscopic environment, so as to allow us to take a fresh, and presumably also philosophically more adequate, perspective on it: he uses the cave-scenario to detach us from our habit of taking for granted the existence of the outside world, and seeks thereupon to establish a causal link between the overwhelming beauty of the firmament, and the existence of divine creators. Here, I take it, the thought experiment provides otherwise unavailable data, not by disclosing hitherto hidden facts, but by providing a new perspective on data that are all too obvious to everyone.
2 Metaphysics

2.1 The “stripping argument”

This is the perhaps most famous thought experiment in Aristotle, and certainly the most famous in his *Metaphysics*. It is a part of his investigation into the question: “what is substance?” Unlike in the previous example, Aristotle here uses the experiment for a critical purpose, namely to refute a particular thesis about what substance is. According to that thesis what makes substances being what they are is that they are underlying subjects of predication. Aristotle puts that thesis to a test. He asks us to imagine an uncontroversial instance of a substance, namely a three-dimensional natural body, and then to strip it of its predicates. The idea is straightforward enough: if the nature of substances really consists in their being the underlying subjects of predication, then stripping away all the predicates from an underlying subject of predication (a natural body) should leave us with its pure substance. That, however, is not what happens:

We have now outlined the nature of substance, showing that it is that which is not predicated of a subject, but of which all else is predicated. But we must not merely state the matter thus; for this is not enough. The statement itself is obscure, and further, on this view, matter becomes substance. For if this [i.e. matter] is not substance, it is beyond us to say what else is. When all else is taken away evidently nothing but matter remains: For the [predicates] other [than substance] are either active doings, and passive affections, and capacities of the bodies, while their length, breadth, and depth are quantities and not substances. For a quantity is not a substance; the substance is rather that to which these primarily belong. But when length and breadth and depth are taken away we see nothing left except that which is bounded by these, whatever it be; so that to those who consider the question thus matter alone must seem to be substance. By matter I mean that which in itself is neither a particular thing nor of a certain quantity nor assigned to any other of the categories by which being is determined. For there is something of which each of these is predicated, so that its being is different from that of each of the predicates; for the predicates other than substance are predicated of substance, while substance is predicated of matter. Therefore the ultimate subject is of itself neither a particular thing nor of a particular quantity nor otherwise positively characterized; nor yet negatively, for negations also will belong to it only by accident.

*(Metaphysics 7.3, 1029a6–1029a26, transl. Ross, slightly modified)*

Aristotle distinguishes two kinds of predicates: predicates that denote what bodies actively do or passively undergo along with their corresponding capacities (powers), and predicates that denote their dimensional extensions (length, breadth, and depth). Stripping away in thought the first group of predicates leaves us with the bodies’ bare spatial extension; stripping away these extensions, however, does not result in the isolation of the *substance* of these bodies; rather, what we then “see” is only what was bounded by their extensions “length,” “breadth,” and “depth,” which for Aristotle is completely
indeterminate physical matter (χύλε). But as physical matter does not meet two other fundamentally important criteria for being a substance, namely having independent (“separate”) existence and being a determinate “certain this” (1029 a27–29), something must be wrong with the criterion the application of which led us to the assumption that matter is substance. The conclusion is that being an underlying subject of predication is not a sufficient criterion for substance.

2.2 A second sun

The passage exhibits two cases of usage of thought experimentation, one of which seems particularly close to some thought experiments in recent philosophy. They occur in Book 7 of his *Metaphysics*, where Aristotle critically confronts the Platonic doctrine of Ideas with difficulties. In the first case, his argument relies on the practice, already common at his time, of defining things by way of proximate genus and specific difference. Previously in the text, it has been established that such definitions are *general*: they apply to whatever “falls under” them. This, however, has the consequence that definitions cannot isolate individuals as such, but merely their universal characterizations (their “being” as Aristotle says). This presents a difficulty for the theory of Ideas because by that theory, Ideas would be both universal objects of definition and unique undefinable individuals. To make his point, Aristotle considers a particular and well-known case of a particular and (according to him and many of his contemporaries) also eternal individual: the sun.

As has been said, then, the impossibility of defining individuals escapes notice in the case of eternal things, especially those which are unique, like the sun or the moon. (a) For people err not only by adding attributes whose removal the sun would survive, e.g. ‘going round the earth’ or ‘night-hidden,’ for from their view it follows that if it stands still or is visible, it will no longer be the sun; but it is strange if this is so; for ‘the sun’ means a certain substance; (b) but also by the mention of attributes which can belong to another subject; e.g. if another thing with the stated attributes comes into existence, clearly it will be a *sun*; the defining formula therefore is general. But the sun was supposed to be an individual, like Cleon or Socrates. After all, why does not one of the supporters of the Ideas produce a definition of an Idea? It would become clear, if they tried, that what has now been said is true.

(*Metaphysics* 7.15, 1040 a27–b4, transl. Ross, slightly modified)

If definitions by proximate genus and specific difference do not isolate individuals, but only their general characteristics, then there can be no definition that isolates a unique Platonic Idea either – there can only be a general characterization under which the Idea would “fall.” Section (b) shows that the terms we use in defining the sun all denote general attributes, each one of which could apply to a plurality of objects, even if it should happen that there actually exists only one of them: hence, if another individual that shares the same characteristics as the sun came into existence, that individual clearly would have to be thought of as a *sun*. Considering the scenario of a second sun shows
that defining formulas are general by their very nature and, therefore, cannot capture individual entities. The other experiment in (a) introduces a different scenario for a different purpose, the refutation of certain definitions of the sun current at his time. What Aristotle doesn’t like about them is that they try to capture the nature of the sun by reference to non-essential attributes, such as that it “goes around the earth” and is “hidden at night.” To make us see why this kind of definition must fail, Aristotle imagines a scenario in which these purportedly definitional attributes are removed: it turns out that even if we counterfactually suppose that the sun stands still or be visible at night, it would still be true that we would think of it as the sun. Hence, defining the sun by way of such and other “attributes whose removal the sun would survive” fails to capture what the sun most fundamentally is (a thing or a substance).

2.3 If all things were colours

Here, Aristotle argues against a certain class of mathematically minded philosophers. These philosophers posit unity (“the one”) and numbers to be fundamental items of their ontologies and explain what things other than numbers are in terms of such metaphysical numbers. His aim is to demolish that thesis by showing how number and unity are too thin as concepts to be able to account for what things other than numbers are. The structure of the argument is a reductio. Aristotle starts by considering a case of metaphysical analysis of things by way of unity and numbers, namely the at his time widely accepted analysis of colours as numerical proportion of white and black.

But in colors the one is a color, e.g. white – the other colors are observed to be produced out of this and black, and black is the privation of white, as darkness of light.

In this instance, the colour white takes the place of “the one,” i.e. the first metaphysical principle, in its domain (colours) because the other colours are generated by way of numerical proportions of white and of black, where black is conceived as the complete absence (or privation, lack) of white on the colour-scale. Aristotle agrees with this theory. He agrees that all other colours are defined as values in-between the extreme values on the colour spectrum white and black, and that therefore all intermediate colours are products of (numerical) proportions of white and black. The colour “green,” for instance, consists in a mixture of a certain portion of white plus a certain portion of black. But since black is just the complete lack of white on the colour spectrum, white is “the one” in the domain of colours: all intermediate colours can be reduced to a combination of it and the lack thereof. Now, Aristotle dramatically expands the scenario:

Therefore if all existent things were colors, existent things would have been a number, indeed, but of what? Clearly of colors; and the one would have to be something one, e.g. white.

(Meta. 1. 2, 1053b29–34, transl. Ross)

Aristotle uses the absurd scenario that all existent things are colours to bring out a fundamental flaw in the theory of the mathematically minded philosophers. These
thinkers assume that unity and numbers are somehow self-subsisting entities, to which all other things can be metaphysically reduced. However, while this may work in the case of numerical quantities, it does not work in the case of other categories, not even in the relatively uncontroversial case of the numerical analysis of colours: for even if Aristotle agrees that colours are to be analyzed in terms of numerical proportions of white and black, they still remain numerical proportions of colours. The numbers of colours are relative to what they are the numbers of, namely colours. So if there is a reduction of colours to numbers, this is so in virtue of the fact that the numbers are numbers of colours. What we learn from this is that the reduction of colours to numerical proportions of other colours, even when possible, does not amount to the reduction of colours to numbers. The mathematically minded theory fails because it ignores this basic conceptual fact. The experiment brings that out by imagining a very simple qualitative world: even if all things were colours, and therefore reducible to numerical proportions of white and black, this would not give us a reduction of colour to unity and number. Unity and number are too thin as concepts to account for anything outside of quantities.13

3 Philosophical psychology

3.1 Why flesh is not the organ of touch: the membrane and the air envelope

Again a thought experiment with a critical purpose. The thesis put to test this time is that flesh is the organ of touch. The experiment comes in two stages. In the first stage, Aristotle tries to defuse what others count as good evidence for thinking that flesh is the organ of touch, namely that we perceive the affections of our flesh immediately:

To the question whether the organ of touch lies inward or not (i.e. whether we need look any farther than the flesh), no indication can be drawn from the fact that if the object comes into contact with the flesh it is at once perceived. For even under present conditions if we stretched a membrane tight over the flesh, as soon as this is touched the sensation is reported in the same manner as before, yet it is clear that the organ is not in this membrane. And if the membrane could even be grown on to the flesh, the report would travel still quicker.

(DA 2. 11, 422b34–423a6, transl. Smith)

Here, Aristotle casts doubt on the idea that our immediate perception of touch upon our flesh shows that flesh is the organ of touch: for if we imagine that an external membrane be stretched tightly over our flesh, it would feel the very same. Why think, then, that our flesh is any different from such a membrane? And if we further imagine that this membrane be grown together with our body (as is the case with our flesh), it follows from the scenario that we would perceive contact upon the membrane with the same immediacy as contact with our flesh. In this case, the justification with which we would think that this outer membrane is the organ of touch is just about the same as the justification with which we now think that the flesh is that organ. In the next step, Aristotle extends the
scenario in order to bring out one of the positive roles our flesh plays in perception. If we imagine our bodies to be surrounded by an envelope of air growing around our bodies – in a way similar to how our flesh grows out of our bodies – we would be naturally lead towards believing that the distal senses of hearing, seeing, and smelling all belonged to one and the same sense modality. But, as it is, we do not believe this because the bodies and organs through which these different sense-objects are channeled to us are different in each case, which is Aristotle’s point:

That is why that part of the body which is of that quality [i.e. the flesh] relates to us in a way very similar to an air-envelope that grows round our body; had we such an envelope we should have supposed that it was by a single organ that we perceived sounds, colours, and smells, and we should have taken sight, hearing, and smell to be a single sense. But as it is, because that through which the different movements are transmitted is not naturally attached to our bodies, the difference of the various sense-organs is evident. But this is now unclear in the case of touch.

(\textit{DA 422}b34–\textit{432}a12, transl. Smith, slightly modified)

What about the proximal senses? In what follows in the text, Aristotle argues that nature had, as it were, no choice but to construe the bodies through which we receive the input of touch, taste, and smell with one and the same kind of body, flesh.

\section*{3.2 If white would be the only perceptible}

This thought experiment is used to suggest that nature has equipped us with a plurality of senses so that we can distinguish, and isolate in thought, the perceptual features common to a plurality of our senses, such as extension, numbers, and movement, from what he calls “special sensibles.” Special sensibles are those perceptible objects that are exclusive to each sense modality (colour for sight, sound for hearing, scent for the sense of smell and so on). Aristotle seeks to establish this point by imagining an extreme scenario of monomodal perception, in which we possess only one single sense modality, namely sight, with one single perceptible object, namely the colour “white.” In that scenario, we would be unlikely to distinguish number, movement, extension and the like from the whiteness we perceive. And this in turn suggests that we possess more than one sense modality – perhaps among other things – in order to be able to distinguish the content specific to each sense modality from the perceptible features common to a plurality of them:

It might be asked why we have more senses than one. Is it to prevent a failure to apprehend the common sensibles, e.g. movement, magnitude, and number, which go along with the special sensibles? Had we no sense but sight, and that sense no object but white, they would have tended to escape our notice and everything would have merged for us into an indistinguishable identity because of the concomitance of colour and magnitude. As it is, the fact that the common sensibles are given in the objects of more than one sense reveals their distinction from each and all of the special sensibles.

(\textit{DA 425}b5–11)
4 Cosmology

4.1 Refutation of the Atlas-theory

This is a particularly interesting thought experiment. Aristotle engages in a continuous discussion of what for him is a manifestly false theory of the movement of the universe. His motive in doing so is to bring across a general limitation of the type of theory as represented by the Atlas-theory. To see the extent of how Aristotle exploits counterfactual scenarios for his philosophical purposes, we must follow the course of his argument along a larger part of a whole chapter of On the Movement of Animals. The context is the discussion of a mechanical principle of animal self-locomotion that Aristotle has introduced and defended in the previous chapters of the treatise. According to this principle, locomotive agents, in order to move their bodies from place to place, necessarily require an external and unmoved resting point, so as to be able to support themselves against it.

EXTERNAL SUPPORTING POINT PRINCIPLE: Self-locomotive agents, in order to move their bodies from one place to the other, necessarily require an external resting point which is unmoved in relation to them.

In the previous chapter, three examples were given to illustrate the impossibility of self-locomotive change without some such external and unmoved prop. 1. Mice whose feet are stuck in a pitch won’t move forward because they cannot separate their own movement from the movement of the ground on which they stand. They take, so to speak, their ground with them. 2. Walkers who walk on sand won’t move forward because the sand fails to provide a support that remains unmoved in relation to their own movement. 3. A sailor on a boat cannot move the boat by supporting himself from within the boat. This last example illustrates very clearly the necessity that the supporting point be external to the self-moving body: the supporting point must be no part of the self-moving body, which in the case of the third example is not the sailor but the boat on which the sailor stands. Without such an external supporting point, says Aristotle, not even the mythical giant Tityus, nor the wind-god Boreas as he blows into the sail, would move the boat. At this point, once the principle is established, Aristotle broadens the scope of discussion to cosmological scale, asking whether the motion of the universe as a whole would require such an external supporting point as well.14

Someone might pose this problem: if something moves the whole heavens, must there, too, be something unmoved which is neither any part of the heavens, nor in the heavens?

\[(699^\text{a}12–14)\]

In response, Aristotle distinguishes two different scenarios in which the universe (“the whole heavens”) is moved by a mover, and answers affirmatively in both cases:

For if it [i.e. the mover of the universe] is moved itself and also moves the heavens, it must touch something that is unmoved in order to impart the movement, and
this must be no part of the mover; and if the mover is unmoved from the first, it must, equally, be no part of what is moved.

(699.14–17)

In the first scenario, the universe is moved by a moved mover, i.e. a self-mover, which on its part will require an external and unmoved resting point; in the second scenario, the universe is moved by a mover in which the two functions of resting point and mover coincide: an unmoved mover. In the former and more familiar scenario, the mover must support itself against an unmoved and external resting point as in the case of animals; in the latter scenario, by contrast, the mover itself will have to be located outside of the universe. Hence both scenarios confirm that the External Supporting Point Principle applies across the board: all motions, including the motion of the universe as a whole, require an external unmoved supporting point.

The cosmological application of the Supporting Point Principle leads to a paradoxical result. How can there be anything outside of the universe? And how can that something be strong enough to serve as a platform for the universe’s movement?15 Now, we know that for Aristotle this outcome is all but absurd, as he teaches in his Metaphysics the doctrine of a first and entirely unmoved mover outside of the universe. But Aristotle also believes in the methodological independence of physics from other branches of philosophy. So he is careful to avoid explicit reference to his metaphysical doctrine here, and therefore has left out his high-minded and contentious claim of a first and entirely unmoved mover outside of the universe. All we “officially” know at this point is that the application of the External Supporting Point Principle on a cosmological scale requires an external platform also for the motion of the universe. Still, as we will see, what drives him here in further pursuing the cosmological dimension of the External Supporting Point Principle is clearly that it provides him with an independent confirmation of his metaphysical doctrine.

So much for the context. Now, Aristotle proceeds to discuss rival theories concerning the origin of the motion of the universe. He starts with a theory that has been suggested by previous thinkers. What makes this theory interesting for him is that these thinkers seemed to have been aware of the problem that the External Supporting Point Principle poses for theories that postulate internal movers of the universe; what is more, they also seemed to have suggested a solution to the problem that avoids the principle’s paradoxical consequence of the existence of a supporting platform outside of the universe. This potential rival to Aristotle’s doctrine of a first unmoved mover of the universe is the so-called Pole-theory.

And on this point, at least, they are quite right who say that when the sphere is borne in a circle no part at all remains still; for it would be necessary either that the whole of it remain still, or that its continuity be torn asunder. But they are not right to ascribe power to the poles, which have no size and are termini and points. For besides the fact that nothing of this kind has any substance, it is impossible for a simple motion to be imparted by what is two; and they make the poles two. From considerations such as these one might doubt that there is something that bears the same relation to the whole of nature that the earth does to animals and the things moved by them.

(699.17–2716)
Aristotle praises the holders of the Pole-theory for having identified a problem that seems to be very close to what he himself had just described in terms of the External Supporting Point Principle: a rotating universe has all of its parts moving, which is to say that no part remains still; however, if mover and moved need to be separate from one another, as the proponents of the Pole-theory seem to agree, none of the parts of the universe can serve as the mover (on pain of either bringing the whole universe to a standstill or disrupting its physical cohesion by making one part of it rest and the other move). This seems to be the fundamental insight on which the Pole-theory rests. And Aristotle agrees. However, the theory suggests a way out of the predicament that he doesn’t agree with: if the poles of its rotational axis are the movers of the universe, the movers will be unmoved (geometrical entities are not subject to motion) and neither physical parts, nor outside, of the universe. So, on the face of it, the Pole-theory fulfills all the demands of the External Supporting Point Principle, while it manages to avoid the counterintuitive consequence Aristotle drew from its application to the motion of the universe, namely that there must be an unmoved platform outside of the universe.

Aristotle’s main move in demolishing the Pole-theory is simply to insist on the causal inertia of poles: poles are geometrical entities. As such they lack physical powers (“have no size” and “substance”): there is nothing they could possibly set into motion. In this regard, poles are no different from other non-physical entities such as lines, points, termini, and so on. With this Aristotle takes himself to have refuted the Pole-theory. Accordingly, he concludes the section, on a somewhat triumphant note, by saying that objections of that kind (i.e. of the kind of the Pole-theory) can be raised against his thesis that there must be an external unmoved supporting point of the movement of the heaven. This clearly implies that theories that seek to circumvent the External Supporting Point Principle on the basis of the assumption of internal movers of the universe must fail.

However, Aristotle continues to discuss a yet further theory that proposes the already refuted hypothesis of an internal mover of the universe, and a particularly crude one at that. This is the Atlas-theory, which is moreover a theory of Aristotle’s own artifice. He extrapolates it from mythically inspired artistic depictions of the Titan Atlas:

> Now those who, in a mythical manner, represent Atlas with his feet on the earth would seem to have told their fable with the intention to describe him as a kind of axis, whirling the heavens around the poles. Now this would be quite reasonable, since the earth remains still.

(699a27–31)

Aristotle does not discuss the Atlas-theory as a viable alternative. Quite obviously the theory falls prey to the same lethal objection against all theories of internal movers of the universe that Aristotle has just leveled against the Pole-theorists: since in a rotating universe no part of the universe stands still, the External Supporting Point Principle will necessitate an external resting point also for Atlas. He either will have to stand on a platform outside of the universe, which by hypothesis he doesn’t, or there will be an unmoved platform for him to stand on inside of the universe, namely the earth. However, as the Pole-theorists already saw, that would tear asunder its physical continuity, as the External Supporting Point Principle requires the platform to be no part of
Why, then, does Aristotle bother to discuss the Atlas-theory? What he is interested in is not the theory as such, but the fact that discussion of the theory will bring out a common feature of all physical theories of internal movers of the universe. This is that all such theories, as we will see, by virtue of proposing physical entities as movers viz. platforms, lack the explanatory power to account for the absolute necessity with which Aristotle believes that the movements of the heavens occur: physical entities are contingent, i.e. they allow for the possibility of being otherwise than they actually are. That modal feature of physical movers makes them unfit to account for the order of the large-scale movements of the universe in Aristotle’s eyes, which he believes cannot be otherwise. To bring out this principled lack in explanatory power of physical theories of the movements of the heavens – and to thereby hint at the virtue of his own theory of a non-physical first unmoved mover – is what drives him in discussing the at this point manifestly false Atlas-theory.

He starts by teasing out some of the consequences and explanatory duties of the Atlas-theory. If Atlas is to function as an axis extending between the earth and the outermost heaven, the External Supporting Point Principle requires not only that the earth remains unmoved, but also that the earth be no part of the universe. This is a first absurd consequence of the Atlas-theory. But Aristotle continues to discuss the Atlas-scenario. His next blow to the theory consists in pointing out just how much physical force Atlas’s supporting platform – the earth – will have to resist. This will not only, as one might perhaps think, have to be the kinetic force with which Atlas whirls the heavens around himself, but also the static forces of the heavens and of Atlas himself:

But if they give such an account they must concede that the earth is no part of the universe. Further, the forces of that which causes movement (i.e. Atlas) and of that which remains still (i.e. the earth) must be made equal. For there is a certain amount of force and power in virtue of which what remains remains, just as there is of force in virtue of which the mover imparts motion. And there is a necessary proportion, just as of opposite motions, so also of states of rest. And equal forces are unaffected by one another, but they are overcome by a superiority of force. So Atlas, or anything similar that imparts movement from within, must exert a pressure no greater than the fixedness with which the earth remains stable, or the earth will be moved away from the center, out of its proper place. For just as the pusher pushes, so the pushed is pushed—i.e., with similar force. But that which imparts the motion starts out by being at rest, so that its force must be greater than, rather than similar and equal to, its own stability, and, similarly, greater than the stability of that which is moved but does not impart movement. Then the earth’s power of stability will have to be as great as that of the whole heavens and that which moves them.

(699a32–b10)

If Atlas stands on the earth, the earth will have to resist the entire weight of both Atlas and the heavens, and, on top of that, also of the moving force with which Atlas revolves the heavens around himself. Given the immense disproportion between the sizes of the earth and the heavens, Aristotle insinuates that attributing such resisting force to the earth amounts to nothing less than a physical impossibility:
And if this is impossible, it is also impossible that the heavens be moved by anything of this kind within them.

(699b10–11)

Aristotle here clearly uses the Atlas-theory to make a general point against all theories of internal movers of the heavens: for the sheer disproportion of the sizes of the mover and the moved, no such theory will succeed in making plausible the claim that there is some resting platform within the universe strong enough to resist both the resting and the moving forces of everything else in it. But, notwithstanding the foregoing, discussion continues. Aristotle further dwells on the scenario to isolate an additional feature of the Atlas-theory and its likes, that he is particularly interested in. This is the principled limitation in the modality with which it, and any such theory, can account for the motions of the heavens. Now the discussion takes the form of a problem (aporia):

There is a problem about the motions of the parts of the universe that we might consider, as being closely connected to what we have just said. For if someone could overcome by power of motion the stability of the earth, it is clear that he would move it away from the center. And it is obvious that the force from which this power would derive is not infinite. For the earth is not infinite, so its weight is not either.

(699b12–17)

Aristotle confronts the Atlas–theory with the following imagined scenario: if we suppose a further mover who moves the earth away from its center position, then this movement would require only a finite amount of force, since the size (and resting force) of the earth is finite as well. This means that the order of the movements of the universe could be dissolved by a finite force, which is to say that, in the scenario suggested by the Atlas theory, and all theories that postulate internal movers of the universe, it would be possible to dissolve the order of the universe. The physical character of their hypotheses imply that the resting force of the supporting point for the universe’s movement will be of a physically determinate, and therefore finite, quantity. It is this possibility of a disruption of the order of the physical world, as it is implied by the physical character of theories like the Atlas-theory, that Aristotle takes issue with:

Now “impossible” has several senses: for when we say it is impossible to see a sound and for us to see the men in the moon, we use two different senses of the word. The former is invisible of necessity; the latter, though of such a nature as to be visible, will not actually be seen. Now we believe that the universe is imperishable and indestructible of necessity.

(699b18–21)

Mere physical impossibility, according to which something that possibly could happen will actually never happen, is not enough for Aristotle when it comes to the physical order of the universe; that order must be impossible to dissolve in the same way in which it is impossible to see a sound, i.e. necessary in the sense of “impossible of being otherwise.” This kind of necessity is something the Atlas-theory (and with it the whole class of theories it here
represents) cannot deliver: these theories explain the order of the universe by way of a physical event. Physical events are finite and contingent. So, regardless whether such theories can account for the movement of the heavens (and Aristotle has given us ample grounds for believing that they cannot), they are incapable to account for the necessity with which Aristotle believes the physical order of the universe exists:

But the result of this argument [of a physical mover of the universe] is that it is not so of necessity. For it is natural and possible for there to be a motion greater than that in virtue of which the earth remains stable, and in virtue of which fire and the body above are moved. If, then, there are overwhelming motions, these bodies will be parted asunder one from another. And if there are not, but might possibly be (since there could not possibly be an infinite motion, because it is not even possible for a body to be infinite), it would be possible for the heavens to be dissolved. For what prevents this from happening, if it is not impossible? And it is not impossible unless the opposite is necessary. Let us, however, discuss this problem further another time.

(699b23–31)

With the concluding statement that the truth of the Atlas-theory is compatible with the possibility of the dissolution of the order of the universe, Aristotle has reached his goal. The discussion of a counterfactual and, for Aristotle at least, also manifestly false and even impossible theoretical scenario served him to isolate a modal feature that all theories of internal physical movers share, and to thus bring out their principled explanatory limitation. Now, Aristotle returns to the question raised at the beginning of the section:

But must there be something unmoved and at rest outside what is moved, and which is no part of it, or not? And must this necessarily hold true of the universe as well? For it looks as if it would be paradoxical if the origin of motion were inside. That is why, to those who see it this way, Homer’s words would appear to be well spoken:

But you could not draw from the heavens to the ground
Zeus, loftiest of all, no, not even if you should struggle exceedingly, till you were weary.
Lay hold of the rope, all you gods and goddesses.

For what is wholly unmoved cannot possibly be moved by anything. Herein lies the solution of the problem we mentioned above, namely whether it is possible or impossible to dissolve of the composition of the heaven, if it depends on an unmoved origin.

(699b32–700a621)

By bringing out the limitations of the Atlas-theory, and with it of all other theories that postulate internal movers of the universe, Aristotle points to what he believes is an important virtue of his own theory (indicated by his triumphant quotation of Homer): only a non-physical (“wholly unmoved”) mover outside of the universe, as claimed in Aristotle’s Metaphysics, is able to account for the absolute indestructability of the order of the universe.
5 Conclusion: how would Aristotle have thought about thought experiments?

Aristotle employs thought experiments, on the minimal conception I have here adopted, in order to generate data in epistemically difficult terrain. As far as we can gather from the few examples I here presented, the contexts of usage vary: some serve to positively establish a point, while others (most of them) are used for critical purposes, i.e. they serve to demolish a given thesis. We may say, therefore, that Aristotle uses thought experiments for argumentative persuasion and in places where, due to the obscure nature of the subject matter or the counterintuitive nature of the thesis they are meant to support, insight cannot be readily communicated by appeal to observational facts. And, as we have seen in the case of the Atlas theory, his target may even be a whole class of theories instead of a particular claim. This, however, is not to say that thought experiments are indispensable for Aristotle. I cannot think of an example whose point he could not have communicated in other, even if perhaps significantly less striking, ways. So much for the different contexts of usage of thought experiments in Aristotle.

How would he himself have categorized thought experiments? This is a difficult question. My best guess is that he would have wanted to distinguish between thought experiments as a method of generating data from imagined scenarios on the one hand and forms of reasoning on the other. The identity of forms of reasoning should be independent from whether their contents involve imagined scenarios or not. Also, the forms of reasoning acknowledged by Aristotle that bear most similarities to thought experiments, namely hypothetical syllogisms, redactio ad absurdum, and (Aristotelian) examples, do not seem to give us what we want: none of them are defined in terms of the quality of the scenarios or assumptions they involve. The features of hypothetical arguments (Aristotelian hypothetical syllogisms) certainly relate importantly, if not crucially, to the argumentative contexts in which he uses thought experiments (I cannot go into this here), but to identify them with hypothetical syllogisms would implausibly broaden the conception of thought experimentation so as to cover perfectly abstract cases as well, such as an argument starting with “assume that not-p.” And as Aristotle’s thought experiments occur both in redactio ad absurdum and in constructive arguments, we can safely rule out redactio as well. Finally, examples, at least in the Aristotle’s distinctive understanding of them as a form of inference (not to be confused with examples as the items that are used in such inferences), do not fit the bill either.

An Aristotelian example (paradeigma) is the inference from a particular as falling under some given universal to another and lesser known particular as falling under that same universal (Anal. Pr. II. 24). That, however, seems to be at odds with the spirit of thought experiments as we understand – and as we found Aristotle to use – them here, since it seems vital for this kind of inference that the particular example it uses be a familiar case of falling under the relevant universal.

It seems more promising to me to look at thought experiments from the perspective of their conditions of usage. We may want to consider thought experiments to be something much weaker than forms of reasoning, namely “strategies of reasoning” (although nothing hangs on that name): as I understand it, a strategy of reasoning is a domain-specific argumentative strategy a reasoner might employ in areas where the standard argumentative repertoire does not lead to satisfying results. An example is Aristotle’s maxim “nature
does nothing in vain,” which serves as a specific heuristic device for the identification of explanatory features in some of the more difficult terrains of his natural philosophy. Another example is Aristotle’s adoption, in his astrophysical work On the Heavens, of the thesis that the heavenly bodies are animated and somehow partake in intentional action. The adoption of this thesis seems to amount to some kind of inference to the best explanation. Aristotle’s motivation in doing so seems clearly strategic: roughly, he argues that given the sparsity of empirical data in astrophysics, due to the remoteness of the heavenly bodies from sense perception, we can best answer otherwise insoluble astrophysical questions by postulating that stars are intentional agents. In terms of methodological self-awareness, this is a remarkable statement. Aristotle here consciously compensates for the lack of empirical data in astrophysics with a (bold) hypothesis that will allow him to account for what for him otherwise would be completely intractable problems. It is tempting to generalize here and infer from such statements a general methodological maxim to the effect that our usage of more inventive ways of reasoning ought to positively co-vary with the empirical inaccessibility of relevant empirical data. This, it seems to me, would be a plausible candidate for a general attitude that Aristotle might have taken towards the employment of more inventive argumentative strategies, including the consideration of hypothetical scenarios in thought experiments. After all, thought experiments, the typical ones at least, serve to make us experience something in thought that we otherwise could not experience.

Notes

1 Which is why the term “scenario” seems more apt than “event”: what thought experiments show may go beyond events.
2 Kant’s classical formulation of the nature of empirical experimentation describes a procedure that seems not only entirely absent in Aristotle but also alien to the spirit of his natural philosophy: “[Reason] compels nature to answer its questions rather than letting nature guide its movements by keeping reason, as it were, in leading strings” (Kant 1998, B xiii).
3 Cf. Anal. Pr. I 30. His treatise on zoological facts Historia Animalium is meant to provide such a collection, see HA 1. 6, 491a7 ff.
4 This conception of empeiria should be distinguished from his epistemological conception of empeiria as a psychological state (Metaphysics 1. 1., Anal. Post. 2.19).
5 This is something the famous Greek physician Galen of Pergamon (Second-century CE) will later take him to task for. He says that Aristotle, while engaging in anatomical speculation, lacked the patience to concern himself with the actual work of anatomical inquiry. (De placitis I 10, 7–8, 96–99, De Lacy). See also Lloyd (1996), who argues that Aristotle had only very limited interest in experimentation.
6 The question why this is so may have to do with the low social status of manual labor in Ancient Greek societies, see, e.g., (Störig 1965, 56f).
7 See, for instance, Hobbes (1994, ch. 1).
8 Ernst Mach goes so far as to claim that “the physical investigations of Aristotle for the most part are thought experiments” (1905, 187).
9 In his Metaphysics where he says that the inquiry into what is farthest removed from sense perception is the most difficult (Meta. 1.2, 982a23–25).
10 In the text, the imagined scenario above occurs in the immediate sequel of the following statement: “Excess in a bodily state is cured by a situation or season of opposite character, but the constitution is best maintained by an environment akin to it. There is a difference between the material of which any animal is constituted and the states and dispositions of that material” (De Juv. 477b16–18).
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11 A much fuller – though still far from complete – collection of thought experiments in Aristotle can be found in Mulligan (2008).
12 In Aristotle's own cosmology, this is an impossible scenario.
13 Aristotle continues with a series of similar scenarios: suppose that all existent things were tunes, the quarter tone would be "the one," in spoken sounds "the one" would be the vowel, in plane geometrical figures the triangle, concluding that the same holds for the other genera of being (categories) as well (up to 1054a19).
14 Translations from De Motu Animalium are from Nussbaum (1985), modified according to Primavesi (2017).
15 There are, to be sure, more questions.
16 In 699a26–27 I read διωρθήσεις instead of Nussbaum's διωρθήσεων, both of which have good support in the manuscript tradition.
17 Note that the Pole-theory can in some ways be seen as a precursor of Aristotle's own theory of unmoved movers. Aristotle certainly seems indebted to the basic idea of the theory that there are unmoved movers of the universe, i.e. entities in which, due to their immaterial nature, the two functions of providing a supporting platform and imparting motion coincide, even if he disagrees with the Pole-theory's contention that these unmoved movers are mathematical entities. Aristotle thinks of mathematical entities as largely fictional, while he conceives of his own unmoved movers as real substances. The author of the Pole-theory has been believed to be Speusippus, who allegedly (and unlike Aristotle) conceived of points as substances. For a recent brief summary of the discussion, see Menn (2012, 441, 457 n. 28), who also mentions Eudoxus as another possible candidate. Aristotle's other argument against the pole theory, at first blush at least, seems less convincing. It seems intended as a refutation of the specific thesis that the poles of the axis of the universe are the causes (movers) of its rotation. He argues that the poles of the axis are two in number, yet since rotational motion is a simple motion, the cause of that motion ought to be simple as well. Aristotle here operates on assumptions about the structural similarity of cause and effect that I cannot go into here. In any case, it seems the main weight of his rejoinder to the Pole-theory lies on the first argument, which can easily be applied to other abstract entities as well, as e.g. the axis of the universe (cf. Plato Timaeus, 40b8f.).
18 One may object here that Aristotle's own cosmology locates the resting earth at the center of the rotating universe. That, however, does not conflict with the External Supporting Point Principle, as Aristotle doesn't make the earth the mover/platform of the universe's motion. I thank Yue Lu for bringing this point to my attention.
19 See the above "by anything of this kind within them" in 111 (hypotinos toieton to on entos).
20 Reading with ms. (Parisinus Graecus 1853) E διωρθήσεις τοιατα απ' ἀλλῆλων in 699a26 (instead of ὑπ' ἀλλῆλων).
21 Aristotle's formulation in 700b6 that the order to the heavens "depends (erētēta) on an unmoved origin" is a direct verbal echo of his statement about the first unmoved mover in his Metaphysics ("on such origin the heaven and nature depend (erētēta)"), 12.7, 1072b14).
22 One may find this characterization to lack breadth, as it seems to neglect the heuristic function of thought experiments when we use them to actually find out what happens if something is the case. That, it seems to me, would be a fair objection. The only grounds I have for not including thought experiments as a tool in the service of actual and open-ended intellectual experimentation in Aristotle is the fact that his writings do not seem to wrestle with their subject matter so as to genuinely lead him to the discovery of new facts. That, however, should not be understood as implying that Aristotle did not actually use thought experiments in that way. He might very well have done that. We just lack evidence for this.
23 For hypothetical syllogisms in Aristotle see Crivell (2011).
24 For a discussion of the distinction between indirect argumentation and thought experiments, see Kukkonen (2002).
26 There is also a perhaps lesser-known method Aristotle uses in establishing his syllogistic theory that might be judged to be a possible candidate. This is what he calls the "setting-out" (ecthesis) of a term. Basically, the method consists in testing a general rule by going through an imagined
particular case so as to either confirm or disconfirm it (Anal. Pr. 28:23–26). Apart from presupposing a general rule (which does not seem to be the case in thought experiments), ecthesis seems too abstract.

27 There is discussion as to whether the principle is part of the actual explanation of phenomena or merely a heuristic device for the identification of explanations (cf. Lennox 1997).

28 See next footnote.

29 Cael. 287e28ff., 291e24ff., especially 292a14: “On these questions it is well that we should seek to increase our understanding, though we have but little to go upon, and are placed at so great a distance from the facts in question. Nevertheless if we base our consideration on things such as the following, we shall not find this difficulty by any means insoluble. We think of the stars as mere bodies, and as units with an order indeed but entirely inanimate; but we should rather conceive them as enjoying life and action. On this view the facts cease to appear surprising” (transl. Stocks 1922, slightly modified). Cf. PA 1.5, 644b22ff, see Burnyeat (2004, 15f.), and Leunissen (2010, 152–174).

References


