
Organon F 23 (4) 2016: 503-524

A Minimalist Framework for Thought Experiment Analysis

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RECEIVED: 12-08-2016 • ACCEPTED: 29-09-2016

ABSTRACT: Thought experiments are frequently vague and obscure hypothetical scenarios that are difficult to assess. The paper proposes a simple model of thought experiments. In the first part, I introduce two contemporary frameworks for thought experiment analysis: an experimentalist approach that relies on similarities between real and thought experiment, and a reasonist approach focusing on the answers provided by thought experimenting. Further, I articulate a minimalist approach in which thought experiment is considered strictly as doxastic mechanism based on imagination. I introduce the basic analytical tool that allows us to differentiate an experimental core from an attached argumentation. The last section is reserved for discussion. I address several possible questions concerning adequacy of minimalistic definition and analysis.

KEYWORDS: Experimentalism – Galileo – minimalism – reconstruction – Rescher – thought experiments.

Despite extensive discussions on the nature of thought experiments, there have been only a few attempts to explicitly grasp the way thought experiments are constructed. In the first part of my text, I present two of those attempts: Ray Sorensen's structure of *refuter* and Nicholas Rescher's quintet of *complex hypothetical reasoning*. While Sorensen emphasizes the similarities between real and thought experiments, Rescher underlines the relevant lesson we draw from a supposition. In the second part, I argue that both approaches rely on

dubious definitions of thought experiment. To avoid their unintuitive consequences, I form a *minimalist* view where thought experiments are identified strictly with contemplation of a hypothetical scenario.

There are three questions I ask in each of the mentioned frameworks:

- (i) What is a thought experiment?
- (ii) What is the structure of a thought experiment?
- (iii) Which discursive role does a thought experiment play?

The first question is conceptual and deals with a definition of thought experiment. The second question is logical and concerns the relation of basic elements within a thought experiment. The third question is dialectical and focuses on a connection of thought experiments and a standpoint in a critical dialogue.

The paper does not address epistemological issues of thought experimentation, at least not directly. Both Sorensen and Rescher offer clues for thought experiments' reconstruction, both elaborate their definitions into robust analytical frameworks—and there are no other major contributions to the explicit and universal *structural* analysis of thought experiments. That is the sole reason why the paper focuses on their accounts; I will however discuss the relation between minimalism and other prominent approaches to thought experiments in the final section.

1. Experimentalist approach

(i) Ray Sorensen defines thought experiment as “an experiment that purports to answer or raise question rationally without the benefit of execution” (Sorensen 1992, 205). In his view, there is a broad category of general experiment. This category covers experiments that are performed by causal manipulation in the environment, and also experiments that are just contemplated. What is a general experiment? Sorensen accepts the classical explication by which an experiment is a process of the variation of the independent variable and the measurement of the dependent variable. A thought experiment is the instance of a general experiment that is conducted by speculation, the change and measurement of variables is *as-if* executed.

(ii) Further, Sorensen explicitly mentions the logical structure of thought experiments (1992, 132). He puts forward two reasoning schemes, necessity

refuters and possibility refuters, which I present here in a simplified and unified version:¹

1. source [S]
2. extraction [if S, then I]
3. content [C]
4. conditional [if I and C, then W]
5. dismissal [non-W]

According to Sorensen, all thought experiments have a structure of paradox. One cannot hold as true all the propositions in the quintet, yet all of them seem plausible. From the argumentative point of view, they are instances of *reductio*: reasoning about an imaginary case *C* leads to an absurd result *W* that makes the provisional hypothesis *S* untenable.

Let me present the experimentalist analysis by using two examples. For the sake of clarity, the first one considers the trivial case of flying pigs, the second one is more subtle and deals with the famous Gettier example.

Case I: Flying Pigs

Suppose that pigs can fly. Wouldn't we know that since we have radars?

1. source: Radars can register flying objects.
2. extraction: Radars would register flying objects of pig size.
3. content: Pigs can fly.
4. conditional: Radars would spot a flying pig.
5. dismissal: No radar has spotted a flying pig yet.

The source statement about radars leads to a consequence that we would detect flying pigs. This consequence is dismissed as absurd—not in terms of logical or nomological impossibility, but in terms of sheer improbability. The following analysis is a very slight modification of Sorensen's own regimentation of Gettier's thought experiment (1992, 137).

¹ Sorensen proposes two variants of the same general scheme based on modalized modus tollens. They differ in few details which I find too minor to reproduce here. For the sake of simplicity I have thus omitted modal operators and distinction between "content possibility" and "content copossibility" in his reconstructions; for the whole picture see Sorensen (1992, 136 and 153).

Case II: Gettier example

Suppose that Mr. Smith has justified belief that is true by some unforeseen coincidence. Does Mr. Smith have knowledge?

1. source: The definition of knowledge is justified true belief.
2. extraction: If knowledge is justified true belief, then if any person has justified true belief that *p*, then the person knows that *p*.
3. content: It is possible for Smith to be justifiably right for the wrong reason.
4. conditional: If all justified true believers that *p* have knowledge that *p* and Smith is justifiably right but for the wrong reason, then Smith knows that *p* because of luck.
5. dismissal: It is impossible for anyone's knowledge to be due to luck.

(iii) What is the dialectical role of thought experiments? Sorensen presents a thought experiment as a tool for attacking a standpoint. Imaginary cases are put forward as counterexamples, they focus on the refutation of a modal statement held or implied by an opponent. In scientific discourse, a thought experiment may serve as a test of hypothesis. The experimenter attempts to falsify the hypothesis by appeal to its counterintuitive consequences.

Karl Popper famously yet vaguely mentions three possible types of thought experiments: critical, heuristic and apologetic (cf. Popper 1992, 464). Thought experiments of the first type are meant to refute a theory, heuristic experiments illustrate and apologetic experiments support a theory. As we see, Sorensen's approach does not count with an apologetic or heuristic use of a thought experiment. In an experimentalist framework, all experiments are aimed at refuting a source statement and therefore are straightforwardly critical.

2. Reasonist approach

(i) According to Nicholas Rescher, thought experiments are complex courses of hypothetical reasoning. A thought experiment is a "lesson learned by deriving a conclusion from supposition and background knowledge" (Rescher 2005, 8). Rescher describes thought experimentation as a train of thought during which we imagine a scenario, consider the circumstances, infer provisional outcomes and pick the most plausible one. However, that is not enough; there has to be a serious question we are trying to answer. Rescher

explicitly mentions answering a *larger* question and drawing a *larger* lesson. Not every conclusion reaching process based on hypothetical reasoning is thus a thought experiment—only some of them qualify as such and the rest is a *mere speculation* (cf. Rescher 2005, 6). Rescher mentions the following question as an example of mere speculation: What if one could converse with flowers? Such a question is not able to constitute a thought experiment; there is no larger problem to solve. I will discuss the distinction in more detail later.

(ii) Thought experiment is a subtype of hypothetical reasoning. By Rescher's definition, there must be five elements present in genuine thought experimentation:

1. supposition
2. context-specification
3. conclusion-deriving
4. lesson drawing
5. synoptic reasoning

The first three steps are quite straightforward: we introduce a supposition into a context to get a conclusion. According to Rescher, a supposition is a provisional accepted proposition, i.e. the proposition we are in fact agnostic about or even the proposition we disbelieve in. Context-specification provides additional information about the scenario. Clues about who, what, where and when may be crucial for reaching the conclusions of the thought experiments. In the third step, we infer the conclusion from the given supposition and background beliefs fixed by context. However, Rescher points out that the result of a thought experiment is not the conclusion itself, but the lesson we learn from the conclusion. To illustrate his view about lesson drawing, he uses a slightly obscure example:

Case III: Yet Again Flying Pigs

Suppose that pigs can fly. Wouldn't it be an interesting thought experiment?

1. supposition: Pigs can fly.
2. context: Animals exercise their abilities on suitable circumstances.
3. conclusion: Pigs will sometimes fly.
4. lesson: Not every thought experiment is all that interesting.
5. reasoning: Yet Again Flying Pigs is an example of uninteresting thought experiment.

There is a strange self-reference in Rescher's reasoning when the first three steps are mentioned in step four. Fortunately, Rescher later offers a more straightforward example when he considers the thought experiment about the relation between morality and our ability to predict (see Rescher 2005, 13). I propose the following regimentation:

Case IV: Unanticipated Results

Suppose people have no capacity for foresight. Would they be responsible for their actions?

1. supposition: People have no capacity for foresight.
2. context: Capacity for foresight is necessary for predicting consequences of actions.
3. conclusion: People cannot predict consequences of their actions.
4. lesson: Predictive foresight is a crucial precondition of morality.
5. reasoning: Moral responsibility is crucially dependent upon foresight.

I understand the quintet as a simple structure where a conclusion derived from a supposition and context serves as an input for reasoning leading to a lesson. A context and reasoning are warrants; they capture the way a supposition is connected to a conclusion, and a conclusion to a lesson, respectively.

(iii) Considering the relation of thought experiments to standpoints, Rescher's approach is in accordance with Popper's. Thought experiments can be used as a constructive support for a standpoint; they can be used destructively as well. However, Rescher and Popper differ in their evaluation of the constructive use. Popper is highly suspicious about apologetic/constructive thought experiments and does not admit them as a legitimate part of scientific method (see Popper 1992, 466 and 473). On the other hand, Rescher is more benevolent towards thought experiments; both destructive and constructive ones are valuable tools of inquiry. Though, he points out that constructive thought experiment does not support a standpoint as a proof but only as a plausible reasoning (see Rescher 2005, 34).²

² Rescher also mentions the explanatory use of thought experiments, but unfortunately not with much detail. As it seems, formulating an explanation of phenomenon B in the form 'if A happens, then B happens' is for Rescher a type of thought experimentation. See Rescher (2005, 16 and 51).

3. Minimalist approach

Both Sorensen and Rescher consider thought experimentation as a process in which we yield a result from the initial supposition. For Sorensen, the result is the *refutation* of the source statement; for Rescher, the result of a thought experiment is the *final lesson* we draw. The minimalist position is different: both of the mentioned results do not belong to the thought experiment itself. The refutation of the source statement and the lesson learned is extra.

(i) Thought experimentation is a particular way we accept a belief. Minimalism sees thought experimentation as a doxastic mechanism built upon imagination. Thought experiment is thus defined as “a set of instructions which specify what to imagine provided a particular cognitive goal is pursued” (Picha 2011b, 22).

There are two necessary conditions for a thought experiment. First, one is asked to *imagine a situation*, a scene, a state of a possible world. Thought experimentation is a method; it is a way of how to try solving a given task, and it requires a specific mental capacity. Let us call the person who brings up a thought experiment a *promoter* and the person who should execute the experiment an *experimenter*. The promoter instructs the experimenter to find the answer by envisaging the scenario followed by the educated guess of the result. It would not be a thought experiment if one finds the answer either by calculating the result, by the real world execution or by a public survey.

Secondly, imagination is involved in order to *find a solution* to the given task. An experimenter is imagining the scenario to guess what would probably happen under the described circumstances. Imagination driven by other motives does not count as thought experimenting—for instance, when someone fantasies about resting in a silent comfortable place to calm down tense emotions or when a child amuses herself by picturing the world where pigs can fly.

(ii) According to minimalism, thought experiments are neither paradoxes nor lessons; thought experiments are just segments of those structures. Thought experiments correspond solely to a *content possibility* in Sorensen’s structure or to the first three steps of Rescher’s structure where a *supposition* and a *context* lead to a *conclusion*. A thought experiment is thus just the part of complex hypothetical reasoning where one contemplates an imaginary situation and resolves the related task. The minimalist structure of a thought experiment resembles the structure of an experiment in general. There are two pairs of interconnected propositions:

1. input *i*
2. output *o*
3. modification *m*
4. result *r*

The *input* is the starting point of thought experiment. A promoter suggests a proposition as an accepted one. The input is meant to be taken for granted and there should be no discussion involved. It usually describes a familiar situation or puts up an obvious point. As an example, here is the input of Flying Pigs:

1. input: Some fairly big animals can fly.

The *output* is a proposition stating what would happen under the circumstances given as the input. More precisely, an output specifies how input should be treated. Besides natural thought experiments concerning what would happen, there are also conceptual thought experiments where we are interested in what one would say. In other cases, we may be looking for answers to the behavioral question what one would do under specified circumstances, or what one morally or instrumentally should do, and so on. I reconstruct the output of Flying Pigs as follows:

2. output: Radars would detect these big flying animals.

Both the input and output instantiate a *baseline* which is normal, usual, obvious, or at least a provisionally accepted description of a segment of our world. The baseline may express various features, causal relation between input and output, traditional evaluation of situation captured by the input, accepted definition, common policy, working hypothesis and so on. It is impossible to give an exhaustive overview of all possible relations between input and output. Generally speaking, there are two kinds of bridging principles forming two kinds of baselines: factive baseline grasping the way the world or its parts behave, and evaluative baseline describing our attitude to the facts.³ The baseline of a thought experiment states what the experimenters should take for

³ Tamar Szabó Gendler proposes a third kind: the conceptual thought experiments. I treat conceptual thought experiments as instances of factual thought experiments. See Gendler (2000, 25) and Picha (2011b, 25).

granted and what they should focus on in forthcoming supposition. The baseline is often implicit; therefore, its reconstructions may vary. However, the proper reconstruction is the one that grasps the bridging principle intended by the promoter of the experiment.

The *modification* of input is the only element that must be explicitly formulated in every thought experiment. A modification is the iconic step in thought experimentation—the *what-if* moment, the supposition. The promoter gives instructions what to imagine; the experimenter at least provisionally accepts the prescribed proposition. The modification of Flying Pigs is obvious:

3. modification: Pigs can fly.

And finally, the experimenter forms a belief about what would happen in such a scenario. In other words, the *result* of a thought experiment is the proposition the experimenter accepts upon consideration of the modification under the aspect fixed in the baseline.

4. result: Radars would detect flying pigs.

As we may see, the minimalist model of thought experimentation is really simple and, well, minimalistic. The baseline tells us what to *focus on* in the following scenario. The modification tells us what scene to *imagine*. The result is obtained by *focusing on the imagined* scene. To get a better picture of the minimalist reconstructions, I propose an analysis of the three thought experiments mentioned above:

Case II: Gettier example

1. *i*: A person has justified true belief that *p*.
2. *o*: That person knows that *p*.
3. *m*: Smith has justified true belief that *p*.
4. *r*: Smith would not know that *p*.

Case III: Yet Again Flying Pigs

1. *i*: Some fairly big animals can fly.
2. *o*: Those fairly big animals would fly.
3. *m*: Pigs can fly.
4. *r*: Pigs would fly.

Case IV: Unanticipated Results

1. *i*: People have capacity for foresight.
2. *o*: People are morally responsible.
3. *m*: People have no capacity for foresight.
4. *r*: People would not be morally responsible.

Minimalism holds that thought experiments themselves bring us nothing more than these almost trivial beliefs. The real struggle begins when the experimental results are implanted into arguments.⁴

(iii) Minimalism is a “narrow” conception: thought experiments are identified strictly with the process of estimating what would happen under the stipulated circumstances. The superstructure built upon the belief accepted in this way is not part of the thought experiment—minimalism thus draws the line between thought experimentation and argumentation. The scenario induces a belief in the experimenter and the belief may then serve as an accepted premise in any type of argumentation.

Thought experiments are usually foundations for paradoxes, lessons and *reductio*, but are not identical with either of these. It means that thought experiments are not constructive or destructive by their inner structure, i.e. baseline and modification, or by their results. Experimental results are simply used in arguments – and it depends on the relation of the argument to the standpoint whether the experimental result is deployed as a support or as a rebuttal.

Sometimes we are satisfied with the answer to the particular question and a thought experiment does not need to be a part of an argumentation. Nonetheless, more often a thought experiment is promoted as a (hypothetical) case study, i.e. the thought experiment plays a part in a persuasive dialogue in a form of an *argument from thought experiment*. The scheme of this argument is very simple—it is a variant of the basic argument from an example, the only special ingredient is the way the particular example is obtained:

1. The thought experiment induces belief that *b*.
2. *b* is an example of the principle *P*.
3. Therefore principle *P* is (sometimes/typically/mostly/always) true.

⁴ For more minimalistic analyses of famous philosophical thought experiments see Picha & Pichová (2013).

While the first premise just sums up the result of a thought experiment and the second premise presents the result as an exemplary case, the conclusion deserves a little more attention. The principle P in the conclusion can have one of the four following qualifications: some x is y (exemplification); x are typically y (plausible generalization); most x are y (probabilistic generalization); all x are y (universal generalization). The qualification of the principle P is an important factor when evaluating the argument: since all three mentioned types of generalization can be subjected to the critique of hasty generalization, the argument from thought experiment based on exemplification is significantly less fragile. The following reconstruction captures the deployment of the Gettier example:

1. Smith would not know that p .
2. Smith's belief is the example of justified true belief that is not knowledge.
3. Therefore some justified true beliefs are not knowledge.

The argumentation scheme enables the thought experiment to play the role of counterexample. In this way, the argumentation scheme based on exemplification probably captures Popper's idea of the critical use of thought experiment.

To sum up, a thought experiment plays exactly the same discursive role as an observation or a real experiment. They all elicit a belief that may further serve as a basis for refuting or supporting a standpoint.

4. Discussion

I would like to face some possible questions about the mentioned analytical frameworks, especially minimalism. I will point out some important differences in the frameworks and show their not so intuitive consequences.

4.1. Is not the minimalist definition of thought experiment too broad?

According to minimalism, whenever we solve a given task by imagining the described scenario and estimating the outcome, we are conducting a thought experiment. A minimalist is thus forced to categorize even the most common imagination-based problem solving as a thought experiment. Let me

give an example: You are facing the question whether your luggage will fit into the trunk of a car. You can find the answer by measuring and comparing the volume of your luggage and the trunk; you can solve the task by real experimentation and physically manipulate the luggage inside the car trunk; or you can rotate a mental representation of the luggage to fit into the mental representation of the car trunk. Minimalism holds that the last procedure counts as a thought experimentation. Minimalist definition with its emphasis on imagination is by no means novel. Similar approach was held by Ernst Mach who supposedly defined thought experiments “as the capacity to ‘imagine mentally the variation of facts’” (Engel 2011, 146); and Tamar Szabó Gendler who treats thought experiments as “reasoning about an imaginary scenario with the aim of confirming or disconfirming some hypothesis or theory” (Gendler 1998, 398). What is new, however, is the fact that minimalism takes this definition strategy seriously and makes a clear cut between thought experiments and superimposed arguments.

Of course, the minimalist definition is liberal. However, I will argue that the mentioned alternatives are either too restrictive, or they are liberal to the same extent. The experimentalist approach seems promising at first, but turns out to be very limiting when it comes to the structure and the usage of such “successful unexecuted experiments”. Experimentalism treats every thought experiment as a disguised paradox with a hypothetical premise. Surely, every thought experiment can be with some extra work built into a *reductio*. However, the goal of many hypothetical examples is just to support a proximate claim, not to refute a distant source statement. For instance, Yet Again Flying Pigs are very unambitious in this way.

The reasonist approach is restrictive by choice. Rescher is explicit about the distinction between thought experiments and mere speculations—a speculation must be a part of some larger problem to be a thought experiment. Alas, Rescher is not clear about the “larger problem” and I see at least three possible interpretations. First, a problem is larger when it relates to something *worthy* and sublime. Thought experiments would be therefore thematically restricted. For example, speculations about conversation with flowers are not thought experiments, but speculations about conversation with newborns might be. Since there are many prototypical instances of thought experiments about unassuming problems, this interpretation seems obviously wrong.

According to the second interpretation, a problem is larger when it relates to something *general*. A speculation becomes a thought experiment when it

supports or disproves a general claim. I find this interpretation of the “larger problem” too restrictive, because the experimenter might be sometimes interested solely in a particular outcome of a hypothetical scenario; for instance, when asked how many road turns would it take to get to the nearest hospital.

The third interpretation holds that a problem is larger when there is a *question* involved in the speculation. The thought experiment would be a hypothetical scenario accompanied by a relevant question. For instance, “What if one could converse with flowers?” is not a thought experiment (cf. Rescher 2005, 6), but “What if one could converse with flowers? Would flowers have some concepts totally incomprehensible for humans?” is a thought experiment. This third interpretation of the “larger problem” is very liberal and in fact perfectly matches a minimalist approach: modification (“mere speculation” in Rescher’s terms) is accompanied by a baseline which determines what in modification should be of the experimenter’s interest (the “larger problematic issue”). Therefore, if the “lesson learned” in a reasonist definition truly means the “question answered”, then the reasonist and the minimalist definitions are equally liberal.⁵

Finally, let me point out the most important distinction between minimalist and reasonist definitions. As was mentioned before, the reasonist considers thought experiments as lessons learned by the combination of supposition and contextual information. Rescher holds that at least some *mathematical problems* are thought experiments. He gives two numerical examples: the first one is “If 4 were a prime, there could be five prime numbers between 2 and 12”, the second one is a set of three equations with two unknown variables (see Rescher 2005, 4-5). The reasonist definition forces such categorization because the mathematical examples are lessons learned by supposing a numerical value in the context of a set or an equation. On the other hand, the minimalist definition draws a strict line between thought experiments and mathematical examples. There is a difference when one is asked to imagine a situation and when one is instructed to do the math. The methodological instructions may be implicit and contextual, but it would definitely be a misunderstanding when one

⁵ I am not convinced though that Rescher is liberal to that extent. The following passage suggests that a lesson is more than just a basic answer: “The larger lesson involved in a thought experiment does not lie in the substances of the consequences that follow from its launching suppositions, but rather in the wider ramifications of the higher-level circumstances that, given the wider cognitive context at issue, those consequences ensue from the supposition” (Rescher 2005, 13).

solves the Flying Pigs in a philosophy class by calculating the surface and the reflective properties of the average pig.

Is the minimalist definition too broad? I hope not. The minimalist definition is not arbitrarily restrictive as with the experimentalist one. However, it allows us to distinguish a thought experimentation from other types of problem solving, namely from a calculation.

4.2. *What are the identity conditions for thought experiments?*

Experimentalism and reasonism are “wide” approaches to thought experiments. They identify a thought experiment not only with a speculation, but also with the way the speculation is further used. For Sorensen, the identity conditions of a general experiment include the experimenter’s intention (cf. Sorensen 1992, 133). Two identical experimental setups may constitute two different experiments depending on the hypothesis they are supposed to prove or disprove. To give Sorensen’s own example, ringing a bell before feeding the animals and observing their behavior may constitute at least two different experiments—one testing the hypothesis that animals can hear and the other testing the hypothesis that animals can be conditioned. Since thought experiments belong to a class of experiments, the same identity condition applies: the setup (i.e. the absurd result *W* obtained from combination of content *C* and extraction *I*) can constitute multiple thought experiments. For instance, in Sorensen’s reconstructions of the Gettier example the result that *Smith knows that p because of luck* rebuts the classic analysis of knowledge. However, it would be a different experiment, if the intention of the experimenter was, for instance, to support a claim about compatibility of knowledge and epistemic luck.

The reasonist approach leads to the same consequences as experimentalism. Rescher claims that a thought experiment is constituted not only by a supposition, a contextual background and a derived conclusion, but by a lesson as well. Therefore, a change of a lesson means a change of the identity of a thought experiment. Let us stay with the Gettier example: the conclusion that *Smith does not know p* may yield a lesson that *the classic analysis of knowledge is wrong* or a lesson that *we should be cautious about testimonial justification*. The two different lessons mean two different thought experiments.

Wide approaches have troubles with open-ended thought experiments, i.e. scenarios without explicit or implicit result. A prominent example is Lucretius’ spear where one is asked what would happen to a spear thrown out at the edge

of the universe. Different answers mean different conclusions, different conclusions mean different lessons, and different lessons mean different thought experiments.

Minimalism holds that the identity conditions of a thought experiment are fully captured by *the modification and the baseline*. The result of the same thought experiment may be used in different arguments, it may change in time and it may be relative to a belief system, but none of that has any influence on the identity of the thought experiment itself. Therefore, the Gettier example may be included in many different arguments about the definition of knowledge or the justification condition or the role of certainty. Lucretius' spear is still the same experiment whether we guess that the spear would hit something or whether we guess that the spear would continue its movement.

4.3. Which level of analysis is appropriate?

Every thought experiment can be reconstructed in several ways. The reconstructions usually differ with respect to the superficial details of the scenario (e.g. "Smith believes that Jones will get the job" vs. "Smith believes that p"), but there could be more profound difference as well. Let me illustrate the point by two possible minimalist reconstructions of Unanticipated Results. The first reconstruction is simple and was already presented above:

- i*: People have capacity for foresight.
- o*: People are morally responsible.
- m*: People have no capacity for foresight.
- r*: People would not be morally responsible.

That is all. The question about moral responsibility is reconstructed as an internal part of the thought experiment. The second minimalist reconstruction of Unanticipated Results is more elaborate and much closer to Rescher's own analysis:

- i*: People have capacity for foresight.
- o*: People are able to predict the consequences of their actions.
- m*: People have no capacity for foresight.
- r*: People would not be able to predict the consequences of their actions.

The result is then qualified through argument from thought experiment to the principle constituting the following argumentation:

1. *Principle*: Foresight is a necessary condition for the ability to predict consequences of action.
2. Ability to predict consequences of action is a necessary condition for moral responsibility.
3. Therefore, people would not be morally responsible.

Which of the analyses is the proper one? The first one where a thought experiment leads us to a moral claim, or the second one where the experimental result is a psychological assessment?

Minimalism holds that there is one major rule of interpretation: the adequate reconstruction of a thought experiment reflects *the intention of the promoter*. Sometimes, the description of a thought experiment is complete or we can even inquire the honest promoter himself, thus we have an excellent source of information about the promoter's intentions. Other times, we have to cope with the limited contextual clues about the intended purpose of the thought experiment.

Let us say that in the case of Unanticipated Results we have nothing more to work with than the explicit instructions: *Suppose people have no capacity for foresight. Would they be responsible for their actions?* There is no mention about the ability to predict the consequences of actions. I would therefore suggest the first minimal reconstruction with a moral assessment. However, if the instructions were as follows: *Suppose people have no capacity for foresight. Would they be responsible for their actions, since they would not be able to predict the consequences of their actions?* I would prefer the second reconstruction with the argumentative extension.

4.4. What about other approaches to thought experimentation?

Minimalism is not a theory of epistemic value of thought experiment. Its purpose is to offer a framework for concise structural analyses based on widely accepted assumption that thought experimentation is a kind of imaginative reasoning. The key element is the careful distinction between doxastic process of belief elicitation through imagination, and argumentation based upon this belief. According to minimalism, thought experiments should be identified with the doxastic process regardless the superimposed argumentation. I will point out relations between minimalism and some distinct contributions to the debate about nature of thought experiments, namely

Norton's eliminativism and Gendler's constructivism. Let me demonstrate their approaches by the famous debate on Galileo's example with falling bodies.

Case V: Pisa Experiment

Then if we had two moveables whose natural speeds were unequal, it is evident that were we to connect the slower to the faster, the latter would be partly retarded by the slower, and this would be partly speeded up by the faster. ... But if this is so, and if it is also true that a large stone is moved with eight degrees of speed, for example, and a smaller one with four [degrees], than joining both together, their composite will be moved with a speed less than eight degrees. But the two stones joined together make a larger stone than the first one which was moved with eight degrees of speed; therefore this greater stone is moved less swiftly than the lesser one. But this is contrary to your assumption. So you see how, from the supposition that the heavier body is moved more swiftly than the less heavy, I conclude that the heavier move less swiftly. (Galileo 1974, 65)

John D. Norton advocates the radical view that all thought experiments are only "disguised arguments", i.e. arguments with premises about hypothetical states of affairs of particulars (Norton 1996, 336). His reconstruction of Pisa Experiments therefore emphasizes the elements of Galileo's general argumentation (Norton 1996, 341-342):

Norton's reconstruction of Pisa Experiment

1. The speed of fall of bodies in a given medium is proportionate to their weights.
2. If a large stone fall with 8 degrees of speed, a smaller stone half its weight will fall with 4 degrees of speed.
3. If a slower falling stone is connected to a faster falling stone, the slower will retard the faster and the faster speed the slower.
4. If the two stones of 2 are connected, their composite will fall slower than 8 degrees of speed.
5. The composite of the two weights has greater weight than the larger.
6. The composite will fall faster than 8 degrees.
7. Conclusion 4 and 6 contradict.
8. Therefore, we must reject Assumption 1.
9. Therefore, all stones fall alike.

The reconstruction is motivated by Norton's view on epistemology of thought experiments. Premises about particulars (i.e. premises 2, 4 and 6) are irrelevant to the conclusion in the sense that they can be replaced by non-particular premises without a loss of demonstrative power. Epistemic value of thought experiments is thus equal to the general arguments behind the particular cases.

Tamar Szabó Gendler refuses Norton's claims about epistemic irrelevance of particular details in two steps. At first, she offers her own stark argumentative reconstruction of the experiment (Gendler 1998, 404):

Gendler's reconstruction of Pisa Experiment

1. Natural speed is mediative.
2. Weight is additive.
3. Therefore, natural speed is not directly proportional to weight.

At second, she claims that the reconstruction does not grasp everything we learn from the experiment. By contemplating the scenario we get to see the proper „way out“—the adjustment of stipulated theory needed to resolve the paradox. The stark argumentative reconstruction leaves many ways out open, whereas the thought experiment specifies which claim needs to be abandoned.

What can minimalism add to this debate concerning epistemology of thought experiments? I will reconstruct Pisa experiment and show that both Norton and Gendler might be right. In fact, I will present *three* possible minimalistic reconstructions; let me start with the most opulent one:

Minimalistic reconstruction of Pisa Experiment I

(The first thought experiment)

- i1: The faster stone is connected to the slower stone.
- o1: The slower stone will slow down the faster stone.
- m1: The faster falling stone is connected to the slower falling stone.
- r1: The slower falling stone would slow down the faster falling stone.

(The second thought experiment)

- i2: Two objects are connected.
- o2: Their composite is heavier than its part.
- m2: The falling stone is connected to the other falling stone.
- r2: The composite of two falling stones is heavier than its part.

(Argument)

1. A composite is heavier than its part. [*from r2*]
2. Speed of fall is proportional to weight. [*assumption*]
3. The speed of falling composite would be higher than the speed of its falling part. [*from r2 and 2*]
4. The speed of falling composite would be lower than the speed of its falling part. [*from r1*]
5. Therefore speed of fall is not proportional to weight.

As said before, minimalism draws a strict line between imagination-based belief acquisition and argumentation. The reconstruction above stresses the role of imagination in Galileo's case. There are two thought experiments which serve as a basis for *reductio*. The reconstruction supports Gendler's critique of eliminativism: these experiments are crucial for backing up premises 1 and 4 in the argument, thus leaving only the premise 2 open for rebuttal.

Another possible reconstruction simply omits the second thought experiment. Let me therefore just repeat the first thought experiment and show the slight change in the argument:

Minimalistic reconstruction of Pisa Experiment II

(Thought experiment)

- i1: The faster stone is connected to the slower stone.
- o1: The slower stone will slow down the faster stone.
- m1: The faster falling stone is connected to the slower falling stone.
- r1: The slower falling stone would slow down the faster falling stone.

(Argument')

1. A composite is heavier than its part. [*assumption*]
2. Speed of fall is proportional to weight. [*assumption*]
3. The speed of falling composite would be higher than the speed of its falling part. [*from 1 and 2*]
4. The speed of falling composite would be lower than the speed of its falling part. [*from r1*]
5. Therefore speed of fall is not proportional to weight.

This second reconstruction is probably the most mundane one. There is only one thought experiment involved, the *reductio* is established partly upon experimental result, partly upon assumption about additive nature of weight.

The third possible reconstruction is radical:

Minimalistic reconstruction of Pisa Experiment III

(Argument’)

1. A composite is heavier than its part. *[assumption]*
2. Speed of fall is proportional to weight. *[assumption]*
3. The speed of falling composite would be higher than the speed of its falling part. *[from 1 and 2]*
4. The slower falling object would slow down the connected faster falling object. *[assumption]*
5. Therefore speed of fall is not proportional to weight.

According to this view, there is no imagination involved in Pisa Experiment. We are dealing with general argument based upon two assumptions presented as obvious (premises 1 and 4) and one theoretical postulate (premise 2). There would be no thought experimentation in Galileo’s example under this reconstruction. This perspective supports Norton’s approach: details about falling objects (i.e. their weight and the fact that they are stones) are irrelevant to the conclusion. Particulars play no epistemically relevant part in Pisa Experiment.⁶

Minimalist reconstructions of Pisa Experiment show us how the debate between Norton and Gendler boils down to the interpretation of two sentences:

Then if we had two moveables whose natural speeds were unequal, it is evident that were we to connect the slower to the faster, the latter would be partly retarded by the slower, and this would be partly speeded up by the faster.

But the two stones joined together make a larger stone than the first one which was moved with eight degrees of speed.

Does the protagonist instruct us to imagine something or is he just explicitly pointing out shared background knowledge? Minimalist framework itself does not tell us which interpretation is appropriate; it does, however, show how

⁶ Gendler (1998, 408) claims that „no austere argumentative reconstruction will be able to do this, because part of the thought experiment’s function is to bring the Aristotelian to accept certain premises“. I have shown that such reconstruction is in fact possible. For more discussion see Norton (2004) or Picha (2011a).

interpretation of the two sentences translates into Norton's view and Gendler's critique. Personally, I am inclined to interpret these two sentences as postulates. They are evident and so simple that further appeal to imagination would be redundant. I favor the third reconstruction of Pisa Experiment; there is no thought experiment involved, Galileo presents a general argument with minor illustrations and Norton's eliminativist approach to Pisa Experiment is sound. However, I strongly disagree with Norton's transfer of the successful elimination of Pisa Experiment to other thought experiments. In many cases we are explicitly instructed to *imagine* a scenario and then transform the result into a premise. Thoughts experiments frequently provide support for less obvious premises and arguments would be significantly weaker without them. On a larger scale, I therefore adopt Gendler's claim on the indispensability of thought experiments.

Let me again point out the fact that minimalism provides an analytical framework and as such is neutral to the debate about justificatory power of thought experimentation. Minimalism has therefore no necessary connections to Mach's conception of instinctive knowledge, Kuhn's conceptualism, Brown's platonism, Williamson's deflationary account and so on.

5. Summary

Thought experiments are hard to deal with. They involve bold suppositions formulated in vague language with distracting details and implicit elements prone to misinterpretation. I have presented three attempts to overcome such difficulties by informal reconstruction of a thought experiment. *Sorensen's experimentalism* emphasizes the compliance between real and thought experiments. Hypothetical scenarios are means of refutation with the structure of paradox. *Rescher's reasonism* focuses on inferring a broad conclusion from a supposition. I argue that both attempts are based on a wide analysis of the notion of thought experiment. Both experimentalism and reasonism therefore motivate reconstructions that include not only the thought experimental core, but the argumentative superstructure as well.

I propose a minimal model for reconstruction, which draws a strict line between the thought experiment itself and the way the experimental result is used. There are two key components: *modification* and *baseline*. A modification instructs an experimenter what to imagine; a baseline tells him what to do

and what to pay attention to. According to minimalism, the modification and the baseline fully capture all the dialectically relevant features of a thought experiment. I further argue that a dismissal of thought experiments is more likely a disagreement with the argument built upon a trivial experimental result. Thought experimentation is more frequent and less suspicious than expected.

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