The function and limit of Galileo's falling bodies thought experiment: Absolute weight, specific weight and the medium's resistance

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We have the general impression that the epistemological literature on scientific thought experiments (TEs) is mainly built on a-historical analysis of case studies. This is especially lamentable for Galileo's falling bodies TE because the literature takes this TE as a canonical case study, while the a-historical analysis of this TE yields wide disagreements about its conclusion, leading to divergences pertaining to its epistemic power. Thus, leading the epistemological literature on TEs astray and even turning an important debate into a red herring: The Norton/Brown debate revolves, in part, around how Galileo's TE justifies its conclusions, by direct a priori access to laws of nature or by being a deductive argument. Nevertheless, the TE's function is misrepresented as revealing and justifying a law of nature.

Indeed, Galileo's Discorsi (1638) falling bodies TE has become a key case study, especially since Brown (1986) famously claimed that it is canonical case of what he labelled "platonic TEs": it is both destructive and constructive. It is destructive since it refutes an old theory (i.e. Aristotle's theory of free fall), it is also constructive since it establishes, in a priori fashion, a new law of nature (i.e. in void, all bodies free fall at the same speed). Brown's analysis was met by Norton (1996) who denied this "platonic" power of the TE and argued that it is reducible to a deductive argument, a TE-argument; i.e. an argument with irrelevant and eliminable particulars. Both Norton and Brown agree that the TE perfectly leads to its destructive conclusion in a deductive manner. In addition, if the TE leads to its constructive conclusion, Norton claims that the TE-argument could deductively lead to this conclusion as well. However, Norton argues that the TE-argument shows us that the TE leads to its constructive conclusion only if we add the following hidden assumption 8a: The speed of a falling body depends only on its weight. Which for Norton amounts to assuming vacuum, something Galileo could not do in the context of the TE, and thus this constructive conclusion is "at worst, a fallacious inference to a falsehood [when assumption 8a does not hold]; or, at best, valid only insofar as it is invoked in special cases in which assumption 8a holds, such as the fall of very heavy, compact objects in very rare media." (my emphasis, Norton 1996, p.345). Norton's conclusion, apart from being in tension with his "elimination thesis", since he seems to grant some important role for the particulars involved it this TE, elicit the need to analyse the function of the particulars involved in Galileo's TE: very heavy, compact spherical objects of the same material falling in a rare medium such as air. More generally, in analysing this TE, the philosophical literature on TEs systematically ignores Galileo's restriction, in the TE's scenario and in its conclusion, to bodies of the same specific weight (i.e., same material).

This restriction has even puzzled many Galilean scholars. For instance, Koyré states that "Galileo's mention of specific gravity - and this, in a reasoning in which it has nothing to do - is extremely curious. And even, historically, very important." (my emphasis, 1960, p.203). More recently, Palmieri (2005) and Van Dyck (2006) analysed the historical development of this TE and its restriction to bodies of the same material, which brought Palmieri to conclude that "[p]erhaps we need a new approach to the question of thought experiment, capable of integrating results from different disciplinary areas, such as, for instance, the history and philosophy of science" (p.238). Regrettably, this was not taken into account by most philosophers working on TEs. For instance, we still find in the Stanford entry on TEs (2017) that "Galileo showed that all bodies fall at the same speed with a brilliant thought experiment" (my emphasis).

The philosophical literature is thus in need of a more careful historical analysis of Galileo's TE and the following questions answered, before trying to analyse if and how the TE justifies its conclusion(s): What is/are the conclusion(s) of Galileo's TE? What is its function in Galileo's both argumentative strategies? What is the role of the particulars involved in its scenario? What are the idealisations involved? Are these idealisations justified? Since vacuum could not be explicitly assumed in the TE, then how did Galileo take into account the effects of the medium's resistance? All these questions could be easily answered once we tackle the more general one: Why is the TE restricted to bodies of the same material?

This paper aims at analysing the function and limit of Galileo's falling bodies TE, which will provide an answer to these questions. First, I retrace Galileo's TE to its first use in the DeMotu (1590), which explicitly indicate his intention of "seeking causes of effects". I show that the TE's function is only refutational: it aims at refuting Aristotle's theory of free fall, one of its two principles to be precise, by showing that the falling body's absolute weight is not a causal factor; i.e. absolute weight could not cause divergences in speed of free falling bodies of the same material. Second, I analyse Galileo's both 1590 and 1638 argumentative strategies that followed the same TE, but led him to defend two incompatible theories of free fall. I argue that both theories stem from arguments (and even real experiments on pendulums in 1638) excogitated by Galileo to analyse specific weight as a causal factor, with conflicting conclusions. Third, I analyse one small effect of the medium's resistance that could not be taken into account by Galileo's choice of particulars; i.e. the medium's disproportionate effect on the falling body's surface to absolute weight ratio. This shows that the TE only works either if we can assume vacuum or by placing the TE in the whole argumentative strategy, where this small effect of the medium's resistance is subsequently explained (which Galileo does in 1638) and thus could be ignored in the TE. Finally, I conclude by drawing some implications relative to the epistemic debate on TEs.