

## When is an Image Not an Image?<sup>1</sup>

Joseph Pitt  
Virginia Tech

The challenge is to tell the truth. In the world of nano this is not as easy as it sounds. Take, for example, the question of images claimed to represent what some nano configuration or another looks like. It is alleged Scanning Tunneling Electron Microscopes (STEMs henceforth) produce such images. Let's rehearse what happens: According to Rasmussen and Hawkes:

...an electron beam that is small compared with the imaged area passes over the specimen in a regular pattern, and a picture of the specimen surface is reconstructed on a video tube...interaction of the beam with the specimen produces varying intensities of backscattered and secondarily released electrons for each position in the scan, and these are registered by a detector placed appropriately near the specimen...All electron microscopes depend on the capacity of magnetic and electric fields to alter the path of electron beams according to the laws of optics (1998, 383).

Using an STEM is one of the ways it is said that we can see what is going on at the nano level. However, I am suspicious. Or, to put it in a less antagonistic way, to accept this claim will, I believe, force us to expand or change our understanding of what it is to see something, and in this case in particular, to understand what constitutes an image. There is nothing wrong with this. The meaning of words do change over time—they often expand, as the meaning of “men” in “All men are created equal” has expanded to include African Americans, other minorities, and women. However, we often do not pay attention to the fact that while we continue to use a word whose meaning we think we understand, in this instance “see” and “Image”, we also sometimes extend the meaning of that word by applying it to novel situations where they only apply at best metaphorically, as I argue below. Eventually what is at first a metaphorical extension of the meaning of a term may become an accepted part of the meaning of the term, but we should be sensitive to the fact that the meanings of words change over time. This claim is part of a more general thesis I am developing: to explain what we are doing when we employ novel instrumentation, we often

employ words whose meanings we already understand in an effort to characterize the sort of thing we think we are now doing with this new instrument, despite the fact that seeing through a microscope is not the same as opening one's eyes and seeing a tree in front of me, if we are to adhere to a strict sense of "seeing". I argue elsewhere that in extending the meaning of words metaphorically we also change the meanings of the family of concepts with which they are associated, such as evidence and explanation.<sup>2</sup>

If we take Rasmussen and Hawkes seriously, what the electron microscope does is to produce an image. But, I suggest, this is unintuitive for the reasons given below. Furthermore, to claim that an image is produced, suggesting by that that the image is a genuine and *realistic* representation of what is really there, has serious ethical and social consequences. I want to talk about images first, and then I will turn to some of disturbing consequences of thinking about "seeing" by way of an STEM.

Imagine if you will, a very accurate tennis ball machine. It is a device that shoots tennis balls at you so you can practice returning them without having a serving partner. Lets assume you take this machine and aim it at a wall built from rough hewed stone. Your job is to construct an accurate representation of the surface of the wall simply by observing the directions of the balls as they bounce off the wall. Well, clearly you need some help to do this. You need to know a lot about the physics of objects colliding and how irregular surfaces change the vectors, etc. You also need to know a lot about translating what you see happening to the balls after they collide with the wall onto paper in a way that captures not the picture of the ball shooting off in this direction and then that, but the texture of the surface of the wall. It is not as if you are directly drawing what you see when you look at the wall. You are interpreting the action of the balls as indicating something about the surface and then you are putting that guess down on paper. That, with some minor modifications, is what the alleged image produced by an STEM is supposed to have accomplished. But instead of a person doing the drawing, a computer program does it. And, we are asked to consider the result an image of the surface. Take your hand, if you will, and run it over your shirt. Now draw what you felt. It is not easy is it? That is why I am asking this question, "when is an image not an image?"

Let us begin by trying to figure out what an image is. This is not an easy task, for we tend to use a substantial vocabulary of what we often take to be more or less synonymous terms when talking about what STEMs produce. Thus, there has been a lot of loose talk about images, representations, etc. Terms like these have been casually interchanged, mangled and generally semantically violated. I will not claim that I offer much of an improvement—but I at least want to alert us to the problem of image talk. In cases like this, my preferred method is to work our way toward a common sense understanding of what ought to count, in this case, as an image.

My intuitions tell me an image is a representation—where a representation is the result of an attempt to capture the salient features of an object, scene, state of affairs, or idea, etc. Fortunately or unfortunately, what constitutes a salient feature is a function of the person or persons constructing the image. As a first pass, consider the following items as images:

- Sculptures
- Photographs
- Portraits
- Still lives
- Landscapes
- Various kinds of drawings
- Motion pictures—both animated and “realistic”
- Visualizations inspired by poetry
- Visualizations inspired by music
- Plays
- Operas
- Ballet and interpretive dance

If we accept the fact that these are images, then a Picasso such as the *Gernica* counts as an image, but it would seem that a Jackson Pollack does not only in so far as it is unclear what a Pollock is supposed to represent.<sup>3</sup> This entails declaring that to be an image is to be representational. But it says nothing about what makes something representational. That said, nevertheless, it is not shocking to note that not all paintings are images, where a painting is nothing more conceptually complicated than paint deliberately applied to a surface. But, if it is

true that not all paintings are images, especially when they are not representational, have we not found a way into our topical question, when is an image not an image? It looks like we could reasonably say that an image is not an image when it is not representational. On the other hand, doesn't that just beg the question? After all, it isn't at all clear that for an image to be an image it must be an image of something. When you think about it, on the one hand, it seems arbitrary to demand that images be representational, but, on the other hand, to do so seems to beg the question. For example, consider the following as candidates for being added to the list above.

- Diagrams
- Flow charts
- Data tables

The interesting feature of these sorts of things is that while they are not representational, they do convey information in visual form. For, on the surface at least, it seems as if these forms of images have a different semantics than written language. The important point however, is that they do seem to have a semantics, for they do manage to convey information. The unresolved problem that remains for us is how to determine if the image is an accurate representation. So, if we accept this approach, then one answer to our question is that an image is not an image when we do not know if it is representational but conveys information none-the-less.<sup>4</sup> With your permission, let's accept that for the time being as a first pass.

However, that just moves us back one step, for now we can re-ask the question that our quick look at electron microscopes motivated: when is an alleged representation a representation? The point here is epistemological.

I think it not too radical to suggest that seeing is a complex activity in which after learning to see that as a tree or as a car, we forget that we had to learn that. In our mature state we see the world around us and assume we see it for what it is. That is why philosophical questions like "but are you seeing what is really there?" seem so silly. But, on reflection, we also understand that seeing is an interpretive process and that we bring to our seeings a load of background information and experience. Elsewhere I have argued that to call it a seeing by

way of images generated by an electron microscope is a metaphorical extension of our common sense notion of seeing (Pitt 2005). But, I have now come to realize that there is a lot involved in appealing to metaphor here. If we unpack it, as I would like to start to do here, we can see that to understand through metaphor is to do a number of things at once. First, we use metaphor to access what is new and different because in a metaphor we take what we know and apply it to the unknown and say that the unknown is like the known in these various ways. It makes the new seem familiar and approachable, usually. Sometimes, as in the example of the tennis gun above, it makes the unknown or the new seem even stranger than we first thought. Second, when using metaphor to make the new and unknown approachable, we are also asked to accept that certain things that we do not really understand are reliable. Metaphors tell you this is like that in certain limited ways, and by the way, just accept that everything else is working just fine, however that happens. In the case of the electron microscope, when asked to accept what it produces as a representative image, we are also asked to accept the fact that the assumptions built into the manner in which that image is constructed are correct and reliable. To use the language of science studies, we black-box the process and merely look at the result. But to call the image created by the electron microscope an image is to ask us to accept in some fundamental way that the science is sound and the technology (programming?) reliable and the people manipulating it reliably are honest.

But, I suggest, this ought to be a lot to ask. What is interesting is that it appears that it is not. It is a measure of the success of the scientific establishment that we, the general public, tend to accept claims based on the use of increasingly complicated instruments working in the realm of the frontiers of science with increasing readiness. That is, the more complicated the science and the more simplified the public explanations, the more readily we tend to accept those fantasies. That is why it is important to know what really happens in an electron microscope before buying into the claims with which it is associated. Before I explore what that ominous sounding remark is supposed to suggest, let me give you just one example of the kind of phenomenon to which I am referring. I think we are all in awe of the images sent to us by the Hubble Space Telescope. The ones of the horse head and crab nebulae are just breathtaking—and the colors are truly inspiring—just one catch—the colors are computer generated. When I tell

my students that, the looks on their faces resemble the one when they learned that there is no Santa Claus. What got me going in this direction was a presentation at the Conference, “Discovering the Nanoscale” at Darmstadt in October 2003 that revealed that the picture of the nano-scale IBM was not just constructed through the assistance of computers, but it too was computer enhanced—with the colors added, for example. This, it turns out is a pervasive problem; even the choice to use grey scale is a decision to create the image in a certain way. So when we say of an image that it must convey information, should we not also be asking (1) whether there is a claim that reality is being representing, and (2) is the image presented of something real or imagined? Perhaps, then, should we not be asking this slightly different question: “When is an image *not* an imagining?”

The issue here is both epistemological and ethical. The epistemological issue concerns, for lack of a better term, noise. We are familiar with the problem of filtering out noise when searching for an identifiable signal. The problem is multi-faceted: what to filter out and on what criteria, what to amplify, to what degree, etc. The problem with color-enhancement and sharpening up of nano-images is that we don't yet know what is important and what is not. Further, the problem may become intractable since we do not have a god's eye view from which to determine if we have it right. In a certain sense then the problem here is an *in principle* lack of access, or to put it differently, a case of very strong underdetermination. But is this really a problem? We have in-principle-lack-of-access to many astronomical events, like the big bang, and we still claim to know a lot about the early universe. We have images from the Hubble of far distant galaxies that we can never get close to in person, and yet we can still understand a lot of what is going on there—or so we think.

My worry is that, unlike the “images” from the Hubble, we have relatively little experience in enhancing the images produced by STEMs. We have ways of checking up on the Hubble images. For example, we can experiment with filters and use smaller telescopes here on earth to check out their effect when we look at mountains or trees. However, although we have lots of experiences with so-called images from STEMs—we do not have such successes in fixing them up. This is, in a curious way, a new version of the what-are-we-going-to-do-when-we-stain-a-specimen-that-we-are-going-to-examine-under-a-standard-microscope problem (see Pitt 2005). Computer enhancement of images is fun, especially with

all the nifty colors we can use. But is it producing an honest replication of the object/surface in question? Clearly not, and that raises the ethical issues.<sup>5</sup>

The ethical issues arise in two forms: strong and relatively minor. The relatively minor issues have to do with the relationships between science and the public. For example, we are misleading the public when we fail to disclose fully what we are doing when we computer enhance our electron microscope constructed images. The strong ethical issues center around the fact that these images raise false expectations. Among them, that we know more than we do. The presentation of these beautiful pictures suggests in a very strong way that this is indeed what it is like out there, in there. But more importantly, they mislead in crucial ways. The beautiful computer simulations we see of nano interactions are not only beautiful simulations, they are also almost heart-stopping in their ability to feed the hubris we sometimes exhibit when employing the newest technological toys, computer and advanced programming techniques, among them. Please do not get the wrong impression—I am not suggesting that we should not employ the latest technologies in science. What I am talking about is the illusion we create not just in the general public but sometimes in the practicing scientific community. The illusion is that we know more than we really do. Never underestimate the ability of human beings for self-delusion. These computer generated and enhanced pictures suggest that the world is at rock bottom a simple place. It can be pictured as individuals atoms resting on stable fields that we can manipulate at will, twirl them, enlarge and narrow them, put them to music, make them dance, when in fact nothing of the kind is the case. The world at the nano and quantum mechanical level is a buzzing, shifting, constantly in motion in non-linear and non-classical causal fashion.

This is all heading in one direction. It is not just misleading to suggest that the world is simple at the bottom. It is epistemically suspect. It employs a crucial but faulty assumption. It is the assumption that the world is better understood if we simplify our presentations of it. I humbly suggest that this is wrong-headed. It may in fact be helpful to extract some feature of the world, color it pretty non-natural colors and play with it. But it is more important to put that heuristically altered item back into the buzz and try to understand it in that environment, its “natural” environment. Most importantly it is crucial that we explain to the

public and our colleagues the purpose of the heuristic move and what it reveals about what is really going on at the bottom.

So what is wrong with simplification? It suggests that we know more than we do and, crucially, that we can do more than we can. The scientific community has done a good job of convincing the public that it has god-like properties—but this situation presents a double-edged sword; the public feeds on gods that fail. Be honest about the mess and you will repeat positive rewards. Further, it is not the simplicity of the universe that makes it the object of our enquiry, it is the complications, the unanswered questions, the mess of it all. The more we look, the more complicated we find it to be. If you cuddle the public and give them simplicity and then in the crunch, when, for instance, in the hospital, you say, well it is more complicated than that, then you will have failed miserably. I love the pictures, but they are not representations. They are heuristic imaginings, extended metaphors, if you will, and they should be recognized as such and treated that way. How will that affect the way in which the work of science is perceived? My guess is that it will enhance it. Doing science is hard work. The public should know that and when they do the successes of science will be all the more appreciated. Telling the truth is also hard.

To conclude, let me summarize. The question is "in what sense is a STEM computer generated picture of nano structures an accurate representation of what is there?" Following some discussion of how "seeing" using a STEM involved a metaphorical extension of the concept of "seeing," It was argued that to be a representation the image must convey information. The problem is in understanding what the information is conveying, since we cannot directly access the domain that we are purporting to represent. The problem is not that we do not know how to interpret what is presented to us as an image, but, rather, that we have loaded the creation of the representation ahead of time without being able to know if our guess that this is what the STEM and its fellow traveler computer programs are producing is an accurate picture of what is really there. The reason why there is so much discussion of when an image is an image is that this really is a question of whether or not the image that is produced is an accurate portrayal of something that is really there or a mere fabrication.



Consider one last attempt to convey a sense of the magnitude of the problem. If we do a random sample of some domain and then plot the results in three dimensions, assuming that is sample is truly random and that there is no natural clumping of the data, which curve is the correct one? We can draw an infinite number of curves through those data. Without an independently certified decision procedure for selecting the correct curve we are simply left with the data. The problem is further complicated by the fact that there are ethical dimensions. (1) To say that this is what is taking place at the nano-level, is to lie, since we don't, in fact, know that to be the case. (2) To present these standard, nicely colored, enhanced, and simplified pictures as genuine representations of what is going on at the nano-level is to claim falsely that nature is in fact simple and clean and neatly colored at that level. But, nature is not neat and tidy at that level. To suggest otherwise is to mislead by way of making it appear that there are simple answers to very complex problems. That approach gets us into trouble at the political level and it should get us into equally big trouble in our epistemology.

## References

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<sup>1</sup> My thanks to Thomas Staley for his assistance. All mistakes are my own.

<sup>2</sup> This thesis is being developed in a book length manuscript under construction entitled tentatively, *Seeing Near and Far, A Heraclitian Philosophy of Science and Technology*.

<sup>3</sup> If turning to art is seen as somehow cheating, it is important to remember that the creation of images began in art.

<sup>4</sup> Yes, "information" is not defined. But, I suggest, we have to start somewhere. If we succeed in making progress by proceeding in the manner suggested we can always return and fine-tune the argument by going deeper into concepts like "information". Call this approach "conceptual bootstrapping".

<sup>5</sup> The "Clearly not..." might be considered contentious, but with a little expansion, I believe it will be obvious. Consider, for example, that the surface on which nano scale objects exist is at the

interface between the quantum domain and the atomic. We have no idea how to visually represent what happens in the quantum domain, so we cannot say we are accurately representing the surface on which the atomic structures we are picturing sit. If we cannot claim to be accurately depicting the surface, then how can be sure of the space in which nano structures function, and if that is uncertain, so must be our representation of the nano structures themselves.