HOW TO SAVE VAN FRAASSEN'S OWN ANTIREALISM: A MODEST PROPOSAL

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ABSTRACT

Bas van Fraassen's antirealist view of science and its aim, *constructive empiricism*, notoriously rests upon a distinction between observable and unobservable entities. In order to back his empiricist stance, the Dutch philosopher put forward his own characterization of observability. Nonetheless, he acknowledges that the point of constructive empiricism is not lost if the line is drawn in a somewhat different way from how he draws it. This means that other characterizations of observability can support this antirealist stance, provided they allow for a viable distinction between the observable and the unobservable. The aim of this work, however, is not to propose another characterization of observability that fits constructive empiricism, but to put forward a little amendment to van Fraassen's own antirealism, to the effect that it can actually be seen as a coherent position, albeit controversial, since its present consistency might be called into question.

Palavras-chave: antirealism, constructive empiricism, observability, realism, van Fraassen.

RESUMO

A vertente antirrealista acerca da ciência e de seus objetivos de Bas van Fraassen, o *empirismo construtivo*, repousa, como bem se sabe, sobre uma distinção entre entidades observáveis e inobserváveis. Para suportar a sua posição empirista, o filósofo holandês propôs uma certa caracterização da observabilidade. Entretanto, reconhece que o ponto do empirismo construtivo não está perdido se a linha divisória for traçada de modo diferente de como ele mesmo a traça. Isso significa que outras caracterizações da observabilidade podem sustentar essa *stance* antirealista, desde que contemplem uma distinção viável entre o observável e o inobservável. O objetivo desde trabalho, todavia, não é propor uma outra caracterização da observabilidade que seja adequada ao empirismo construtivo e sim sugerir uma pequena emenda ao antirealismo de van Fraassen, de modo que esse possa de fato ser considerado uma posição coerente, ainda que controversa, pois sua consistência atual poderia ser questionada.

Keywords: antirrealismo, empirismo construtivo, observabilidade, realismo, van Fraassen.

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Introduction

If one asks what the realism vs antirealism debate in the philosophy of science is about, a good answer comes from Anjan Chakravartty: "The essence of the controversy between realists and antirealists concerns the possibility of having knowledge of the unobservable" (CHAKRAVARTTY, 2007, p. xiii). In this area of philosophy, being an antirealist means being a 'non realist'; the prefix 'anti' indicating the refusal to endorse (typically realist) epistemological and/or ontological commitments to the unobservable entities posited by the theories we accept and use. As a matter of fact, the standard antirealist attitude - at least nowadays - is not the denial that unobservable entities exist, but rather an agnostic stance towards them, to the effect that accepting a scientific theory does not compel one to believe that it gives a true description of a putative unobservable reality.[2]

It is clear that in this field 'antirealism' and 'empiricism' amount to the same position.[3] In this context, "the empiricist's preoccupation with sense experience takes the form of a thesis about the role of *observation* in science" (SOBER 2008, p. 129), namely, that commitments to the unobservable are supererogatory. It can be legitimately maintained, in general, that the issue of observation and observability, although under different forms, constitutes a central topic of both the 20th and the 21st century philosophy of science - the realist side frequently seeming more an anti-antirealist stance than an independent one.

If these days the interest of many authors seems to be shifting towards structuralism, then, it should not be forgotten that any topic related to the role of observation in science - such as trying to establish what 'to observe' means or which is the scope of 'observable', wondering whether instrumental detections can be considered observations or not, etc. - is still absolutely crucial in the philosophy of science; at least for the realism/antirealism dispute.

Moreover, as Jennifer Nagel put it in the past decade, "the version of empiricism that constitutes the most influential contribution to traditional

[2] In his seminal work *Empiricism, Semantics and Ontology* (1950). Rudolf Carnap explicitly claimed that the thesis of the reality of the external world is a pseudo-question. However, this same thesis apparently underlies the debate between realism and antirealism (and philosophy of science in general), nowadays.

[3] For a comprehensive discussion of the various meanings of 'empiricism', with a focus on the philosophy of science, see SOBER (2008).

epistemology since the collapse of positivism has been put forward by Bas van Fraassen, in support of the view of science he calls 'constructive empiricism'" (NAGEL 2006, p. 240).[4] Constructive empiricism has been much discussed since it came into being in 1980, with the publication of van Fraassen's seminal book *The Scientific Image*. An extensive literature on observation and observability is part of this discussion, for these concepts play a decisive role in the antirealist stance promoted by the Dutch philosopher; but also because of van Fraassen's controversial position on this matter, particularly when it gets to the use of instruments in science.

Admittedly, while constructive empiricism is (still) recognized as a prominent antirealist position, there is also a general dissatisfaction with van Fraassen's treatment of the issue of observability. His position on the matter, however, is ancillary to the view on science and its aim that he proposed almost forty years ago, but not part of it (see, for example, HACKING 1983, p. 208 and BUENO 2011a; but also VAN FRAASSEN 2001, p. 162-163 and 2008, p. 110).

Since van Fraassen aims not only at the acknowledgment of his position as a coherent alternative to scientific realism (see KUSCH 2015, p. 172), but at making sense of science too (see BUEKENS & MULLER 2012, p. 94 and 99), there is room for alternative proposals concerning the observable/unobservable distinction, while preserving an empiricist spirit. Van Fraassen's notion of observability, in fact, may very well be coherent and meaningful; however, as Hasok Chang claimed, "his critics are correct when they argue that van Fraassen's notion of observability does not have all that much relevance for scientific practice" (CHANG 2004, p. 85). Alternative proposals can then be advanced, in case one thinks constructive empiricism can be brought closer to the actual scientific practice - provided she agrees with Chang, of course.

The aim of this paper, however, is not to propose another characterization of observability that fits constructive empiricism, but to put forward a little amendment to van Fraassen's own antirealism, to the effect that

[4] Van Fraassen's view of science is a version of empiricism - of course, as its name suggests - which is meant to be an antirealist stance. Right after presenting it in the first pages of his book *The Scientific Image*, in fact, van Fraassen adds: "This is the statement of the anti-realist position I advocate; I shall call it *constructive empiricism*" (VAN FRAASSEN, 1980, p. 12) - which confirms what has been said before: in the philosophy of science, 'antirealism' and 'empiricism' amount to the same position and are frequently used as synonyms.

it can actually be seen as a coherent position, albeit controversial, since its present consistency might be called into question.

Constructive empiricism, observability and observation

Constructive empiricism is probably the most prominent antirealist view of science nowadays, but it is not the only one. Still, van Fraassen gives the observable/unobservable distinction such a crucial role - and maintains such a controversial stand on the issue - that it can be hardly denied that it is the appearance of his empiricist stance in 1980 what brought back observation and observability to the center of the stage, in the debate between realists and antirealists over the last four decades.

What he wrote in 2005, in a paper called "The day of the dolphins. Puzzling over epistemic partnership", about what it means to accept a theory from a constructive empiricist point of view, leaves nothing to the imagination: "what the sciences say about the observable parts of the world is true, the rest need not matter. I'm putting this very roughly, but it is enough to make you see the immediate challenge" (p. 111). The epistemic weight put on the shoulders of 'the observable' is manifestly enormous.

The challenge, of course, includes clarifying what 'observable' means.[5] "What I mean by 'observable' here is just what is accessible to the unaided human senses" (2005, p. 111-112), explains van Fraassen in the same page. This is in line with both what he has always defended - and reaffirmed in his last book: "observation is perception, and perception is something possible for us, if at all, without instruments" (2008, p. 93); and with the 'rough guide' of 'observable' he proposed in *The Scientific Image*: "That something is observable does not automatically imply that the conditions are right for observing it now. The principle is: X is observable if there are circumstances which are such that, if X is present to us under those circumstances, then we observe it" (1980, p. 16).

This explains why, according to van Fraassen, celestial bodies such as the moons of Jupiter or an extrasolar planet are observable (see VAN

[5] Van Fraassen ends up putting forward a characterization of observability, in his works - albeit in a fragmentary way. His opinion, however, is that it is not a matter for philosophers: "If anyone wants to frame opinions about just what is observable, I would urge him to draw on physiology and psychology, and empirical science in general, and not to ask philosophers at all" (VAN FRAASSEN, 1992, p. 20).

FRAASSEN 1980, p. 16; and KOSSO 2006, p. 225, footnote 1), while a paramecium is not (see VAN FRAASSEN 2001, p. 160; and 2008, pp. 105-109). As he claims in "Empiricism in the Philosophy of Science" (1985), in fact, observability presents *special limits* that are due to the physiology of the human species (our epistemic community). It is because of them that *observable* is an indexical term (to van Fraassen, *observable* is short for *observable-to-us*) and that we cannot admit circumstances in which the constitution of the human species is modified - as, on the contrary, happens in the 1966 film "Fantastic Voyage". There are also *general limits*, that do not depend on the human physiology: these are spatial and temporal limits determined by Einstein's relativity theory. Interplanetary travels of human crews certainly fit within these limits and so there is no problem (?) in imagining contexts in which astronauts are in the vicinity of Jupiter or of an extrasolar planet.

Yet, constructive empiricism depends on a viable distinction between observables and unobservables, but not on *van Fraassen's* distinction: "To explain my view of what science is, and specifically what is its aim, I need a feasible distinction between what is observable and what is not",[6] wrote the Dutch philosopher in the preface to the Greek edition of *The Scientific Image* (2004, p. 1). It is then clear that feasible distinctions other than van Fraassen's own one can do the job. Ian Hacking understood this back in 1983: "Imagine a reader initially attracted by van Fraassen, and who thought that objects seen only with light microscopes do not count as observable. That reader could change his mind, and admit such objects into the class of observable entities. This would still leave intact the main philosophical positions of van Fraassen's anti-realism" (HACKING, 1983, p. 208).

Van Fraassen's own antirealism could not survive a modification in the scope of the observable, but constructive empiricism might survive it:

> What about the observable/unobservable distinction then? The main points of our discussion are not much affected by just where precisely the line is drawn. I draw the line this side of things only appearing in optical microscope images, but won't really mind very much if you take this option only, for example, for the electron microscope. After all, optical microscopes don't reveal all that much of the cosmos, no matter how veridical or accurate their images are. *The empiricist point is*

[6] Interestingly enough, back in 1968 Henry Byerly wrote: "If philosophical problems raised by *both* phenomenalism and instrumentalism are to be handled, it is necessary to characterize 'observables' more perspicuously" (p. 415) - which shows that the issue of observation and observability has indeed always been a central topic in the philosophy of science.

> *not lost if the line is drawn in a somewhat different way* from the way I draw it. The point would be lost only if no such line drawing was to be considered relevant to our understanding of science (VAN FRAASSEN, 2008, p. 110).

The point would be lost also in case we concluded that there are no limits to observability - as some authors sustain (see, for example, MITSUO NIXON, 2004). But even admitting that, say, electron microscopes produce visual evidence with the same epistemic status such as that produced by unaided human perception, the same could hardly be said of the evidence produced by a scanning tunneling microscope. Such a stand is defended by Otávio Bueno, a self-declared constructive empiricist, who in 2011 offered "a way of extending the observable beyond instances of unaided perception, but which still preserves, within an empiricist view, cases in which certain objects cannot be observed" (BUENO, 2011a, p. 290). Bueno's position is a good example of a version of constructive empiricism apparently closer to the actual scientific practice than van Fraassen's own one.

Telescopic and microscopic detections

According to van Fraassen, detection by means of instruments is to be distinguished from observation, for the latter is unaided (see VAN FRAASSEN, 2008, p. 93; and CONTESSA, 2006, p. 456). Likewise, he notoriously prefers considering instruments in general, and microscopes in particular, as 'engines for the creation of new phenomena' rather than 'windows on an invisible world' (see VAN FRAASSEN, 2008, p. 96-97; and KUSCH, 2015, p. 171).

This means that when he wrote that a look through a telescope at the moons of Jupiter is a clear case of observation, "since astronauts will no doubt be able to see them as well from close up" (1980, p. 16), he was not really admitting that it is possible to observe through telescopes - while it is not through microscopes. As Paul Teller explained, in fact, according to the originator of constructive empiricism, "what we do with a telescope does not itself count as observing (…) in the relevant sense" (TELLER, 2001, p. 126).

Whether one can observe through a device such a microscope or a telescope is, in truth, controversial - at least among philosophers. Martin Kusch thinks that "the engine-of-creation view is actually shared by constructive

empiricist and scientific realist" (KUSCH, 2015, p. 172), but this does not seem to be the case, for there are authors who claim that it is possible to perform observations through instruments (see, for example, ALSPECTOR-KELLY 2004).

Be that as it may, seeing the result of either a microscopic or a telescopic detection displayed in a monitor is increasingly common in nowadays scientific practice. In this case, no one can deny that what scientists observe is an image[7] - and that the instruments have acted as 'engines of creation'. How should one deal with such images? Are they veridical?

In the case of microscopes, van Fraassen claims that one is allowed to keep neutrality with respect to the existence of the entity allegedly represented by their outputs. In a quite famous passage from his 2001 paper "Constructive Empiricism now", the Dutch philosopher challenges the possible parallel with what is undeniably a picture of a real thing:

> If you see a reflection of a tree in the water, you can also look at the tree and gather information about the geometric relations between the tree, the reflection, and your vantage point. The invariances in those relations are precisely what warrant the assertion that the reflection is a picture of the tree. If you say similarly about the microscope's images that they are pictures of e.g. paramecia, then you are asserting that there are certain invariant geometric relations between the object, image, and vantage point. But now you are *postulating* that these relations hold, rather than *gathering information* about whether that is so (VAN FRAASSEN, 2001, 160).

[7] An already famous one was released a couple of months ago (April 2019). "The image (…) showed the edges of [a] black hole - called the 'event horizon' - for the first time" (BORENSTEIN, 2019). In order to produce the now-world-famous image of one of the largest known supermassive black holes - M87*, located at the center of Messier 87, a massive elliptical galaxy in the Virgo cluster, 53 million light-years away from Earth - a network of radio telescopes known as the Event Horizon Telescope was created; the telescopes were synchronized to focus on the same object at the same time and act as a giant virtual telescope. "As each telescope acquired data from the target black hole, the digitized data and time stamp were recorded on computer disk media. Gathering data for four days around the world gave the team a substantial amount of data to process. The recorded media were then physically transported to a central location because the amount of data, around 5 petabytes, exceeds what the current internet speeds can handle. At this central location, data from all eight sites were synchronized using the time stamps and combined to create a composite set of images, revealing the never-before-seen silhouette of M87*'s event horizon" (LUTZ, 2019). "It then took more than a year for that data to be processed into the first glimpse of images that scientists saw in the summer of 2018" (BORENSTEIN, 2019). We tend to consider a photograph on a par with an observation, i.e., as warranting (among other things) the belief in the existence of the represented entity. Does the same apply to the image of M87*? Is it even adequate to call it a photograph, as newspapers around the world did in April 2019? "There actually were a few academic holdouts who denied black holes existed, but now they can't, said Boston University astronomer Alan Marscher, who was on one of four imaging teams" (BORENSTEIN, 2019). Are scientists actually justified, now, in their belief in the existence of black holes?

Kusch explains that, according to van Fraassen, keeping neutrality about whether a microscopic image is a copy of a real thing or not is "more illuminating since it allows us to identify realist commitments [as] optional" (KUSCH, 2015, 172). Such neutrality, however, he then adds, does not prevent us from gathering information with microscopes. What about telescopes?

If Teller is right and van Fraassen never really meant that one can perform an observation through a telescope, he then surely considers that in this case the situation is analogous to that of the reflection of a tree in a pond - or else what would 'a clear case of observation' mean? But even in the case of the moons of Jupiter, we are in no position (from Earth, at least) to gather unaided information about the geometric relations between the moons, the image, and our standpoint - and therefore to claim that the invariances in those relations warrant the assertion that the image is a picture of, say, Ganymede.

The possibility of triangulating or comparing the entity represented by the image with the real one is only hypothetical and may never become reality. It seems more a logical/theoretical possibility than an actual one and relying on such an argument to defend a realist interpretation of the image produced by a telescope might not warm many people's hearts.

In the face of this, one might then want to modify the general limits of observability so that extrasolar planets and other celestial bodies are not classified as observable anymore (as happens with any object outside our light cone) and thus their observability status cannot be invoked to guarantee that a look at them through a telescope is a clear case of observation - whatever that means.[8] However, such a move would not solve the problem, for the very same situation can arise with terrestrial entities:

> do we or do we not observe foxes in pitch darkness using an infra-red camera? One might answer 'Clearly, yes' (denying that there is any vagueness), on the grounds that if there were adequate illumination we could see the foxes with unaided vision. But since the illumination is not actually adequate, it can only be our confidence in the camera which backs our belief in this counterfactual, and, if it is a vague matter how far instruments can expand the domain of the genuinely observable, it will be an equally vague matter when this confidence is justified (MENUGE, 1995, p. 61).

[8] Note that such an argument would not apply to *any* telescopic detection, for in many cases it is actually possible to triangulate and make a comparison with the real entity. This happens, for example, when one takes a look at *our* Moon through a telescope.

Leaving aside the question of whether it is possible to observe through an instrument or not, Angus Menuge's argument can be evoked to question van Fraassen's appeal to the observability status of an entity in order to support the belief that the image which represents it is veridical.

Still in 1982, Philip Hanson and Edwin Levy, authors of one of the first reviews of *The Scientific Image*, wondered why there should be a difference between accepting a theory about the moons of Jupiter - that van Fraassen considers observable, but that have never been observed directly - and one about bacteria - which belong to the class of the unobservable, since they can only be detected by means of a microscope. According to the two philosophers, statements about the moons of Jupiter or about bacteria are close to being evidentially on a par, for it is not clear "how the fact that we could in principle observe some objects directly gives greater evidential warrant to statements about such objects" (HANSON & LEVY, 1982, p. 291).[9] Hanson and Levy talk about statements, of course, but one might want to say that what goes for statements goes also for pictures of entities like bacteria or celestial bodies.

It is worth remembering another criticism along the same lines, made by Peter Kosso in the past decade and directed against van Fraassen, concerning the detection of extrasolar planets (ESPs):

> The constructive empiricism of Bas van Fraassen would classify ESPs as observable, on the grounds that a human being in the right place could see them with the naked eye. But this kind of externalist epistemology, allowing justification to rely on unavailable information (we are not in any position to see ESPs with the naked eye) is unhelpful in deciding which particular scientific claims warrant belief (KOSSO, 2006, p. 225, footnote 1).

Appealing to the observational status of the entity represented by a certain picture seems to be a very weak criterion, not capable of justifying the belief in the veracity of the image, and should probably be rejected - unless one does actually compare it with the real entity, as in the example of the reflection of a tree in a pond. Are there other criteria, capable of supporting

[9] Still in 1982, Paul Churchland made a similar comment: "I (…) fail to see how van Fraassen can justify tolerating an ampliative inference when it bridges a gap of spatial distance, while refusing to tolerate an ampliative inference when it bridges a gap of, for example, spatial size" (CHURCHLAND, 1982, p. 276).

van Fraassen's selective confidence in the images produced by the instruments used in science and acceptable to the originator of constructive empiricism?

Buekens' criterion

"Observing in a space of reasons" is a manuscript originally written by Filip Buekens in 1996 (revised in 1999), and that is circulating in the philosophy of science community ever since.[10] In the paper, Buekens stresses the importance of being able to identify an object from different points of view, so that it can be considered observable. Following Christopher Peacocke, who summarises P.F. Strawson's and Gareth Evans's views on what counts as an observable object, Buekens endorses a criterion almost 'tailor-made' for van Fraassen:[11]

> It is crucial to our conception of an observable object that it be the centre of a *perceptual polygon* - it can be perceived or observed from different angles (when the observer moves) and remain observable when it moves in space. (…) It comes with our concept of an observable object that it can be observed - identified - to be *that object* from different perceptual angles. The observer must be able to place it at the centre of a perceptual polygon. The 'able' in 'observable' partly depends on whether this condition can be fulfilled. The angles of the polygon are locations in space from which the observer is able to identify the object as it moves in space, or as he moves in that space (BUEKENS, 1999, p. 26).

According to Buekens, microscopic entities cannot be placed at the center of a perceptual polygon, for there is only one perceptual angle from which we have access to them, namely, the one provided by the instrument. Hence, they are not observable - note that there is no mention to the reliability of the instruments here. Following the same criterion, on the other hand, one is allowed to classify the moons of Jupiter as observable, since they can be perceived from different points of view - and because we can keep track of them as they move in space.[12] The same goes for anything that can be detected

[10] "Observing in a Space of Reasons" could originally be found in Buekens's page on Tilburg University's website. A new version of it (but with a different title), that dates 2005, was kindly sent to me by Professor Buekens in 2013. In an e-mail message of 28 October 2013, he authorized citing both 1999 and 2005 (unpublished) versions.

[11] The argument van Fraassen presents in "Constructive Empiricism now" seems to be inspired in this criterion, but there is no mention to Buekens in the paper.

[12] Keeping track of the object of perception is (quite obviously) considered as a characteristic and constitutive feature of observation (see, for example, GHINS, 2005, p. 96).

through a telescope.[13] Is van Fraassen's different treatment of the outputs of microscopes and telescopes finally backed up?

Unfortunately, Buekens's conclusions do not seem to apply to the case of the paramecium (and of many other microscopic entities). As a matter of fact, this microorganism *can* be perceived or observed from different angles, when the observer moves, and remains observable when it moves in space. *Contra* Buekens, it is therefore possible to say that the paramecium can actually be placed at the centre of a perceptual polygon. It is not true that we have only one angle from which we have access to it, despite this being provided by the instrument. Paramecia *do* satisfy Buekens's observability criterion.

Moreover, in the passage above Buekens implicitly admits the possibility of performing observations through instruments. It then becomes clear why van Fraassen almost ignored the criterion presented in this section.[14] It is not 'tailor-made' for him, as perhaps Buekens thought it was. If one wants to defend van Fraassen's antirealism, Buekens's criterion is actually of no help.

What then?

In *The Scientific Image* van Fraassen wrote: "Seeing with the unaided eye is a clear case of observation" (p. 16) - which is unquestionable. A few lines further on, still in the same page, he added: "A look through a telescope at the moons of Jupiter seems to me a clear case of observation, since astronauts will no doubt be able to see them as well from close up". In line with van Fraassen's idea that "the language of science must be literally understood" (VAN FRAASSEN, 1980, p. 11), one might then be tempted to interpret in a literal way the above claim about telescopic detections (of the moons of Jupiter, at least) - which seems a quite natural thing to do - and judge that, according to the originator of constructive empiricism, it is actually possible to observe even when one uses a telescope - while the same is not possible with a microscope.

"Since we can't see things that don't exist" (VAN FRAASSEN, 2001, p. 158), this argument would give a robust support to a realist interpretation of

[13] This is why it has been said that the criterion put forward by Buekens seems to be 'tailor-made' for van Fraassen.

[14] "Observing in a Space of Reasons", in its 1996 version, is marginally mentioned by van Fraassen in his 2002 book *The Empirical Stance*.

an image produced by a telescope - and to van Fraassen's dichotomic attitude with respect to telescopes and microscopes. However, there is a clear *petitio principii* here, for claiming that it possible to perform an observation through a telescope because the detected entity is observable is obviously circular. If one wants to sustain that telescopic detections are observations, other reasons must be put forward.[15]

As is well known, Galileo Galilei defended the veracity of the detections made by means of his *cannocchiale* on the grounds that through it one could also observe familiar terrestrial entities. Why should it deceive us when aiming the instrument at celestial bodies? Now, while it is quite natural to agree with the father of the scientific method and reject his opponent's famous counterarguments, van Fraassen would not be too happy with such a line of reasoning, for the above argument is notoriously used to support a realist interpretation of microscopic detections too:

> Examples of overlap arguments are familiar to all of us. We trust what we see through a low-powered telescope because its domain of applicability overlaps what we can see with the naked eye, and within the visual domain the telescope reproduces accurately, precisely, and with good resolution familiar features of the world. I see my wife on the plain over yonder, and when I train the telescope on her, there she is again, simply larger and clearer. I can just see the fruit fly on the microscope slide - I put it under the low-powered microscope and here it is; I can see the head in much more detail through the greater resolution of the microscope (HUMPHREYS, 2004, p. 18).

Here is a picture that shows how the overlap argument can be used to justify a realist interpretation of the detections performed with an electron microscope - and how microscopes are actually calibrated against each other:

[15] A couple of decades ago, Jesús Mosterín made the following comment: "We do not have at our disposal any satisfactory philosophical account of the notion of observation which fully incorporates its technology-mediated character in modern science" (MOSTERÍN, 1998, p. 73). It is not clear that the situation has changed since then - provided one agrees that observation can be technology mediated, of course.

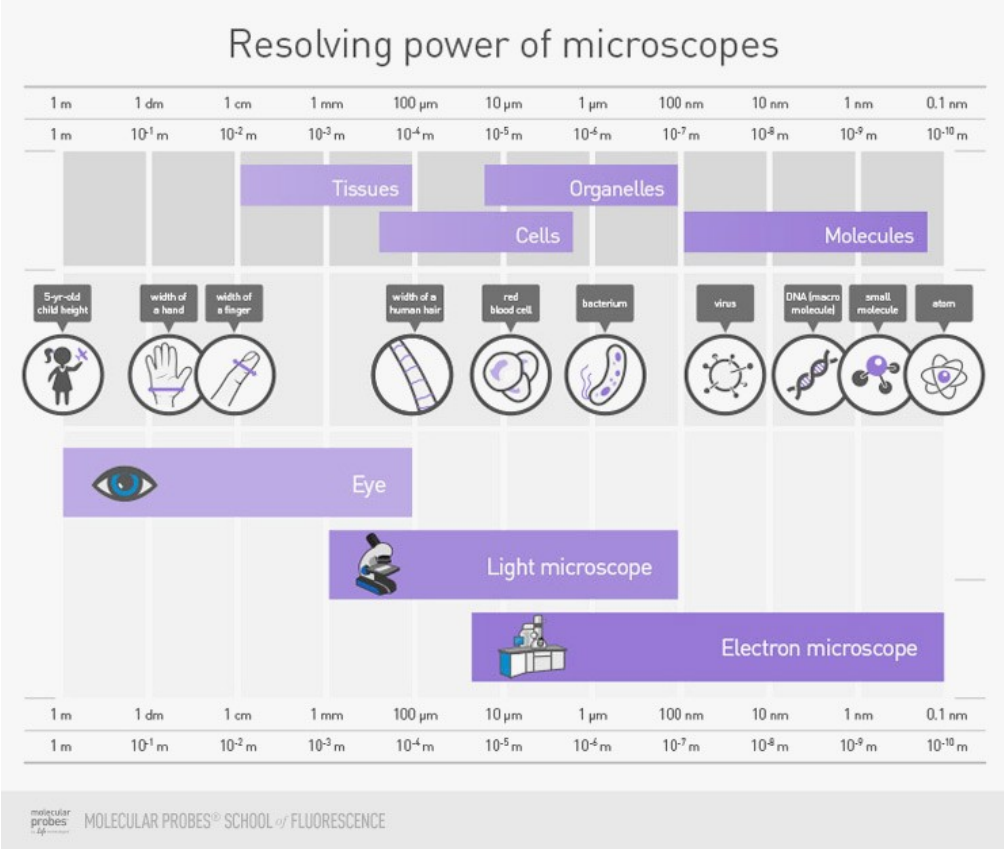

Figure 1. The resolving power of various microscopes, with representative objects within range for both light microscopes and electron microscopes. Source: <https://www.thermofisher.com/br/en/home/life-science/cell-analysis/cell-analysis-learning-center/molecular-probes-school-of-fluorescence/fundamentals-of-fluorescence-microscopy/epifluorescence-microscope-basics.html>

Of course van Fraassen would not be willing to accept such an argument as a justification of the belief in the veracity of the output of an imaging instrument, on pain of having to admit that bacteria are observable too - and thus jeopardizing his own antirealism.[16]

Alternatively, a quite obvious way of supporting a realist interpretation of the use of the telescope is by appealing to the reliability of the instrument; but of course the same argument can also be invoked by the supporters of a realist interpretation of the use of the microscope - not to mention that geometrical optics is the theory behind the construction of both optical telescopes and light microscopes. The same happens in case one wants to rely on a counterfactual argument such as the one Bueno put forward in 2011

[16] Unless he maintains that while such an argument works for telescopes, it does not in the case of microscopes; but it is very unlikely that van Fraassen would make such a claim.

(Bueno actually uses it to defend a realist interpretation of the use of most kinds of microscopes!):

> (i) Had the scene before our eyes been different (within our cognitive device's sensitivity range), our perceptual experience would have been correspondingly different. (ii) Had the scene before our eyes been the same (within our cognitive device's sensitivity range), our perceptual experience would have been correspondingly the same (Bueno 2011a: 278, our translation).[17]

In sum, it seems that when it gets to interpreting the function of telescopes and microscopes, these instruments are actually on a par: any argument one puts forward in support of a realist interpretation of the use of the first - meaning here either the admission that it is possible to observe through them or the claim that their outputs are veridical - can also be invoked to support a realist interpretation of the use of the latter. The only exception seems to be van Fraassen's appeal to the observability status of the detected entity, which should allow for a different treatment of telescopes and microscopes. This argument, however, only works when there is an actual comparison between what is detected and the real object (or between the image produced by the instrument and the real object);[18] otherwise, the line of

[17] See also Noë (2003, p. 94-97) and, for a version of these counterfactual conditionals specific for microscopes, Bueno (2011b, p. 256). Note that here Bueno clearly admits that perception can be instrument mediated - such as happens with Bueken's criterion. As said before, this should allow to extend the observable beyond instances of unaided perception; and yet, within an empiricist view, there should be cases in which certain objects cannot be observed (see BUENO, 2011a, p. 290). According to Bueno, in fact, "not only should perception offer a reliable information generation process, but it must be such that one *knows* that the process is indeed reliable; or, at least, we should have access to the factors sustaining its reliability" (BUENO, 2011a, p. 281, our translation). This *internalistic requirement* should ensure that a viable distinction between observable and unobservable will always exist, for in cases such as that of the scanning tunneling microscope it is not obvious at all that one can know that the relevant counterfactual conditions are satisfied; therefore, maintaining an agnostic attitude in this case is perfectly legitimate. *Salve*, van Fraassen!

[18] A quarter of a century ago, remote sensing was a quite new discipline. From it, William Seager borrowed the locution 'ground truth', which fits relatively well what has just been said: "The term 'ground truth' comes from the relatively new and, I am told by some, faintly disreputable discipline of Remote Sensing. Satellite or aircraft images of both observable and unobservable features of the earth can be formed through a variety of techniques such as x-ray imagery, infrared imagery, side-scan radar and the like, and these are said to reveal important more or less large-scale terrestrial phenomena. The interpretation of such images is not straightforward, though they do give every appearance of imaging something. Let's say that an infrared image of a field shows up certain 'patches' of diseased potato plants, revealed as such by the color of these patches in the infrared image although this is 'false color' of course, selected by film technicians, since we don't see infrared (…). We know that such images are reliable because we have obtained ground truth: somebody, sometime, went to see just what corresponded with what in an infrared image of a real field of potatoes" (SEAGER, 1995, p. 469).

reasoning is too weak - or even circular, in case one maintains that a detection performed through a telescope is an observation.

No way out for van Fraassen's selective antirealism then?

Conclusion: did van Fraassen pick an unnecessary fight?

In the previous sections we have seen that, according to Kusch, in discussions about the function of instruments in science, the engine-of-creation view is shared by constructive empiricists and scientific realists (see KUSCH, 2015, p. 172). Since it was van Fraassen who put forward this view, Teller explained that for a constructive empiricist a look through a telescope does not count as an observation in the relevant sense (see TELLER, 2001, p. 126), notwithstanding the fact that the originator of this antirealist stance wrote that it is a *clear case* of observation (see VAN FRAASSEN, 1980, p. 16).

Still, van Fraassen does not consider that the situation is the same as that of a paramecium detected via a microscope, for in the case of this protozoarium we cannot empirically investigate the geometrical relations between the eye, the microscopic image and the postulated unobservable entity. "For the constructive empiricist this is the difference that makes all the difference: since we are unable to study the geometrical relations between empirical and postulated entities, we are entitled to suspend belief in the latter" (KUSCH, 2015, p. 172).

In case one detects the moons of Jupiter through a telescope, on the other hand, she can in principle compare the instrumental detection with the real entities, "since astronauts will no doubt be able to see them as well from close up" (VAN FRAASSEN, 1980, p. 16). Now, if the truth be told, van Fraassen has never clarified his position on telescopic detections, but it seems quite straightforward that to him microscopes and telescopes are not a par, since in the first case it is not possible to compare the instrumental output with the entity allegedly detected, while in the second it is, at least in principle - again, were this not the case, what on earth would 'a clear case of observation' mean then (and, especially, why adding that it is so since astronauts will no doubt be able to see the moons of Jupiter as well from close up)?

As discussed before, however, appealing to the observability status of the detected entity, in order to establish whether an instrumental output is

veridical or not, is a very weak criterion - if not wrong, for it has 'a circularity flavor' - and should be rejected. Again, Kusch stresses the importance of "reading the results of science in a way that is neutral with respect to the debate between scientific realist and constructive empiricist" (2015, p. 180). Why should this be the case only when it gets to microscopes?

Perhaps the neutral way to read the results of science *with respect to the debate between scientific realist and constructive empiricist* entails interpreting realistically the outputs of a telescope, for this seems to be a position actually shared by the common-sense-realist van Fraassen[19] and his opponents.[20] Therefore, if "van Fraassen is entitled to demand that the scientific evidence be rendered in a neutral way, and that this neutral way is precisely the constructive-empiricist interpretation" (KUSCH, 2015, p. 180), one might think that the veracity an image of the moons of Jupiter is not a topic in hand.

However, Kusch focuses only on microscopes because his aim is to defend van Fraassen's view on these instruments in particular, but in the same paper he acknowledges the possibility of maintaining a neutral attitude with respect to telescopic detections:

> Note also that our readiness to speak of 'seeing' in the case of, say, the Hubble Space Telescope (HST) or the Scanning Tunnelling Electron Microscope (STEM) is rather unstable (…). Upon first encountering images produced by the HST or the STEM most 'naïve' subjects are indeed happy to speak of the HST allowing us to see very distant objects in the universe, or the STEM enabling us to observe nanoscale objects. And yet, the naïve subjects' willingness to speak of seeing and observing in these cases is easily disrupted. Once the subjects learn how the images are produced, and how much computer enhancement is involved - e.g. all the colours are computer generated - they begin to withdraw terms like 'seeing' and 'observing' (KUSCH, 2015, p. 178).

The same, one might add, happens with the images produced by telescopes, such as the one that has recently become known as 'the first photo ever captured of a black hole'. Once the subjects learn how the image has been produced, [21] and how much computer enhancement is involved - e.g. all the

[19] "I try to be an empiricist, and as I understand that tradition (what it is, and what it could be in days to come) it involves a common sense realism in which reference to observable phenomena is unproblematic: rocks, seas, stars, persons, bicycles…" (VAN FRAASSEN, 2008, p. 3).

[20] In this paragraph, 'constructive empiricist' should then be read as meaning 'van Fraassen'.

[21] "Astronomical observations often take place in astronomical observatories, but nowadays the telescopes in the observatories lack eye-pieces for direct observation by the astronomer. Instead, nitrogen or helium refrigerated CCDs occupy their place. The astronomers are in a

colors are computer generated - they will probably begin to withdraw terms like 'photograph' and 'veridical'.

I will then borrow another passage from Kusch's work and suggest that a second idea for motivating the coherence of an agnostic stance with respect to the outputs of a telescope is based on the fact that the engine-of-creation view is, according to the Austrian philosopher, actually shared by constructive empiricists and scientific realists. "Van Fraassen suggests that we do not need to go beyond this common baseline. We might think of the microscope image as a copy of a real thing, invisible to unaided perception, but '…it is accurate and in fact more illuminating to keep neutrality in this respect…' (2001, 155; 2008, 109). It is more illuminating since it allows us to identify realist commitments [as] optional" (KUSCH, 2015, p. 172).

Accordingly, I claim that we might think of the *telescopic* image of a black hole or of an extrasolar planet as a copy of a real thing, invisible to unaided perception (from Earth), but it is accurate and in fact more illuminating to keep neutrality in this respect - unless one does actually compare the telescopic detection with the real entity. Such neutrality does not prevent us from gathering information with telescopes. "And it does not prevent us from focusing on the regularities in the phenomena that Hacking too rightly stresses" (KUSCH, 2015, p. 173).

Saying that a look through a telescope is an instance of observation is clearly at odds with the claim that observation is unaided perception. But maintaining that the output of such an instrument is a faithful representation of a real state of affairs on the grounds that it is in principle possible to compare the produced image with the represented entity (or entities) does not seem to be an acceptable criterion either. In most cases, in fact, as said before, it seems more a logical possibility than a physical possibility. Think of the exoplanet *Beta Pictoris b*, for instance. Will a human being ever be capable of directly observing a planet which is 63 light-years away from Earth? I do not think so.

One might quite rightly say, then, that an extrasolar planet and a paramecium are actually "close to being evidentially on a par" (HANSON &

separate room and watch the screens of their computers (…).What the astronomer sees on the screen has gone through multiple transductions of photons into electric charges and currents, and electronic transformations inside the computer, till finally the last electrons are transduced back to photons in the cathode ray tube of the computer screen" (MOSTERÍN, 1998, p. 70).

LEVY, 1982, p. 291) and that, being so, telescopic images should receive the very same treatment van Fraassen grants to the microscopic ones. Unless one does actually compare the output of a telescope with the part of the real world depicted in it (remember Seager's 'ground truth'), it is accurate and in fact more illuminating to keep neutrality with respect to the claim that the image is a copy of a real thing. As in the case of the microscopes, it is more illuminating since it allows us to identify realist commitments as optional.

"As constructive empiricism has it, there is nothing incoherent in the thought that we find out by inference, not observation, 'how unobservable things are' (where 'unobservable' means unobservable by our naked eyes)", says Kusch (2015, p. 179). In most cases of telescopic detections, the situation is exactly that described by the Austrian philosopher. There is nothing incoherent in the thought that we find out by inference, not observation, 'how extrasolar planets are', for example.[22]

Moreover, it is my contention that even if van Fraassen admitted that it is accurate to keep neutrality - and thus that realist commitments are optional - also in the case of the images produced by telescopes, his antirealism would not be affected. If observation is unaided perception, a telescopic detection makes no difference at all for the observability status of the detected entity (or entities). Being so, it does not affect the constructive empiricist's belief in the existence of extrasolar planets and the like either.

This also means, however, that an image of an exoplanet cannot guarantee that the depicted celestial body exists and therefore cannot justify the related belief; it can only offer, at most, Popperian-style corroboration. On the other hand, if van Fraassen kept a neutral attitude with respect to the outputs of a telescope, such as he does with the microscopic ones, the present consistency of his antirealism would not be called into question, for it would not be resting upon an objectionable criterion - that an instrumental detection is on a par with an actual observation, when the detected entity is an observable (which is what it means to claim that a look through a telescope at

[22] One might think that the observability status of the celestial bodies strengthens the inference, in the case of telescopic images; and so that there still is a difference with the images produced by a microscope. I would find this questionable, for the reasons seen in this work (see Kosso's argument, for example); but, admittedly, it would be less 'compromising' than using this same argument as a justification for the belief in the veracity of the telescopic outputs.

the moons of Jupiter is a clear case of observation since astronauts will no doubt be able to see them as well from close up).

In conclusion, van Fraassen might have picked an unnecessary fight, with his claim about the telescopic detection of the moons of Jupiter. As a matter of fact, whichever way one interprets his branding such a detection as 'a clear case of observation', serious objections may arise. Perhaps a more modest attitude, like acknowledging that the assertion of the veracity of an instrumentally-produced image can only be vindicated by a comparison with the real state of affairs (even in the case of nocturnal foxes and other 'Menuge-like' situations), could prevent this from happening. Van Fraassen's own antirealism would easily survive this admission and the originator of constructive empiricism could avoid the eventuality of being charged with applying double standards with respect to instrumental outputs.

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