Michael Stuart, Yiftach Fehige and James Robert Brown (eds.), The Routledge Companion to Thought Experiments

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Book Reviews

Michael Stuart, Yiftach Fehige and James Robert Brown (eds.), *The Routledge Companion to Thought Experiments*, London: Routledge, 2018, xiii+567 pp.

The Routledge Companion to Thought Experiments is a comprehensive and unprecedented collection of works meticulously compiled by Stuart, Fehige and Brown, the pioneers on the topic of thought experiments. The magnitude of the volume is nothing short of impressive as it draws together contributors dispersed across numerous spheres of philosophical inquiry. It is divided into four major parts, taking four different perspectives in approaching the discussion.

The first part is a selection of papers covering the topic of thought experiments from a historical perspective. It opens with a piece entitled "The triple life of thought experiments" by Katarina Ierodiakonou. In the beginning, she presents a couple of thought experiments from the antiquity including the one found in Aristotle's *Physics* of a man standing on the edge of the universe trying to extend his hand, the famous Ring of Gyges from Plato's *Republic* and the Sextus Empiricus' in *Against the Physicists* dealing with the possibility of motion with regards to the existence of atoms, all of them serving the function of either confirming or refuting a particular theory. The purpose of her article is twofold; she explores the notion of thought experiments in ancient philosophy as a concept compared to its use in contemporary philosophy while also introducing a novel, somewhat uncommon role of thought experiments which was characteristic of the ancient Sceptics. In discussing the former she emphasizes that the term itself is a novel concoction and as such it has not been used by the ancient Greeks. Furthermore, she argues that they did not think of thought experiments as a special category of philosophical endeavor as they are thought of in contemporary philosophy but rather they were considered to be examples, corresponding to the Greek word *paradeigmata*. Nonetheless, she does not consider that to be an obstacle in applying the term thought experiments to their 'examples' as they share some of the core properties with what we call thought experiments.

After she has laid the ground for discussing the ancient 'examples' as thought experiments she delves into the function and usage of TE's by the ancients offering an additional role to the confirmation or refutation of a theory, namely the suspension of belief, which can be found in the works of ancient Sceptics. Looking past refutation and confirmation as their func-

tion in discussions, she takes a step back specifying a general characteristic of ancient thought experiments: "the imaginary assumption initiates a process of thinking without a previously settled or determined conclusion, namely a series of arguments that should be clearly spelt out, compelling us to make up our mind on a particular subject" (35) which she considers to be the controversial nature of thought experiments. In support of that claim, she outlines the discussion between the Stoics and the Sceptics on several thought experiments, two of which are Plutarch's The Ship of Theseus and Chrysippus's Dion and Theon. Both the Stoics and the Sceptics agreed on the aforementioned controversial nature of thought experiments although they reached opposing conclusions; the Stoics used them to confirm or refute a thesis while Sceptics aimed at inducing a suspension of belief by allowing the possibility of reaching different conclusions.

Thus, what we can take home from her article is not just a piece of the historical puzzle of the ancient thought experiments but a lesson from the Sceptics as to the suspension of judgment which, in the contemporary setting is not advisable to be used with relentlessness and vigor of the Sceptics, but could at least make us more wary and less eager to settle for a conclusion which is controversial and ambiguous. Our skepticism should be rationed in healthy doses but employed nonetheless for it keeps us on our philosophical toes.

The second part of the collection is dedicated to the thought experiments with regards to specific branches of philosophy. Georg Brun's "Thought experiments in ethics" is a compact and systematic analysis of thought experiments in the domain of ethics. After briefly outlining several thought experiments of the contemporary discussion including the 'Trolley', 'Pond', 'Violinist', 'Ticking Bomb', and the 'Original Position' he engages in a reconstruction of the thought experiments by explicating three key elements: "(1) A scenario and a question are introduced. (2) The experimenter goes through (imagines, thinks about, etc.) the scenario and arrives at some result. (3) A conclusion is drawn with respect to some target (e.g., an ethically relevant claim or distinction)" (196). Consequently, he makes a distinction between 'core' thought experiments which rely on the first two conditions and the extended ones which involve all of the three aforementioned properties thereupon dedicating the rest of the article to the analysis of the extended thought experiments. Firstly, his efforts are directed towards 'epistemic' thought experiments where he differentiates between constructive and destructive ones which are certainly the most prevalent functions of thought experiments together with it being one of the more commonplace classifications, inspired by James R. Brown. Constructive ones can either argue for the possibility of certain scenarios or provide support for a particular claim or a theory, while destructive are used as counterexamples to some claims emphasizing the problems with certain ideas. Subsequently, he turns to illustrative and rhetorical thought experiments. Illustrative, as the name says, are intended to illustrate or make the problem more vivid and relatable thus increasing the understanding of the experimenter. Rhetorical ones are similar to illustrative, however, they are employed when proving a particular point or arguing for a certain position. Pond experiment can be used as both of those. Another type are heuristic thought experiments

whose function resembles an 'exploratory mission' where the core experiment is run in experimenter's mind in order to analyze the consequences and where it takes the experimenter. Sometimes they are used in determining which factors are relevant for evoking certain intuitions. As an example, Foot's Trolley case has several variations which entice different intuitions about the problem. Their function is to extract the information relevant for making moral judgments.

He emphasizes that although epistemic thought experiments are the locus of the discussion on thought experiments, according to some accounts illustrative and heuristic ones do not fall behind in relevance. Specifically, it has been argued that understanding could be an important epistemic goal of thought experiments, no less potent than generating novel knowledge, to which illustrative and heuristic experiments majorly contribute. In discussing the functions of thought experiments, he narrows the scope to the ones grounded on reflective equilibrium since the functions vary with respect to meta-ethical theoretical framework. He discusses 'wide' reflective equilibrium which contains two components; one being that "judgments and principles are justified if judgments, principles and background theories are in equilibrium" (202) and the other that "this state is reached through a process that starts from judgments and background theories, proposes systematic principles and then mutually adjusts judgments and principles" (202). Under the assumption of cognitive equilibrium, thought experiments can be constructive in which an experimenter can produce a commitment to an option at any stage in the process, either in core experiments or in the extended ones, while deconstructive thought experiments use as a premise the result of a core experiment to point out the flaws in a theory or in the background assumptions which are challenged in the extended version.

There are several issues with the thought experiments in ethics, which are outlined in this paper. On the one hand, concerning those aiming at the result of core thought experiments, it has been argued that they reveal explicit commitments which appear in experimenter's mind which is not necessarily how they would act were they faced in real situations. Furthermore, there is an issue with regards to intuitions since core thought experiments elicit 'raw' intuitions which can be revised in the extended ones during the process of cognitive equilibrium. The person could conclude the opposite of the content of his intuition in cognitive equilibrium, and some would argue that defeats the purpose of finding out what really is morally relevant. On the other hand, concerning the problems of extended thought experiments, destructive thought experiments do not always succeed in refuting the theory and it can point to the need for rethinking some assumptions, however, it does not pinpoint which information, in particularly, has to be revised. Moreover, some thought experiments are analogies constructed based on a theory in support of it which is problematic since in order for transferring assumptions they need to be explicated.

Challenges to thought experiments are numerous and are directed either to a certain function of thought experiment or to a specific thought experiment. The author briefly outlines various ways in which thought experiments are put on spot, for example, the issue of intuitions generated by them, the possibility or lack thereof to be carried out in the real world,

deriving to conclusions etc. Naturally, Brun pays more attention to some well-known objections directed to ethical thought experiments, namely the ones questioning how realistic should thought experiments be and the others that argue for them being misleading or generating faulty results.

Turning to challenges which address the problem of thought experiments being unrealistic, it is argued that they do not justify moral principles which are developed to govern our actions in real life situations to which the author replies that some thought experiments deal with more fundamental principles that lead moral judgments to which thought experiments still hold relevance. Another challenge argues for the unreliability of core experiments of unrealistic scenarios by either questioning the reliability of intuitions or inability to discern what is morally relevant because of our own beliefs.

A distinct set of challenges assert that thought experiments are misleading on several accounts; one being that they pose dubious questions not encountered in our day-to-day lives or questions which limit the scope of answer. As an example he uses the "Should you pull the lever?", one which is not a plausible real life situation and which can only be answered with 'yes' or 'no' thus 'leading the witness', so to speak. Additionally, it is argued that they implicitly contain problematic assumptions while side tracking the additional information which might prove to be essential. Lastly, there is one more challenge to thought experiments, addressing the fact that some thought experiments are constructed in the form of analogies so that they lead the experimenter to draw conclusions about a situation different than what has been depicted in the experiment, examples of which are Pond and Ticking Time-bomb thought experiments. The author replies to two such objections to using analogies.

The author concludes with the warning that the discussion on thought experiments in ethics should not be taken lightly as inadequately constructed thought experiments may be used in public discourse for promoting immoral and problematic agendas. This paper is instructional both for novices in the exploration of ethics as a branch of philosophy as well as for the students tinkering with the subject of thought experimentation. It would prove to be no less useful for the experts of both fields as it compresses a masterfully elegant compendium of ethical intricacies which could prove to be a valuable reference text.

Nancy Nersessian's article "Cognitive science, mental modelling, and thought" experiments explores the underlying cognitive mechanisms which are employed in the process of thought experimenting. Her efforts are directed to accounting for the psychological frameworks which make such inquiries possible and which ultimately generate the knowledge that is novel in our everyday lives as well as in the work of science. Her hypotheses are supplemented by an overview of the body of work she offers from the fields of psychology, cognitive and neurosciences, and philosophy. After briefly introducing some basic notions and problems of thought experimentation, she outlines the 'story so far' concerning the mental model framework of which she has been the architect alongside Nenad Miščević in this vast edifice that is the discussion on thought experiments. From the introduction of the term 'mental model' by Kenneth Craik in 1943 who hypothesized them as a

modus operandi of people's reasoning about physical situations by means of employing internal models in exploring them, to the no less influential work of Johnson-Laird whose *Mental Models* (1983) exploring the notion of logical reasoning, working memory and mental models. Although their views of mental models differ in some respects it undoubtedly casts a shadow over the investigation and discussions of them in years to come which is enormous and beyond the scope of Nersessian's paper.

Consequently, her attention is directed to interpreting literature on discourse and situational models in dealing with the issue of how mental models are constructed, the prevalent view being that thought experiments are revealed through narrative. However, the importance of narrative does not lie in the "system of propositions representing the content of the text" (313) to which we apply rules of inferences but rather that the model being manipulated is that of the situation represented by narratives as "discourse models make explicit the structure not of sentences but of situations as we perceive or imagine them (Johnson-Laird 1989: 471)" (313) In support of that claim, she mentions several experiments all pointing to the aforementioned hypothesis.

According to Nersessian, another key cognitive faculty which partakes in thought experimenting is mental spatial simulation which means that humans have the ability to mentally transform and manipulate objects in space that is akin to the physical transformation. After giving a couple of examples in overviewing the literature exploring such capacities she concludes with the words of Kosslyn that: "psychological research provides evidence of rotating, translating, bending, scaling folding, zooming, and flipping of images" (314). It is hypothesized that such abilities are due to 'internalized constraints assimilated during perception'. Additionally, she cites the research which points to physical knowledge taking part in imaginary transformation noticing the subtle connection of imagination, perception and action emphasis that mental spatial simulation can be employed in manipulating both representational and non-representation content. Supplementing that notion with the literature on mental imagery and spatial simulation she concludes that perceptual and motor mechanisms do in fact largely contribute to construction and manipulation of mental images.

Together with mental simulation she explores the subject of mental animation. Even though they are closely related, mental simulation deals with spatial and temporal transformation, while mental animation includes causal and behavioral knowledge. In other words, mental animation is about mentally bringing static representation to life by inferring motion. To illustrate this, she uses prominent research done by Mary Hegarty's Pulley systems and Daniel Swartz's gear rotation studies which supply evidence for the human ability to perform "simulative causal transformations of static figures" (316). She highlights several findings, some of which are that participants animate the objects in a sequence which is dissimilar to how they would be manipulated in the physical world, they often use gestures while performing such mental actions, etc. together with the findings from the interference paradigm which imply that performing physically incongruent action to the mental animation prolongs the participant's response time. Additionally, she provides insight into neuroimaging studies which show that

the same brain areas involved in carrying out motor actions are employed in mental simulation, not to mention the fact that observing an action engages the brain in a similar fashion to actually performing the action.

In efforts to ground her theory in the long-term memory representation as the paper so far outlines compelling evidence just in the domain of working memory she includes the research done on embodied mental representation. The research on embodied mental representation aims to show that perception and action are integral to numerous cognitive processes such as "memory, conceptual processing, and language comprehension" (317). She outlines two strands of research in the domain of embodied mental simulation. One deals with the representation of spatial information in mental models the results of which indicate that spatial representation is not '3D Euclidian' in relation to one's body and gravity. In other words, representation of spatial information is 'egotistical' linked to the person's body as a frame of reference.

Another line of research she lays out tackles the representation of concepts. In support of Barsalou's view that mental representations maintain perceptual features which are reenacted during cognitive processes, which is his interpretation of current research in cognitive and neurosciences, she also outlines his distinction between modal and amodal features of concepts, introducing the idea of perceptual symbols as fundamental representations of both conceptual and sensimotor processing.

The aim of the research disclosed to this point aimed at setting the stage and being constituent of thought experiments as simulative model based reasoning. The cornerstone of such view is that people in their reasoning take advantage of mental models which they manipulate through simulation. Thus, mental models can be described as organized representations which are determined by the constraints of experience and current understanding like the knowledge of spatio-temporal relations and properties of entities, processes etc. The aforementioned constraints are as Nersessian enumerates them: "tacit and explicit knowledge of spatio-temporal relations, the represented situations, entities, processes, and other pertinent information such as causal structure" (319). In manipulating mental models we draw from linguistic, auditory, visual, kinesthetic and many other cognitive faculties. She sees thought experiments as fundamental to human reasoning and as such its application to scientific reasoning is all the more reasonable. Even though certainly more complex in nature, they are also accessed through narratives, which, as we have already seen, entice the experimenter to manipulate the mental model of the situation depicted, rather than draw inferences from proposition-like statements. Further, she distinguishes between fictitious imaginings and thought experiments with real life consequences in human day-to-day reasoning deeming the latter as far more significant. On that account, she argues that thought experiments in science exploit the same capacities she outlined so far in the paper. Her hypothesis being:

> that the carefully crafted thought-experimental narrative leads to the construction of a mental model of a kind of situation and that simulating the consequences of the situation as it unfolds in time affords epistemic access to specific aspects of a way of representing the world. (320)

Lastly, she tackles Norton's view of thought experiments as arguments which enforces the notion that thought experiments produce truths about the nature. Nersessian, seeing such a view as too "epistemically potent" (320), offers two arguments to oppose it. The first being that thought experiments refer to the kind of phenomena being explored, not to the particular situation, thus making them generic. Second, she argues that science uses many devices and practices which do not always generate truths about the phenomena but, nonetheless, tell us something about the nature of things.

In the introduction of their paper "Intuition and its critics", Steven Stich and Kevin Tobia draw a parallel between linguistics and philosophy with regards to intuition. In Chomskian terms, intuition drives the spontaneous application of grammatical properties and rules to novel sentences. The speaker does not have to be consciously aware of the rules when they make grammaticality judgments and sometimes it is possible to make errors in judgments because of various factors that might impede on speaker's attention, memory etc. Similarly, philosophers have posed questions about the world and its characteristics in the form of hypothetical situations, evoking the intuitions which present themselves instantly in minds of participants of such discussions without explicit appeal to the rules of reasoning. On that note, their paper is based on the use of term intuition "for the spontaneous judgments that people make about philosophical thought experiments" (370).

After defining their use of the term "intuition", they set out to explore the usage of intuition as evidence in philosophy which brings them to the pre-Chomskian years of logical positivists whose view on the purpose of philosophy was conceptual analysis. Alongside this view, one of the methods of conceptual analysis were thought experiments and compiling intuitions evoked by them was the means of acquiring evidential significance. Justification for their use is similar to the aforementioned Chomskian take on intuitions about grammar shared by philosophers such as Alvin Goldman who maintains that intuitions can bear relevance in exploration of the content or extension of the concept. Another view makes use of intuitions as evidence for or against theories about phenomena in philosophical discussions for example truth, justice, good etc. different from conceptual analysis in that they do not seek to pinpoint the people's concept of these things. Conjointly, these two stances correspond to two ways of dealing with philosophical problems depending on their goal as outlined by Goldman and Pust:

> Broadly speaking, views about philosophical analysis may be divided into those that take the targets of such analysis to be in-the-head psychological entities versus outside-the-head non-psychological entities. We shall call the first type of position *mentalism* and the second *extra-mentalism* (1998, 183). (370)

Accordingly, mentalist analysis deals with investigation of concepts or in-the-head psychological entities sometimes aided by implicit or tacit theories in their explanation of intuition generation. Conversely, extra-mentalism's analytic aim is harder to discern thus Goldman and Pust in efforts of narrowing down the scope of its inquiry emphasize three domains of their exploration: universals or Platonic forms, modal truths and natural kinds, taxonomy to which Stich adds moral facts. Their common denominator is that: "the correctness or incorrectness of an extra-mentalist theory does not depend on what is in the head of a person whose intuitions are used

as evidence" (371). They consider people's intuitions to be the truth about the extra-mental entities they explore. The problem with such account is the ambiguity and inexplicability of the connections between intuitions and aforementioned domains since it is not clear how we intuitively access for example Platonic forms. However, more problematic claim of extra mentalism is the previously mentioned stance that intuitions derived from thought experiments indiscriminately illicit the truth about these extra mental entities. Further, intuitions are challenged by another strong and budding philosophical branch: the experimental philosophy. Contrary to extra-mentalist position, evidence from experimental philosophy indicate that intuitions vary among people depending on a number of factors which they briefly outline in the followings sections including the variation of intuition with regards to demographic groups, language and order in which the experiments are presented. Furthermore, findings from experimental philosophy also indicate that intuitions are not immune to framing effects and that they are affected by the physical and social environment in which they are evoked. (Thus, intuition one person has in the Trolley case of pulling the lever does not mean that pulling the lever is morally permissible since another person has the intuition of not pulling the lever) Besides the fact that studies show that intuitions vary across groups and conditions in which they are elicited, an additional problem is that people of the same groups and under the same conditions still seem to report having differing intuitions.

As a side note, most of these studies also endanger the mentalist stance on concepts with the exception of evidence that suggests that people of different demographic groups have in fact distinct concepts. As an example, people's concepts vary with respect to the academic field of their interest. Though such evidence do not pose problems for mentalist position on concepts per se, it should be specified beforehand whose concepts and why they are investigating. The findings brought forth by experimental philosophy undoubtedly pose problems for mentalist and extra-mentalist analyses. In rising to their challenge, Stich and Tobia propose two ways of overcoming them.

The first appeals to professional ineptitude of the participants in the studies, also known as the expertise defense, which argues that the studies do not offer valuable insight for philosophy since the participants themselves are not professional philosophers. Analogous to other professions, we seem to deem the intuitions of doctors or chess players of more relevance than those of amateurs in those fields. There are several positions one can assume in taking the expertise defense; one asserts that philosophers are less likely to be seduced by the aforesaid factors which interfere with generating intuitions such as the order of presentation, framing or "ambient odors" while the other relies on the notion that intuitions of philosophers are more accurate than those of non-philosophers.

Stich does not hold the former approach in high-esteem as evidence, although scarce, does not seem to point to philosophers' immunity to such hindrances. The latter approach, enforced by Daniel Devitt in the domain of philosophy of language leave much to be desired. He engaged in an extensive theoretical exploration of the subject which regrettably has not barren fruit in the empirical, experimental examination so far. Granted, it is extremely difficult to empirically test whether philosopher's intuitions are

in fact more accurate than regular folk's intuitions so Devitt's efforts are nothing if not commendable. Still, one can take an alternative approach to what has been outlined so far, known as the restrictive accounts of philosophical intuitions. By defining intuitions more narrowly, their incentives are to explain why intuitions might be reliable enough to count as evidence and to fend of the attacks of experimental philosophy. One of the authors who endorse the restrictive position with respect to intuitions is Ludwig who proposed that only the intuitions derived from conceptual competence are the ones which are valid. Conversely, those influenced by factors mentioned earlier like framing or order of presentation which do not fall under the conceptual competence should not be regarded as intuitions. Such view, however, is not without its problems since it is almost impossible to tease apart conceptual competence from those interfering factors since the experimenter herself is not consciously aware of them. Authors like Cappelen even go a step further in their restriction of what intuitions entail narrowing their scope so profusely that even philosophical discussions do not seem to include them. In that sense, experimental philosophy does not endanger the philosophical practice but consequently, his proposal has not gained much momentum among philosophers. The paper ends on an optimistic note that even though intuitions are highly problematic they should not be discarded but rather they should be thoroughly explored further in which experimental philosophy should play a key role.

Let me pass on to Michael Stuart's "How thought experiments increase understanding". As the title indicates, this paper belongs to the domain of epistemology, its aim being the capability of thought experiments to increase understanding. The answers to why that function of thought experiments should be analyzed, are brought forth in the very beginning of the paper. Upon noticing that a great deal of discussion on thought experiments from the epistemological perspective is concerned with the question of how thought experiments generate new knowledge without experience, the author has directed his efforts to an important epistemological aspect which does not receive as much attention as it should, namely the contribution of thought experiments to understanding. As he points out, there are numerous roles thought experiments can assume to contribute to understanding the world among which are illustration of a theory, exemplification of properties and relations, provision of hypotheses and many others. Their sole function need not be increasing the experimenter's knowledge to be epistemologically significant. In order to see how thought experiments increase understanding, the author first tackles what understanding is and what it entails. He highlights Catherine Elgin's view on the subject which does not limit understanding to propositional knowledge but widens the scope to include work, actions, passions, situations etc.

Along the lines of her claim, there have been many classifications and subtypes of understanding; transitive and intransitive, propositional and non-propositional, interrogative and noninterrogative, to name a few. However, the focus of this paper is on three types of understanding: explanatory understanding (EU), objectual understanding (OU) and practical understanding (PU). Explanatory understanding is based on explaining, as the name says, of why some state of the matter is the way it is and it often but

not always, takes the form of propositions. Objectual understanding is the understanding of a thing, or an object itself and in relation to the context and subject matter it is immersed in. Finally, practical understanding is akin to tacit or implicit knowledge, basically knowledge "how" for example "Jimi understands how to play the guitar" (529) and it is contrasted with explanatory as it is not run-of-the-mill propositional knowledge.

It is mentioned that there is a debate about whether some kinds of understanding previously outlined can be reduced to just two or even one subtype of understanding. Stuart insists on their separation arguing that each type is obtained differently and we have distinct ways of pinning down their realization. Naturally, while explanatory understanding should strive for providing a better explanation of a phenomena and practical understanding should foster some abilities, objectual understanding is not as easy to pin down as its purpose is the understanding of the relations between things such as entities, events or experiences, objects and background knowledge. The authors opts for understanding the semantic content.

In subsequent sections the possibility of each of these types of understanding as a result of thought experimentation are given a closer look. In support of the hypothesis that thought experiments contribute to explanation, several arguments and studies are offered; one being an online survey which showed that people (some of which professional philosophers) strongly favor thought experiments as a method of explanation, another was a study on thought experiments in textbooks which reported that many thought experiments are employed because of their explanatory power even though they may be outdated. Further, they are prevalent in literature for explaining a variety of phenomena, for example, Darwin's vertebrate eye, Newton's cannonball etc. Explanation can also be viewed as consolidating phenomena that are in opposition to each other "why does x happen as opposed to y?" (531). In such case thought experiments also do not fall short. It is also stated that they provide explanation in situations where causal relation is sought, for example, in counterfactuals, causal chains etc. What these examples tell us is that thought experiments do increase understanding since explanation and understanding seem to be inextricably linked. Furthermore, thought experiments, as it is argued, seem to increase meaningfulness by enhancing the semantic connections between objects, entities, experiences and so on in contribution to objectual understanding (OU). The scientific thought experiments often assume such roles as they make the problematic and sometimes unfathomable concepts or theories more accessible to the laymen as well as to the students on their way to becoming experts. The history of science is abundant with such examples and two of them are briefly outlined in this paper, namely Darwin's vertebrate eye and Maxwell's demon.

Thus, the author asserts that thought experiments help us make semantic connections between concepts, theories, entities and between our past and present experiences, abilities etc.

Consequently, several remarks are disclosed in arguing for their fruitfulness. What is meant by that is the property of some thought experiments which makes us able to do something we had not been able to do before engaging in thought experiment for example "manipulate a model, make

a successful prediction, produce a good explanation for a phenomena, derive to a particular conclusion" (533). To support his claim, he mentions a couple of examples such as using thought experiments in therapy in order for clients to confront their fears, in education for incapacitating students to make further predictions and inferences about phenomena but also in the history of science as Darwin's vertebrate eye nudged the scientists in the following years to acquire the mechanisms by which evolution functions thus generating new hypotheses. As to how thought experiments increase understanding, the author focuses on objectual and practical understanding since explanatory is beyond the scope of this paper.

In explaining objectual understanding he references the work of Elizabeth Camp and her notions of perspective, characterization and frames. Perspective is the position we assume with respect to the world described in the narrative "as if it were the way the narrative presents it" (534). The application of perspective to a particular instance or a situation is labeled characterization (534). Framed is described as: "a representational vehicle that crystalizes a perspective by suggesting a characterization" (534). With the aid of these terms, the author further explicates how they contribute to understanding. Thought experiments provide frames with which we tap into characterizations. Although they are non-propositional they can be transcribed in forms of propositions but that is not where their potency lies. As Stuart asserts, they are "tools for thinking" (535) and good thought experiments are those which provide good frames by which we can assume a certain perspective which will be of epistemological significance.

In dealing with practical understanding, he highlights Alison Hill's explanation in terms of 'grasping' and 'cognitive control'. Having cognitive control means having the ability to manipulate propositions, i.e. to explain propositions and what can be deduced from them, to form analogies of propositions etc. Even though her account focuses primarily on propositions, Stuart argues that it can be applied in cases of gaining practical understanding by thought experimenting. That can be achieved by exposure to questions and analogies which have to be worked through to get a certain result. In that sense, they thought experiments should be formed in a way that they provide the necessary information and some guidelines to point the experimenter in the right direction, however, the result should be gained independently by working out a certain conundrum thus gaining 'cognitive control'. Gaining practical understanding can also be achieved through various tasks and puzzles, the important element being, as he asserts, the open-endedness of a particular problem without giving away possible solutions before going through an experiment in one's mind. Finally, he proposes some ways of exploring whether thought experiments increase understanding by introducing and testing them in educational academic settings.

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