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The Perspective of the Instruments: Mediating Collectivity

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Abstract Numerous studies in the fields of *Science and Technology Studies* (STS) and philosophy of technology have repeatedly stressed that scientific practices are collective practices that crucially depend on the presence of scientific technologies. Postphenomenology is one of the movements that aims to draw philosophical conclusions from these observations through an analysis of human–technology interactions in scientific practice. Two other attempts that try to integrate these insights into philosophy of science are Ronald Giere's *Scientific Perspectivism* (2006) and Davis Baird's *Thing Knowledge* (2004). In this paper, these two approaches will be critically discussed from the perspective of postphenomenology. We will argue that Giere and Baird problematically assume that scientific instruments (a) have a determined function, and (b) that all human members of a scientific collective have immediate access to this function. However, these assumptions also allow them to offer a clear answer to the question how scientists can collectively relate to scientific phenomena. Such an answer is not yet (explicitly) formulated within the postphenomenological perspective. By adding a postphenomenological touch to the semiotic approach in Actor-Network Theory, we offer an account of how different individual human–technology relations are integrated into larger scientific collectives. We do so by showing that scientific instruments not only help constitute scientific phenomena, but also the intersubjectivity within such collectives.

Keywords Technological mediation · Scientific instruments · Postphenomenology · Scientific Perspectivism · Thing knowledge · Actor-Network Theory

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1 Introduction

It has been common knowledge in *Science and Technology Studies* (STS) and philosophy of technology that the collective and technological nature of scientific practice has consequences for the way scientific knowledge is produced (e.g., Knorr-Cetina 1999; Latour 1987; Lynch 1994). However, the importance of these findings have only been slowly been acknowledged in epistemology and philosophy of science. Two attempts that try to integrate these findings into philosophy of science are Ronald Giere's *Scientific Perspectivism* (2006) and Davis Baird's *Thing Knowledge* (2004).[1] While they diverge in their specific approach regarding the role of technologies in scientific practice, Giere and Baird share the intuition that the production of scientific knowledge is not something that is exclusively limited to the human realm, and that technologies actively shape the way scientists understand the world.

Both Giere and Baird take as a starting point that the importance of scientific instruments becomes immediately clear when looking at scientific practice. According to Giere, scientific knowledge is the product of a network of scientists using instruments that offer a specific perspective on the phenomenon that is studied. These instruments have a crucial role in structuring these networks; they offer a solid perspective dependent on their internal design. The central point of Baird's philosophy is that 'instruments, just as theories, bear knowledge' (Baird 2004, xvii). Baird's central claim is that scientific instruments have an important epistemological function in guiding scientific developments. Contrary to Giere's idea, this is not the case because they are used in a specific way, or offer a certain perspective on the world, but because scientific instruments are instances of solidified knowledge. Instruments can be detached from the context in which they develop and can be used by other scientists who can learn new things from them (Ibid. 119). Their solidity makes it possible for different scientists to encounter a stable phenomenon, which makes scientific instruments essential in the development of scientific knowledge.

In this paper, we will argue that both Baird and Giere problematically assume that (a) scientific instruments have a universally determined function, and (b) that all human members of a scientific collective[2] have immediate access to this function. However, empirical research on the impact and use of concrete technologies in STS and philosophy of technology suggests that the function of technologies varies across cases, and that the specific nature of this function depends on how it is integrated in the lifeworld of the user. Postphenomenology is the movement aiming to develop a philosophy of scientific practice that is most closely tied to this line of empirical research (e.g., Friis 2012; Ihde 1991, 1998, 2011, 2012; Olesen 2012; Rosenberger 2008, 2011; Rosenberger and Verbeek 2015; Verbeek 2005). One of the central ideas of this movement is that technologies mediate our relations with the world. In this view, scientific instruments are no neutral

[1] Another branch within philosophers of science, known as *New Experimentalism* also attempts to do justice to the importance of scientific instruments. However, rather than focusing on the general importance of scientific instruments, their work is specifically concerned with the use of scientific instruments in relation to experiments. A discussion of this line of research is beyond the scope of this paper. For an excellent overview, see Boon (2015).

[2] In this paper, we use the notion of 'collective' to denote a group of scientists that work in the same laboratory to investigate topic X through the use of specific set of technologies. While we think that a similar objective may apply to Baird's and Giere's theories if we would expand the notion of 'collective' to a larger group of scientists (say, everyone investigating topic X through the use of a specific set of technologies), we restrict ourselves to this narrow notion of collective to make as clear as possible that scientific observation are grounded in human-technology relations.

intermediaries, but have an active role in determining how the world is revealed to scientists. However, this active shaping cannot be cut loose from the scientists that uses this instrument, which is captured in the postphenomenological notion of technological mediation.

As we will make clear, the idea of technological mediation entails that there is nothing prior to the relation between scientist (human) and instrument (technology). In this paper, we will contrast this idea with Baird's and Giere's analyses of scientific practice in which the internal design of a technology is decisive in the way a scientist relates to the world. Doing so, we aim to specifically make clear how a philosophy of scientific practice grounded in human–technology *relations* differs from one in which the importance of either humans or technologies is prioritized. From a postphenomenological perspective, neither scientist nor technology is the decisive factor determining the way in which the world is revealed.

But how can a scientific instrument offer a collective, shared perspective or a clear function when those are not pre-determined by the design of the instrument? The postphenomenological focus on human–technology relations has not yet formulated an explicit answer to this problem.[3] In this paper, we argue that to understand the collectivity of scientific practice from a postphenomenological perspective, it does not suffice to understand the specific individual relations between observers and scientific instruments. The relations *between* scientists should be taken into account as well. Scientific instruments have a crucial role in structuring these relations as all involved scientists necessarily have to relate to them. In this relation, it becomes clear what counts as intersubjective knowledge and what is subsequently acted upon (cf. Latour 1987; Hutchins 1995).[4]

The idea that scientific practice must be interpreted in terms of human–technology relations will be compared with Latour's Actor Network Theory (ANT) account of collective scientific knowledge. We will argue that in ANT, it is taken for granted that a group of scientists can have a clearly determined perspective with regard to an instrument. From the perspective of technological mediation, how it is possible that scientists engage in a similar relation with a scientific instrument is precisely the matter at stake. We will argue that the collective relations between scientists and instruments are not presupposed or immediately given, but that they are the product of negotiations between scientists.[5] That is, only in developing a relation with an instrument that is collectively workable does it becomes possible to produce scientific knowledge.

In what follows, we will firstly discuss Giere's and Baird's understanding of the relation between scientists and technologies in scientific practice. Secondly, we will discuss Giere's account of how networks of humans and non-humans are capable of generating knowledge. Thirdly, the concept of technological mediation will be used to criticize this understanding, and to stress that scientific instruments can offer multiple coherent perspectives in relation

[3] This question is related to what Rosenberger (2016) has recently called postphenomenology's problem of invariance. That is, if technologies in scientific practice should be understood in non-essentialist, non-foundationalist terms, how can a (multi-)stable use of them be maintained across individuals?

[4] In this paper, the term 'intersubjectivity' is not cognitively interpreted in terms of the mental states of a (set of) individual(s). Rather, it is understood as a shared stance that enables individuals to perform certain actions.

[5] Note how this idea differs from the idea that the relation between scientists and instruments are structured through already existing social mechanisms. In our view, this view mistakenly assumes a social structure that exists outside of human-technology relations. A detailed discussion of this difference is beyond the scope of this paper. For an analysis of the way in which social relations between scientists change and take a specific shape in different human-technology relations, see Vertesi (2012).

with scientists. Fourthly, we will argue that ANT's approach of revealing networks of humans and non-humans that produce scientific knowledge neglects the importance of technologies in this process. Lastly, we will sketch the contours of an account of how individual human–technology relations are integrated into a larger scientific collective, thereby clarifying how scientific instruments can give rise to an epistemic stance within such a collective.

2 Scientific Instruments as Solidified Knowledge

Baird's aim is to do justice to the importance of instruments in science, and to connect this importance to the epistemic role of these instruments. His main argument is that, just as with scientific theories, the instruments used in science bear knowledge that is independent of the presence of an individual observer. Accordingly, he argues that there is something *in* the instrument that is of epistemological significance (Baird 2004, 4). Baird's notion of 'instrument' includes a wide array of devices ranging from telescopes and MRI scanners to Boyle's air pump, or Watson's and Crick's material realization of the Double Helix. However, he does not aim to develop a generic framework capable of explaining the epistemic role of each instrument through a similar mechanism: 'Different things, and even different aspects of the same thing, operate epistemologically in different ways' (Baird 2003, 40).

Even though different things have different specific epistemic roles, they have in common that they are all instances of solidified thing knowledge. According to Baird, this type of knowledge is restricted to the domain of things, and should be distinguished from our subjective (propositional) knowledge of the world. Contrary to the knowledge of the scientist (the subject), thing knowledge is objective knowledge, as 'the epistemological world of science and technology is too big for a single person to comprehend' (Ibid. 44). It is only in the things that the knowledge of the scientific community remains solid. Hence, according to Baird, the knowledge of the scientific community is not kept together by the scientists, but by the instruments.[6]

Although Baird recognizes that different instruments have different epistemic roles, he does not situate these roles in relation to the users of the instruments (cf. Pitt 2007, 53). In Baird's view, scientific instruments are in fact black boxes, and it is in this aspect that he identifies their epistemic role. For example, it is because a radiologist does not need to have a precise understanding of the working of MRI that he is capable of using it. The fact that misdiagnoses still appear and medical images can give rise to different conclusions is unimportant for Baird in this context since 'there can be no question that our diagnostic capabilities are vastly improved with these new black boxes [new imaging technologies]' (Baird 2003, 59).

In Baird's view, an MRI scanner would be classified as a specific kind of thing knowledge: encapsulated thing knowledge (Baird 2004, 68), indicating that it offers a representation of the brain, as well as it embodies the physics of magnet resolution. The scanner contains knowledge of magnet resolution physics, and this knowledge can be studied by investigating the specific nature of the working of the scanner. But in addition, brain scans are used to obtain knowledge of the brain; knowledge that is external to the

[6] In line with Popper's notion of the "third world", Baird argues that scientific instruments bear objective knowledge that may remain undiscovered. For a critical discussion of this aspect of Baird's philosophy, see Kletzl (2014, 199).

working of the scanner. From Baird's perspective, both are instances of objective knowledge: the MRI bears knowledge of both the human brain and the physics of magnet resolution independent of the presence of an observer.

However, a brain scan can neither be made, nor be interpreted without the involvement of at least two human individuals; a scientist and a person lying in the scanner. As a consequence, the epistemic role of an instrument only becomes visible when users relate to it. Consider the following example to illustrate this: Assuming that all cars would work in a similar way, we would not need (and to some extent we actually *do* not need) precise knowledge of the exact working of a car. However, the practical situation is profoundly different; traffic rules are not part of the internal structure of the car. In the relation between the driver and the car, the decision how to interpret the traffic rules is made. Similarly, it is in the relation between a neurologist and an MRI scanner that an interpretation of a brain scan is made, and in which the epistemic role of an instrument is revealed.

Baird is not entirely unsympathetic to the idea that something relevant happens when an instrument is used by a scientist. He suggests that things can be 'read', and that they 'enlarge our ability to bring our cognitive apparatus to bear on the world' (Baird 2004, 40). However, how things are put to use remains unaddressed in his analysis. In the end, there remains a gap between the objective knowledge present in the things and the way scientists obtain knowledge through the use of scientific instruments. This gap is simply not there in scientific practice; in practice, scientists and instruments do interact in order to obtain scientific knowledge. As we will show, the outcome of this interaction cannot be exhaustively determined with reference to what is 'in' the scientific instrument, but it is the product of the relation between the scientist and instrument. This change of focus enables us to ask how it is that scientists and instruments interact such that scientific knowledge can originate within a particular practice.

3 Scientific Instruments as Offering Perspectives on Reality

This interaction between scientist(s) and instrument(s) is one of Giere's focal points of interest. His starting-point is the idea that this can be the case because different scientific instruments—when put to use—offer different perspectives on reality. Giere's focus on the role of instruments in scientific practice functions to understand the *Contingency Thesis*, which states that 'reality seems capable of sustaining more than one account of it' (Giere 2006, 8) without embracing social constructivism. When using scientific instruments to detect phenomena that cannot be observed with the naked eye, we can only look at these things from the perspective of the instrument we use. And precisely because we cannot cut ourselves loose from this perspective, it makes no sense to think of science as an attempt to grasp the objective structure of an external reality. The strongest claim a scientist can make is that 'according to this highly confirmed theory (or reliable instrument), the world seems to be roughly such and such' (Ibid. 6).

In Giere's account, technologies are decisive in adopting this or that perspective: 'these artifacts [scientific technologies] typically incorporate a built-in perspective on the world' (Ibid. 116). Which specific perspective a technology offers is in Giere's view determined by its internal design. But this does not explain why scientific instruments offer perspectives, instead of establish a one-on-one relationship with the world out there. According to Giere, the perspectivism comes in because scientific instruments—just as human vision—obey physical laws. Telescopes and microscopes respond only to electromagnetic radiation, just as the human visual system. As a consequence, all of these systems are blind to cosmic rays and neutrinos, and are incapable of seeing the particles that constitute for example a tree (Ibid. 42). Apparently, the world is physically structured in such a way that specific technologies, which have a specific internal design, allow us to detect certain physical processes and make us blind to others.

The way in which the world becomes visible through the interaction between scientist and instrument in Giere's view, is hence dependent on the interaction between the physical constitution of the world, the physical constitution of the instrument, and the physical constitution of the human visual system. For example, MRI images of the brain are the result of atomic interactions on a quantum mechanical level, and despite the fact that the structure of the image crucially depends on the choices made on which parameters to measure and the way the data is analyzed, our access to the brain is the function of the way MRI scanner generates a certain output (a brain scan) on the basis of the input it gets (Ibid. 56).

Brain scans are therefore not photographs of the brain, but offer a view onto the brain from the perspective of an MRI-scanner (cf. Roskies 2007). For example, EEG graphs will offer a different perspective on the brain. It is in this sense that Giere understands the contingency thesis: the account of reality that science gives is dependent on the perspective offered by the scientific instrument. Still, scientists know that they can draw certain conclusions from MRI images that they cannot from EEG graphs and vice versa. In choosing between these technologies, scientists decide which perspective to take in relation to the goals they have and in relation to the aspects of the brain they want to highlight. Despite the fact that it is impossible to go beyond the perspective of one specific type of technology, it is possible to compare the results of these technologies and to decide which one is most likely to suit your goals. Because of their relation to specific goals, perspectives are not rigid and change over time; either with the introduction of new technologies, or by the combination of existing perspectives. However, as Giere stresses, the combining of different perspectives can never eliminate perspectivism; multi-perspectivism is not transcending perspectivism.

In this view, scientists have an active role in determining which perspective to take at which moment. Giere summarizes this in the formula: 'S uses X to represent W for purposes P. Here S can be an individual scientist, a scientific group, or a larger scientific community. W is an aspect of the real world' (Giere 2006, 60). But where do the specific purposes of the scientist come from? Giere tries to explain these purposes by expanding the notion of perspective from scientific technologies to the level of scientific theories. He argues that theories are sets of models of the world, and that the matching of the models with the world can be tested through the provision of scientific instruments (Ibid. 61). Hence, there is a continuity between the perspective offered by an instrument, and the reliability of the consequences of having a specific theoretical perspective, which can only be addressed through the use of a scientific instrument.

Scientific knowledge of the world is therefore always the function of the relation between the theoretical perspective of a scientist or a scientific community and the perspective of a scientific instrument, in which the latter allows for 'an intersubjective objectivity in that there is roughly a way something looks from a particular location for most normal viewers' (Ibid. 13). Thus, according to Giere, also shared theoretical perspectives can never escape the relation between the internal design of an instrument and the physical structure of the world to which the instrument obeys.

4 Distributed Knowledge

According to Giere, obtaining scientific knowledge is an activity of a system containing minimally a human and a non-human. Considering that no one is capable of conducting current scientific research on his own, and that science always involves relations between humans and scientific instruments, Giere proposes to interpret scientific practice in terms of a distributed cognitive system (cf. Hutchins 1995). Rather than individual scientists, these systems as a whole are responsible for the output of scientific practices. From this perspective, it is no longer necessary to ascribe some form of hyperrationality or other special intellectual capacities to individual scientists. In Bruno Latour's words: 'No 'new man' suddenly emerged sometime in the sixteenth century. […] The idea that a more rational mind … emerged from darkness and chaos is too complicated a hypothesis' (Latour 1986, 1).

Through a critical discussion of the work of Latour, Giere and Moffatt (2003, 308) argue that distributed cognition is the only plausible explanation for the fact that ordinary human beings with normal cognitive capacities are capable of doing science. Accordingly, the collectivity of modern scientific systems consisting of both scientists and technologies is of primary explanatory value. In this collectivity, both the role of concrete technologies and of individual human cognition dissolve into the cognitive activity of a system that cannot be explained in terms of its parts. Thus, while Baird explains this success in terms of the objectivity of thing knowledge that exists outside the human subjective domain, Giere tries to do justice to the fact that what counts as scientific knowledge is in most cases the outcome of relations between scientists and between scientists and instruments.

CERN's Large Hadron Collider can be used to exemplify this view. Located 175 m under the ground, this 27-km-long collider is developed to test the predictions of fundamental physical theories, and is primarily for the search of the Higgs boson. This project involves hundreds of scientists and engineers working from different continents, indicating that the experiments performed at CERN can hardly be considered as the project of an individual scientist. Rather, it is the complex relation between different scientists and the instrumentation of the CERN that gives rise to new experimental results. Put in Giere's terms, we should treat the Large Hadron Collider as a distributed cognitive system, and attribute cognitive capacity to this system as a whole, i.e., to the total organization of individuals and machinery (Giere 2002, 5).

But how is knowledge generated by and distributed through these kinds of systems? And how do the human parts of the system relate to the system's non-human parts? Minimally, a distributed cognitive system has to consist of a human and an external representation of some sort, for example a symbolic manipulation of an arithmetic operation (say 4876×8765) that for most of us is too difficult to perform 'in our heads'. While such a system is relatively simple, much more complex systems are responsible for obtaining scientific knowledge. Not only are there way more elements involved in the system, the importance of scientific instrumentation adds to the complexity as well. As we saw, Giere argues that these instruments force us to investigate things from a specific perspective that is determined by the instrument.

Key in Giere's analysis is the idea that scientific knowledge should be interpreted as the *cognitive* output of a system. In other words, he maintains the idea that scientific knowledge in the end is a product of a mind. But when the cognitive output of the system cannot be located in the head of a single individual, not even in the heads of a group of individuals, but in a system consisting of both humans and non-humans, where to find the mind(s) responsible for generating this knowledge? In the end, these systems 'make possible the acquisition of knowledge that no single person, or a group of people without instruments, could possibly acquire' (Giere and Moffatt 2003, 305). Yet, *how* this acquisition can happen remains an open question in his analysis.

5 The Postphenomenological Perspective of Technological Mediation

Similar to Baird's analysis, Giere explains the role of scientific instruments in constituting this or that perspective in terms of the internal design of the instrument. As we already showed above, in Giere's view, the physical structure of the world is organized in such a way that technologies having a specific internal physical design allow us to detect certain physical processes that scientists can then see. Such an analysis of the collectivity of scientific practice in fact crucially depends on two assumptions: (A) Scientific instruments offer only one perspective on a phenomenon, and (B) all human members of a scientific collective immediately share this perspective.[7]

From a postphenomenological point of view, though, both assumptions are problematic. Giere explains the relation between scientist and technology as a relation between a scientist and the pre-determined perspective of a certain technology. But how do scientists come to know what this perspective is, if it is shaped as the function of the relation between the scientist and the technology, and cannot exist otherwise? Applied to scientific research collectives, answering this question would imply that we should get an understanding of how what counts as knowledge is constituted in the relation between scientists and their instrumentation. For example, in the relation between a scientist and a brain scan, some epistemic decisions are to some extent made on the basis of the scan itself (cf. Hutchins 1995). That is, when using fMRI to access the brain, a researcher cannot but interpret human cognition in terms of brain activity that is represented in terms of the blood flow in a specific brain area. The underlying assumption of this kind of brain research is that blood flow and neuronal activity are coupled in one way or another.

In postphenomenology, this relation between human being and technology is conceptualized in terms of technological mediation (e.g., Ihde 1991, 1998; Verbeek 2005). The MRI scan mediates our knowledge of the brain. That is, what is considered to be knowledge about the workings of the brain is not solely determined by the scientific observer. And neither is this knowledge the consequence of the internal structure of the instrumentation. It is only in the relation between scientists and their instrumentation that knowledge is constituted, such that part of what *counts as* knowledge is to some extent determined on the scan itself. fMRI-scans limit the range of explanations of human behavior (for example, they do not allow for understanding human behavior in terms of balancing the four human humors), but they require interpretation to be understood.

How the brain is seen through an MRI scanner is not merely an interaction between two physical systems, such that the internal design of the scanner offers a specific perspective on the physical structure of the world, which is accordingly brought within the limits of the human visual system. Seeing the brain on an MRI-generated image requires the active prior involvement of the researcher, who is actively manipulating the content of the image with

[7] Giere uses the term 'system' to denote a collective of humans and non-humans, which we believe to be closely related to his idea that scientific practices should be understood in terms of distributed cognition. We prefer to use the more general term 'collective', because the view of scientific practice developed in this paper is not necessarily to be understood in terms of distributed cognition.

an intention to filter and simplify the things that an MRI scanner is detecting, an activity which is not part of the causal interaction between two physical systems.

The MRI scanner confronts the scientist with an image that allows drawing inferences about the working of the brain (cf. Suárez 2004). However, not only the process of construction, but also the constructed image itself allows for a variety of interpretations. In Ihde's words, these images are *multistable*; they can be coherently interpreted in several ways. To determine the meaning of an fMRI-image is to determine the relevant features of the image: to consider certain aspects as relevant, and others as not. A scientist has to employ a specific hermeneutic strategy to be able to do so (Ihde 2009, 53; Rosenberger 2008, 72). The relation between the fMRI-image and the observer is what opens the possibility for deciding what counts as relevant brain activity. The knowledge of the brain is not just determined by the perspective of an MRI scanner that obeys the laws of physics. The way a scientist observes and the kind of knowledge of the brain he can obtain are the products of this process of technological mediation.

When a scientist accesses the brain through fMRI, his interpretation of the brain scan cannot be reduced to the fact that an fMRI scan portrays brain activity in a certain way. When interpreting such a scan, the blue and red dots are related to a certain cognitive task. The way we interpret the distribution of these dots is in itself not determined by the physical design of the imaging technology. The association of brain activity with certain cognitive tasks is not internal to the information present in the brain scan. While this imaging technology makes it possible to interpret human cognition in terms of blood flow in a certain brain area, the meaning of this increase cannot be reduced to the way it is measured. For example, when linking activity in certain brain areas to the way human beings process visual information, neuroscientists need to link the concept of visual processing to the red and blue dots present in the brain scan. Even stronger, the basic assumption underlying the use of fMRI in research in the cognitive neurosciences, i.e. the coupling of cerebral blood flow to neuronal activity, is itself not entailed in the working of the MRI scanner, and neither can this hypothesis be specifically put to test by the scanner. In relating to—and investigating with—the MR-scanner, scientists have to actively construct a perspective on the brain, that necessarily requires the modelling of the relation between blood flow and neuronal activity, which greatly influences the way in which the brain becomes present.

Interpreted in this way, an fMRI scan does not offer a perspective on the pre-determined structure of the brain, but makes the brain present in a very specific way. This translational process is the product of the individual relation between the scientist and the MRI scanner. Varying on Giere, this can be formalized as 'in the relation between S and X, an aspect of W comes into being for purposes P at time T.' S refers to an individual scientist having a relation with the mediating technology X (say, an MRI scanner) such that an aspect of W (the brain) becomes present to him to investigate this or that phenomenon at a certain point T in time in which a specific set of scientific technologies are available.

In this view, the MRI scanner does not stand in between the scientist (subject) and the brain he is studying (object), such that it offers a way to see aspects of the brain the scientist was previously incapable of. Rather, it is in the relation between human and technology that a scientist can experience the brain in the way it is portrayed on a brain scan (cf. Verbeek 2005, 130). In contrast with what Baird and Giere argue, the MRI scanner is not some technology in which a specific perspective or specific kind of knowledge is hidden that can be discovered by a scientist. From a postphenomenological perspective, the working of an MRI scanner cannot be reduced to the physical law which it obeys. When confronted with a brain scan consisting of several blue and red dots, the scientist is not presented with a photograph of the brain, but (s)he has to interpret what these dots mean (cf. Carusi and Sissel Hoel 2014). And it is precisely the specific interpretation of this brain scan that is not part of the internal design of the scientific instrument.

6 Immutable Mobiles and Scientific Networks: The Role of Scientific Instruments from an Actor-Network Perspective

Studying how scientists and scientific instruments interact in order to construct 'facts' about 'nature' is one of the main ambitions of Actor-Network Theory, which aims to investigate science-in-the-making. Phenomena and their interpretations are not taken as 'given' or 'discovered' but as constructions that can be studied while being assembled. In his article *Visualization and Cognition: Thinking with Eyes and Hands* (1986), for instance, Latour developed an account of how knowledge is stabilized in networks of scientists, instruments, and other artifacts. His analysis focuses on how drawings and images are capable of mustering the largest number of well aligned and faithful allies. One of his most important arguments is that it is precisely these visualizations that make it possible to muster allies, as they allow for showing the whole of the conducted research at one glance (Latour 1986, 5).

Consequently, for Latour it is not only the perceptual content of the image that is at stake, but rather how the content of the image becomes factual because of its ability to muster as many powerful allies as possible. By introducing the concept of *Immutable Mobile*, he tries to account for the fact that different people draw similar conclusions when confronted with a specific kind of representation of an object. He states that:

> If you wish to go out of *your* way and come back heavily equipped so as to force others to go out of *their* ways, the main problem to solve is that of *mobilization*. You have to go and come back *with* the "things" if your moves are not to be wasted. But the "things" have to be able to withstand the return trip without withering away. Further requirements: the "things" you gathered and displaced have to be presentable all at once to those you want to convince and who did not go there (Ibid. 7).

In Latour's view, therefore, scientific images are in fact to be seen as embodiments of power—comparable to the way in which Giere approaches them as embodiments of knowledge. Images have the power to bring facts into existence. Yet, the question remains if this analysis exhausts the role of instruments in scientific practice, since it neglects how images are interpreted in the first place, and how they inform the interpretational frameworks of scientists. Latour is primarily interested in the extent to which a scientist or a group of scientists are capable of mustering *other* allies, and passes over the question how this group of scientists *itself* comes to treat one potential immutable mobile as more effective than the other.[8]

The absence of this concern is clearly visible in Latour's and Woolgar's *Laboratory Life*. They stress that scientific 'phenomena *are thoroughly constituted by* the material setting of the laboratory' (Latour and Woolgar 1986, 64), and that 'each item of apparatus [is] combined with certain skills to form specific devices' (Ibid. 69), while not paying any attention to *how* these phenomena are constituted, and *what* skills are used to work with the available scientific instruments. Instead, they focus is on the way in which the material

[8] Note that this does not imply that a group of scientists is only interested in mustering allies *outside* science per se, but also can be considered an attempt to convince other (groups of) scientists.

environment of the laboratory dissolves when transformed into a scientific paper. However, as we argue in this paper, scientific instruments, and other technologies such as brain scans have to become immutable mobiles *within* a scientific community as well, when they are to be used and interpreted in similar ways.

It is exactly at this point that the 'postphenomenological' approach of technological mediation differs from Actor-Network Theory. Because of its phenomenological orientation, the mediation approach studies the role of technologies in scientific practices 'from within'. Rather than looking 'outside-in' to the formation of networks of relations between scientists and technologies, it looks 'inside-out' to the formation of perceptions and interpretational frameworks in relation to the technologies that play a role in scientific practices.

The central ambition is not to 'deconstruct' the networks behind scientific facts and theories, but to develop accounts of the mediating role of technologies in 'science-in-the-making'. From a postphenomenological point of view, such accounts can only be studied from a first-person perspective—i.e. by analyzing how scientists develop concepts and interpretations in interaction with the scientific instruments and technologies they use. That is, the concepts that scientists apply when 'reading' a brain scan cannot be reduced to the visual content of the brain scan itself. Establishing a relation between the visual content of a brain scan and a cognitive concept such as aggression, requires to interpret the visual content in terms of something else, i.e. aggression. Only when a neuroscientist is able to make this translation do brain scans become relevant for cognitive research. A phenomenological perspective has the potential to take into account such 'interpretational-frameworks-in-the-making'. The central question then is not if and how scientific instruments 'embody' specific interpretational frameworks or scientific theories, but rather how they help such frameworks and theories to come into being.

Scientific instruments help to shape relations between scientists and the reality they study; in doing so, they help to organize how reality is 'given' to scientists, and how scientists are constituted in relation to the phenomena they study. Scientific instruments, therefore, need to be seen as hermeneutic devices (Ihde 1998)—they are 'epistemology engines' (Ihde and Selinger 2004), establishing relations of investigation, in which both the investigator and the investigated are constituted in a specific, technologically mediated way.

7 Technological Mediation and Collective Knowing

When it is only in relation to scientific instruments that the objects of research can be observed, instruments function as common denominators to which all scientists within a collective have to relate to, both individually and collectively. As we have tried to show, this has two important consequences: Firstly, because scientific instruments are not neutral extensions of human sight, but constitute a specific type of the observer and the observed, we should analyze scientific observations in terms of technological mediations.[9] For example, the way cognitive phenomena such as aggression must be explained changes when accessed through fMRI, as those become necessarily related to neuronal activity. However, the linking of neuronal activity to aggressive behavior requires a prior

[9] Vertesi (2012) has recently discussed how human-technology relations shaped the social order in laboratories. The present discussion focuses on how scientific instruments structure epistemic judgments, rather than how they contribute to the social organization of laboratory work.

understanding of aggression that is materialized in an extensive experimental set-up that presupposes this specific understanding of aggression. This specific prior understanding is in turn reflected in the way aggression is visualized through the use of fMRI. Hence, we hold, contrary to Giere's analysis, that the perspective an instrument offers is not merely a matter of the interaction between the physical constitution of a technology and the physical structure of the world.

Secondly, the human parts of a scientific collective must develop a shared epistemic stance with regard to the mediating technology, which allows for multiple coherent interpretations. For example, there are several coherent ways to interpret the content of a brain scan. Since no specific perspective is built into an MRI scanner, a workable stance towards the epistemic function of the scanner is something that has to be established. This forces the postphenomenologist to develop an alternative answer to the question how a shared epistemic stance can come into being.

Let us try to answer this question through an analysis of an everyday example, and by pointing out the differences with Baird's and Giere's approaches.[10] Imagine that you have to walk from one place to another using a map of the area you are in. The map limits several possibilities; a possible route straight through a dark forest is not indicated on the map since it only covers registered walking paths, but the map will also not stop you from taking an unregistered route. Moreover, it will not exactly tell you where you are; you have to decide that in relation with the map. In other words, both you and the map have an active part in determining the path you will walk. In making certain aspects of the landscape relevant, while neglecting others, the map shapes the landscape and your position in it in a specific way. That is, in your relation with the map, the map mediates how the landscape that you are in is revealed to you.

Now, consider the situation that a group has to perform a similar exercise. One or more of the more adventurous group members offer the suggestion to cross the dark forest even though its structure is not displayed on the map, because they are that convinced that it will be a faster route. Only after discussion this possibility is ruled out or accepted by the group as a whole; in this discussion that the members of the group start to display a similar epistemic stance with regard to the map (at least for the moment). Furthermore, in this situation the map will also not 'tell' the group where it is. Probably, the location of the group on the map will be the result of a discussion as well. In both situations, an intersubjective epistemic stance is not presupposed, but the consequence of how the group acts in relation to the mediating technology. The point here is that the road to intersubjectivity can be studied by analyzing the mediations of which it is the product (cf. Heritage 1984, 259).

Baird would understand the epistemic function of the map as offering a *model* of the relevant surface. In Baird's sense this would mean that in the map, there is knowledge of the specific landscape. However, in his model it remains unclear how, and if, the group can access what is inside the map; hence, it remains unclear how the group can obtain knowledge of the terrain through the map. What is at stake is the relation between the instrument and its knowledge of the landscape, without a user entering this epistemological picture. When considering larger collectives such as the one described in the example, Giere suggests that the perspective that an instrument offers is immediately grasped by every member of the collective. Thus, given that the visual capacities of the group

[10] ANT is deliberately omitted from this comparative analysis, as we hope to have shown in the previous section that ANT primarily aims to understand the working of a scientific instrument when a shared epistemic stance is already established.

members are roughly similar and have similar purposes, they will all immediately grasp how the map relates to the environment where they are.[11] This immediacy is guaranteed by the 'intersubjective objectivity' that is presupposed in the perspective offered by the map (cf. Giere 2006, 13). However, he acknowledges that the situation is slightly more complex than noted above when discussing the role of MRI in the neurosciences:

> MRI, in particular, makes it abundantly clear that not only is scientific observation perspectival, but also that there are multiple perspectives from which one must choose and no "objectively" correct choice [can be made]. A lot depends on the goals of the investigation at hand (Ibid. 56).

Considering that scientists determine the goals of their investigation in relation with both each other and the scientific instrumentation, this would already imply a shared epistemic stance with regard to the instrument.

In terms of the map example, Giere understands 'the goals of the investigation at hand' as already present before the map is put to use. However, as we have tried to make clear, it is precisely these things that are still unclear when a map is put to use. Similarly, how and what can be seen while using an MRI scanner, and which investigative goals are developed in relation with MRI, is not part of the internal design of the scanner. Of course, our eyes cannot look beyond their visual capabilities and the working of an MRI scanner must work in accordance with the technicalities of its design. However, collective knowing can never be reduced to these technicalities. As Van Baalen et al. (2016) have shown in the context of multidisciplinary clinical decision-making, collective knowing is always mediated both by the social relations between scientists and the technologies that shape the knowledge that is distributed within a group of scientists. We believe that this does not only apply to multidisciplinary clinical contexts, but extends to non-clinical and non-multidisciplinary scientific practices as well.

While scientists use instruments that are capable of detecting and visualizing phenomena invisible to the naked human eye, they do not provide us with an immediate understanding of those phenomena. Giere correctly emphasizes the importance of the former aspect, but he neglects that visualizations do not have a univocal meaning and can be interpreted in multiple ways. And if the goals of the investigation at hand co-evolve with the interpretation of the visualization, there is no reason to presuppose agreement with regard to which goals the visualization should be put to use. Hence, the perspective of the instrument cannot function as offering an objective ground that is able to establish intersubjectivity. Similarly, there is nothing *in* the map that allows the members of the group of travelers to establish an intersubjective understanding of its precise meaning. As indicated in the example, the displayed intersubjectivity is the consequence of the way the members of this group relate to the mediating technology (in this case the map), and how this relation structures the way the members of the group relate to each other.

[11] In his discussion of mapmaking, Giere for example states that maps are *interest relative*. He argues that road maps are useful to car drivers because they highlight relative distances, but that they are less useful for cyclists because they do not give a clear indication of elevation, which would be of great importance when riding a bike (Giere 2006, 73).

8 Conclusion: Developing a Collective Epistemic Stance

The philosopher and historian of science Hasok Chang proposes something along these lines by suggesting that we should understand science in terms of epistemic activities that have a particular aim. According to Chang, it is possible to understand scientific practice in terms of the aims of scientists and the expectations they have. However, there is neither a standard model of the actors at work within the collective, nor are the aims of a collective set from the start as ‘it only exists because someone upholds it by means of some mechanisms for propagation and maintenance’ (Chang 2014. 73). Here, Chang opens the door for understanding the shared epistemic stance of a group of scientists as something that is actively put together by the involved agents, rather than presupposing that they share some form of ‘intersubjective objectivity’. Furthermore, it makes it possible to understand how specific aims of a collective are related to the available instrumentation. After all, the agents within a collective are not rigid entities, but come into being in relation to the technologies at hand.

Still, the question how scientists can have a workable shared epistemic stance with regard to an instrument can potentially generate multiple perspectives remains unclear. It is clear that researchers working at CERN are capable of speaking the same language with regard to a similar set of objects, and that neuroscientists can draw meaningful conclusions from brain scans collectively. The fact that the technological mediation of knowledge originates in the individual relation between scientist and instrumentation does not prevent scientific theories from being developed or clinical decisions from being made.

But, when it is not the objective features of the scientific instrument that make it possible to adopt a similar perspective, how then is a shared epistemic stance with regard to the instrument being established? Does it presuppose some form of intersubjectivity that makes it possible to use it collectively? This question can be answered both in the positive and in the negative. In the positive because an intersubjective epistemic stance seems to exist in scientific practice; after all, how would it otherwise be possible to talk about experimental results? It should be answered in the negative as well; the intersubjectivity is not presupposed. This is not to say that establishing intersubjectivity would be the final goal of such a collective; displaying a shared epistemic stance is the dynamic and preliminary product of the individual relations between scientists and mediating technologies.[12]

In the end, the ongoing development of a workable epistemic stance of a group of scientists with regard to an instrument mediates how the world becomes present to this group of scientists.; However, we should neither interpret these collectives as instruments having access to ‘nature’ or to ‘the world’, nor as unchanging systems determining how the world comes into being. In the end, an epistemic stance is a fluid state changing over time and relative to the interactions of the members of the collective, rather than a universal decision to use a scientific instrument in this or that way such that the world can be accessed in this particular manner (cf. te Molder 2015). The shared epistemic stance is not an extension of Giere’s idea from the level of scientific instruments that ‘typically incorporate a built-in perspective on the world’ to collectives having a similar built-in design. The crucial difference is that nothing can be built-in into such a collective since the relation between scientists and mediating technologies is not fixed.

[12] It should be emphasized that intersubjectivity is not a cognitive state that is shared by the members of a system, but rather is something that is displayed in action by this system (see also footnote 3).

This leaves us with the issue how collective scientific practices are structured around individual human–technology relations. As we have tried to make clear, this collectivity is not something that is an inherent property of the system as such. In stressing that agents are responsible for those mechanisms of propagation and maintenance, the implication is that the development of a mechanism requires action. These actions cannot be performed outside the technological realm when the mediation role of scientific technologies is taken into account. The specific nature of those actions is not pre-given, but is structured by the relation with a mediating technology. Accordingly, what this mechanism looks like is dependent on the specific relations between scientists and mediating technologies, and the actions that are performed such that a shared epistemic stance is displayed within a scientific collective.

If we look at the role of scientific instruments within scientific collectives in this way, it becomes visible that the way knowledge of the world is obtained is not the product of the rigid functioning of a scientific instrument, or of the rules a scientific collective is following. Having an intersubjective workable epistemic stance with regard to a scientific instrument and concerning what is observed through it is dynamically constituted and relates to the specific actions a collective aims to undertake in relation to a scientific instrument. If this group of scientists would use a map to walk through a landscape, the collective epistemic stance would be constituted by the specific action they want to perform (where do we want to go?) in relation to the way the landscape they walk through is structured by the map (how do we get there?). The actions the group aims to perform influence how the map is used, yet the kind of actions a group strives for are influenced by the structure of the map; both mutually constitute each other. The path this group will take can therefore not be reduced to either of these parts; it is only through a dynamic interaction with the map and with each other that the group will move from one place to another.

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