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Prove it! The Burden of Proof Game in Science vs. Pseudoscience Disputes

Massimo Pigliucci · Maarten Boudry

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Abstract The concept of burden of proof is used in a wide range of discourses, from philosophy to law, science, skepticism, and even in everyday reasoning. This paper provides an analysis of the proper deployment of burden of proof, focusing in particular on skeptical discussions of pseudoscience and the paranormal, where burden of proof assignments are most poignant and relatively clear-cut. We argue that burden of proof is often misapplied or used as a mere rhetorical gambit, with little appreciation of the underlying principles. The paper elaborates on an important distinction between evidential and prudential varieties of burdens of proof, which is cashed out in terms of Bayesian probabilities and error management theory. Finally, we explore the relationship between burden of proof and several (alleged) informal logical fallacies. This allows us to get a firmer grip on the concept and its applications in different domains, and also to clear up some confusions with regard to when exactly some fallacies (ad hominem, ad ignorantiam, and petitio principii) may or may not occur.

Keywords Burden of proof · Pseudoscience · Logical fallacies · Bayesian theory

Introduction

The concept of burden of proof (henceforth, BoP: Brown 1970; Walton 1988) is invoked often in philosophy (Kopelman et al. 2004; Lycan 2010), law (Prakken 1999), and in debates concerning (allegedly) pseudoscientific claims (Gill 1991; Annas 1999; Caso 2002). Especially in the latter case, it often seems like skeptics and proponents of pseudoscience alike simply throw the BoP to the other side in what amounts to little more than a rhetorical move.

Instead, we think that BoP, when properly understood and carefully used, can play a major role in a broad range of epistemic disputes. The concept can be characterized more rigorously within the formal statistical framework of Bayesian decision making theory (Madruga et al. 2003; Borges and Stern 2007), and bears interesting

M. Pigliucci (✉) · M. Boudry
Philosophy Program, The Graduate Center, City University of New York, New York, NY, USA
e-mail: massimo@platofootnote.org

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relationships with a number of other issues in inference formation (Harman 1965), particularly with some well-known informal fallacies (Walton 1988, 1996).

In this paper we begin with a brief introduction to a number of different types of burden of proof (The Varieties of Burden of Proof section), discuss how to reasonably assign BoP (How to Assign Burden of Proof? section), explore the relationship between BoP and logical fallacies (Beyond the Burden of Proof: Informal Logical Fallacies section), and conclude with considerations aimed at keeping supporters of diverging views honest when they deploy challenges based on BoP (Conclusion: Keeping it Honest section).

The Varieties of Burden of Proof

Evidential vs. Prudential BoP

To begin with, then, an important distinction needs to be made between prudential and evidential burden of proof. The prudential BoP is applicable when there are cost asymmetries in arriving at two judgments about whatever matter is under dispute, whereas the evidential burden of proof applies when there are no such cost asymmetries involved. Consider, for instance, the question of the safety of food additives (Mepham 2011). If approached as a straightforward scientific question, then the relevant concept is that of evidential BoP: there is no "cost" associated with arriving at the right judgment, other than the symmetric cost in getting a chunk of reality wrong. This is analogous to Type I or Type II errors in statistics, which refer, respectively, to the incorrect rejection of a true null hypothesis (false negative) and the failure to reject a false null hypothesis (false positive). If we approach the issue of food additives from the standpoint of its potential consequences for public health, however, there is a differential cost in getting the wrong answer, so the idea of prudential BoP seems more appropriate. The (controversial) precautionary principle, which is an application of the prudential burden of proof, states that—if a certain action or policy is suspected to be harmful—the burden falls on those who believe that a new policy or course of action is not harmful. The status quo is perceived as less costly than a potentially dangerous new policy or course of action (Annas 1999; van den Belt and Gremmen 2002; Kopelman et al. 2004).

In more general terms, the prudential BoP can be applied in situations where the cost of a false positive is significantly different (greater or smaller) from the cost of a false negative. Examples of prudential BoP where the cost associated with a false negative outweighs that of a false positive include smoke detection alarms, environmental hazards, cancer screening, etc. Walton (1999) discusses the case of someone picking up a firearm and wondering whether it's loaded. An example of the opposite case, where false positives are perceived as more costly, include the presumption of innocence in a court of law (Prakken 1999). This principle in American criminal law clearly skews things in favor of the defendant, but this is done because the risk of a false positive (convicting an innocent) is treated as much less acceptable than the risk of a false negative (exonerating a guilty party). Another example is the dynamics of military conflict, where the decision to strike the first blow or to act on a perceived provocation by the other party has the potential to initiate an escalation of violence (think about the dilemma facing the Kennedy administration during the Cuban missile crisis).

Of course, cases of prudential BoP always involve an evidential dimension as well, while the opposite is not the case. In prudential BoP, cost asymmetries have to be taken into account in addition to prior probabilities. For example, in discussions about cancer and cell phones, the initial plausibility of low-energy electromagnetic radiation being carcinogenic has to be taken into account in addition to cost asymmetries. If prior probabilities are ignored, the precautionary principle is misused and can have paralyzing effects on public policy. Conversely, one cannot just invoke a Bayesian perspective (as useful as it is) to settle issues where cost asymmetries are involved, since even when competing claims have equal priors, a prudential approach (but not an evidential one) could easily tip the balance in favor of one claim over the other.

There are a number of important discussions in science (Lloyd 1999), pseudoscience (Gill 1991; Caso 2002; Fisher 2003), and even in straightforward philosophical argumentation (Flew 1984; Lycan 2010), that can reasonably be approached either from an evidential or from a prudential perspective, depending on the interest of the parties involved. For instance, the force of the philosophical argument behind Pascal's wager (Hájek 2012) is supposed to be that the risk of a false negative (you don't believe there is a god, but it turns out there is one) is much higher than that of a false positive (because of the threat of eternal damnation in Hell). By contrast, to take another philosophical example dealing with the import of paranormal or supernatural hypotheses: the risk (in terms of practical consequences) of falsely accepting the existence of Bertrand Russell's tea pot orbiting the sun (false positive) seems to be the same as the risk of rejecting the tea pot when there really is one (false negative).

Sources of Subjectivity

Importantly, if we are to make sense of "proper" placement of BoP in a debate, taking seriously its implicit normative dimension, the determination of priors and cost asymmetries cannot be an entirely subjective affair. In the case of evidential BoP, a purely subjective interpretation of Bayesianism risks making the allocation of BoP a matter of personal opinion, because it merely demands that our beliefs form a coherent whole (for example, that the prior of any given proposition and its negation add up to 1). Suppose a ufologist argues that, given the countless UFO sightings reported so far (and even more so the number of reported abductions), his subjective prior of alien visitation has increased over the years, to the point where any unexplained sighting is more likely to have an extraterrestrial origin (in his belief system). This will not do. If we want to avoid such subjective arbitrariness, we should demand that everyone's priors are determined on the basis of common background knowledge. How should we do this? The ideal answer would be to use only objective priors, but these are available for a limited range of problems (e.g., estimation of genotype frequencies in population genetics: e.g., Consonni et al. 2011), and are unlikely to come by in most cases pertinent to beliefs at the borderline between science and pseudoscience. Instead, in our view the intersubjective agreement among relevant experts is the most suitable candidate to play this role (see, for instance, Rowbottom 2013). In the case of ufology, the large majority of astronomers agree that, although the sheer size of the universe makes it quite plausible that life has evolved on other planets, the prior probability of an alien species developing interstellar space crafts that has crossed the vast distances to the earth, though not impossible, is exceedingly

improbable. Those who insist that some UFO sightings have an extraterrestrial origin therefore carry the burden of proof.[1]

The obvious counter to our expert-based approach is to say that ufologists are themselves "experts" on UFOs, and that the consensus within that community is that aliens are indeed visiting earth. (Something similar could be said of the community of astrologers, that of acupuncturists, and so forth.) But remember that we are interested in the differences between science and pseudoscience (Pigliucci and Boudry 2013). As such, disciplines that are currently outside of science proper—such as ufology, astrology and the like—are the ones that have not yet succeeded in convincing the rest of the scientific community of their legitimate expertise in the domain in question (in the same way that genuine scientists from different fields defer to each other's expertise in their respective domains). Therefore, the relevant community of experts is made up of those who are already inside the established club (i.e., the scientists), so to speak. This, incidentally, should not be interpreted as a move toward sociologically justified epistemic relativism: we maintain that philosophy of science and epistemology are normative, not just descriptive.

In the case of prudential BoP, the problem of assigning costs to respective events makes for an additional source of (potential) subjectivity. In the case of Blaise Pascal's prudential endorsement of faith, for example, we may reasonably question the costs he associated with a false negative (not believing in god when he really does exist). Why should we accept the assumption that god, if such a being exists, would punish non-believers with eternal damnation? That idea is inspired by a particular Christian theology, the truth of which is of course exactly what is at stake. Why should such a perfect being care at all about the beliefs of earthly denizens? (Maybe he is more forgiving, or he will even congratulate skeptics for their critical thinking skills?).

In discussions about prudential BoP and the precautionary principle, however, there is often a reasonable degree of consensus on the undesirability of the negative event, and controversy is more focused on the probabilities. In discussions about global warming, for example, there may be disagreement about the total costs associated with the melting of the Antarctic ice sheet, but in general, we all understand that the melting of the Antarctic ice sheet would be disastrous. The largest bone of contention is: how likely is it that the melting is going to happen?

Global vs. Local BoP

Henry Prakken and his research group (Prakken and Sartor 2006; Prakken et al. 2005, 2006) have introduced an additional distinction between global and local burdens of proof. The global BoP is fixed throughout a discussion, because it is related to what a discussant ultimately wishes to establish (or her opponents wishes to deny). Within that broad goal, however, a number of local burdens of proof may arise, which shift during the debate itself, as they pertain to smaller pieces of the overall puzzle. In general, at any stage of a debate, each side can challenge a step or premise in the other side's argument, demanding that the BoP for that specific claim be met. For example, during a trial, I can raise suspicions about the trustworthiness of one of my adversary's witnesses, say

[1] If the expert view is silent on some issue, arguably the BoP rests on whomever is making a new or interesting claim. Probably this is where the (misguided) idea stems from that the BoP is always on those who are making the "positive" claim, see How to Assign Burden of Proof section.

because the witness has financial ties to the defendant. A dispute may then arise about the witness' credibility, within the broader project of establishing guilt or innocence. This local assignment of BoP, in which a specific claim is at stake, can again be cashed out in terms of evidential and prudential BoP. For example, a conflict of interest—financial or otherwise—is usually good reason to distrust a witness. That is because, as an empirical generalization, people who have a shared interest with the defendant (or who have an axe to grind against him) can be expected to be biased in their judgment. If all that we take into account is evidence about prior probabilities, we are dealing with a case of evidential BoP. For prudential reasons, however, it is sometimes sufficient for me to simply raise an issue to shift the BoP back to my opponent. For example, in a murder trial, merely to hint at the possibility of legitimate self-defense, even on flimsy grounds, may be legally acceptable to shift the BoP to the prosecution.

Considering the field of (alleged) pseudoscience, in discussions about climate change the BoP used to be on the scientific community to provide sufficient evidence for anthropogenic climate change (AGW). Early on it was reasonable to be skeptical of that theory and to ask for sufficiently compelling evidence to back it up. The global BoP was still on the claimants. Nowadays, however, the multiple threads of accumulated evidence are so convincing that the BoP has been met by proponents of AGW, and has now shifted to the skeptics. In fact, this gradual shift in BoP is nicely tracked by the wording of the five successive iterations of the report of the Intergovernmental Panel on Climate Change (http://www.ipcc.ch/). Since scientists have met the global BoP on AGW, the discussion should move on[2]—if it were based solely on rational criteria. In terms of subjectivity of priors, this is an example of the criterion mentioned above, according to which priors should be estimated on the basis of the consensus (if it exists) of the relevant community of experts.

The local BoP can be understood by considering a charge often made by those who still dissent from the general agreement on climate change. The overwhelming consensus among climate scientists, they allege, is the artifact of perverse mechanisms for ensuring the continued funding of said climate scientists. Given the charge, it is up to the deniers to produce evidence of this conflict of interest and its impact on the findings of climate change, within the broader context of the debate. In fact, they have tried, but the "scandal" centered on the private email correspondence of scientists at the University of East Anglia turned out to be more evidence of paranoia on the part of the deniers than of unethical behavior on the part of the scientists (Reay 2010).

How to Assign Burden of Proof?

In a early paper on burden of proof, Brown (1970) characterizes the request for meeting the burden by a given side in a debate as amounting to the claim that, prima facie, that side's position is more initially plausible than the alternative(s). Brown's framework does not involve the costs associated with different judgments, and can thus be seen as a characterization of evidential BoP. A major exponent of modern

[2] This, of course, most emphatically does not mean that the public at large has in fact been convinced of the truth of AGW. But equating the two conditions would be to confuse the public as it actually is with an ideally unbiased group of epistemic observers.

skepticism, Michael Shermer, describes the principle of (evidential) BoP as follows: "The person making the extraordinary claim has the burden of proving to the experts and to the community at large that his or her belief has more validity than the one almost everyone else accepts" (Shermer 1997, 50–51). Psychologist Terence Hines, in another compendium on pseudoscience, agrees that the burden should fall on the claimant of the extraordinary, because "it is often impossible to disprove even a clearly ridiculous claim" (Hines 2003, 16), such as that Santa Claus exists.

In philosophy of science, Laudan (1965) formalized what amounts to the evidential BoP in the context of falsification and ad hoc reasoning, based on the famous Duhem thesis[3] that apparent falsification of a given focal hypothesis can be avoided by altering one or more of the ancillary hypotheses that provide the background necessary to test the focal one. As Laudan summarized the idea, consider a hypothesis H (say, extraterrestrial spaceships regularly visit earth), an observation statement O (e.g., we have a number of reports of flying saucers), and nontrivial auxiliary conditions A (e.g., knowledge of physics and engineering pertinent to space travel). The Duhem thesis can be thus formulated: "In the absence of a proof that no appropriate hypothesis saver exists (i.e., unless we prove that $\sim(\exists A)\ (H + A \rightarrow \sim O)$), then ~O is not a conclusive refutation of H, even if $H + A \rightarrow O$." Laudan wrote this in the context of a critique of falsificationism, continuing: "The scientist who claims to have falsified an hypothesis H must prove that $\sim(\exists A)\ (H + A \rightarrow \sim O)$. Unless such a proof is forthcoming, a scientist is logically justified in seeking some sort of rapprochement between his hypothesis and the uncooperative data" (Laudan 1965, 298).

The logical point is unassailable, but there must be a limit to it in terms of actual scientific practice, because it is pretty much always possible to alter A in order to rescue H in the face of whatever "uncooperative" O. As we hinted at above, arguably the most suitable framework for resolving this problem is provided by Bayesian analysis (Madruga et al. 2003; Borges and Stern 2007; however, see Williamson 2011, showing that several of our points hold even if Bayesian updating of a traditional fashion is not used; there are also non-Bayesian ways to tackle Duhem's problem: e.g., Rowbottom 2010), with its ability to take into account (and constantly update) the background information (priors) available at any given point during an ongoing debate. So, for instance, given current knowledge of the physics and engineering of interstellar travel, the prior probability of frequent extraterrestrial visits to our planet is exceedingly low. According to Bayes's theorem, then, substantial new evidence E will be required to yield posterior probabilities that would make the hypothesis of $P(\text{ET visits} \mid E) > \sim P(\text{ET visits} \mid E)$.[4] If this is right, then skeptics of UFOs are correct in placing the BoP firmly on proponents of the ET visits hypothesis—given currently accepted background knowledge within the relevant community of experts. It is perfectly possible that such background knowledge will change (we will soon discover warp drive, say), thus significantly altering the Bayesian equation and re-opening the debate about BoP when it comes to UFOs. (It is also possible, of

[3] We distinguish here between Duhem's and Quine's theses, as opposed to treating them as one aggregate, as it is often done. There are very good historical and conceptual reasons to do so, as articulated in Ariew (1984).

[4] The reader will notice the similarity between our argument and Hume's famous critique of miracles. This point was explored in detail by Owen (1987) and Sobel (1987), and we will return to it toward the end of the paper.

course, that future observations will be so compelling—e.g., a televised visit by alien beings to the headquarters of the United Nations—that even with current background knowledge the skeptic will be forced to accept the ET visits hypothesis.).

This analysis, however, should not be cause for too much complacency on the part of the skeptic of pseudoscience, since it doesn't license an automatic rejection of any claim of the paranormal or extranormal, except when the prior probability of the paranormal hypothesis is exactly zero (e.g., when it is logically incoherent). The reason why BoP rests on the believers is also often misconstrued in the skeptical community. The evidential BoP is not on "whoever makes the positive claim" (e.g., Gill 1991, but see Caso 2002 for a critique). First, it is very easy to turn any positive claim into a negative one, and vice versa, by simple application of basic logical rules. In general, affirming P is exactly the same as denying ~P. Any existential claim can be translated into a negative universal, and vice versa ($\exists x Ax$ is logically equivalent to $\sim\forall x \sim Ax$, and $\sim\exists x Ax$ is logically equivalent to $\forall x \sim Ax$). Resorting to such moves would merely amount to sophistic word play rather than a substantive consideration of epistemic burden. Second, there are cases in which the BoP rests on those who are putting forth what may most plausibly be construed as the "negative" claim, in the sense of denying the material existence of some X. For example, the burden of proof is no longer on historians to provide evidence of Zyklon B use in the nazi concentration camps, although, apart from logical sophistries, they are the ones making a "positive" claim. In this case, then, the BoP rests on those making the "negative" claim. In most discussions of pseudoscience and the paranormal, admittedly, the believers in pseudoscientific notions are making positive claims, in the sense of affirming the existence of entities (spaceships, psi force, qi energy lines, auras) that are rejected by modern science, but this—per se—is not the reason why the BoP rests on them. Evidential BoP assignment always reflects substantial background knowledge and prior probabilities, and these assumptions of plausibility, we argue, should be based on the expert consensus on the matter.

Occam's Razor

One general factor affecting the initial plausibility of hypotheses is the criterion of simplicity or parsimony. Skeptics often invoke Occam's razor in these contexts. A facile use of Occam is to say something along the lines of "assuming that there are visiting aliens is a more complex hypothesis than assuming there are none, so…" But of course Occam's razor doesn't always favor simpler hypotheses. The parsimony principle has a number of different guises, the simplest of which can be applied to the number of theoretical entities invoked by a given hypothesis (and even then, counting entities is not always a trivial matter). Occam's razor urges us to reject theoretical constructs that are "superfluous," in the sense that they are not strictly demanded by the evidence. However, determining whether the constructs invoked by a given theory are indeed "superfluous" can be far from straightforward, as Brown (1970, 80) elegantly summarized: "Entities are superfluous if and only if their absence does not make the simpler hypothesis false."

The intuitive plausibility of Occam's razor can be captured by a Bayesian framework. The simplest version of Occam's razor concerns the number of discrete entities postulated by a theory (quantitative parsimony). In most philosophical and scientific

discussions, however, we are comparing the number of types (or kinds) of entities assumed by a theory (qualitative parsimony, see Baker 2010).[5] In any case, the more (kinds of) entities a theory assumes, the lower its initial probability (probabilities become smaller as they are multiplied). An entity X is superfluous for a theory, given some evidence E, if that theory is fine without X; more technically, if X's absence does not significantly diminish the posterior probability of the theory in question. The entity X is not superfluous if the theory falters without it, in other words, if the posterior probability of the simpler theory, given E, is much lower than that of the extended theory (incorporating X). That is, as Brown (1970, 80) put it, when its absence makes the simple hypothesis false. Thus, we may accept a more complex theory if, despite its low prior probability, the updated probability is higher than that of the simpler theory, given the evidence at hand. The priors can be significantly modified by new observations, perhaps to the point where the "superfluous" entity becomes an integral part of a new theory (and therefore yields significantly different new background conditions). The take-home message is that, all other things being equal, more complex hypotheses initially take on a heavier burden of proof (because complex hypotheses have more ways of being wrong), but that strong evidence can quickly tip the balance in their favor. The newly accepted complex hypothesis then becomes part of our background knowledge, to be deployed in order to evaluate further hypotheses.

The Skeptical Burden

Believers of the paranormal and supernatural have often tried to turn the tables on skeptics, finding various ways to shift the BoP back to the latter. In particular, rhetorical moves of the type "you can't prove it wrong" (Gill 1991; Caso 2002) are unfair requests that fail to appreciate the proper BoP procedure. In some cases, such requests can be straightforwardly fulfilled (e.g., it is very easy to prove that the co-authors of this paper, at this very moment, have far less than $1 M dollar in their pockets), but even then, the skeptic is doing the accuser a favor in taking on a BoP that does not really fall on him (we are under no obligation to empty our pockets after each such gratuitous insinuation). Similarly, if ufologists claim that some crop circle was left by a space ship, the BoP is firmly on their side to come up with extraordinary evidence. If the skeptic chooses to take on their sophistic challenge to "prove that there was no spaceship," (see below on argument from ignorance) by way of providing direct or circumstantial evidence that that particular crop circle was in fact a human hoax, they are indulging the believers by taking on a BoP that, rationally speaking, does not pertain to them at all.

For most actual para/extranormal claims, however, the space of possibilities cannot be exhausted in a finite (and suitably short) time. For instance, to arrive at proof that there are no alien spaceships visiting earth—at any moment, not just in the case of a specific alleged incident—would require a type of temporally protracted exhaustive monitoring of the entire planet's surface, something that it is so far beyond current technological possibility that the request can easily be dismissed as a simple debating trick.

[5] Others versions of parsimony concern the syntactic of mathematical simplicity of a theory, which is more complicated.

This, however, leads the skeptic with a dilemma. Although it may sometimes be rhetorically persuasive for her to take on a BoP that, strictly speaking, does not fall on her (for example, providing a natural explanation of a given UFO sighting), this may be perceived as an implicit acknowledgement that skeptics do carry the negative BoP for every single anomaly that believers come up with. The result is a mug's game for skeptics: all believers have to do is throw around challenges for the skeptic, who will surely not be able to answer every single one of them. To refer again to the ufological literature (Sheaffer 1998), even ardent skeptics do admit that a small percentage (at most 10 %, and likely significantly less than that) of alleged UFOs cannot be turned into IFOs (Identified Flying Objects), even after direct investigation of the available evidence.

There are at least three replies the skeptic has available here. To begin with, investigative resources are limited, especially when it comes to likely pseudo-scientific claims, so it should not be surprising that on a certain number of occasions the researcher simply does not have sufficient means to carry out a positive identification of the allegedly unexplained phenomenon. Second, even in the case of genuinely scientific questions one has to contend with limited epistemic access to the relevant phenomena, access that can be affected by the lack of sufficient empirical traces or by the intrinsic epistemic limits of human reason. Think of the long—and so far still largely unsuccessful—quest for an explanation for the origin of life, for instance. Third, as Kuhn (1962) reminded us, even successful "normal" science constantly has to deal with a number of unsolved "puzzles," and it is only when the puzzles become numerous and widespread that they genuinely begin to threaten the reigning paradigm, forcing scientists to seek alternative theoretical frameworks. Even if skeptics cannot provide a complete explanation for every single anomaly, what they often can do is to offer promissory notes for explanations, speculating about potential natural interpretations. Given that the BoP really falls on believers to come up with convincing evidence, this is all that can be expected from skeptics under these circumstances.

Intelligent Design proponents and assorted creationists, for instance, have often pointed to alleged instances of "irreducible complexity" in the living world: biological systems that are so intricate that they could not possibly have evolved. In dealing with such challenges, evolutionary biologists can suggest possible evolutionary pathways leading to a given complex biological structure. When they have done so, there is an extra BoP on ID advocates to rule out all of the proposed natural explanations. Contrary to what believers think, the BoP is not on skeptics to demonstrate which one of the natural explanations is the correct one. Given the overwhelming evidence for the power of natural selection to produce adaptive complexity, and the difficulty of garnering information about a distant evolutionary past, this kind of informed speculation is all that is needed to put ID arguments to rest (of course, evidence of specific mutations and selection processes further strengthens the case for evolution, but its fate no longer depends on it). The amount of anomalies (in casu, evolutionary puzzles) has simply not come even close to the Kuhnian threshold for a paradigm shift, though of course this says nothing about whether it might do so in the future.

We turn next to a broader perspective on the issue of BoP within the context of debates between skeptics and believers, a context that invokes the general concept of informal logical fallacies and their surprisingly close association with the idea of BoP.

Beyond the Burden of Proof: Informal Logical Fallacies

Another rhetorical weapon often hurled by both sides of debates about pseudoscience (Pigliucci and Boudry 2013) is a quick charge of committing "a logic fallacy," by which usually it is meant one of a number of informal fallacies. What is interesting here is that a) some informal fallacies are closely related to the concept of burden of proof, and b) in many actual instances of usage the alleged fallacy turns out to be a perfectly reasonable precautionary position to take, and therefore not a "fallacy" at all (Walton 1988, 1996).

Walton (1988) characterizes many informal fallacies as persuasive argumentative strategies that reflect an (often reasonable) attempt to shift the burden of proof. On the importance of properly laying the burden, he quotes as early a source as Whately (1846, in Walton 1988), who made the analogy with a garrison defending a sieged fort. The fort may be impregnable as long as the garrison plays defensively, but if the commander decides for a sortie in open field, defeat may swiftly follow. Similarly, often one only needs skeptical arguments to successfully defend one's position because the BoP is indeed on the other side. Should one forget that and accept an invitation to come up with positive arguments (i.e., battling in the open field), one may find such arguments very weak and ultimately damaging to one's position. This is precisely the dilemma facing the skeptic that we sketched above.

Walton argues that three well known informal fallacies are conceptually related to burden: ad hominem, petitio principii and especially ad ignorantiam. Let us begin with ad hominem: suppose a skeptic of astrology points out the lack of evidence that the practice works. The believer may retort with an ad hominem along the lines of "well, it is widely known that you have an axe to grind with astrologers, because your own astrology chart is not very flattering." Here the skeptic stands accused of personal prejudice against astrology. The believer's strategy can be understood (regardless of whether (s)he understands it that way!) as an attempt to shift the burden of argumentation back to the skeptic. The skeptic now has two options: a) to meet the newly established burden (engaging in a sortie, to use Whately's analogy) by trying to demonstrate that (s)he is a passionate truth lover and is not driven by a personal grudge against astrologers; or b) to reject the accusation out of hand (stay in the fort) and clarify that such ad hominem accusations have no place at all in a rational discourse, proceeding immediately to refocus the debate on the evidence (or lack thereof) for astrology.

The point is that, although strictly speaking the personal background of a critic has no bearing on the quality of his/her argument, they are relevant in the context of expertise and credibility (Yap 2012). For example, accusations of hidden agendas may be legitimate ways of shifting the discussion to the personal integrity of the critic. If a medical researcher is on the payroll of a pharmaceutical company, this may indeed cast doubt on his impartiality, even if his research may be impeccable. Experimental evidence is always testimonial to some extent, even if scientists take pains to eliminate the subjective elements from their work, for example by making all their data publicly available and describing the exact procedures that were followed in gathering them. Even if they have ensured this, however, we still have to trust the researcher that no data were omitted or manipulated, that the described protocol was duly followed, etc. Failure in these respects need not be a matter of fraud. For example, few people suspect that the distinguished psychologist Daryl Bem had

resorted to outright manipulation when he presented his alleged demonstration of psi (Bem 2011). However, because of Bem's avowed sympathy for the paranormal, it was legitimate to be suspicious about his results (Wagenmakers et al. 2011; Alcock 2011), as was indeed borne out by subsequent failures to replicate them (Ritchie et al. 2012). Subtle methodological errors or sloppy controls may have been responsible for Bem's spurious conclusions. Indeed, because of the overwhelming improbability of his hypothesis, involving spooky backward causation, even after Bem's initial results the (evidential) BoP was still firmly on the proponents of parapsychology to replicate the findings. Likewise, if someone is an avowed supporter of the libertarian Cato institute, say, this may call into doubt his or her ability to objectively assess arguments about market regulation. There is no formal way to distinguish between legitimate suspicions about someone's personal background and ad hominem slander. Thus, a facile accusation of "ad hominem" reasoning often misses the point, and is itself fallacious.

Concerning petitio principii, Walton distinguishes between benign and viciously circular arguments. Arguing in circle, says Walton, is not necessarily fruitless, and it is not subject to refutation in all cases. Begging the question, however, should always be considered as a bad move in rational discourse. The difference lies in an unmet BoP in the case of vicious circularity: "the very idea of begging the question is linked to the context of dialogue where there is an obligation to prove. Begging the question is inappropriate precisely because the thesis to be argued for is 'begged for' instead of being proved. … An argument that begs the question could be formally valid, but it is not useful to persuade a rational opponent in dialogue precisely because it fails to meet the burden of proof" (Walton 1988, 236).

Finally we arrive at the link between burden and argumentum ad ignorantiam. This is perhaps the most interesting case discussed by Walton, as it has wide application in court rooms (for instance, in the difference between criminal and civil cases), in philosophical disputes, and of course in the category we are concerned with, discussions about alleged science-pseudoscience. Again, the idea is that an argument from ignorance is not necessarily fallacious (though it certainly can be), and that the difference between a fallacious and a reasonable one lies in the placement of the BoP with respect to background knowledge.

First, consider a case of the argument from ignorance to a negative conclusion.[6] The theory behind acupuncture invokes a novel form of energy, qi, which flows through specific life-energy paths known as "meridians." A skeptic can (reasonably) argue that, even though acupuncture has a long-established tradition in Chinese medicine, modern science has not discovered anything that fits into the concepts of qi and meridians, to which the believer could reply with a charge of ad ignorantiam. But the skeptic's argument is reasonable: while one cannot categorically exclude the existence of qi and meridians, modern science is advanced enough that the BoP is on the believer to explain why this new form of energy has not yet been discovered, as well as how it would fit into the tightly knit logic of contemporary fundamental physics.

[6] As we pointed out above, any negative claim can of course be translated into a positive one: any existential claim can be translated into a negative universal, and vice versa ($\exists x Ax$ is logically equivalent to $\sim\forall x \sim Ax$, and $\sim\exists x Ax$ is logically equivalent to $\forall x \sim Ax$). The claim that *qi* energy exists is obviously a positive claim in that, it posits the existence of a biological entity/force.

Now consider a case of the argument from ignorance to establish a positive claim, in which the failure to disprove a hypothesis is taken as a presumption for accepting it. A notorious instance is that of senator McCarthy accusing American citizens of communist sympathies on the grounds that "there is nothing in the files to disprove Communist connections" (quoted in Walton 1999, 167). The charge seems gratuitous, because our intuition (and sense of fairness) tells us that the BoP falls on McCarthy to provide evidence for Communist sympathies, not on the accused to disprove such accusations, which may be very difficult to do. This moral intuition can be supported in terms of prudential BoP: we feel that the cost of falsely accusing and incriminating an innocent person is much higher than letting someone with real communist ties get off the hook. McCarthy may have begged to differ, of course, and indeed, his argument cannot be rejected as fallacious on purely formal grounds. The crux seems to be how large the threat of communism was for American society at the time, and how highly we value the moral principle of presumption of innocence. Presumably McCarthy had made a different prudential calculation (assuming he had actually given that much thought to the whole issue, which seems doubtful).

Less controversial examples also illustrate the problems with dismissing "ad ignorantiam" arguments on formal grounds. What about a skeptic who assumes that a newly discovered crop circle is man-made, on the grounds that there is nothing on the site that suggests otherwise? Or what about a biologist who assumes that the species she just discovered uses DNA as a mechanism of inheritance, on the grounds that this presumption has not been disproven? These arguments seem eminently reasonable, but they are formally equivalent to McCarthy's accusation.

It is then impossible to distinguish between legitimate and fallacious arguments ad ignorantiam on any formal grounds. The difference lies in acknowledged pertinent background and relevant likelihoods, which can be quantified in a Bayesian framework. Take the oft-heard mantra that "absence of evidence is not evidence of absence," typically brought up by defenders of notions ranging from that of a personal god to believers in UFOs, the Loch Ness monster or Bigfoot. Sometimes the dictum is true. For instance, there are many gaps in the fossil record studied by paleontologists and evolutionary biologists, but these gaps are well understood as the predicted outcome of the rarefied conditions that lead to fossilization. In contrast to the case of qi lines or UFOs, we have no reason to expect the fossil record to contain every intermediate form, and indeed, we have good, independent reason to expect it to be scattered and incomplete. In Bayesian terms, the likelihood P (E | H) is low in the case of fossil evidence for evolution (with respect to evolutionary theory), but it is high with respect to evidence for qi lines and ufology. If qi energy really exists, it should have a biological mechanism and empirical effects, and surely that would have been discovered by medical science by now.

So a creationist arguing against the currently accepted theory of evolution on the basis of fossil gaps is on shaky grounds because the BoP is on him, not on the geologist, to give scientists sufficient reason to reject their currently accepted background knowledge. The creationist should demonstrate that the likelihood of

digging up intermediate fossils for any given intermediate species, conditioned on the truth of evolution, is much higher than scientists admit. If the creationist fails to take up this BoP, he is committing a fallacious form of the argumentum ad ignorantiam.[7]

The skeptic too should have good reasons for assuming that the likelihood of documented evidence for UFOs, conditioned on the truth of frequent extraterrestrial visits, is reasonably high. As indeed it is. Surely a massive spacecraft landing on earth would leave material traces, or at least be (occasionally) captured on high-quality footage by now. All we have, however, is a handful of blurry photographs, reports of strange lights in the night sky and the occasional hoax.[8] Solid evidence for UFOs would be expected and yet is still lacking despite at least 67 years of continued and frequent (alleged) visits by aliens to earth.[9]

In short, BoP cannot be allocated on the basis of absence of evidence alone. Let's assume a case of equal priors (H and ~H), determined by the expert consensus on the issue, without prudential asymmetries. As a first move, defenders of ~H can put forward some argument why evidence E should be expected on H (high likelihood). Now the BoP moves to the defenders of H to produce E, and absence of evidence indeed constitutes evidence of absence. If defenders of H can either produce E, or provide an independently motivated explanation for why E should not be expected to occur given H (low likelihood), then they have fulfilled their BoP. The BoP now shifts back to middle ground. In the next stage, the defenders of ~H may give other reasons for thinking that the likelihood P (E | H) is high, or that some other piece of evidence F should be expected on H. Defenders of H can make similar moves, for example arguing that some evidence G should be expected if H were false, etc.

Overall, then, it seems that just shouting "logical fallacy" is not going to do it, either for the skeptic or the believer, and whether a given move during reasoned discourse can rightly be rejected as fallacious or not often depends on the agreed placement of the BoP. In the final section we are going to discuss some more general considerations aimed at helping critics and supporters of para- or extra-normal notions to keep their debate intellectually honest.

Conclusion: Keeping it Honest

The word "skepticism" has, of course, a long and venerable history in philosophy. When it comes to disputes about allegedly pseudoscientific notions, though, the term may refer to one of two distinct attitudes: one corresponds to someone who knows

[7] Instead of taking up the BoP when it is their turn to do so, creationists often try to shift a heavier burden back on evolutionists. For example, when biologists have pointed out possible intermediate forms leading up to some piece of functional complexity, which creationists had challenged them to do in the first place, the latter shifted the burden to the *actual* evolutionary history. The move is disingenuous, because ID arguments, such as "irreducible complexity" and "complex specified information," had been touted as objections *in principle* against the power of evolution by natural selection. See Boudry et al. (2010).

[8] Ufologists typically resort to invoking large-scale cover-ups to explain away this dearth of evidence—involving various governments, the Illuminati, the aliens themselves, or all of them together—but such explanations are blatantly ad hoc (Boudry and Braeckman 2011).

[9] The first modern flying saucers were reported by American private pilot Kenneth Arnold on 24 June 1947, over Mount Rainier in Washington State.

that the para- or extra-normal claim is wrong and is out to prove it. Although this may in fact be the case in many actual instances, such a figure is not at all intellectually interesting. The second meaning is the Humean sense in which "a wise man proportions his belief to the evidence" (Hume 1748). If we are to be honest Humean skeptics, though, we need to set the bar for evidence of extraordinary claims at the right level, not as low as a gullible believer would wish it, but not as high as for the BoP to be impossible to meet.

Modern skeptics are fond of quoting Carl Sagan's rendition of the Humean dictum mentioned above: "Extraordinary claims require extraordinary evidence." This is fine as far as it goes, but we clearly need criteria to credibly establish when a claim is indeed "extraordinary," and what would count as commensurate evidence. Hume's own famous argument against miracles is sometimes (uncharitably, we think) interpreted as amounting to a statement of the impossibility, not just very low likelihood, of miracles, and people who believe in ufological or paranormal phenomena echo that sentiment when they claim that skeptics will never be satisfied no matter how compelling the evidence is going to be.

However, as we mentioned above, Hume's approach in Of Miracles (1748) can be reasonably reformulated in Bayesian terms (Owen 1987; Sobel 1987), with the priors—and consequently the BoP—being set by the accepted background conditions pertinent to the dispute at hand. Seen from this perspective, all we need to avoid are the extremes of setting our priors to 0 (complete skepticism) or to 1 (complete belief), since no amount of data can possibly move us away from those limit cases. Indeed, there are some instances in the skeptical literature on pseudoscience where priors have significantly moved over time. For instance, while acupuncture is still criticized in terms of both the underlying theory and the exaggerated claims of its supporters, there may now be sufficient evidence of its limited efficacy that a skeptic needs to reconsider outright rejection (Cherkin et al. 2009). This is even more so for a variety of transcendental meditation techniques, where again one may reasonably reject the underlying metaphysics while agreeing that qua techniques they do work for a range of claimed effects (Tang et al. 2009).

If anything, it is harder to find prominent exponents of para- or extra-normal beliefs that have changed their mind in the face of skeptical arguments (though even those can be found, if one digs deep enough). Which brings us to the last point in this paper: discussions of BoP in the context of science vs pseudoscience disputes are, of course, a type of Wittgenstenian language game that presupposes a minimum commonality of standards. People cannot agree on how to fairly allocate BoP unless they find themselves at the least in the same ballpark when it comes to the type of background knowledge that constraints the priors pertinent to the dispute at hand. And that is precisely the most common obstacle in debates between skeptics and believers: the former too often simply reject out of hand even the possibility of an anomalous phenomenon turning out to be real, while the latter are equally quick to label the entire scientific enterprise as "too reductionist" or narrow minded to be able to come to terms with novel phenomena. This sort of impasse depends on a widespread lack of appreciation for the sort of epistemic issues we have described in this paper, but it also boils down at least in part to individual psychological attitudes, whereof a philosopher is better served not to speak.

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