

Kusch and van Fraassen on Microscopic Experience

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Abstract: Martin Kusch has recently defended Bas van Fraassen's controversial view on microscopes, according to which these devices are not "windows on an invisible world", but rather "image generators". Both authors also claim that, since in a microscopic detection it is not possible to empirically investigate the geometrical relations between all the elements involved, one is entitled to maintain an agnostic view about the reality of the entity allegedly represented by the produced image. In this paper I argue that, contrary to what Kusch maintains, this might not be a neutral way to render scientific evidence. Moreover, a constructive empiricist can support a realist interpretation of microscopic images. In fact, constructive empiricism and van Fraassen's own anti-realism do not necessarily amount to the same thing.

17

Key-words: constructive empiricism, Kusch, microscopes, theory-ladenness of experience, van Fraassen.

Kusch y van Fraassen sobre la experiencia microscópica

Resumen: Recientemente, Martin Kusch ha defendido la controvertida posición de van Fraassen acerca de los microscopios, según la cual estos instrumentos no son “ventanas a un mundo invisible”, sino más bien “generadores de imágenes”. Ambos autores sostienen que, dado que en la detección microscópica no es posible investigar empíricamente las relaciones geométricas entre todos los elementos implicados, uno está autorizado a mantener una posición agnóstica sobre la realidad de la entidad presuntamente representada por la imagen producida. En este artículo argumento que, contra lo que sostiene Kusch, esto podría no ser una manera neutral de formular la evidencia científica. Además, un empirista constructivo puede apoyar una interpretación realista de las imágenes microscópicas. De hecho, el empirismo constructivo de van Fraassen y su propio antirrealismo no son necesariamente una misma cosa.

Palabras clave: empirismo constructivo, Kusch, microscopios, carga teórica de la experiencia, van Fraassen.

81

In his “Microscopes and the Theory-Ladenness of Experience in Bas van Fraassen’s Recent Work”, Martin Kusch discusses van Fraassen’s notoriously controversial view on microscopes (see Kusch 2015). Countering the quite usual perspective under which these devices are seen as “windows on an invisible world”, the originator of constructive empiricism prefers to consider them as “engines for the creation of new phenomena”; i.e., of new observables that scientific theories must account for. According to van Fraassen, the same metaphor can guide our interpretation of the use of instruments in general (see van Fraassen 2008: 96–99). Kusch’s work is a defense of van Fraassen’s stand against some of the criticisms that appeared since *The Scientific Image* was published in 1980.

In this paper I introduce and discuss Kusch’s arguments. In particular, I will maintain that a constructive empiricist position does not necessarily match van Fraassen’s own anti-realism. I will also maintain that, because the Dutch philosophers’ view on science aims at making sense of science, maintaining that it is a legitimate alternative to scientific realism, on the ground that it is not proven to be incoherent or false by its opponents (see Kusch 2015: 172), is not enough.

1. *On van Fraassen's reply to Hacking*

The first criticism I want to consider is Ian Hacking's famous paper on microscopes (see Hacking 1981), which offers three specific arguments to undermine van Fraassen's view: the "manipulability argument", i.e., the "microscopists' practical ability to interfere with the entity on the microscope slide that convinces them of the reality of the structures they observe" (Kusch 2015: 169); the "argument from preposterous coincidence" (as Kusch calls it), which claims that it would be a "cosmic coincidence" if different kinds of microscopes, functioning according to very different physical principles, produced similar outputs; and the well-known "argument of the grid". While van Fraassen ignores the first one, all of them are addressed by Kusch, who nonetheless takes the Dutch philosopher's answer (see van Fraassen 1985) to be on target.

I am afraid that van Fraassen's reply to the "argument of the grid" might fail to convince all, however. Kusch presents Hacking's argument in these terms:

Assume we draw a grid and reduce it photographically until it is no longer visible. Assume further that we then place the (photographically reduced) object under a microscope; if the latter is working properly, then we are going to see the original grid again (Kusch 2015: 169).

19

Hacking (1983: 2003) adds that one knows that what we see through the microscope is veridical "because we made the grid to be just that way". According to van Fraassen (and Kusch), Hacking is begging the question:

van Fraassen detects a circularity here. It is a precondition of the possibility of our knowing that the microscopic image is veridical that the photographic reduction has maintained the structure of the drawn grid. And it is a part of the evidence for the belief that photographic reduction has maintained the structure of the drawn grid that the microscopic image is veridical (Kusch 2015: 170).

In order to know that the microscopic image is veridical, however, one might be happy to just compare it with the original (visible to the naked eye) one. Do we actually have to make assumptions before reaching the conclusion that the microscopic image faithfully replicates the grid we have drawn and then photographically reduced? Perhaps we do not.

Now, Hacking may have not been very clear (or even unhappy) when he said that we made the grid to be just that way, but he adds: "Moreover

we can check the results with any kind of microscope” (Hacking 1983: 203). Kusch ignores this addendum, however, as it has allegedly been answered before in reply to the “argument from preposterous coincidence”: “we might have used the first microscope as the standard for the correctness of the output of the second. But then the two microscopes cannot count as independent witnesses of a real structure” (Kusch 2015: 170; see also van Fraassen 1985: 297–298). Microscopes are calibrated against each other, says van Fraassen; therefore checking the result of one by relying on another is redundant and, above all, inconclusive.

This answer is not completely convincing either, since calibration is a bit more refined operation than van Fraassen and Kusch think it is.¹ Not to mention that claiming that “we do not need the ‘imputed unobservable structure’ in order to explain the similar or even identical outputs of the two microscopes” (Kusch 2015: 170), since the sameness of the input suffices to explain this circumstance, might not be true. As a matter of fact, it might suffice in case one knows that the imputed entity is actually interacting with similar mechanisms, which is what Kusch maintains (see Kusch 2015: 170; in van Fraassen 1985: 298 there is no mention to the alleged similarity of the microscopes); but Hacking is quite clear in stressing that he is talking about devices that function according to very different physical principles – “two totally different kinds of physical systems” says Hacking (1983: 202). They just share the name ‘microscope’, one might add, but are different instruments. Why shall we say that they are similar then?

10 |

It would be better, in this case, to just stick to the sameness of the inputs – as van Fraassen apparently does – and insist that there is no need for further explanations. For it is “such an unlimited demand for explanation [that] leads to a demand for hidden variables, which runs contrary to at least one major school of thought in twentieth-century physics” (van Fraassen 1980: 23; see also van Fraassen 1989: 178). But would this be appropriate?

Then again, it is not only by verifying whether another microscope provides the same output that the belief in the veridicality of the produced image is warranted. Not only can we generally check the results with any kind of microscope, but in the case of the grid, we can check the result with the original grid too.

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¹ Moreover, saying that “we might have used the first microscope as the standard for the correctness of the output of the second” might not be very effective, unless we do know that this is the case. Otherwise, a very obvious reply could be: “but we don’t have!”.

2. *On van Fraassen's reply to Teller*

Since van Fraassen ignored Hacking's "manipulability argument", Kusch passes then to Teller's phenomenological objection against van Fraassen's application of his "engine of creation" metaphor to all the instruments used in science (see Teller 2001). A reply to the argument from manipulative realism is nonetheless left for the second part of the paper, when Kusch links the realist interpretations of the use of microscopes to the issue of the theory-ladenness of experience.

Teller has a say about van Fraassen's metaphor: it might very well work for devices such as the oscilloscope, says the author of "Whither Constructive Empiricism?" (see Teller 2001) but not for the stethoscope or the microscope. These instruments, in fact, allow their users to perform direct observations.

Van Fraassen replies to Teller in his "Constructive Empiricism Now" (2001) (and in his last book too, see van Fraassen 2008); yet he ignores the stethoscope case – so does Kusch, accordingly – probably under the assumption that the response to the microscope case is enough (it would have been interesting to hear what he and Kusch have to say in the stethoscope case too, though). At any rate, Kusch considers van Fraassen's counter-argument on microscopes effective.

I 11

Still, some few remarks are worth considering. First, it is certainly true that the microscope's output can be sent into a scanner that transmits to a computer or projector, so that we can see the image on a monitor or a screen, as van Fraassen explains (see 2008: 106). The tenet that we are seeing the microstructure of the object on the slide (rather than an image) vanishes at the moment we scan and project the image on a screen, adds Kusch (see 2015: 176). The same is true of telescopes as well, though.²

Of course this is not news. In *The Scientific Image* van Fraassen wrote: "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" (van Fraassen 1980: 16). This may lead one to think that van Fraassen admits that it is possible to observe through

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² Van Fraassen's reply to Teller can be read as an answer also to William Seager, who in a 1995 paper on the debate between Hacking and the Dutch philosopher invites the latter to provide an alternative description to the former's "manipulability argument": "The anti-realist owes us an alternative understanding of our micro-practices which can dissolve our sense of conviction or at least explain it in terms which do not presuppose the reality of microstructure" (Seager 1995: 461).

telescopes – while not through microscopes. But Teller explained that in spite of the above, “what we do with a telescope does not itself count as observing (...) in the relevant sense” (Teller 2001: 126). As I said in the introduction, according to van Fraassen the engines-for-the-creation-of-new-phenomena metaphor can guide our interpretation of the use of instruments in general, not only of microscopes (see Van Fraassen 2008: 96-99; see also Kusch 2015: 171).

Does this mean that one could keep neutrality with regard to the existence of the entities allegedly represented by an image obtained through a telescope? Are realist commitments optional in this case as well, as it happens with microscopes (see Kusch 2015: 172-173)? Of course they are, or at least no less optional than the commitments one can assume in the case of a microscopic image. True, in the case of the telescope, it is in principle possible to empirically (here meaning with no instrumental assistance) investigate the relations between the eye and the telescopic image on the one side, and the postulated observable entity on the other side – while it is not in the microscope case, according to van Fraassen and Kusch.³ But it seems a logical rather than a physical possibility, in most cases. Think of the exoplanet *Beta Pictoris b*, for instance. Will a human being ever be able to observe a planet that is 63 light-years away from Earth? I do not think so. Following Philip Hanson and Edwin Levy, one might say that exoplanets and bacteria are actually “close to being evidentially on a par” (Hanson and Levy 1982: 291). Van Fraassen has given us an account of microscopes; he owes us one of telescopes too. Or so I argue.

12 |

Be that as it may, another brief remark is on Kusch’s implicit idea that a constructive empiricist should share van Fraassen’s vision on the outputs of any type of microscope (see 2015: 172). My opinion is that one can be a constructive empiricist even admitting a realist interpretation of some microscopic images instead. Van Fraassen seems ready to admit that:

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³ The locutions “empirical” and “detectable with no instrumental aid” are considered as synonyms by the two philosophers. Clearly, then, saying that it is not possible to perform observations through a microscope, because it is an “engine of creation” (of images), rather than because it is not possible to empirically prove what one allegedly sees when using this device, only apparently prevents van Fraassen from one possible charge of circularity: that it is not possible to observe through a microscope because it not possible to detect the same object without it, which would be the result of taking for granted in advance that observation is unaided detection. In fact, the very same charge resurfaces when the issue is the veridicality of the images produced by microscopes (see Kusch 2015: 172). Actually, the issue of circularity seems to lurk under the surface of the whole discussion on microscopes.

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 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: 110).

In view of these considerations, perhaps it would be more cautious not to use "van Fraassen" and "constructive empiricist" as interchangeable locutions – as Kusch instead does. Constructive empiricism can survive the admission of the reality of bacteria and paramecia (see also Hacking 1983: 208); van Fraassen's own anti-realism cannot. They are two different positions.

3. On van Fraassen's reply to Alspector-Kelly

The third and more important attack to van Fraassen's position on microscopes is analyzed by Kusch thereafter. It came from Marc Alspector-Kelly in his article "Seeing the Unobservable" (see Alspector-Kelly 2004), which Kusch takes to be a mere development and refinement of Hacking and Teller's previous arguments. Alspector-Kelly in fact claims that "the sense that one really is looking at something real when one looks through the microscope at a cell remains phenomenologically irresistible" (2004: 336); which of course reminds Teller "phenomenological objection" and Hacking's "dramatic sense of the reality" of what one (apparently) sees when one looks through such device (see Alspector-Kelly 2004: 332).

Alspector-Kelly is explicit about the pull the argument from phenomenology has on him. Like Hacking he aims to underpin it with further, allegedly independent, reflections some of which try to turn the tables on van Fraassen. But here too the constructive empiricist can make a plausible case that the further arguments are toothless without the argument from phenomenology, and that the latter invokes a realist theory-laden experience (Kusch 2015: 181).

Alspector-Kelly claims that van Fraassen's idea that observation is unaided perception is neither a conceptual truth nor an obvious result of

our intuitive judgments.⁴ Therefore, van Fraassen's stand should be backed up by an argument – or better by a philosophy of perception (see Alspector-Kelly 2004: 332). In other words, a discussion about what “to observe” means should precede a debate on the alleged possibility of performing an observation by means of some instrument.

Alspector-Kelly's arguments are meant to show that one can actually see paramecia and other microscopic entities through a microscope.⁵ One line of reasoning is that epistemic considerations shape our use of “to see”; and since this use tracks correlation and fidelity and very often instruments score better than unaided perception in this respect, then we should admit that in some cases we do observe through them.

Kusch answers that other factors are involved in the determination of the scope of the verb “to see”, such as analogy. Therefore, Alspector-Kelly is not allowed to stick to correlation and fidelity only. However, if “seeing a dream” or “seeing a hallucination” is a legitimate way of speaking, as Kusch seems to suggest (see 2015: 178), then this might rather be a point in favor of Alspector-Kelly's argument than the contrary. It is van Fraassen, in fact, the one who wants to limit the scope of the verb to a very narrow range and exclude instruments. But if we can see a dream or a hallucination, then why couldn't we also see a paramecium or a microstructure in a blood cell through a microscope?

14 |

Our intuitive judgments are another important factor in determining our applications of “to see”. According to van Fraassen (1992: 18), “the word ‘observe’ (...) has a common use, more or less the same as that of ‘perceive’”. The same is true of the word ‘observable’ (...). In philosophical discussion I take it that it is meant to have its common use, unless otherwise indicated”.⁶ Which is the common use of the verb “to see”? Which are the criteria that govern its use?

In the microscope case, the common use of this verb is what

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⁴ Not even Feyerabend and Sellars's “pragmatic theory of observation”, that van Fraassen endorses (see his 1992: 14), rules out the possibility of performing an observation by means of some instrument (see Alspector-Kelly 2004: 339-342).

⁵ Which means that the claim that “the engine-of-creation view is actually shared by constructive empiricist and scientific realist” (Kusch 2015: 172) is not so pacific.

⁶ It should also be remembered that van Fraassen's crucial distinction is the observable/unobservable one and that sight is of course just one of the modalities through which an observation can be performed, despite being almost always considered the paradigmatic case. Peculiarities of the verb “to see” should not make one lose sight of the general picture. What about the stethoscope case mentioned by Teller? Does the physician hear the patient's heartbeat through it?

probably leads Teller and Alspector-Kelly to conclude that one actually sees a paramecium through a microscope (Hacking too?). Just as one undoubtedly judges that we actually see a copy of *The Scientific Image* on the table even if we are wearing glasses, or a stamp collector reckons that she perceives small details of her Penny Black through a magnifying lens.

Still, our intuitive judgments may very well be wrong. As a matter of fact, as van Fraassen (2001: 158) explains,

[...] my experiences are the events that happen to me of which I am aware. Such an event has two sides, so to say: what really happens to me and the spontaneous judgment I make in response, which classifies that event in some way. In good cases the two coincide, but often they do not.

Sometimes one can even be aware of having made a spontaneous judgment of which she then doubts if pressed, such as in the case of the detection of very distant objects or of nanoscale ones, through the Hubble Space Telescope or a Scanning Tunneling Electron Microscope. “Once the subjects learn how the images are produced, and how much computer enhancement is involved (...) they begin to withdraw terms like ‘seeing’ and ‘observing’” (Kusch 2015: 178).

Yet, intuitive judgments could be wrong even in the case of unaided perception. Van Fraassen (2001: 158) provides an example: “I tripped over a marmot but take it to be a cat. What happened to me was that I tripped over a marmot, but I ‘experienced it as’ tripping over a cat”. Does it mean that intuitive judgments should not be a relevant factor in determining our applications of “to see”? Perhaps that would be too much. But since unaided perception is admittedly fallible, then the fact that experience “has two sides” might not be such a strong argument against “aided observation” (insofar as it is appropriate to speak this way) either.

Now, as said before, Alspector-Kelly (2004: 336) writes that “the sense that one really is looking at something real when one looks through the microscope at a cell remains phenomenologically irresistible”. One of the reasons underpinning this claim is explained by Hacking and has to do with the (alleged?) manipulability of (some of) the entities detected by using a microscope. Van Fraassen did not address this specific argument in his 1985 response, but Kusch maintains that he implicitly did – *pace* Resnik, who criticized van Fraassen for this very reason (see Resnik 1994).

Kusch’s point is that what the spontaneous judgment “I see the paramecium” shows is merely that “microscopic experience is already laden with the philosophical view of microscopes-as-windows on an (otherwise) invisible world”, though “many non-philosophers in our culture will also

spontaneously make judgments of the realist thought when using microscopes” (Kusch 2015: 180). Only against the backdrop of a realist philosophical theory, widespread as it can be, is it plausible to think that the microscopist observes herself as manipulating microscopic entities (see Kusch 2015: 181).

Let us assume that any spontaneous judgment of the I-see-the-paramecium kind does not provide an independent confirmation of one’s realist epistemology of instrumentally-aided visual experience, but is rather *an expression* of that very realist epistemology (see Kusch 2015: 180). What about unaided vision then? As van Fraassen admits, sentences like “Soggy bread is a common complaint about microwaved sandwiches” or “With satellite television you can go anywhere. Miami, New Orleans, London, Belfast and Berlin”, show that we are “immersed in a language which is thoroughly theory-infected” (van Fraassen 1980: 81), living in a world our ancestors of two centuries ago could not enter. But of course, in this respect, our ancestors’ world was also different from their ancestors’ one (“I bought sugar plums near Saint-Lazare station in my recent trip to Paris by train”). And so on.⁷ We have always been immersed in a language which is thoroughly theory-infected, and this obviously applies to any spontaneous judgment that results from detection, whether aided or not. If one can be skeptic about microscopic detection on the grounds that the alleged dramatic sense of reality that some of them deliver is nothing but an

16 |

expression of a realist epistemology, even when one sees that a mite cannot jump anymore after a microscopist has (allegedly?) removed its legs, then how can she rebut a skeptic argument about the reality of a tree that she judges she sees in front of her?

Remember than van Fraassen himself is a self-declared common sense realist:

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: 3).

What makes him judge that when he looks at the sky in a cloudless night he sees a lot of stars? And that the object he is riding is a bicycle? One of the main assumptions he implicitly needs to make in order to

⁷ It is not only a matter of different historical periods, of course, as the famous example of “the Stone Age people recently found in the Philippines” provided by van Fraassen in *The Scientific Image* (1980: 15) shows.

know these facts, is common sense realism. Only against the backdrop of a common-sense-realist philosophical theory, in fact, widespread as it can be, is it plausible to think that the philosopher observes himself as seeing and manipulating macroscopic entities. But, one might reply (borrowing Kusch's words), that the mere fact a philosophical theory has gained widespread acceptance – indeed that it has become part of our folk-understanding of stars and bicycles – does not make it less of a theory, or less philosophical.

To summarize, the argument of theory-ladenness may constitute a double-edged sword; and perhaps it would be dangerous for an *à-la-Kusch* constructive empiricist to invoke it against a realist interpretation of microscopic detection as it might debunk common sense realism too. But then what?

Kusch (2015: 181) closes his paper by saying:

Nor does it help to invoke our folk-theory of seeing as supporting the case of the realist: even if this theory were realist, it would only confirm the suspicion of the constructive empiricist, to wit, that we may be in the grip of a false or at least unconfirmed theory.

Depending on what Kusch means by “unconfirmed”, however, we may very well be in the grip of a false or at least unconfirmed theory even about trees, stars and bicycles. Does this suffice to undermine the case of the constructive empiricist and confirm the suspicion of the skeptic? Wouldn't we run the risk of throwing out the baby with the bath water, when we appeal to the theory-ladenness of our spontaneous judgments?

I 17

Moreover, Alspector-Kelly might in turn reply that van Fraassen and Kusch's arguments are toothless unless it is coupled with the argument from common-sense-realist phenomenology, and that the latter invokes a common-sense-realist theory-laden experience (or worse, a “fraassian-sense” theory-laden experience).⁸ Perhaps, contrary to what Kusch thinks, not even van Fraassen's arguments are launched “from a platform that would be neutral regarding the two opposed views” (Kusch 2015: 181).

⁸ In *Laws and Symmetry*, van Fraassen (1989: 178) notoriously wrote: “we can and do see the truth about many things: ourselves, others, trees and animals, clouds and rivers – in the immediacy of experience”. But he did not include in this list any microscopic entity. Hence Alspector-Kelly (2004: 331) replied: “what we can see in the ‘immediacy’ of experience and what is detectable by means of the unaided senses – are not the same. There is no incoherence in maintaining that the immediacy of experience is capable of disclosing to us truths concerning entities that are not detectable by the naked eye”.

4. “A biological objection” and the realists’ beachhead

William Seager (1995: 468) reckons that since van Fraassen sets human observability as the great epistemological divide, then “the realism battle must be fought at the fairly moderate level of unobservability represented by the grid and the receptacles. These form the realists’ beachhead, from which an assault deeper into the territory of the unobservable would be hard to contain”.

Charles and Carol Chihara seem to have taken on Seager’s suggestion and raised “a biological objection” to van Fraassen’s stand on aided detection – before Seager’s claim, though. In their paper “A Biological Objection to Constructive Empiricism” (1993), these authors report the case of a kind of mite, *Histiostoma laboratorium*, which is barely visible to the naked eye (yet “observable” in van Fraassen’s sense): “Still, these organisms are so tiny that people are unable to discern any of the organism’s structure with the naked eye. One can see that such an organism can move quite rapidly across a glass plate. How does it do this? How does it get around?” (Chihara and Chihara 1993: 654). The obvious answer is that these mites have legs. As a matter of fact, the two authors continue, one can “see” what appears to be eight leg-like structures that move in ways appropriate to locomotion, if we use a microscope. Since these leg-like structures are not visible to the naked eye, however, van Fraassen would probably reply that “one is not warranted by any empirical evidence in concluding that these leg-like structures exist” (Chihara and Chihara 1993: 654).

It turns out that a scientist trained to do dissections with the aid of a dissection microscope can remove these legs – at least (not to beg any questions) this is what the scientist would claim that she has done, when peering through her microscope she ‘sees’ that the mite no longer possesses these eight appendages. One could then see, with the naked eye, that the mite no longer changes its position on the glass slide. Indeed, one could then see that the mite falls off the glass slide when the slide is tilted. Of course, one need not terminate one’s investigations at this point. There are a great many additional experiments that could be performed with these mites that biologists would regard as providing us with convincing evidence that these legs exist. Suppose, for example, that it is found that when the legs on one side of the mite are removed (according to what the scientist ‘sees’ through the dissection microscope), the mite continues to move, but in a strange almost circular fashion. Would not such results provide us with additional evidence for the existence of these legs? (Chihara and Chihara 1993: 654-655).

Chihara and Chihara (1993: 655-656) describe other consequences of the alleged removal of the mite's legs – it cannot jump anymore, for example – and ask: “If all such results are held by the constructive empiricist not to provide any significant evidence for the existence of these legs, will not biologists begin to wonder just what these philosophers mean by ‘evidence?’”.

The authors here raise an important point that Kusch seems to overlook: not only has constructive empiricism the ambition of being a coherent alternative-to-realism description of science, but it is meant to make sense of it too – this is actually constructive empiricism's aim! (See Buekens and Muller 2012: 94). And of course the biological example the authors provide is meant to show that constructive empiricism fails to do that.

I will come back to this point later in the paper. Sticking to Chihara and Chihara's “biological objection”, instead, is it only against the backdrop of a realist philosophical theory that we can plausibly to think that the microscopist observes herself as manipulating the mite's “legs”, as Kusch claims? Again, Alspector-Kelly has a view about this. Talking about the examples of observables and unobservables provided in *The Scientific Image*, he writes: “Van Fraassen sets up the issue in a way that suggests that there really is not much to discuss, as it is pretty obvious in the cases that he emphasizes that we do not really see the unobservable in question” (Alspector-Kelly 2004: 333). It seems that the same can be said about Kusch, who just takes on van Fraassen's examples – or the ones to which the latter replies – and does not discuss any other. If, on the other hand, it is at the border set by van Fraassen that the realist must fight, as suggested by Seager, then it is at the very same border that the anti-realist à la van Fraassen must try to uphold her position. There lies the trench that the realist must try to sweep away and cross and that the anti-realist (at least the “orthodox one”) must try to defend.

I 19

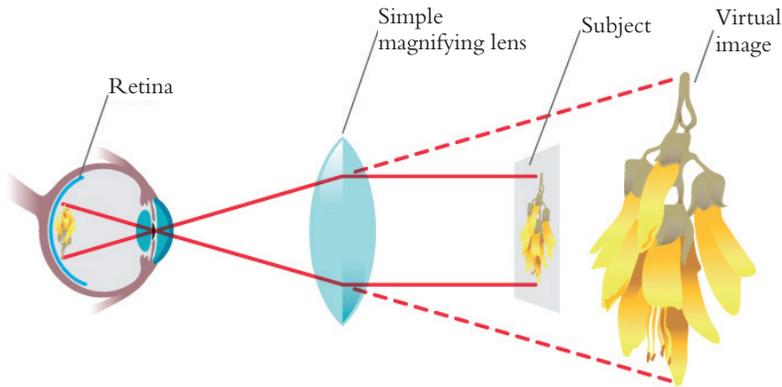
5. Magnifying lenses, optical microscopes and their outputs

Magnifying lenses certainly stand at the abovementioned trench.⁹ Thanks to these tools, visible entities appear closer (or bigger), but one can also detect invisible-to-the-naked-eye details of them, such as in the previous example of the stamp collector. How do these instruments work?

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⁹ So do glasses?

A magnifying lens is just a biconvex lens made of glass. According to classical (geometrical) optics, light rays from the detected object pass through the lens and are refracted toward the eye of the observer, in such a way that the subject has the impression of seeing the object bigger (or closer).



Source: <<https://www.sciencelearn.org.nz/resources/496-how-microscopes-magnify>>

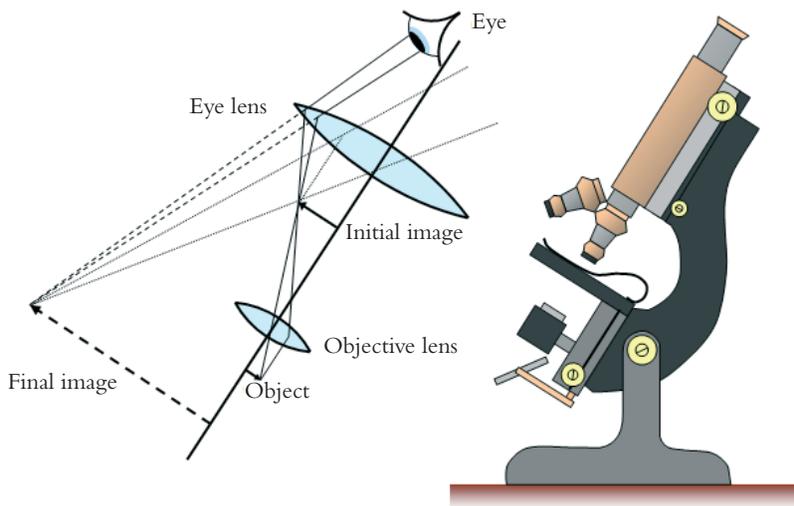
Figure 1

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As the above picture shows, the only real image involved is the one that is formed on the observer's retina. Just as in unaided vision. The sole difference is that a transparent medium bends the light rays. Terrestrials usually receive light rays from the objects they see after these rays travel in a medium. In most cases air, sometimes water. Differences in atmospheric density can cause a deflection of the rays, giving rise to phenomena like mirages and fata morganas – and consequently motivate wrong intuitive judgments about the location of the detected objects. The presence of a medium between the object and the observer should not constitute a reason to deny that the detection of the flower through the magnifying glass is an observation, then, on pain of denying that one can see *tout court* – on Earth, at least. On what grounds could van Fraassen or Kusch maintain that in this case what we see is an image of the flower and not (directly) the object? Again, the only real image involved is the one formed on the observer's retina. Just as in unaided vision. If one denies that the subject actually sees the flower, despite using an (optical) instrument, how does she vindicate this claim? Does the observer see the flower?

The case of the optical microscope is slightly different. Light microscopes are built in accordance with the very same theory that explains how a magnifying lens works and do actually rely on lenses for their functioning. The so-called “compound microscope” has two short-

focal-length convex lenses. According to classical (geometrical) optics, the objective gives a real, inverted image of the object which is then magnified by the eye lens, offering a final virtual image.



Source: <<http://www.schoolphysics.co.uk/age11-14/Light/text/Microscope/index.html>>

Figure 2

I 21

The above description apparently fits van Fraassen's engine-of-production account of instruments. According to the very same theory followed to build them, microscopes produce a real image of the object on the slide, which is what the observer actually detects through the eye lens. Is van Fraassen right then? Is it an image what an observer sees through a microscope, *pace* Teller and Alspector-Kelly? Is that the intervening observable between the eye and the slide whose existence Alspector-Kelly (see 2004: 334) denies?¹⁰

However, the real image is not the final one. Both in the microscope and in the magnifying-glass cases what the observer sees is actually a virtual image. That being so, according to classical optics even a simple magnifying lens is but an engine of creation, and the appropriate way of speaking would be that what the observer sees through this tool is an image – and not that she can actually (directly) see the object that the image represents. Were

¹⁰ One might wonder how van Fraassen could know in his case that what an observer detects through a microscope is an image, though.

this not the case, then the observer would not have the impression that the object is closer (or bigger) than it is in fact. Perceiving an object bigger or closer than it actually is happens in unaided vision too, though. The so-called “Moon illusion”, for instance, causes the Moon to appear larger near the horizon than it does higher up in the sky. Moreover, in unaided vision objects might also appear dislocated, such as in the previously mentioned mirage and fata morgana cases.

Yet, one might object that virtual images do not actually exist, as the adjective “virtual” indicates. They might be considered a mere geometrical projection. What is seen, it might then be added, is the object, in the case of the magnifying glass; and a real image, in the case of the light microscope (light rays have been bended, but have not lost the information they were carrying). Van Fraassen would probably not be happy with this account of what happens when one uses an optical instrument, for it would force him to admit that one can actually observe some invisible-to-the-naked-eye structures through a magnifying lens, such as the legs of a mite.

Even from this perspective, then, and according to classical optics, microscopes do actually produce an image, here meaning the real one that – as explained before – is created between the objective lens and the eye lens (see the picture above). Since a real image corresponds to a concentration of light rays – but the same is true of virtual images too –, one could actually consider that “it is something” (van Fraassen 2008: 105), even if not a *thing*, not a material object (and yet, since $E = mc^2$ and van Fraassen seems to admit the theory of relativity as our conceptual background...).

Still, van Fraassen (2001: 158) wrote that images do not exist:

We never see images, because images do not exist. (...) Since we can't see things that don't exist, the phrase “seeing an image” is code for something we are describing metaphorically or analogically. It is similar to “Macbeth saw a dagger” in the scene where he reports that sort of experience although there is no dagger there.

Of course, this does not apply to images which are actually material objects, such as paintings and photos (see 2001: 159). In *Scientific Representation: Paradoxes of Perspective*, van Fraassen put forward a table containing a categorization of images (see 2008: 104). His aim in the book, however, was to discuss the reality of what they represent and not the issue of images *per se*. As a matter of fact, van Fraassen suggested that, for all we know, the images produced by a microscope could be in a situation analogous to that of the rainbows, which are “images of nothing”. He added that reflections in the water, rainbows, and the like (including microscopic images) are “public

hallucinations” and apparently retreated from denying their existence; yet it is not clear whether they constitute an ontological category apart or an empty set. In fact, this remains as an open question.

Apparently, then, the optical theory fits the engine-of-creation vision on the use of instrumentation in science, at least when it comes to microscopes. Still, this argument cannot be used to support van Fraassen’s stand on microscopic detection, as it would turn the latter theory dependent (see van Fraassen 1980: 57-58).

Thus the point is whether the real image produced by the objective lens (or rather the final one, which is a virtual image) is veridical or not – in other words, whether it faithfully represents an extant entity. Kusch thinks we will never know, since there is no empirical (unaided) access to the detected entity that guarantees the belief that the image is in fact veridical. Does this apply to any optical tool?

6. An inference to the best explanation?

E^{ye loupes} consist in low-magnification (usually between 4X and 10X) glass lenses, mounted in plastic eye cup cells. They allow the wearers (watchmakers and jewelers typically use them), to visualize small details of the object they manipulate. The images these devices produce (insofar as it is appropriate to speak this way) give the observer a dramatic sense of reality. Most likely, the same sense of reality the mite’s legs from Chihara and Chihara’s example involve. Various kinds of mite are visible to the naked eye and can of course be detected with the use of a loupe too. Is the image produced by the magnifier veridical or can one only claim that it is partly veridical and partly accept that “there is no way of knowing”?

I 23

Besides, would it be appropriate to say that in the case discussed by Chihara and Chihara it is but an inference to the best explanation (IBE) what leads the microscopist to conclude that the mite she has detected can move thanks to an invisible-to-the-naked-eye leg-structure, which is what Hacking has been “charged with” by van Fraassen (see van Fraassen 1985: 298 and Kusch 2015: 170)? What happens in the example of the mite is not that the microscopist gets to the conclusion that these organisms do have legs from the available evidence (and prefers this hypothesis to other ones). Rather, she has the impression of seeing a leg-like structure “attached” to the mite and performs a series of experiments to test the hypothesis that what she has detected are actually the legs of the little animal. Since it turns out that everything goes as expected (and she can actually *see* that the mite does not jump anymore if the legs are (allegedly) removed, or that it keeps

still, falls off the glass slide when the slide is tilted and so on), she feels that her belief in the existence of a leg structure in the mite is warranted. Hasty conclusion? Another case where “whether this microscopic object is well behaved or not, is, for the constructive empiricist, something that we infer on the basis of the microscopic image” (Kusch 2015: 176)? An inference to the best explanation? An expression of a realist epistemology? In case van Fraassen and Kusch still wanted to maintain a skeptic attitude towards the legs of the mite, then “will not biologists begin to wonder just what these philosophers mean by ‘evidence’?” (Chihara and Chihara 1993: 656).

7. The debate on microscopes and the aim of constructive empiricism

24 | **T**he debate on microscopes – a very actual matter in the philosophy of science – is often presented as part of a wide debate between realists and anti-realists. Is this an accurate way of presenting it? Is admitting that the abovementioned (observable) mite does have (unobservable-to-the-naked-eye) legs tantamount to being realist? The “believer” would be a realist with respect to this particular entity, of course; but, I argue, that is not enough to make her a realist *tout court* (meaning a scientific realist). The microscopist from Chihara and Chihara’s example could very well be a constructive empiricist and continue to be one even in case she believed in the existence of invisible-to-the-naked-eye structures in mites and other entities, such as paramecia and the like. Again, van Fraassen (see 2001: 163 and 2008: 110) seems ready to admit this. So perhaps the trench that the anti-realist must try to defend might be dug in a safer area, elsewhere from where van Fraassen dug it initially.

Describing the debate on microscopes as a realism-vs-anti-realism one, then, as it often happens, might not be accurate; furthermore, it could even be detrimental for constructive empiricism (or anti-realism). For, if the border is traced “at the fairly moderate level of unobservability represented by the grid and the receptacles” (or at the even more moderate level of the mite’s legs), then the realists might quite easily cross that border and “an assault deeper into the territory of the unobservable would be hard to contain” (Seager 1995: 468).

This also means that throwing all microscopes into the same pot, as Kusch (see 2015: 177) seems to do, is perhaps not accurate either. Simple optical microscopes, such as the ones that can be bought in a toy shop, produce images that a constructive empiricist might consider veridical. Such devices are definitely different from scanning electron microscopes, which

means that they just share the name “microscope” and nothing else. That being so, admitting the existence of a general category of tools that fall under the label “microscopes” can be sound, but treating them all alike is not.

Now, the reason why Kusch throws all microscopes into the same pot has already been explained. If “empirical” is tantamount to van Fraassen’s “observable” (that is, detectable with no instrumental aid), as it is to him, then there is no possible empirical access to the microscopic entities detected through a microscope. According to the two philosophers, “empiricism asks us to limit our commitments to empirical phenomena” (Kusch 2015: 175), yet microscopic entities are not empirical phenomena (for the reason just explained), ergo commitments to the existence of paramecia, leg-like structures in the mite, etc. are optional.

Since this is an argument used to rebut Teller’s “phenomenological objection”, however, Kusch (and van Fraassen) might be charged of missing the target, at least in this specific case. It is quite clear, in fact, that the above syllogism depends on the equivalence between “empirical” and “à-la-van-Fraassen observable”. Teller and many others would not accept this premise, hence they would reject the conclusion.

Of course, as Kusch is aware of this he adds:

The scientific realist might object here that van Fraassen is assuming the very point he is trying to prove against the realist: to wit, that the object on the slide is not directly observable, and that there is a relevant epistemic difference between the case of the reflection and the case of the microscopic entity. The answer to this is, to repeat, that van Fraassen is not trying to refute the scientific realist. All he is seeking to establish is that the constructive empiricist stance is not incoherent (Kusch 2015: 172).

I 25

Are we all running in circles and do not actually communicate? If this were the case, then one might say that scientific realists have their own vision on scientific instrumentation and their own interpretation of what “empirical” and “observable” mean, while van Fraassen has his own. If so the each position could only defeat its rival by finding some inconsistency in it. Both scientific realism and constructive empiricism are rational and legitimate positions, however, therefore this war can have no winner. But since voluntarism allows for the peaceful coexistence of two different positions on the same topic, then there is no problem with it. Within voluntarism, the epistemological framework adopted by van Fraassen, issues of justification do not arise and one’s set of beliefs just needs to show logical consistency and probabilistic coherence in order not to be considered rational (see Dicken, 2010: 27-28). Nonetheless, van Fraassen can be considered the moral winner,

for his aim was just to show that there is a coherent alternative to scientific realism, namely his constructive empiricism, and he succeeded in fulfilling his purpose.

All hunky-dory then? Well, not so fast. Van Fraassen's aim is not just "to show that his stance is not incoherent or proven false by his opponents" – rather than demonstrating "that it is the only viable position" (Kusch 2015: 172). As Buekens and Muller (2012: 94 and 99) clearly state, instead, making sense of science *is* "the aim of CE [constructive empiricism]". Of course it is. If van Fraassen's goal were just to propose a coherent alternative to scientific realism, then would he focus on the observables given all the problems that the concept of observability entails? Why not sticking to the observed, instead (see Alspector-Kelly 2001)? Here is van Fraassen's answer: "constructive empiricism is a doctrine about the aim of science. The doctrine that science aims to give us theories which match what we actually observe is incompatible with what it is virtually universally agreed about scientific practice" (Monton and van Fraassen 2003: 407). Recall also that, in "Constructive Empiricism Now", van Fraassen (2001: 164) wrote that "constructive empiricism is a view of what science is". Buekens and Muller are right then: constructive empiricism's aim *is* to make sense of science! (And that is the reason why they criticize van Fraassen's notion of observability).

26 |

A full defense of van Fraassen's position on instruments should not only focus on its coherence, but on its adherence to scientific practice too. On the latter aspect, however, things are not so bright for the Dutch philosopher. Several authors regard his as being divorced from "real science" and its practices. Both scientists and philosophers do it – such as Carol and Charles Chihara, for instance. Hasok Chang (2004: 85) wrote: "I think that his critics are correct when they argue that van Fraassen's notion of observability does not have all that much relevance for scientific practice".¹¹ Accordingly, "without denying the validity of van Fraassen's concept of observability, I believe we can also profitably adopt a different notion of observability that takes into account historical contingency and scientific progress" (Chang 2004: 86). And of course Chang here refers to van Fraassen's account of instrumental detection.

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¹¹ Seager writes: "If we define the *observable* as what can be perceived with the unaided human senses, we obtain a reasonably clear and fairly sharp distinction between what can be observed and what cannot. This is not a distinction that can be argued away; it is the significance of this distinction within the general issue of scientific realism that is moot" (1995: 459). And so on.

8. On the alleged neutrality of constructive empiricism

My final remark is on the alleged neutrality of constructive empiricism. Kusch (2015: 180) says that Alspector-Kelly “does not recognize the importance and possibility of reading the results of science in a way that is neutral with respect to the debate between scientific realist and constructive empiricist”. According to the Austrian philosopher, “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: 180). But is there really a neutral way to render scientific evidence? Moreover, and more importantly, is the constructive-empiricist interpretation a neutral one (all the more “neutral with respect to the debate between scientific realist and constructive empiricist”)? Granted, the constructive-empiricist interpretation might be seen as a “middle way” between scientific and instrumentalist realists. But this does not render this account *neutral*. “None of Alspector-Kelly’s arguments is launched from a platform that would be neutral regarding the two opposed views” (Kusch 2015: 181), says the author of “Microscopes and the Theory-Ladenness of Experience” in the conclusion of his paper. Yet if Kusch and van Fraassen’s reply relies on a non-shared acceptance of “empirical” and “observable”, then they could perhaps be charged with the same sort of “misconduct”.

I 27

9. Conclusion

According to van Fraassen and Kusch, both microscopes and telescopes produce images, nonetheless their outputs allow for different interpretations. The difference relies on whether it is possible to empirically study the geometrical relations between the elements involved or not. While in the telescope case it is, at least in principle, the same is not true of the images produced by microscopes. In this case, “the geometrical relations are not all open to empirical study: we cannot empirically investigate the geometrical relations between the eye and the microscopic image on the one side, and the postulated unobservable entity on the other side” (Kusch 2015: 172). This is why van Fraassen feels one is entitled to suspend belief and embrace an agnostic stance about the reality of the entity detected through a microscope.

It is quite clear that van Fraassen’s (and Kusch’s) use of “empirical” is pretty narrow, though. As Teller (2001: 129) puts it – as mentioned in previous sections – “van Fraassen has a quite specific criterion: Something

counts as empirical if it can be observed, without the use of instruments, by oneself or by any in one's epistemic community".

Here, "empirical" means "originating in or based on observation or experience" and references to experience trace back to the etymology of the word. According to van Fraassen, experience can offer us information only about what is observable (see van Fraassen 1985: 253), which explains why, at the end of the day, "empirical" and "observable" are interchangeable, at least to him (and Kusch). Nothing about the use of instruments is implicit in the concepts of experience and of observation, nor in their etymology, however. This allows Sara Vollmer, among many others, to criticize van Fraassen's position and remark that "instrument-assisted observation can give experiential information, too" (Vollmer 2000: 362).

"Observation" is not necessarily equivalent to "unaided detection". If it were, van Fraassen's stand on the use of instruments in science would be shared by many. Instead, his position on microscopes is controversial and quite isolated – to say the least! Now, the aim of this paper is neither to support nor to reject any alternative account of what one can do by using an optical instrument. But I hope I have made it clear that if, ultimately, these alternative arguments "are toothless without the argument from phenomenology, and (...) the latter invokes a realist theory-laden experience" (Kusch 2015: 181), then perhaps the same can be said of van Fraassen's (and Kusch's) defense of their view on microscopes. With the obvious difference that, in their case, the argument relies on an *anti-realist* account of microscopic experience.

According to van Fraassen, *to detect* is to be distinguished from *to observe* (see, for instance, van Fraassen 2008: 93). As Contessa (2006: 456) writes:

Microscopes, cloud chambers, laser interferometers and other scientific instruments allow us to detect entities, but *detection* has to be carefully distinguished from *observation*. A look through a microscope does not allow us to observe directly a paramecium; only to observe *an image* of a paramecium, or to *detect* a paramecium.

Of course "van Fraassen is entitled to demand that the scientific evidence be rendered in a neutral way" (Kusch 2015: 180). This is very likely a key desideratum shared by any scientist and any philosopher of science. But the claim that "this neutral way is precisely the constructive-empiricist interpretation" (Kusch 2015: 180) is not at all pacific.

Constructive empiricism is a doctrine about the aim of science, namely "to give us theories which are empirically adequate" (van Fraassen 1980: 12). Since this might be roughly interpreted as meaning that, according to a constructive empiricist, full acceptance of science involves believing that

what the sciences say about the observable parts of the world is true, while the rest need not matter (see van Fraassen, 2005: 111), it is clear that this anti-realist view of science must rely on a feasible distinction between what is observable and what is not (see van Fraassen 2004: 1). Van Fraassen (2008: 110) draws the line “this side of things only appearing in optical microscope images”, but admits that it could be drawn elsewhere. In fact, “this would still leave intact all the main philosophical positions of van Fraassen’s anti-realism”, as Hacking (1983: 208) correctly pointed out.

As a consequence, it is possible to distinguish van Fraassen’s own anti-realism from constructive empiricism. Kusch, instead, equates the two; and when he says that the constructive-empiricist interpretation is a neutral way of rendering the scientific evidence (see Kusch 2015: 180), he there has in mind, among other things, the identity between “empirical” and “observable” and that between “observation” and “unaided perception” – the latter being not uncontroversial.

For this very reason, there are several alternative constructive-empiricist ways of rendering the scientific evidence. An example is (the-self-declared-constructive-empiricist) Otávio Bueno’s characterization of “visual evidence”, put forward in this decade, which offers “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 2011: 290). Actually, many others’ arguments – such as Teller’s and Alspector-Kelly’s, for instance – could be used to extend the observable beyond instances of unaided perception, but still within an empiricist perspective.

Again, this could help constructive empiricism to get closer to making sense of science which, as already suggested, is one of its fundamental desiderata. Merely contenting with the acknowledgment that it represents a coherent alternative to scientific realism is not enough, *pace* Kusch.¹²

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¹² I would like to thank an anonymous reviewer of this Journal for the insightful comments on an earlier draft of this paper.

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