Studies in History and Philosophy of Science 54 (2015) 102–112

Contents lists available at ScienceDirect

Studies in History and Philosophy of Science

journal homepage: www.elsevier.com/locate/shpsa

Knowing what would happen: The epistemic strategies in Galileo's thought experiments

Kristian Camilleri

School of Historical and Philosophical Studies, University of Melbourne, Parkville, Victoria 3010, Australia

ARTICLE INFO

Article history:
Received 23 February 2015
Received in revised form
28 July 2015
Available online 24 August 2015

Keywords:
Thought experiments;
Galileo;
Epistemic strategies;
Rhetoric;
Early modern science

ABSTRACT

While philosophers have subjected Galileo's classic thought experiments to critical analysis, they have tended to largely ignored the historical and intellectual context in which they were deployed, and the specific role they played in Galileo's overall vision of science. In this paper I investigate Galileo's use of thought experiments, by focusing on the epistemic and rhetorical strategies that he employed in attempting to answer the question of *how one can know what would happen in an imaginary scenario*. Here I argue we can find three different answers to this question in Galileo later dialogues, which reflect the changing meanings of 'experience' and 'knowledge' (*scientia*) in the early modern period. Once we recognise that Galileo's thought experiments sometimes drew on the power of memory and the explicit appeal to 'common experience', while at other times, they took the form of demonstrative arguments intended to have the status of *necessary truths*; and on still other occasions, they were extrapolations, or probable guesses, drawn from a carefully planned series of controlled experiments, it becomes evident that no single account of the epistemological relationship between thought experiment, experience and experiment can adequately capture the epistemic variety we find Galileo's use of imaginary scenarios. To this extent, we cannot neatly classify Galileo's use of thought experiments as either 'medieval' or 'early modern', but we should see them as indicative of the complex epistemological transformations of the early seventeenth century.

1. Introduction

Galileo is widely recognized as a masterful exponent of the use of thought experiment in science. His writings are replete with imaginary scenarios involving moving ships, falling stones and balls rolling down inclined planes. In 1969 Charles Schmitt noted, "the role of thought experiments" in Galileo's early work, "as well as the more general problem of their changing function as Galileo developed from youth to maturity and adage—is a very important one which should be dealt with in detail" (Schmitt, 1969, p. 87). Yet, in spite of the prominent role that thought experiments assumed in Galileo's writings, there has been relatively little detailed historical analysis of how they functioned in his science. Scholars have long recognised that thought experiments played an important rhetorical role in Galileo's writings. Michel Segré, for example, argues that while Galileo did perform many concrete experiments, he often preferred to present his reader with "much simpler, "ideal" experiments". In "presenting his science" to the reader, "Galileo put his trust more in thought experiments than in real ones" (Segré, 1980, p. 246). Yet the question of *how* Galileo attempted to persuade his reader of conclusions by means of the contemplation of imaginary scenarios is one that merits further attention. This paper attempts to address just this question, through an examination of the different epistemic strategies that Galileo employed in his use of thought experiments, particularly in his later dialogues.

Notwithstanding the important recent work of and Paolo Palmieri (2005) and Carla Rita Palmerino (2011), the general neglect of serious historical scholarship into Galileo's use of thought experiments can be sharply contrasted with the fact that

E-mail address: kcam@unimelb.edu.au.

http://dx.doi.org/10.1016/j.shpsa.2015.08.009
0039-3681/

many of them feature prominently in the now extensive philosophical literature on thought experiments. While philosophers have subjected many of Galileo's classic thought experiments to careful critical and logical analysis, they have tended to ignore the historical and intellectual context in which they were deployed, and the specific role they played in Galileo's overall vision of science (Adler, 2003; Atkinson, 2003; Atkinson & Peijnenburg, 2004; Brown, 1991; Gendler, 1998; Humphreys, 1993; Kuhn, 1977). This is a problem, because as many historians have noted, in spite of the popular image of Galileo as the progenitor of modern science, his *episteme* was in many respects foreign to that of the modern era. Indeed, as Nicholas Jardine has argued, many of his "basic assumptions about the proper ways to investigate and explain natural phenomena" were "entirely alien to our conception of science" (Jardine, 1991, p. 102). Here it is important to appreciate that Galileo's use of thought experiments needs to be situated within the context of the complex transformations that occurred in natural philosophy in the late sixteenth and early seventeenth centuries. It was during this period that the traditional meanings of 'experience' and 'knowledge' (*scientia*) would be contested and redefined.

Galileo's thought experiments were almost always presented in dialogical form, and often involved attempting to convince one of the protagonists in the dialogue of the truth of a proposition to which he was initially unwilling to give assent. The question of how Galileo attempted to persuade his readers of the certainty or probability of conclusions reached through the contemplation of imaginary scenarios, some of which could never be realized in practice, is therefore a question that brings to light both the epistemological and rhetorical aspects of Galileo's science. Indeed there is now an extensive literature that has demonstrated the complex ways, and the different contexts, in which these two aspects understood to be inextricably intertwined in the Renaissance and early modern natural period (Finocchiaro, 1980; Jardine, 1991; Moss, 1984, 1986; 1993; Vickers, 1983; Vickers & Struever, 1985; Wallace & Moss, 2003). As R. W. Serjeanston points out:

> The sixteenth and seventeenth centuries saw more self conscious theoretical reflection on how to discover and confirm the truths of nature than any period before or since; the same period also manifested a huge range of practical strategies by which investigators of the natural world set about demonstrating their findings and convincing their audiences of their claims… Inquiry into the early modern natural world, then, was inextricably bound up with the ways in which it was presented. Forms of proof and persuasion cannot be dissociated from the content of natural knowledge in the sixteenth and seventeenth centuries (Serjeanston, 2008, pp. 132, 175)

With this in mind, the problem I wish to examine, in Galileo's later writings, is: *how can we know what would happen in an imaginary scenario?* Framing the question in these terms brings to light the different ways in which Galileo understood the relationship between the traditional categories of 'experience' and 'knowledge', and in doing so provides us with a vantage point from which we can assess what, if anything, was novel or distinctive about Galileo's use of thought experiments. But equally importantly, by looking at the question of thought experiments from this perspective, we become aware of the different epistemic strategies employed by Galileo, which all have come to be identified as thought experiments. As Carla Rita Palmerino has rightly pointed out, the variety of different arguments "lumped together under the label 'thought experiments' were not regarded by Galileo as a unitary category" (Palmerino, 2011, p. 125). This contains an important clue to understanding Galileo's frequent invocation of imaginary scenarios in his writings. Here we do well to heed Kuhn's warning that "the category "thought experiment" is too broad and vague for epitome" (Kuhn, 1977, p. 241).

In this paper I distinguish three different epistemic and rhetorical strategies that Galileo used in generating knowledge about the world from imaginary scenarios. In the sections that follow, I illustrate each of these strategies through examples taken from Galileo two major dialogical works of the 1630s—*Dialogue Concerning the Two Chief World Systems* and the *Two New Sciences*. In the first class of thought experiments I consider, Galileo makes an appeal to 'common experience' or 'memory'. Here the reader is invited to consider what would happen in a given scenario, not by referring to any actually performed experiment or observation, but rather by appealing to the knowledge previously acquired through experience in course of everyday life. In doing so, Galileo remained close in spirit to the medieval Aristotelian tradition, though he often deployed such thought experiments to refute the conclusions reached by Aristotle.

The second class of thought experiments derives conclusions that are intended to have the status of *necessary truths*. Such thought experiments are much more like arguments, in the sense that they attempt to force the reader to arrive at a particular conclusion by exposing a contradiction or inconsistency in certain assumptions. In many respects these are much like *reductio ad absurdum* arguments, (though one need not be committed to the view that such thought experiments are simply picturesque forms of inductive or deductive inference). The demonstrative force of such thought experiments, for Galileo, lies in the fact that in executing them we feel compelled to reach the conclusion we do, because "it could not be otherwise". This class of thought experiment closely embodies the demonstrative ideal of science, which accorded with the traditional aim of *scientia* in the early 17th century—to arrive at necessary, and not merely contingent, truths about the world.

The third and final class of thought experiments I trace in Galileo's writings is perhaps the most interesting, because it involves explicit appeal to real experiments. Here Galileo argued that we can arrive at knowledge of what happens in the hypothetical scenario (such as free fall of bodies of different materials in a vacuum), not by imaginative speculation or reliance on previous experience, nor by demonstrative argument, but by observing what happens in series of cases which more and more closely approximate the ideal case. In this sense, Galileo advocated extrapolating from the concrete to the abstract, thus departing from the forms of reasoning he employed in his use of imaginary scenarios in other contexts. Before considering each of these epistemic strategies in more detail, it is worthwhile review the way in which historians and philosophers of science have attempted to make sense of Galileo's thought experiments by situating him in the context of medieval and early modern intellectual traditions.

2. The historiography of Galileo's thought experiments

Most historiographical approaches to Galileo's use of thought experiments have typically revolved around the question of whether, and to what extent, Galileo's use of thought experiments represented a decisive break with medieval natural philosophy, or represent a continuation of forms of argumentation that had their roots in medieval scholasticism. The different views expressed with regard to the place of thought experiment in the transition from medieval to early modern natural philosophy rehearse the familiar concerns of an earlier generation of historians of science, who grappled with the complex question of how best to understand the extent to which Galileo's science represented a continuation, or a departure from, the medieval tradition (Wallace, 1981; 1984). Of course framing the historical question in this way presents a