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POSTPHENOMENOLOGICAL VARIATION OF INSTRUMENTAL REALISM ON THE "PROBLEM OF REPRESENTATION"

fMRI IMAGING TECHNOLOGY AND VISUAL REPRESENTATIONS OF THE HUMAN BRAIN

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VARIACIÓN POSTFENOMENOLÓGICA DEL REALISMO INSTRUMENTAL SOBRE EL "PROBLEMA DE LA REPRESENTACIÓN"

Tecnología de imágenes de fMRI y representaciones visuales del cerebro humano

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ABSTRACT

In the present paper, I take findings from the postphenomenological variation of instrumental realism to develop an 'environmental framework' to provide a philosophical answer to the 'problem of representation.' The framework focuses on three elements of the representational environment, image-making technology, image as a representational device, and scientific hermeneutic strategies occurring within the image interpretation process in the laboratory set-up. The central idea in this regard is that scientific images do not produce meanings without their instrumental environment or that an image becomes representational through the interplay between three framework elements. In the second part of the paper, I apply the framework to contemporary debates on fMRI imaging. I show that fMRI images receive meaning not in isolation but within a complex instrumental environment.

Keywords: problem of representation. scientific image. instrumental realism. postphenomenology. fMRI.

RESUMO

No presente artigo, tomo as descobertas da variação pós-fenomenológica do realismo instrumental para desenvolver uma "estrutura ambiental" a fim de fornecer uma resposta filosófica ao "problema da representação". A estrutura se concentra em três elementos do ambiente representacional, a saber - tecnologia de criação de imagens, imagem como um dispositivo de representação e estratégias hermenêuticas científicas que ocorrem dentro do processo de interpretação de imagens no laboratório. A ideia central a esse respeito é que as imagens científicas não produzem significados sem seu ambiente instrumental ou, dito de outra forma, uma imagem torna-se representativa pela interação entre três elementos da estrutura. Na segunda parte do artigo, aplico a estrutura aos debates contemporâneos sobre imagens de fMRI. Mostro que as imagens de fMRI recebem seu significado não isoladamente, mas dentro de um ambiente instrumental complexo.

Palavras-chave: problema da representação. imagem científica. realismo instrumental. pós-fenomenologia. fMRI.

RESUMEN

En el presente artículo, tomo los hallazgos de la variación posfenomenológica del realismo instrumental para desarrollar un "marco ambiental" con el fin de proporcionar una respuesta filosófica al "problema de la representación". El marco se centra en tres elementos del entorno de representación, a saber: la tecnología de creación de imágenes, la imagen como dispositivo de representación y las estrategias hermenéuticas y científicas que ocurren dentro del proceso de interpretación de imágenes en el laboratorio. La idea central en este sentido es que las imágenes científicas no producen significados sin su entorno instrumental ni, dicho de otro modo, una imagen se vuelve representacional a través del juego entre tres elementos del marco. En la segunda parte del artículo, aplico el marco a los debates contemporáneos sobre imágenes de IRMf. Muestro que las imágenes de fMRI reciben su significado no de forma aislada sino dentro de un entorno instrumental complejo.

Palabras clave: problema de la representación. imagen científica. realismo instrumental. posfenomenología. fMRI.

1. Introduction

Contemporary experimental science provides us with a wide variety of different representations. The scope of them is ranging from digital atlases of our galaxy to weather forecast maps and X-Ray medical images (van Fraassen, 2008). All of them give us insights into the world we are living in and facilitate our scientific worldview with new intuitions and hypotheses. While philosophers from different domains are emphasizing the significance, if not the primacy, of various representational devices in science, there are still numerous debates around how representations are constructed, what they represent and how they should be interpreted by scientific communities (Amann & Knorr Cetina, 1988; Collins & Evans, 2002).

Moreover, there are different types of representational devices in science. Not all of them are the same. An X-Ray image, for example, makes visible an ankle joint differently from a biomechanical model, while an electric circuit model shows the brain activity in a different manner than a neural network model (Roman & Nguyen, 2021). In addition to that, every representation has its 'technical' part. Contemporary representations are mainly generated within a complex set-up of imaging technologies with the use of computer modeling techniques, mathematical analysis and sophisticated algorithms (Ihde, 2009). The structure, inner architecture and software environment of the imaging technologies affect the accuracy, visual appearance and 'readability' of the representation (Rosenberger, 2009).

The expanding role of representations in experimental science raised a list of questions about the nature, exactness, and ontological status of representational devices (Carusi et al., 2014). In contemporary philosophy of science, these questions have been titled under the name 'problem of representation' (Tibbetts, 1988). While scientific images are arguably the most frequently used representational devices nowadays (Friis, 2017; Sturken & Cartwright, 2017), in the present paper I will focus on the images as representational devices. Moreover, I will try to specify the role of scientific images within the 'problem of representation'.

In the simplest terms, this problem might be formulated in the following manner[1]. On the one hand, a scientific image always displays particular content (non-random data points) (Devitt, 2005). As a

[1] For another classification of the 'problem of representation' see Roman & Nguyen, 2021.

particular object, an image embraces something certain within its readout. An image of something is not just an image of anything (Psillos, 2017). Said differently, it is obvious that the use of scientific images does have an 'intent' to a truth-function and this 'intent' is realistic by its nature (Fumerton, 2002). Thus, it seems critical that scientific images 'truly represent' something real (realism claim[2]).

On the other hand, a scientific image isn't just a copy of the 'real' object (Hoeppe, 2015). It is isomorphic only to some extent[3] (Knorr-Cetina, 1999). Moreover, the meaning of scientific images is constantly open to various interpretations[4] (Rosenberger, 2008). Different scientists produce different perspectives on the interpretation of an image (constructivist claim[5]). As Bruno Latour and Steve Woolgar put it: "'out-there-ness' [i.e., the external world] is the consequence of scientific work rather than its *cause*" (Latour & Woolgar, 1986, p. 182).

In this sense, realism and constructivism provide two different perspectives on the nature of the scientific images. Realists claim that the image relies on the independently existing reality which substantially grounds the image (Devitt, 2011; Saatsi, 2018), while constructivists insist that through images scientists 'construct' what is real. Reality isn't something that we have from the very beginning – constructivists would argue – but, on the contrary, something that we 'build' by means of various scientific practices[6] (Lynch & Woolgar, 1988).

However, there is a third possible perspective on the 'problem of representation'. This perspective is provided by instrumental realism[7] (Ackermann, 1988; Hacking, 1983; Heelan, 1989; Ihde, 1991). Instrumental realists claim that rather than stressing on reality itself (or social practices that construct it) we should better take a closer look at the scientific *instruments* which give us access to what realists would call 'real' (de Boer et al., 2021; Ihde, 1998; Verbeek, 2003). Moreover, scientific instruments are never neutral because they mediate our access to the world, transform our perception, and thus - shape the process of knowledge production (Liberati, 2016; Mykhailov, 2020). As a result, when realists and constructivists focus their attention on the one pole of the 'representational' schema (either on the reality or on the social practices), instrumental realists insist that we should better concentrate on the transformative role of *the instruments* that are actively mediating (and co-shaping) both poles together (Aydin et al., 2018; Kudina, 2021; Mykhailov & Liberati, 2022).

Taking all this into consideration, I am going to show that instrumental realism can make a strong contribution to the 'problem of representation' on both theoretical and practical levels. On the theoretical level, I will develop a threefold 'environmental framework' for the analysis of the scientific images. Using this framework, I am going to show that an in-depth understanding of the nature of representation should include not only the philosophical conceptualization of a representational device (an image) but also surrounding elements that constitute its environment. The central idea in this regard is that representations do not produce meanings without their instrumental environment, which is their constitutive element[8]. Keeping this in mind, the framework focuses on three 'environmental' components fundamental for every scientific image. The first component is image production

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[2] Here I refer to a 'minimal' form of realism (not to be confused with the 'minimal' realism by Juha Saatsi (French & Saatsi, 2020) that is shared by almost every type of realism in the philosophy of science. According to the minimal form of realism, the object of representation exists independently of subjective observations. For more on various forms of realism see Saatsi, 2018.

[3] There are not only isomorphic images (as some medical images like X-ray scans) but also various non-isomorphic images like mathematical models of elementary particles or images of quasars taken from radio telescopes. To read more on non-isomorphism in scientific images see Hoeppe, 2014; Kuchinskaya, 2013; Lynch & Ridder-Vignone, 2014.

[4] Especially in the case of the medical diagnosis. I will return to this point in the second part of the present article.

[5] For the sake of our argument, I refer to a 'radical' form of constructivism here. This view is shared by authors such as Karin Knorr-Cetina (1999), Bruno Latour (2003), David Woolgar and Michael Lynch (1988).

[6] In-depth analysis of the realists vs constructivists debate on the 'problem of representation' falls outside the scope of this paper. For more on these debates see Tibbetts, 1988.

[7] In the present paper, I introduce the postphenomenological variation of instrumental realism. There are other kinds of instrumental realism that were developed by authors such as: Patrick Heelan (1989), Robert Ackermann (1988), Ian Hacking (1983). For more on different kinds of instrumental realism see Ihde, 1991.

[8] Another significant part of the scientific infrastructure that I am not going to touch upon in this paper is scientific collectives (Hasse, 2008). From this, much wider perspective, any scientific image gets its meaning not only through particular relations between scientist and instrument but through broad scientific 'cultures' which establish theories, hypotheses, rules of observations, etc.

technology. The second component is an image as a technological artifact. Finally, the third component relates to hermeneutical strategies, which are taking place among scientists in a laboratory set-up.

On the practical level, the present paper contributes to the debate with an application of the 'environmental framework' to a specific class of medical imaging technologies, namely - fMRI. Within the last decade, fMRI technology has attracted the attention of scholars from different fields (Aydin, 2018; Carusi & Hoel, 2014; Fried & Rosenberger, 2021; Joyce, 2016). Such an increasing interest was called forth by the revolutionary impact that fMRI had on almost every part of neuroscientific research (Cabeza & Nyberg, 2000). However, fMRI technology images have a peculiar nature. On the one hand, fMRI technology images are not 'mere' representations because they are not just a 'copy' of the human brain (Hoeppe, 2015), while on the other hand, these images are often used as representational devices within medical diagnostics (Beaulieu, 2016; de Boer et al., 2021). As I will show in this paper, the 'environmental framework' can provide better understanding of the problematic nature of the fMRI scans. In terms of the current paper, the medical image becomes representational as a result of the interrelation between three elements of the framework.

My argumentation in the present paper will be developed in two steps. The first step is theoretical. Here I will introduce the 'environmental framework' concerning the 'problem of representation'. I will show how each of the three elements plays its role in a meaning-creating process and how through each of them an image becomes representational. The second step is practical. In this part, the argument will be developed with the reference to the fMRI technology. I will demonstrate that fMRI visuals receive their meaning not in isolation but within a complex instrumental environment. Each element of the representational environment will be analyzed through the lens of postphenomenological variation of instrumental realism. As usual, the conclusion will summarize the results and link them to the findings provided within the article.

2. Instrumental realism and the 'environmental framework' for the 'problem of representation'

As it becomes apparent from the title, instrumental realism is about *instruments* (Ihde, 1991). More specifically, about the role of the instruments in the manufacturing of scientific knowledge (Ackermann, 1988; Heelan, 1989). What comes into focus at first glance is that the adjective 'instrumental' stands *before* the noun 'realism'. In the same way as the notion of 'technoscience' put technology *in front* of science (Hongladarom, 2012; Ihde & Selinger, 2006; Zwart, 2022) instrumental realism shifts philosophical attention from reality in itself to the role of instruments in a knowledge production process (de Boer, 2021a). Keeping this in mind, in what follows, I will focus on the instrumental component within the 'problem of representation'.

2.1. Imaging technologies and hermeneutic mediation

It is common knowledge that contemporary experiments take place within a complex set-up of different imaging technologies (Carusi et al., 2014; Latour & Woolgar, 1986; Lynch & Woolgar, 1988). In this instrumental set-up the object of study (for example, the human brain) is placed in unnatural, artificially designed conditions - conditions in which this object has to 'meet' requirements put to it by the experimental environment (van Fraasen, 2008, p. 93-94). In this sense, imaging technologies 'force' the object of study to become visible (Verbeek, 2003). Said differently, instruments are *transformative technologies* that change the appearance of the object and make it available for scientists (Rosenberger, 2017). Without instruments, the object of study is either invisible in principle (like fundamental particles in physics or quasars in radio astronomy) or inaccessible for scientific perception and manipulation (Hoeppe, 2014). The latter becomes apparent in the case of many medical technologies which, for example, help us to see organs without surgery (like X-Ray or ultrasound), or enable us to accomplish diagnosis without 'direct' access to the patient's body (like in the case of the telemedicine) (Ihde, 2019).

According to postphenomenological variation of the instrumental realism imaging technologies are not just neutral tools that ‘mirrors’ reality but active participants of the scientific process (Hasse, 2008; Wellner, 2020). Within this process, imaging technologies are interpreting the object of study and making visible those phenomena that were previously unperceivable (Liberati & Nagataki, 2015). This interpretive role of the imaging technologies has been titled ‘hermeneutic mediation’ (Ihde, 1978; 1998; Nørskov, 2015). With the notion of ‘hermeneutic mediation’ representatives of instrumental realism in philosophy of science aim to conceptualize the transformations that the imaging technology has generated upon the object of study within the image creating process (Rosenberger, 2008). In this sense, during a hermeneutic mediation, imaging technologies create a representation of reality, a representation that will ask for interpretation from its ‘readers’ (e.g. scientists). What is more important, the imaging technology itself makes a ‘translation’ of the particular object of study into a representational device like an image, graph, or map (Verbeek, 2008).

The other significant feature of hermeneutic mediation is tightly related to technological selectivity (Briedis, 2022). Imaging technologies do not just copy the object of reference but ‘select’ specific elements of this object to be a part of the image while at the same time reducing other components from the image readout (Alač, 2013). According to Don Ihde, such an interpretative selectivity has a ‘magnification-reduction structure’ (Ihde, 1998). It highlights some parts of the content while concealing the others. In this sense, we can consider imaging technologies more as ‘interpretative’ rather than blindly ‘representative’ tools (de Boer, 2021a).

2.2. Image as a representational device

Scientific image has a peculiar nature. On the one hand, an image is a material artifact, an object among other objects, while on the other, an image is more than a ‘mere’ object (van Fraassen, 1980). It always *represents* another object by referring to the ‘external’ thing in the world (Hoeppe, 2015). However, an image as a representational device is never neutral. It always transforms the object of reference in both space and time.

Spatial transformation

The spatial transformation includes several changes of the object of reference. The first transformation is a ‘transfer’ of the three-dimensional object into flat, two-dimensional content of the image (Rosenberger, 2020). Consider the photo of the tree taken in the forest. Although the photo saves a lot of realistic elements (like color, shape, etc.), the original object (a tree) has lost its three-dimensional features. Now it is reduced to flat image content only (Ihde, 1998).

This spatial transformation goes along with numerous ‘perspectival’ transformations. As the content of the image is always ‘one-sided’ the perspective of the viewer is shaped and, in some way, ‘sticks’ to the only possible perspective provided by the image (Beaulieu, 2016). An X-Ray image, for instance, shows patient’s bones from one specific position without letting the doctor take a different look at the patient’s body (Friis, 2008; Briedis, 2022). The weather forecast map displays a part of the territory mediating scientific ‘practices of seeing’ to one perspective only (Hoeppe, 2014). The intelligent decision support system in diagnostics pin potentially dangerous spots on the medical image ‘channeling’ practitioners view to a particular area on the imaged data (Kudina & de Boer, 2021; Mykhailov, 2021).

Except for ‘dimensional’ and ‘perspectival’ transformations, there is also a ‘morphological’ transformation, which is a transformation of the object in shape and size (Verbeek, 2008). In many cases, such ‘morphological’ transformation is a necessary condition for a successful experiment. For example, an electron microscope that has a higher resolving power compared to the light microscope is able to magnify the object up to 10,000,000× (Hacking, 1983; Lynch, 1985b). However, within such a magnification procedure, the size of the object of reference (for example a human cell) is transformed completely.

Temporal transformation

Together with spatial transformations, images simultaneously produce temporal transformations as well. Perhaps the most obvious transformation of this kind is the 'freezing-time' effect. The image can 'freeze' the dynamic processes and reduce them to a 'snapshot' (Rosenberger, 2005, 2009). For example, an fMRI scan 'pauses' a dynamic process of blood circulation in the brain and provides a practitioner with static renderings of the patient's brain activity (Joyce, 2006).

Except for a 'freezing-time' effect, scientific images are able to slow down some processes or, vice versa, speed them up (Prasad, 2005). A classic example in this regard is a video record (which is another type of image). By means of a simple video player, everyone can 'pause', slow-down or speed up the record. Another example of this transformation may be found in many medical imaging techniques that provide practitioners not only with one image but with the whole set of images generated at different points in time. Such a set of images provides a practitioner with a deeper insight into the patient's body, helps to understand the evolution of the disease and find the right treatment strategy.

2.3. Hermeneutic strategies in image interpretation

As it has been already noted, every scientific image doesn't 'mere' provide us with a straightforward representation of the world itself but rather exists as a technological artifact open to multiple interpretations (Friis, 2008). To put it simply, an image by itself doesn't have the meaning 'outside' of the scientific (and technological) environment (Alač, 2013). The meaning appears *as a result* of the image generation and interpretation process (Joyce, 2016).

Within instrumental realism such interpretational practices have been titled 'hermeneutic strategies'[9] (Ihde, 1998). Usually, during the first encounter with an image, a scientist can interpret the image in one way, while after a laboratory colleague provides an alternative hermeneutic strategy, s/he can see these alternative variations as well (Rosenberger, 2008). Such a hermeneutic strategy attracts scientific attention to particular elements of an image and helps to understand those features in a meaningful way (Goodwin, 1994, 1995).

The notion of hermeneutic strategy, thus, embraces and highlights various practical dimensions that occur inside the laboratory (Lynch, 1985). Usually, this interpretation process is extremely multidimensional and begs for a broad set of knowledge. For example, a scientist who interprets an image should know the related scientific context (both theoretical and experimental), details of the image-making process, recent related findings, etc. (Friis, 2017). Successful hermeneutic strategies also require knowledge about interpreting the contents of the image, what characteristics should be expected, what the background is, what the essential aspects are, what an irrelevant instrumental artifact is, and what the relation between different parts of the image is (Briedis, 2019; Rosenberger, 2020; Sturken & Cartwright, 2017).

Another significant idea related to the hermeneutic strategies is its *collectiveness* (de Boer, 2021a). Regularly, the image interpretation process is not just a byproduct of individual human-technology relations. On the contrary, the meaning of the image is usually born among different members of scientific collectives (Hasse, 2008). I will touch more on this during the discussion of the role of the practitioner in interpreting fMRI scans. For now, it is important to highlight that various hermeneutic strategies play a vital role in the discussion about the nature of representation.

3. fMRI in focus – practical application of the 'environmental framework'

[9] Hermeneutic strategies are related to the other concept inside the postphenomenological domain, namely, multistability. For more on this relation see de Boer, 2021b; Liberati, 2019; Wellner, 2020; Whyte, 2015.

“For the first time in the history of neuroscience, it is now possible to ‘observe’ cognitive activity in the intact human brain” (Cabeza & Nyberg, 2000, p. 1). This observational opportunity became possible because of fMRI technology. It enables us to see inside the brain without surgery or any other clinical invasion (Briedis, 2019). But how is it possible from the technical point of view? Let’s take a brief look at how fMRI works.

The fMRI (Functional magnetic resonance imaging) is one of the major brain-mapping imaging technologies used nowadays. The main aim of fMRI is to generate images of the human brain (Prasad, 2005, p. 292). Medical images are generated using magnetic fields, radiofrequency, and computer software (Aydin, 2018). To generate such images, an experimental subject is scanned. Within a scanning session, “hydrogen protons in brain tissues are magnetically induced to emit a signal that is detected by the computer” (Alač, 2013, p. 1). The recorded results are being processed by computer models, mathematically analyzed, algorithmically enhanced and transformed into brain-mapping images (e.g., fMRI scans) (Ihde, 1998, p. 58).

Broadly speaking, fMRI is used to study and observe dynamic processes inside the brain that take place as a consequence of changes in blood flow (Joyce, 2006). Thus, the purpose of fMRI images is to show the degree of activity in different brain areas. If during the scanning session the experimental subject is involved in a specific cognitive task (for example, counting or recalling something), the fMRI can point out those regions of the brain which are most active during that task (de Boer, 2021). Unlike other medical imaging technologies, which rely on a single parameter within the image generation process “fMRI can use multiple parameters such as relaxation times, proton density, or diffusion of blood or other fluids for image production” (Prasad, 2005, pp. 298–299).

3.1. Hermeneutic mediation of the fMRI

Within an image generation process, fMRI accomplishes several hermeneutical tasks over its experimental object (e.g., human brain). In what follows, I will analyze them in the same order as they take place in the laboratory set-up.

Broadly speaking, the hermeneutic activity of fMRI can be generally divided into three parts. The first part is taking place inside the scanner when “hydrogen protons in brain tissues are magnetically induced to emit a signal” (Alač, 2013, p. 1). At this stage, a scanner generates a magnetic field that enables the recording of the brain activity. Within the second stage, the signal is being transformed into digital data that can be mathematically analyzed and recorded by a computer (Ihde, 2019). For evaluation reasons “the computer programs divide the section of the body into discrete, consecutive slices, and measure how long it takes for hydrogen atoms in each of these slices to release the energy absorbed from radio-frequency waves” (Joyce, 2016, p. 440). Thus, *the original data generated by fMRI is numeric, not visual*[10]. Finally, the last part of fMRI hermeneutic activity takes place when numerical measurements are converted via computer into a defined set of anatomical pictures (Prasad, 2005).

As it becomes apparent from the description above, several steps of material translation take place within the fMRI examinations. First, bodies are being changed into numbers[11]. Afterward, numbers are

[10] Generally speaking, having a numeric origin is true not only for images generated by the fMRI. All images produced by algorithms are images made by numbers (Mitchell, 1992; Couchot, 2002). It does not matter if the image comes from a camera on a mobile phone or from the computer (as in the case of fMRI). Every digital image – even the letters in a computer – is structured by bits – combinations of “zeros” (0) and “ones” (1). In fact, the image that results from bits is also composed of a set of points – the pixels – which are also numbers (fixed addresses on the screen to which colors are attributed).

[11] The question of body transformations through technologies might be fruitfully illustrated with references to the contemporary science fiction genre, namely, body horror. One of the main representatives of this genre in movies is Canadian film director David Cronenberg. Almost each of his movies dives into the ambiguous nature of the human body. For example, in the movie “Existenz” Cronenberg provides a deep philosophical interpretation of human bodies that permanently shift between ‘the reality’ and the computer game called Existenz. All the feelings and impressions in the computer game are so vivid that the main characters can’t grasp the difference between ‘real’ and ‘digital’. Said different, characters can’t understand are they act as a real body (flash) or as a set of digits (bodies as numbers). That is why the movie ends up with the rhetorical question of one of the characters who asks: “Are we still playing?”. The latest Cronenberg movie

transformed into images. Images are then interpreted by the laboratory practitioners[12] (Joyce, 2006). As a result, the imaged brain never shows itself within the laboratory settings as something "natural" or independent object (Alač, 2013). On the contrary, the brain goes through several hermeneutic transformations generated by fMRI technology. The latter 'selects' specific brain features which will get to the image and those that will not. In this sense, only certain brain traits that are relevant for the particular research, are transferred into the images. Moreover, only some of the many features that appeared on the fMRI visuals are desirable (De Rijcke & Beaulieu, 2014).

3.2. fMRI scans

As I hope is by now clear, fMRI scans mediate the object of representation (human brain) and 'show' it in a transformed manner. Moreover, scans make the brain visible in such a way, that a practitioner can 'read' it. However, to convert a human brain into a 'readable' image several transformations have to be made. In what follows, I will focus on the spatial and temporal transformations that fMRI scans possess.

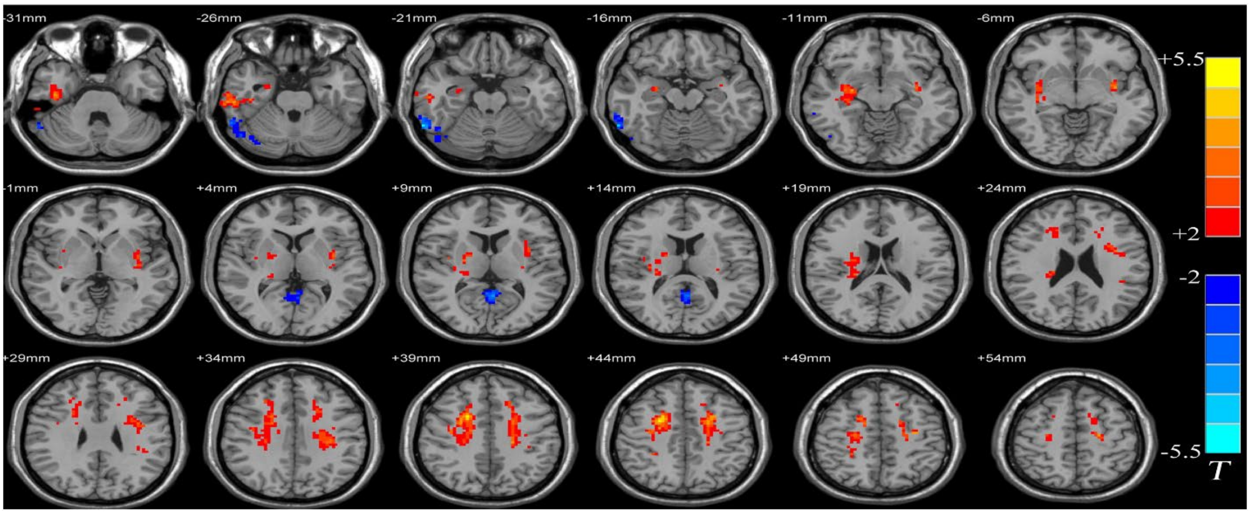

Figure 1. fMRI scans of patients with benign epilepsy with centrotemporal spikes.

Source - (Yan et al., 2017)

Spatial transformation

As the main purpose of the fMRI scan is to place brain activity in space (Beaulieu, 2016), it seems reasonable to focus on several spatial transformations initially. At first glance, one can see that the fMRI scan (either on the paper or on the screen) has a specific size. It means that the object of representation (e.g., the human brain) is 'framed' into the scan. Moreover, even though the representation proposes a high level of realism, the size of the brain on the screen does not coincide with the size of the brain in the patient's head (Verbeek, 2008). Moreover, the human brain is represented on the scan in a specific perspective (see figure 1). In scientific literature, this perspective is usually named a 'bird-eye perspective'[13] (Rosenberger, 2020). Of course, such a perspective isn't random or accidental but has functional purposes. The 'bird-eye perspective' provides the fMRI practitioner with a better 'view' of the human brain as a whole. From this perspective, practitioner can observe the human brain in its totality. This is what differs fMRI from other methods of brain study. Other techniques "make one small

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"Crimes of the Future" questions the nature of the human body from a different perspective. Cronenberg describes the near future where people can't feel pain anymore. The main character is an artist who makes public surgeries on his body in order to put his body closer to the 'pain experience'. In this way the pain brings pleasure and the standard limits of the human body are shifting.

[12] The practitioner doesn't delete the image from the computer immediately. These data are usually preserved for several days just in case the doctor will come up with some new findings related to the patient's diagnosis. For a detailed analysis of the whole set of practices inside the radiology laboratory see Briedis, 2019, 2022.

[13] It is worth mentioning here that the 'bird-eye' perspective (also known as an 'upside down' perspective) isn't the only possible. There are some fMRI scans that can provide a view from the -right or -left sides of the brain.

measurement by probing the brain, whereas functional imaging can encompass the whole volume of the head" (Beaulieu, 2016, p. 73). Such a benefit opens up an opportunity to study a brain at a system level.

The other observation about the transformative role of the fMRI scans is that some parts of the brain are highlighted with different colors while others are left in a 'gray zone'. This happens because of the particular computer software, which allows an active interaction with the image data. The practitioner, for example, can "use the contrast between different shades of gray or can dynamically change the shades of gray to locate the pathology. This process is called *windowing*. The radiologist can also make comparisons by changing the contrast of gray in a particular region of the image through a process that is called *leveling*" (Prasad, 2005, p. 299). This effect mediates the practitioner's attention, attracting his/her attention to the parts highlighted with the color and at the same time decreasing the practitioner's attention from other parts of the brain (de Boer et al., 2020; Friis, 2008).

Temporal transformation

fMRI scans are placing brain activity not only in space, as in the case of spatial transformations analyzed above, but also in time. In this sense, fMRI scans mediate not only spatial but also a temporal representation of the human brain.

The temporal transformation takes place because fMRI image reduces the dynamic process of the neural brain activity into a frozen 'snapshot' (Rosenberger, 2005). This transformation provides fMRI practitioners with a unique opportunity to 'grasp' the brain-activation momentum and, by doing this, to understand which zone of the brain is responsible for a specific cognitive task (Cabeza & Nyberg, 2000). This temporal transformation is a 'game-changer' that gives birth to a whole 'cognitive revolution' in neuroscience (De Rijcke & Beaulieu, 2014). Philosophically speaking, this temporal transformation enables to reveal new scientific phenomena like "finding neuronal networks and brain regions that are specific to the functional realization of particular cognitive tasks" (Aydin & de Boer, 2020, p. 730).

Moreover, this temporal transformation enables a cross-referential process. It becomes possible due to the comparison between fMRI scans generated at different points in time. The intention of such comparisons is to monitor the evolution of a disease stepwise. For instance, a cross-referential process is used to follow up on the status of a cancerous lump in order to understand if the lump is decreasing, increasing, or remaining unchanged within different stages of the treatment (Prasad, 2005, p. 297).

fMRI hermeneutic strategies – noise reduction

As has been mentioned above, the hermeneutic strategies embrace a wide scope of different interpretative activities that a scientist has to produce within the image-interpretation process (Friis, 2008). In what follows, I will focus on one hermeneutic activity that is vitally important for fMRI technology and taking place in every fMRI laboratory. Its name is 'noise reduction' or 'cleaning the data'. Within this process, fMRI practitioner has to choose values for various parameters. Each parameter selected by the practitioner will influence what comes up to appear or disappear on the image (Beaulieu, 2016).

As I have already pointed out, before the image becomes accessible on the practitioner's screen, it should go through several technological transformations. These transformations increase 'readability' of the image and improve the practitioner's workflow. However, technology is not enough. There are many elements of the image-making process that fMRI can't accomplish without humans. Noise reduction is one of them (Goyal et al., 2018). Usually 'noise' in the dataset appears because fMRI 'adds' some undesirable elements into the image. In the vocabulary of fMRI practitioners these undesirable elements are named 'artifacts' (Lynch, 1985). Within fMRI scans artifacts can occur as white spots, black spots, wavy lines, or double-images of the various body parts (Joyce, 2016, p. 448).

In what follows I will focus on the so-called 'movement artifacts'. These artifacts appear in the picture because of the subject's movements during the scanning session (Alač, 2013). Usually, patients can't avoid small movements inside the scanner. These movements may cause some distortion in the image and lead to misdiagnosis or incorrect data analysis[14]. For this reason, the practitioners should identify the type of movement which the experimental subject generated inside the scanner so that they can immediately reduce noise from the data set (Prasad, 2005, p. 294). However, practitioners do not actually see the movement since the body lying in the scanner is no longer available for direct observation. This fact makes the practitioner's task truly 'hermeneutic'. The practitioner has to detect body movements that the experimental subject performed without *direct* access to his/her body but using computer visuals only.

For this reason, a practitioner has to apply a complex set of various hermeneutic strategies which might include laboratory knowledge and 'practices of seeing' like: image navigation (rotation, zooming-in/out), disclosing relations between different components on the image, prioritizing primary and secondary findings, technical talks with other practitioners (Briedis, 2019, 2022; Goodwin, 1995; Lynch, 1985b). These laboratory practices are actively synchronized with the fMRI visuals in a way that the practitioners can 'make' the movement of the subject visible on the brain scans (Alač, 2014). Thus, the movement does not just *appear* on the scans but is *produced* through a 'synchronization' of bodies and scientific instruments supplemented with cultural knowledge and laboratory practices. In this sense, 'noise reduction' represents a complex hermeneutic strategy within which a practitioner should 'select' what will be represented on the image and what should be omitted as 'undesired' artifacts.

Conclusion

The purpose of this paper was to contribute to the debates on the 'problem of representation' from the perspective of instrumental realism. To accomplish this task, I have developed an 'environmental framework' consisting of three main elements: imaging technology, scientific image, and hermeneutic strategies applied within an image interpretation process. On the theoretical level, the framework shows that to understand how the image receives its meaning one should take into account the whole representational environment where the image has been generated. Said differently, the image does not represent anything unless, at least, one element out of three is missing.

To show how these theoretical implications could be further applied to a practical domain I took the case of fMRI technology. At this stage of inquiry, I have analyzed all the steps of the image-making process produced by fMRI within the laboratory set-up. First, I have specified several hermeneutical tasks produced by this technology. Secondly, I have shown which spatial and temporal transformations fMRI scan renders over its object of reference (e.g., the human brain). Finally, I have focused on how the image receives its meaning within various hermeneutic strategies, which take place among practitioners in the laboratory environment.

Moreover, the framework developed through the current paper has other practical implications. As the environmental components defined through the framework are standard for any image-production process, the framework can be successfully applied to many other imaging technologies outside the medical domain. In this sense, the present article opens up new directions for further theoretical and practical findings within the problem of scientific representations.

Acknowledgement

[14] In this sense, the representation of the patient's body through fMRI visuals begs for the cooperation of the patient too. The patient has to keep still within the scanning session because even the slightest movement inside the scanner results in the production of undesirable artifacts.

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References

Ackermann, R. (1988). Experiment as the motor of scientific progress. *Social Epistemology*, *2*(4), 327–335. https://doi.org/10.1080/02691728808578500

Alač, M. (2013). Handling Digital Brains. In *Handling Digital Brains*. The MIT Press. https://doi.org/10.7551/MITPRESS/9780262015684.001.0001

Alač, M. (2014). Digital Scientific Visuals as Fields for Interaction. *Representation in Scientific Practice Revisited*, 61–88. https://doi.org/10.7551/MITPRESS/9780262525381.003.0004

Amann, K., & Knorr Cetina, K. (1988). The fixation of (visual) evidence. *Human Studies 1988 11:2*, *11*(2), 133–169. https://doi.org/10.1007/BF00177302

Aydin, C. (2018). From Camera Obscura to fMRI: How Brain Imaging Technologies Mediate Free Will. In *Postphenomenological Methodologies* (pp. 103–121). Lexington books.

Aydin, C., & de Boer, B. (2020). Brain imaging technologies as source for Extrospection: self-formation through critical self-identification. *Phenomenology and the Cognitive Sciences*, *19*(4), 729–745. https://doi.org/10.1007/S11097-020-09667-1

Aydin, C., González Woge, M., & Verbeek, P.-P. (2018). Technological Environmentality: Conceptualizing Technology as a Mediating Milieu. *Philosophy & Technology 2018 32:2*, *32*(2), 321–338. https://doi.org/10.1007/S13347-018-0309-3

Beaulieu, A. (2016). Images Are Not the (Only) Truth: Brain Mapping, Visual Knowledge, and Iconoclasm: *Http://Dx.Doi.Org/10.1177/016224390202700103*, *27*(1), 53–86. https://doi.org/10.1177/016224390202700103

Briedis, M. (2019). Phenomenological ethnography of radiology: expert performance in enacting diagnostic cognition. *Phenomenology and the Cognitive Sciences 2019 19:2*, *19*(2), 373–404. https://doi.org/10.1007/S11097-019-09612-X

Briedis, M. (2022). Sensing Diagnostic Images: Skilful Embodied Cognition in Oncoradiology. *Sensing and Imaging*, *23*(1). https://doi.org/10.1007/S11220-021-00372-0

Cabeza, R., & Nyberg, L. (2000). Imaging Cognition II: An Empirical Review of 275 PET and fMRI Studies. *Journal of Cognitive Neuroscience*, *12*(1), 1–47. https://doi.org/10.1162/08989290051137585

Carusi, A., & Hoel, A. S. (2014). Brains, windows and coordinate systems. In *Visualization in the Age of Computerization* (pp. 145–169). Taylor and Francis. https://doi.org/10.4324/9780203066973-8/

Carusi, A., Hoel, S., Webmoor, T., & Woolgar, S. (2014). *Visualization in the age of computerization*. Routledge.

Coeckelbergh, M. (2020). *AI Ethics* . The MIT Press.

Collins, H. M., & Evans, R. (2002). The third wave of science studies: Studies of expertise and experience. *Social Studies of Science*, *32*(2), 235–296. https://doi.org/10.1177/0306312702032002003

Couchot, E. (2002). Digital hybridisation: A technique, an aesthetic. *Convergence*, *8*(4), 19–28. https://doi.org/10.1177/135485650200800403

de Boer, B. (2021a). Image Interpretation as Object Constitution: Hermeneutic Strategies in Neuroscientific Practice. In J. F. & R. Rosenberger (Ed.), *Postphenomenology and Imaging: How to Read Technology*. Lexington Books.

de Boer, B. (2021b). Explaining multistability: postphenomenology and affordances of technologies. *AI & SOCIETY 2021*, 1–11. https://doi.org/10.1007/S00146-021-01272-3

de Boer, B., te Molder, H., & Verbeek, P. P. (2020). Constituting 'Visual Attention': On the Mediating Role of Brain Stimulation and Brain Imaging Technologies in Neuroscientific Practice. *Science as Culture*, *29*(4), 503–523. https://doi.org/10.1080/09505431.2019.1710739

de Boer, B., te Molder, H., & Verbeek, P. P. (2021). Understanding science-in-the-making by letting scientific instruments speak: From semiotics to postphenomenology. *Social Studies of Science*, *51*(3), 392–413. https://doi.org/10.1177/0306312720981600

De Rijcke, S., & Beaulieu, A. (2014). Networked neuroscience: brain scans and visual knowing at the intersection of atlases and databases 1. In C. Coopmans, M. Lynch, J. Vertesi, & S. Woolgar (Eds.), *Representation in Scientific Practice Revisited* (pp. 131–152). MIT Press.

Devitt, M. (2005). Scientific realism. In F. Jackson & M. Smith (Eds.), *The Oxford Handbook of Contemporary Philosophy*. Oxford University Press. https://philpapers.org/rec/DEVSR

Devitt, M. (2011). Experimental Semantics. *Philosophy and Phenomenological Research*, *82*(2). https://doi.org/ppr201182222

French, S., & Saatsi, J. (2020). *Scientific realism and the quantum*. Oxford University Press.

Fried, S. J., & Rosenberger, R. (2021). *Postphenomenology and imagining : how to read technology* (S. J. Fried & R. Rosenberger (Eds.)). Lexington Books.

Friis, J. K. B. (2008). Interpreting Visual Culture: Explorations in the Hermeneutics of the Visual. *AI & SOCIETY*. https://doi.org/10.1007/S00146-020-01056-1

Friis, J. K. B. O. (2008). Enactive hermeneutics and smart medical technologies. *AI and Society*. https://doi.org/10.1007/S00146-020-00944-W

Friis, J. K. B. O. (2017). Gestalt descriptions embodiments and medical image interpretation. *AI and Society*, *32*(2), 209–218. https://doi.org/10.1007/S00146-015-0615-6

Fumerton, R. A. (2002). *Realism and the correspondence theory of truth*. Rowman & Littlefield Publishers.

Goodwin, C. (1994). Professional Vision. *American Anthropologist*, *96*(3), 606–633. https://doi.org/10.1525/AA.1994.96.3.02A00100

Goodwin, C. (1995). Seeing in Depth. *Social Studies of Science*, *25*(2), 237–274. https://doi.org/10.1177/030631295025002002

Goyal, B., Dogra, A., Agrawal, S., & Sohi, B. S. (2018). Noise issues prevailing in various types of medical images. *Biomedical and Pharmacology Journal*, *11*(3), 1227–1237. https://doi.org/10.13005/BPJ/1484

Hacking, I. (1983). Representing and Intervening: Introductory Topics in the Philosophy of Natural Science. In *Representing and Intervening*. Cambridge University Press. https://doi.org/10.1017/CBO9780511814563

Hasse, C. (2008). Postphenomenology: Learning cultural perception in science. *Human Studies*, *31*(1), 43–61. https://doi.org/10.1007/s10746-007-9075-4

Heelan, P. A. (1989). *Space-perception and the philosophy of science*. University of California Press.

Hoeppe, G. (2014). Working data together: The accountability and reflexivity of digital astronomical practice. *Social Studies of Science*, *44*(2), 243–270. https://doi.org/10.1177/0306312713509705

Hoeppe, G. (2015). Representing Representation. *Science Technology and Human Values*, *40*(6), 1077–1092. https://doi.org/10.1177/0162243915594025

Hongladarom, S. (2012). Don Ihde: Heidegger's Technologies: Postphenomenological Perspectives. *Minds and Machines 2012 23:2*, *23*(2), 269–272. https://doi.org/10.1007/S11023-012-9296-9

Iconoclash: Beyond the Image Wars in Science, Religion, and Art. (2003). In B. Latour & W. N. Arnold (Eds.), *Leonardo* (Issue 4). MIT Press. https://doi.org/10.1162/LEON.2003.36.4.329

Ihde, D. (1998). *Expanding hermeneutics: Visualism in science*. Northwestern University Press.

Ihde, Don. (1978). *Technics and Praxis* (Vol. 24). Springer Netherlands. https://doi.org/10.1007/978-94-009-9900-8

Ihde, Don. (1991). *Instrumental realism : the interface between philosophy of science and philosophy of technology*. Indiana University Press.

Ihde, Don. (2009). From da Vinci to CAD and beyond. *Synthese*, *168*(3), 453–467. https://doi.org/10.1007/S11229-008-9445-0

Ihde, Don. (2019). Medical Technics. In *Medical Technics*. University of Minnesota Press. https://doi.org/10.5749/j.ctvpmw56v

Ihde, Don, & Selinger, E. (2006). Chasing Technoscience: Matrix for Materiality. *Human Studies*, *29*(3), 399–403.

Joyce, K. (2016). Appealing Images: Magnetic Resonance Imaging and the Production of Authoritative Knowledge. *Http://Dx.Doi.Org/10.1177/0306312705050180*, *35*(3), 437–462. https://doi.org/10.1177/0306312705050180

Joyce, K. A. (2006). From Numbers to Pictures: The Development of Magnetic Resonance Imaging and the Visual Turn in Medicine. *Science as Culture*, *15*(1), 1–22. https://doi.org/10.1080=09505430600639322

Knorr-Cetina, K. (Karin). (1999). *Epistemic cultures : how the sciences make knowledge*. Harvard University Press.

Kuchinskaya, O. (2013). Twice invisible: Formal representations of radiation danger. *Social Studies of Science*, *43*(1), 78–96. https://doi.org/10.1177/0306312712465356

Kudina, O. (2021). "Alexa, who am I?": Voice Assistants and Hermeneutic Lemniscate as the Technologically Mediated Sense-Making. *Human Studies*, *44*(2), 233–253. https://doi.org/10.1007/S10746-021-09572-9/FIGURES/3

Kudina, O., & de Boer, B. (2021). Co-designing diagnosis: Towards a responsible integration of Machine Learning decision-support systems in medical diagnostics. *Journal of Evaluation in Clinical Practice*, *27*(3), 529–536. https://doi.org/10.1111/JEP.13535

Latour, B., & Woolgar, S. (1986). *Laboratory life : the social construction of scientific facts*. Sage Publications.

Liberati, N. (2016). Technology, Phenomenology and the Everyday World: A Phenomenological Analysis on How Technologies Mould Our World. *Human Studies*, *39*(2), 189–216. https://doi.org/10.1007/s10746-015-9353-5

Liberati, N. (2019). Emotions and Digital Technologies. The Effects Digital Technologies Will Have on our Way of Feeling Emotions According to Post-Phenomenology and Mediation Theory. *Mente Journal of Philosophical Studies*, *36*(36), 292–309.

Liberati, N., & Nagataki, S. (2015). The AR glasses' "non-neutrality": their knock-on effects on the subject and on the giveness of the object. *Ethics and Information Technology*, *17*(2), 125–137. https://doi.org/10.1007/s10676-015-9370-0

Lynch, M. (1985). *Art and artifact in laboratory science*. Routledge.

Lynch, Michael. (1985a). *Art and artifact in laboratory science : a study of shop work and shop talk in a research laboratory*. Routledge & Kegan Paul.

Lynch, Michael. (1985b). Discipline and the Material Form of Images: An Analysis of Scientific Visibility. *Social Studies of Science*, *15*(1), 37–66. https://doi.org/10.1177/030631285015001002

Lynch, Michael, & Ridder-Vignone, K. de. (2014). Making the strange familiar: Nanotechnology images and their imagined futures. In *Visualization in the Age of Computerization* (pp. 97–117). Taylor and Francis. https://doi.org/10.4324/9780203066973-6/

Lynch, Michael, & Woolgar, S. (1988). Introduction: Sociological orientations to representational practice in science. *Human Studies 1988 11:2*, *11*(2), 99–116. https://doi.org/10.1007/BF00177300

Mitchell, W. J. (1992). *The reconfigured eye : visual truth in the post-photographic era*. The MIT Press.

Mykhailov, D. (2020). The Phenomenological Roots of Technological Intentionality: A Postphenomenological Perspective. *Frontiers of Philosophy in China*, *15*(4), 612–635. https://doi.org/10.3868/s030-009-020-0035-6

Mykhailov, D. (2021). A moral analysis of intelligent decision-support systems in diagnostics through the lens of Luciano Floridi's information ethics. *Human Affairs*, *31*(2), 149–164. https://doi.org/10.1515/humaff-2021-0013

Mykhailov, D., & Liberati, N. (2022). A Study of Technological Intentionality in C++ and Generative Adversarial Model: Phenomenological and Postphenomenological Perspectives. *Foundations of Science 2022*, 1–17. https://doi.org/10.1007/S10699-022-09833-5

Nørskov, M. (2015). Revisiting Ihde's Fourfold "Technological Relationships": Application and Modification. *Philosophy and Technology*, *28*(2), 189–207. https://doi.org/10.1007/s13347-014-0149-8

Prasad, A. (2005). Making images/making bodies: Visibilizing and disciplining through Magnetic Resonance Imaging (MRI). *Science, Technology, & Human Values*, *30*(2), 291–316. https://doi.org/10.1177/0162243904271758

Psillos, S. (2017). The Realist Turn in the Philosophy of Science. In *The Routledge Handbook of Scientific Realism* (pp. 20–34). Routledge. https://doi.org/10.4324/9780203712498-3

Roman, F., & Nguyen, J. (2021). "Scientific Representation." In *Stanford Encyclopedia of Philosophy*. https://plato.stanford.edu/cgi-bin/encyclopedia/archinfo.cgi?entry=scientific-representation

Rosenberger, R. (2005). Bridging philosophy of technology and neurobiological research: Interpreting images from the "slam freezer." *Bulletin of Science, Technology, and Society*, *25*(6), 469–474. https://doi.org/10.1177/0270467605278878

Rosenberger, R. (2008). Perceiving other planets: Bodily experience, interpretation, and the mars orbiter camera. *Human Studies*, *31*(1), 63–75. https://doi.org/10.1007/S10746-007-9078-1/FIGURES/2

Rosenberger, R. (2009). A Case Study in the Applied Philosophy of Imaging: The Synaptic Vesicle Debate: *Http://Dx.Doi.Org/10.1177/0162243909337117*, *36*(1), 6–32. https://doi.org/10.1177/0162243909337117

Rosenberger, R. (2017). On the hermeneutics of everyday things: or, the philosophy of fire hydrants. *AI and Society*, *32*(2), 233–241. https://doi.org/10.1007/s00146-016-0674-3

Rosenberger, R. (2020). A Preliminary inventory of the transformations of Scientific Imaging. *Acta Baltica Historiae et Philosophiae Scientiarum*, *8*(2). https://doi.org/10.11590/abhps.2020.2.02

Saatsi, J. (Ed.). (2018). *The Routledge handbook of scientific realism*. Routledge .

Sturken, M., & Cartwright, L. (2017). *Practices of looking : an introduction to visual culture*. Oxford University Press.

Tibbetts, P. (1988). Representation and the realist-constructivist controversy. *Human Studies*, *11*(2–3), 117–132. https://doi.org/10.1007/BF00177301

van Fraassen, B. (1980). *The Scientific Image*. CLARENDON PRESS.

van Fraassen, B. C. (2008). Scientific Representation: Paradoxes of Perspective. In *Scientific Representation: Paradoxes of Perspective*. Oxford University Press. https://doi.org/10.1093/ACPROF:OSO/9780199278220.001.0001

Verbeek, P.-P. (2003). Material hermeneutics. *Techné: Research in Philosophy and Technology*, *6*(3), 181–184.

Verbeek, P. (2011). *Moralizing technology: Understanding and designing the morality of things*. University of Chicago Press.

Verbeek, P. P. (2008). Obstetric ultrasound and the technological mediation of morality: A postphenomenological analysis. *Human Studies*, *31*(1), 11–26. https://doi.org/10.1007/s10746-007-9079-0

Wellner, G. (2020). *The multiplicity of multistabilities: Turning multistability into a multistable Concept* (pp. 105–122). Springer.

Wellner, Galit. (2020). Material hermeneutic of digital technologies in the age of AI. *AI and Society*, 1–8. https://doi.org/10.1007/s00146-020-00952-w

Whyte, K. (2015). *What is multistability? A theory of the keystone concept of postphenomenological research* (pp. 69–81). Lexington Books.

Yan, X., Yu, Q., Gao, Y., Li, L., Yu, D., Chen, Y., Yao, X., Yang, W., Chen, Z., Yin, J., An, Y., & Tan, K. (2017). Cognition in patients with benign epilepsy with centrotemporal spikes: A study with long-term VEEG and RS-fMRI. *Epilepsy & Behavior*, *76*, 120–125. https://doi.org/10.1016/J.YEBEH.2017.06.033

Zwart, H. (2022). Philosophy of Technoscience: From Cis-Continental to Trans-Continental. *Philosophy of Engineering and Technology*, *38*, 229–245. https://doi.org/10.1007/978-3-030-84570-4_8