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Photographic Evidence and the Problem of Theory-Ladenness

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Abstract

Scientists use visualisations of different kinds in a variety of ways in their scientific work. In the following article, we will take a closer look at the use of photographic pictures as scientific evidence. In accordance with Patrick Maynard's thesis, photography will be regarded as a *family of technologies* serving different purposes in divergent contexts. One of these is its ability to detect certain phenomena. Nonetheless, with regard to the philosophical thesis of theory-ladenness of observation, we encounter certain reservations concerning the status of photography and that of photographic pictures in the process of measurement in science. Accordingly, the aim of this paper is twofold: We will discuss suggested solutions both for the *technological* and for the *psychological part* of the problem of theory-ladenness appearing in the context of the use of photography in scientific observations. The essential proposal will be to follow Christian Suhm in his advice to make a distinction between theory-relativity and theory-ladenness.

Keywords: evidence, Patrick Maynard, photography, scientific observation, technology, theory-ladenness

1 Introduction

A variety of different kinds of visualisations play an important role in science. They are related to a no less extensive realm of technology producing such images. Recently, philosophers of science have been showing more and more interest in this non-verbal kind of scientific activity. Nevertheless, a thorough examination of this domain is still lacking. One reason for this neglect is mentioned by Laura Perini. She argues that it is still unclear what contribution visual representations can make concerning scientific arguments. This is due to the fact that most philosophers of science regard *argumentation* as a kind of verbal behaviour, a stance that clearly excludes visual representations from this domain (see Perini 2005a, 262). Scientists, however, do not seem to share this conviction. They use visualisations in a variety of ways in their scientific work. This leads to the following question: "Why do scientists include visual representations – why not defend ideas just with linguistic or numerical representations? Scientists do not act as if figures are 'mere illustrations' that are redundant expressions of information presented in the text, or convey information inessential to the argument. On the contrary, scientists treat figures as if they play integral roles in the arguments in which they appear […]" (Perini 2005b, 913).

In this paper, I will examine just one small aspect of this wide-ranging topic: I will confine myself to taking a look at a special kind of visualisation – namely photographs – and I will approach just one special problem concerning the role of photography in the process of detection and the use of photographic pictures as scientific evidence – namely the problem of theory-ladenness. In this sense, let us start by fleshing out the thesis that photographs are used as evidence in science. What exactly does this mean?

2 Photographic Evidence

Scientists use cameras as measuring devices.[1] Therefore, photographs thus become a kind of verifying or falsifying data. They can play a part in confirming or disconfirming the theory at hand. The photograph plays an evidential role in that we take it for granted that it offers us a correct reproduction of the observed entity, process or whatever. A famous example of a scientific experiment, so to speak, where a photograph provided decisive evidence is Eadweard Muybridge's picture series "The Horse in Motion", which was made to find out whether a galloping horse has all its hooves up in the air at once or not. It is not possible to decide this without the aid of an instrument. Nowadays we are used to employing this photographic function in different kinds of sports. Photo finishes help to find out the winner of a race, if the naked eye is not able to discriminate between the two or more competitors.

One can imagine a variety of other contexts where photographs are used as evidence. In astrophysics, for instance, photographs are used, amongst other tasks, to create maps of other planets' surfaces (see e.g. http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10333/). *Photometry* is the technical term in this context for using a star's emitted radiation to define its brightness or mass or age etc. (see http://www.britannica.com/EBchecked/topic/458013/photometry). Another domain where

[1] This is not to say that there is not a great variety of other possible ways of using cameras in science.

examples can be found is the medical context where X-ray images etc. are used for diagnostic purposes.[2] Accordingly, Aaron Meskin and Jonathan Cohen point out that "[...] photographs seem to have a distinctive epistemic status compared to other sorts of pictures. [...] we are inclined to trust them in a way that we are not inclined to trust even the most accurate of drawings and paintings" (Meskin/Cohen 2008, 70). Even though our scientific practices as well as our everyday behaviour seem to support this thesis, it is an open question *why* photographs can play this role. What is the basis for ascribing photographs such a unique evidential status?

A variety of theorists have discussed this topic since the invention of photography as a medium itself.[3] Especially in aesthetics, the question about this particular status of photographs has been raised. In this context, philosophers discuss the reasons for *photographic realism*, i.e. the thesis that photography is a particularly realistic medium, in contrast to other kinds of depiction.[4] One way to explain this distinctive feature of photographs consists in pointing out the mechanical process of picture production. Considering photographs in this way, we can say that these pictures are the output of a technological device that, therefore, also somehow determines the features which those pictures can have – provided the mechanical process of picture production runs without

[2] On the problem of establishing the evidential status of X-ray photographs from a historical point of view (see Golan 2002).

[3] A compendium of more recent contributions to this discussion is presented by Walden 2008.

[4] An influential voice in this context is Kendall L. Walton. His thesis of the *transparency of photographs* forms a good starting point for critical discussions. Walton's assumption is that photographs literally allow us to see the depicted object itself. "Photographs are *transparent*. We see the world *through* them" (Walton 2008, 22, his italics).

interruption.[5] Let us take a look at some of these special features first and later return to the point of technology.

2.1 Features of Photographic Pictures

A good starting point for our investigation is the work of Catharine Abell. She discusses the evidential benefit a photograph may yield and notes – in accordance with Meskin and Cohen's thesis – that they can fulfil epistemic roles other pictures cannot: "Firstly, they can provide compelling evidence that the things they depict existed at the time they were taken. […] Secondly, photographs play a unique investigative role, enabling us to identify features of their objects that are easily overlooked" (Abell 2010, 81). *Richness of details* and *proof of existence* are the features that Abell emphasises. Accordingly, the pictures that the *HRSC* (High Resolution Stereo Camera) of the *Mars Express mission* takes from the surface of Mars (see http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10364/548_read-400/) do not only show details of the planet (rocks or valleys) with a resolution of about ten metres, but also allows for considered judgments about their being proper parts of Mars.

Both aspects mentioned by Abell depend on the *reliable process* of producing the photograph, i.e. on the *causal relation* between picture and depicted object (see Abell 2010, 83). She then spells out this causal component as a counterfactual dependency relation. "A picture's having a certain feature carries the information that an object has a certain property if and only if, had the object not had that property, the picture would have

[5] Roger Scruton's work offers us an insightful example about the difficulties that such an attempt to describe an "ideal" way of the photographical developmental process can cause (see Scruton 2008).

lacked that feature" (see ibid., 85). In addition to that, she points out that a photograph's ability to depict a vast amount of information – its richness in this respect – is the result of the technological development of photographic cameras (see ibid., 98). *Reliability* and *richness* are then taken by Abell to account for the special epistemic value which we normally ascribe to photographs.[6] With respect to our former example of the photographs taken by the camera of the *Mars Express Orbiter* we can note the benefits of these photographic features for science.

Using a camera as a measurement device only makes sense if there is a reliable connection between the instrument and the measured entity. Normally, such a connection is of a causal nature, the entity or process under investigation gives rise to the detection and recording of certain signals – just as in photography (we will come back to the technological details in due course). And, as a corollary of this, the richer the details of those signals are, the more questions about the object under investigation can be answered by the scientist.

Accordingly, the suggestion in this paper is that in the realm of a scientific usage we can take Abell's approach as a first step to explain what reasons might be responsible for the use of photographs as scientific evidence. How those features of photography are related to our reasoning about the reliability of photography is then open to the different ways of accounting for the epistemic processes of justification. Abell, for example, chooses an externalist approach: "[...] the process linking picture and object must be such that we

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[6] Even though photographs can be used in such a way, Abell admits that not all photographs necessarily play such an evidential role (see Abell 2010, 81). Some may be the result of fraudulent intentions.

are likely to form true beliefs about objects on the basis of pictures produced by that process" (ibid., 85). In order to constitute such a reliable process of belief formation, two conditions must be met: The picture has to provide information about its object, and, secondly, this has to happen in a depictive form (see ibid., 85ff.).

In any case, there is no constraint that forces us to take this externalist explanation at face value. It would also be possible to require that the subject should have *good epistemic reasons* for regarding photographs as evidence. The causal component of photographs, however, can be significant in this scenario as well. Here it is the *belief* that the causal component is responsible for the adequacy of the photograph. Barbara Savedoff takes up this line of reasoning in pointing out that the special kind of "documentary authority" which we normally ascribe to photographs is related to just this kind of background belief about the way in which photographs normally come about (see Savedoff 2008).

What all these approaches have in common is their emphasis on the relevance of certain beliefs (or processes of belief formation) about photographic pictures and their process of production. In order to explain why scientists ascribe an evidential status to photographs, we can adhere to these conceptions by arguing that two aspects are of special importance to scientists and play the decisive role in their background assumptions: the *causal connection* between the picture and its object and the *resemblance relation* between both. Interestingly, both aspects overlap: Photographs resemble their objects since they are causally related to them.[7] Consequently, scientists use these pictures as evidence because

[7] William J. Mitchell, for instance, points this out: "A photograph is fossilized light, and its aura of superior evidential efficacy has frequently been ascribed to the special bond between fugitive reality and permanent

they are convinced that they resemble their object of investigation in relevant respects – the features they are interested in finding out more about.

What then does the term *resemblance* stand for in this context? Scientists take, for example, infrared or false colour images, even diagrams, to resemble the source of the radiation detected. They do not limit the concept of resemblance in the way some philosophers do.[8] Therefore, resemblance is to be understood in a wider sense here. What constitutes the relevant relation then is a *mathematical mapping function*, which ensures the connection between input and output signal of the measurement process.[9] Consequently, the relata involved can be of rather different kinds. For example, we can analyse the emitted light of a star (input signal) to find out its degree of brightness (output signal) by just taking a photograph. To find out what we are looking for we need a familiar star for means of comparison. Then, as a simplified assumption[10], we will see a star which is twice as bright as our star of comparison to be also twice as dark on our negative. The

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image that is formed at the instant of exposure. It is a direct physical imprint, like a fingerprint left at the scene of crime or lipstick traces on your collar. The correspondence with reality is thus causally established" (Mitchell 1994, 24).

[8] Oliver R. Scholz offers a critical discussion of different suggestions of how to spell out the idea of resemblance in picture theory (see Scholz 2009, ch. 2),

[9] What exactly is expressed by this function may vary with regard to the context of application. In some cases it might be filled out by a lawlike statement, in others it might be of a more local decision of the scientist, e.g. what false colours attached to a given photograph may stand for in the particular context. It is important that such local decisions are adequately communicated – e.g. by including a caption – and are hold constant in the context of application to allow for correct interpretations.

[10] For a real world mapping function we have to consider the distance from Earth, intermediate matter etc.

correlated mapping function defines just this proportionality between the blackness of your negative and the quantity of the emitted light (see Unsöld and Baschek 2005, 138).

In philosophy both aspects – resemblance and causality – are common starting points for theories to clarify the question: *What is a picture?*[11] Although it is not the purpose of analysis in this paper to clarify what accounts for the *pictorial status* of a photograph[12], we can stick to the point that both resemblance and causality play an important role in its *epistemic status* in science. Nonetheless, we have to explain why photography is able to offer these two features which make the resulting pictures so interesting for scientists. This explanation will then also put forward reasons for evaluating the justifiedness of scientists holding such beliefs to account for the evidential status of photographs. And here we come back to the point of technology mentioned earlier in this paper.

2.2 Photography as a Technology

We can state more precisely the proposal of the technological nature of photography as an explanation for its special epistemic status with the aid of Patrick Maynard's contribution to this topic. He criticises the fact that most theoretical reflections on photography start with the photographic picture rather than with the *process of picture production* or with the *use of photography* (see Maynard 2000, 9). The resulting problem is that the former approach forces the theorist to make a general claim about *the nature* of *the* photograph, although there are a lot of different kinds (see ibid., 17). Furthermore, Maynard goes on,

[11] A detailed discussion of approaches in this realm can be found in Scholz 2009 and in Sachs-Hombach 2006.
[12] For a critical discussion of this point see e.g. Scruton 2008 and Davies 2008.

the proponents of the described approach do not only have to face the difficulty of finding such a common nature for quite disparate kinds, they also have trouble in explaining new variants brought about by the medium. “[...] photographs are of rather different natures, uses, appearances, and have been produced and valued in these different ways from their first inventions. Besides underestimating this diversity, the usual »photographs« approach to photography falls short in its ability to help us understand *new* kinds of photo imagery [e.g. digital photography, NM] as they appear” (ibid.).

Having pointed out these shortcomings of the classical approach, Maynard then presents his own theses about photography. First of all, he emphasises that photography is a *family of technologies* enabling us to do different things. “We should begin with the photograph*ic* rather than with »the photograph,« approaching photography not as one thing or essence but as group of related *technologies*, serving different, often overlapping, functions in our society” (Maynard 1989, 263, his italics). This at first glance somehow puzzling suggestion becomes immediately clear when we take into account that the same kind of technology which allows us to take family snapshots is also included in such divergent processes as photolithography to produce, for example, solar cells, photocopying, and the fabrication of microchips. In all these instances, light rays are used to mark a certain surface – just as in the case of our family snapshot.

Nonetheless, the above-mentioned processes serve quite different functions. The production of solar cells is not meant to produce pictures in any sense. Accordingly, Maynard’s next step is to draw our attention exactly to this point, namely the different functions photography fulfils. He restricts his analysis to photography as an *imaging* technology – one that produces depictions – and as a *detecting* technology (see Maynard 1989, 264; Maynard 2000, ch. 4 and 5). And it is precisely this distinction that we have to take up from his theory to explain, why and in what way scientists can use photography as a measuring device.

Maynard’s distinction between detection and depiction meshes neatly with the idea presented in this paper that photography plays different roles in different contexts. The advantage of this becomes immediately clear: Taking his distinction seriously, we are no longer forced to assume the same conditions for photographic snapshots in family albums and for photographic recordings of radiation sources in science. Indeed, they belong to the same “family of technologies” (see Maynard 2000, 3), but this does not mean that we have to analyse them epistemically in one and the same way.[13] They serve different purposes in different contexts and we can learn from Maynard’s approach how this happens. About the detective function of photography he writes: “Intended photochemical effects on specially prepared photosensitive surfaces enable reliable detection of the effects’ causal situations, and have great importance for forensic, industrial, military, scientific, and many other forms of evidence. Though they no more depict nor constitute *photographs of* anything [...], plates and films recording the photochemical effects of electromagnetic radiation upon silver halides continue to play a very important role in modern scientific experimentation,

[13] Take another example for illustration: Park distant control systems and radar traps belong to the same family of technologies. The former, however, measures the distance between your car and objects in its surroundings, while the latter measures speed.

in detection and in trace recording, via radiations" (Maynard 1989, 264, his italics). Via the causal relation, cameras can record certain kinds of radiation – that is the relevant point. Digital photography makes no crucial difference to this; it just changes the media of inscription so to speak. Without the causal input, however, there would be no recording in this case either.

To put the proposal of this paragraph in a nutshell, instruments in science are usually deployed to detect and record certain features of entities, processes or whatever is under investigation. To fulfil this task a kind of causal connection normally has to be in place. Regarding photography in Maynard's way – as a family of technologies which amongst others offers the function of detection – makes it a suitable candidate to be used in the scientific context as a measurement device. Moreover, provided that the process of detection runs without interruption and that the camera functions properly, certain features of the photographed entity can be read off the picture at the end. They resemble, in the way explained above, the object detected or recorded. And in addition to that, the causal connection ensures the counterfactual dependency relation described by Abell. Finally, the scientists' knowledge about these interrelations makes their opinion about the evidential status of photographs apprehensible. The causal component of the photographic process can help us understand what is meant by the term *evidence* in this context. Last but not least, this is all that measurement in science is about – obtaining data via an instrument that connects in a causal way the source of information (the object under investigation) with the 'inscription mode' of the data that can afterwards be 'read' and analysed. Considering photography in such a way – i.e. putting forward its technological nature and emphasising its causal connection –, however, leads us to certain difficulties. We will take a look at some of them in the next section.

3 The Problem of Theory-Ladenness

Thinking of photography as a measurement device and taking photographs as a kind of scientific evidence confronts us with different problems. Most of them arise when certain aspects of photography are related to objectivity as a crucial feature of scientific evidence.[14] A particular tension arises from this combination which, at first glance, seems to speak against a scientifically valid use of photography. In the following we will consider only one of these difficulties: the problem of the theory-ladenness of observation. What does this mean?

Martin Carrier formulates the problem as follows: "The claim of the theory-ladenness of observations means that observations, observation statements or measuring

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[14] An ongoing and lively debate in aesthetics, for example, consists in balancing the causal component of picture production against the role of the photographer's intention (see e.g. Walton 2008, Scruton 2008). Another aspect that is critically discussed is related to the digitalisation of the photographic process. It is argued that this allows for a lot more, much easier and hardly recognisable manipulations of photographs. Barbara Savedoff, for instance, draws our attention to the negative consequences of the rapid expansion of digital technology in this context. From her point of view, this development will lead to a significant loss of credit concerning the evidential status of photographs: "Digital manipulation is relatively fast and easy for anyone with the appropriate software [...] As a result, not only are we finding ourselves surrounded more and more by images that have been altered in some way, but it is also becoming impossible to tell which images are straight and which have been altered. [...] In a world where digital manipulation – digital collage – has become the norm, we may simply come to assume that a photograph has been altered if it is at all challenging to read it as straight" (Savedoff 2008, 136f.).

procedures are influenced (or even determined) by theoretical assumptions or background knowledge" (Carrier 1994, 5). Some philosophers have interpreted this thesis in a rather broad way and, as a consequence of this, also discuss the problem in everyday contexts. In any case, even if we restrict the topic to the scientific realm it remains a pressing issue. It makes us aware of the fact that our background knowledge influences the way we observe things and, consequently, that we are not like neutral machines merely recording all kinds of incoming information. Peter Kosso endorses this assumption. He claims that "[a]ll observation in science is influenced by theory" (Kosso 1992, 113) and summarises three aspects where theoretical assumptions are of significance and are largely in accordance with Carrier's points:

Observation: Firstly, theories tell us *where to look for the relevant data* we need to verify or falsify our assumptions (see ibid., 114-115). There are plenty of observable facts in the world that are irrelevant for the theory under investigation at the moment. Theoretical assumptions can help us not to waste our limited time and other resources in guiding us to the evidential data we need. Carrier calls this "perceptual theory-ladenness" and adds to Kosso's point Norwood Hanson's work about the relevance of gestalt psychology and Thomas S. Kuhn's work about the influence of paradigms on scientists' perceptions.[15] They defended the thesis that what we perceive is not only the result of

[15] Thomas S. Kuhn makes an even stronger point when he claims that all scientists are related to a paradigm by virtue of being a member of a certain scientific community. For Kuhn, *perceiving* means perceiving with the aid of such a paradigm. It tells the scientist what exists in the world. Thus, the epistemic burden of a certain tradition leads to ontological commitments in the end and, as a consequence, scientists belonging to different paradigms will live in different worlds (see Kuhn 1996, 111, 135).

images on our retina.[16] Seeing something also involves being aware of something, but awareness is dependent on our background assumptions (see Carrier 1994, 6).

Measuring procedures: The second way Kosso mentions that theories influence our observations in science concerns our *evaluation* of what we have perceived. “Theories play a key role in the accountability of observations by supplying standards to evaluate the reliability of observational reports. The assessment of the viewing conditions, attesting that there are no distorting factors or correcting for any distortions that persist, is based largely on an understanding of the causal mechanisms of observation” (Kosso 1992, 115). That we have to be aware of our observational conditions – loosely speaking that everything runs properly – can be combined with Carrier’s last point in the above quotation as observational conditions also include the proper use of instruments. “Measuremental theory-ladenness” is related to the *instruments* used by scientists (see Carrier 1994, 9). To ensure the correlation between measurement data and empirical phenomena we need the aid of theories, too. “Interpreting a signal peak of the registering device [...] presupposes, among other things, the availability of a theory about how the detecting device actually operates” (ibid.). Therefore, those theories influence our observations which are made in the form of measurements.

Observation statements: And thirdly, theories offer us the *concepts* we need to classify what we have observed. To play an evidential role our observational statements

[16] The same point is made by Alan F. Chalmers: “Two normal observers viewing the same object from the same place under the same physical circumstances do not necessarily have identical visual experiences, even though the images on their respective retinas may be virtually identical“ (Chalmers 1999, 5).

have to be formulated in the language of the theory. To illustrate this point, think of an untrained layperson and an astronomer observing the sky. Whereas the former may just perceive some distant dots of light – that is to say some stars – the latter will be able to differentiate between stars and planets. He will know the constellations and where the Milky Way is. He will know that some of the stars are in effect galaxies and globular clusters. He will know the names of them and so on. While observing the same entity, namely the night sky, the layperson and the specialist will actually observe different things. Furthermore, Carrier points out that the thesis of "contextual theory-ladenness" is that the *meaning* of scientific terms is the result of "its integration into some corpus of laws" because they constitute the rules of its proper use (Carrier 1994, 6f.).[17] The application and the understanding of those terms, therefore, presuppose an adequate comprehension of the theories involved.

The consequence of all this is that observational data become questionable in their justificatory role. Kosso says that "[t]o function as evidence in science, the act of observation must offer reason to think that we believe truly what we see" (Kosso 1992, 119). However, taking the above-mentioned aspects into account, it becomes a moot point whether observational reports can offer such justifying reasons.

Let that suffice as general remarks on the topic of theory-ladenness and let us return to the initial attempt of this paper: How is *photography* and, additionally, the *photographic picture* related to the problem of theory-ladenness? Taking our suggestion into account, to regard scientific photography as a kind of detection technology relying on a causal relation

[17] This presupposes a theory of meaning as use like the one put forward by Wittgenstein.

for its reliability as a measurement device, we have to face two related difficulties: Firstly, photographic cameras as measurement devices are affected by the aspect of *measuremental theory-ladenness*. Here we have to consider the *technological side* of the problem. Secondly, as scientists have to interpret the resulting photographs, we have to consider on the *psychological side* both aspects of *perceptual* and *contextual theory-ladenness*.

3.1 The Technological Aspect

Photography is used as a kind of measuring device in science allowing us to detect and also to record certain events or properties of objects etc. In this sense, cameras are features in scientific processes in the same way as other kinds of instruments. That we need their support for many observational instances is due to the fact that often the object of investigation is too small (e.g. atoms, quarks) or too far away (e.g. stars, galaxies) or does not appear in the appropriate wavelength for unaided observation (e.g. ultraviolet or infrared radiation) etc. The essential point than is that a causal relation holds between the data output and the investigated object. In the case of photography – taken as a detecting technology – we found this kind of connection to be available.

Ascribing to photography this instrumental role, however, also implies that we have to take into account the thesis of measuremental theory-ladenness. Although it is the causal connection that relates data peak and empirical phenomenon, some theoretical knowledge comes in on the level of the camera's construction. The theories here involved play an important role in reliability judgements about the proper functioning of the camera which are necessary for its being of use in the scientific process. These include explaining why the detected datum is a reliable indicator of a certain phenomenon, bringing to our attention possible disturbing factors which can lead to deviations in our measurement results and also suggesting procedures to avoid such sources of confusion (see Carrier 1994, 12f.). Consequently, as in any case of an instrument used in science, one might ask whether those theoretical assumptions, which are obviously necessary to construct an adequately functioning device, do not mislead the scientist in the end. It could critically be argued that the camera he produces with their aid amounts to no more than an artificial 'verification engine' only yielding *confirming* instances for the theory at hand. One may object therefore that photography excludes the possibility of falsification in producing artefacts the scientist wants to believe in.

However, it is not only the reliability of the technological side – i.e. the question whether the camera is a reliable detecting device or, in other words, the question about the trustworthiness of the relation between object and measurement – that deserves critical investigation. Christian Suhm, in agreement with Peter Kosso and Holger Lyre, points out that *scientific observations consist of two parts*: the causal relation between object and measurement device, in our case the camera, and the scientist's perception (see Suhm 2005, 308). Therefore, we do not only have to analyse the technological aspect of photography, but also the psychological aspect of interpreting its outcome.

3.2 The Psychological Aspect

Maynard drew our attention to the ability of photography to be used as a detecting technology. Detecting a certain phenomenon – measuring a certain reflected wavelength, for example, to find out the true colour of an object – does not come to an end in the recording device. It has to be perceived and, finally, also evaluated by the scientist. Photography here offers a further advantage: Not only does it enable us to detect certain things, it also allows for depiction – the *photographic picture of* something as the output of the uninterrupted photographic process. Maynard, therefore, also identifies detection and depiction as two main functions of photography, which can also coincide (see Maynard 1989, 268ff.). This particularity of photography can be of special value for human observers. "Since humans are visual it is little wonder that, where possible, access is through (enhanced) visual recognition, technically specialized: in other words, combinations in which depiction serves detection" (Maynard 2010, 30).

This visual evaluation of the photographic picture brings us back to what we said about the resemblance relation between measurement result and the object under investigation. To assess a photographic picture – i.e. to make a judgment about its effects with regard to the hypothesis in question – means that we rely heavily on the adequateness of the mapping function relating datum and object. The knowledge about this function allows scientists to interpret the properties shown on the photograph as the properties of the object they are interested in.

This apparent advantage of the imaging function of photography, however, takes us directly to the next level of the theory-ladenness of observations as it is a theoretical assumption that allows the scientist to infer certain results in favour of or against our hypothesis from the read-off data. The mere detection tells us nothing about the *quality* of our measurement and about its relevance for our investigation. Scientists have to interpret the results or, in our case, the photographic picture (whether it is a depiction or not[18]) in the light of their theory at hand. Consequently, we are confronted with perceptual and contextual theory-ladenness here. Scientists will, for instance, use cameras only if they are theoretically convinced that these devices can reveal the data they are searching for; they will focus them on certain phenomena and, furthermore, use the concepts of their theory to formulate their observation statements.

In the end, it seems as if we are facing a dilemma: On the one hand, scientists use photographic pictures as evidence, suggesting that they can be used in the same way as neutral data. For example, the astrophysicist Thorsten Ratzka states that the use of photographs in astronomy makes observations more objective (see Ratzka 2012, 246). Observing the stars with the unaided eye only leads to subjective impressions which are not necessarily accurate. One example of the problem of observations without the aid of instruments is to determine the true colour of the observed stars – an essential feature to identify their age and magnitude. Atmospherics can mislead the eye. Furthermore, the results of the unaided observation vary, depending on where and when the observation is made and on personal abilities. Photographs, on the other hand, can register the colour of the object (its correct wavelength) and, therefore, the observation can be checked

[18] Maynard also offers a convincing example where the photographic picture is not taken as a kind of depiction, namely a description of the tasks of the Herschel space observatory. "Its cameras' function is *not to depict* opaque bodies, but to derive information about the formation of stars and galaxies [...]" (Maynard 2010, 30, my italics). And: "Herschel's output is not pictures, but rather data (part of which is accessed pictorially, within technical constraints)" (ibid., 31).

intersubjectively. Thus, the claim is that *intersubjectivity with regard to observational data, understood as the basis for objectivity, can only be reached with the aid of photographs*. If we, as philosophers of science, want to stick to current scientific practice as an approach leading us to (approximately) true descriptions of the world, we have to deal with this. On the other hand, the problem of theory-ladenness as discussed above seems to forbid just this kind of scientific activity. What can we make of it?

4 A Way Out?

To regard photography along the lines of Maynard's approach, allows us to be more precise about the challenges resulting from the different theses of theory-ladenness with regard to its scientific use. Accordingly, to tackle the problem we have to take into account both the technological and the psychological aspect. Let us start with an approach for the use of photography as an instrument in science, i.e. the technological part of the problem.

4.1 Photography as a Detection Technology?

To sort out the problem of measuremental theory-ladenness the suggestion in this paper is to follow Christian Suhm's advice to be more precise about the nature of the relation between theory and the measurement outcome. He suggests that we should make a distinction between a *severe dependency relation* and a *rather harmless relativity* (see Suhm 2005, 282f., 289). The former term is meant to cover those claims whose proponents defend the view that scientific facts and physical reality itself are dependent on our theories etc. (see ibid., 54). Such claims we find in the constructivists' camp, put forward by philosophers like Thomas Kuhn or Paul Feyerabend.

The suggestion then is that we have to admit that we *do* need theories for the construction of instruments we use in scientific observations. However, this fact only becomes problematic if the theory which we use for the construction is the same as the one we want to test with the aid of the corresponding instrument. When we use a theory to build an instrument which we want to apply to test the very same theory, the suspicion arises that we are simply constructing the evidence needed to confirm our theory – i.e. we face the problem of measuremental theory-ladenness. In order to come to grips with this problem, it is a necessary requirement that those theories (or set of theories) are different.

What is it like then in the case of photography? Let us pick up our example about astrophysics and the detection of the true colour of stellar light to infer the magnitude of the stars photographed. On the one hand, what we have here is the theory which is relevant for constructing a camera. This explains how the emitted and detected light rays leave their traces either via photochemical effects on a material medium (see Maynard 1989, 264) or via electronic effects on a digital medium (see Maynard 2010). On the other hand, the theory we need to detect the star's colour is about photometric systems. An example would be the *Johnson-Morgan system*, also called the *UBV system*[19]. The idea here is to use different colour filters so that only an amount of light per defined range of wavelength (commonly known as "colour") can be detected by the camera. In this context, the term

[19] *U* stands for ultraviolet, *b* for blue and *v* for visual, referring to the defined wavelength of light (see Unsöld and Baschek 2005, 183).

colour means the measure of the magnitude difference of a star in two passbands, i.e., for example, to take the measured magnitude the star has in the blue passband minus that in the visual passband. Additionally, we need as a point of comparison the magnitude of the star *Vega* whose magnitude in the UBV system has been defined as zero (see Unsöld and Baschek 2005, 180). *Antares*, for example, has a B-V magnitude of 1.87 (in comparison to Vega) and, according to the definition, a star is red when its colour index is greater than 1.5. Consequently, *Antares is red* (see http://spiff.rit.edu/classes/phys445/lectures/colors/colors.html#blink). Photographs made with the aid of those filters are then the measurement results.

Consequently, two completely different sets of theories are in play here – one explaining the process of photography and the other explaining the method for detecting the colour of the starlight.

In accordance with this, Suhm writes that although empirical evidence – the photographs as the output of the instrument in our example – is in this way interwoven with the theories at hand, it is *not dependent* on them in this context (see Suhm 2005, 282). Our theories, therefore, can no longer be suspected of triggering the production of confirming instances. Nonetheless, it was said at the beginning that the technological part of the problem is just one aspect. What about perceptual and contextual theory-ladenness which represent the more challenging part?

4.2 Photographs as Evidence?

Apart from our approach with regard to photography as a technology used in science, with its ability to make *neutral* data available (in the sense of not artificially constructed data), the problem remains that photographs have to be interpreted by human beings in the light of the theory under investigation. Consequently, a psychological aspect comes into play. Although the situation seems to be more complicated in this case than in the foregoing technological part, there is more than one argument at hand to avoid severe consequences from theory-ladenness.

At first, we can stick to Suhm's advice to make a difference between theory-ladenness and theory-relativity on this level, too. It might be the case that we use the concepts of our theory to describe our results and it might be the case that it informs our investigation, nevertheless, as long as the tested theory does not become a presupposition for its testing, i.e. as long as the measurement results are logically independent of the theory under investigation, no serious problem arises (see Suhm 2005, 298).

That this requirement can be fulfilled in the case of photography and the interpretation of the photographic picture is a consequence of the causal relation between the photograph and its object. The effect of this causal component in the scientific realm can best be described in the counterfactual way that Abell puts forward. "Moreover, photographic mechanisms operate such that all photographs have external objects, and the design features of any photograph (those features in virtue of which it depicts its object) depend causally on the features of its external object, such that the former depend counterfactually on the latter" (Abell 2010, 83). This means you cannot take a photograph of something that is not there – except if someone fakes the object, for example, in artistic contexts. Under normal conditions though – i.e. setting fraud aside and under circumstances where photography is the appropriate measurement device – we can take photographic detection to be reliable. To show this let us take a look at two concluding examples from scientific practice.

The first one stems again from the realm of astronomy. The astrophysicist Ratzka stresses the point that a virtue of photographic pictures consists in the fact that older images can be used to check current calculations of orbits or in the search for variable stars (see Ratzka 2012, 246). In these cases, the photographic pictures are evidence for the existence of the latter or the position of the former. With regard to the fact that at the time those photographs were made the object under investigation now was not the reason for them being taken, we can conclude that the theory to test with the aid of the photographic picture did not guide or influence the search for evidence. The discovery of the dwarf planet Pluto in 1930 can be taken as a concrete example here. In this case, too, old photographs were used to detect the planet. This example shows that the scientists who interpret the pictures direct their attention to different aspects when looking at them with different background theories. Nonetheless, the causal relation between object and picture ensures that a real entity is involved here and not mere wishful thinking. If Pluto did not exist, it could not appear on a photograph.

The second example is discussed by Laura Perini. In answering the question what kind of contribution visual representations can offer in scientific arguments, Perini analyses, among other things, images produced by electron microscopes. In doing so, she comes to the following interesting conclusion: “As in this case, figures that support the existence of unexpected structural features can be produced. This system can also represent very complicated structural properties, *even when there are no linguistic terms* for the same feature. So the causal relation between visible form of the micrograph and the structure of the sample is a source of the credibility of the representations that are produced, and allows for representation of novel and complex phenomena” (Perini 2005b, 921, my italics). This means that visual representations can exhibit features of the research object the scientist was not aware of and did not expect in view of his background theory. Moreover, not even the theoretical concepts played a significant role, as might be argued that it did in the above example about Pluto. There are no technical terms available for the newly discovered phenomena, they have still to be denoted. And, although, the example deals with electron microscopy the main idea can easily be transferred to photography, too. It is the *causal component* that is of relevance in both instances. Accordingly, the discovery of X-rays with the aid of photography can be described in the same manner as Perini’s description for microscopy here (see Maynard 1989, 267). The fact that certain materials (e.g. uranium salt) had the ability to accidentally darken photographic plates which were also in the laboratory informed investigations on this matter. This example clearly illustrates the detecting function of photography. Neither theoretical concepts nor background assumptions were in play, because the discovery preceded the invention of the theory of radioactive radiation. However, if visual data are able to bring about such discoveries, the problem of theory-ladenness cannot be as serious as some philosophers suggest.

5 Conclusion

The aim of this paper was to address the apparent dilemma arising from the practice of using photographic pictures as evidence and cameras as measuring devices in science in contrast to the different theses of theory-ladenness of observation. Our starting point was Patrick Maynard's approach of regarding photography as a family of technologies to serve different purposes. His proposal of making a distinction between the function of detection and that of depiction in the case of photography allowed us to explain why scientists use photographs in their professional realm. We found the causal component of photography to be the decisive factor here. It allows the detective function of photography and makes it a member of the class of scientific instruments. Ultimately, this is all that measurement is about: *Detecting a signal (radiation, sound wave or whatever) causally related to the object under investigation, where a certain mapping function tells us how to interpret the signal qualitatively later – and thereby also constituting a certain kind of resemblance relation between the recorded signal and its source.* Furthermore, the function of depiction allows the scientist in some cases to visually read off the data from the resulting photographic picture. And, as Maynard claims, detection and depiction can accompany one another but do not have to.

To follow Maynard in his sophisticated conception of photography also made clear that in our discussion of the problem of theory-ladenness of observation we have to deal both with the technological part – the camera as measurement device – and the psychological part – the perception and interpretation of the photographic picture. The suggested solution was to take into account Christian Suhm's thesis that we should be more precise in formulating the problem. It has to be established whether we are facing a severe dependency relation or a rather harmless relativity. The proposal was that in the case of photography in science – both for the technological and the psychological part – it can be shown that we are only confronted with a kind of theory relativity and not with theory-ladenness as a dependency relation.

As a brief outlook we should be mindful of the fact that, of course, there are more functions which photography and photographs can fulfil in the scientific context. One example would be to attract public attention and, consequently, to gain better funding for one's research. The pictures published from the Hubble Space Telescope are an illustrative example (see http://hubblesite.org/). In such a context, the aspect of postprocessing becomes relevant again – an aspect we were happy to eliminate in the context of detection and depiction in the sense above. However, here aesthetic decisions have to be made to create the image that will serve the intended purpose best – though this is a different story.

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