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A Causal-Pluralist Metatheory of Observation

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Abstract: An extended definition of "observation" is developed in order to account for the usage in the physical sciences and in neuropsychology. An observation is initially defined as a perception that has a focus of attention and is guided by theoretical considerations. Since the focus may change, one adopts a pluralist position according to which the object of perception may involve any stage of the causal chain that leads to perception, such as the source of light or sound, the obstructions, the medium or even the receptor. The "neutral" observations of the empiricists are seen as involving only low-level or medium-level theorization. Examples are examined, such as a lunar eclipse, the rainbow, and observations mediated by instruments, whose "artifacts" are considered observations of the instrument itself. One also defines null-effect observations. Observations of photographs and drawings may be considered either the observation of a printed sheet of paper or the observation of the pictured object or people. This causal-pluralist metatheory of observation also accepts that one may "observe light", observe the retina, and observe parts of the brain which are outside the region of the "sensorium". Illusions and hallucinations are analyzed within this "observational materialism", which considers that qualia are self-observations of the brain. Criticisms that the approach is too wide in scope are analyzed in the conclusion.

Keywords: Observation, Perception, Neutral observations, Null-effect observations, Observational materialism, Sensorium

1 Introduction

The use of the term "observation" in the physical sciences has led to assertions that black holes, invisible neutrinos, and molecular orbitals have been observed, raising some discussion of whether such usage is appropriate, in comparison to the more colloquial use of the term, which considers, for example, that the observation of a bear track is not an "observation of a bear", but only evidence upon which the bear's passage might be inferred. Another extension of the term "observation", in neuropsychology, refers to events occurring inside the brain, such as an aura in a migraine attack. If an observation is defined as a form of perception, then the philosophical problems related to the nature of perception in hallucinations, illusions, and dreams must also be addressed by a theory of observation.

The present paper is an attempt to extend the notion of observation so as to encompass the aforementioned uses in the physical sciences and neuropsychology, offering a solution to the philosophical problems of perception. The basic idea is to consider that, in an observation, the conscious observer has access to information originating at *any stage* of the causal chain leading to perception. But such information can only be obtained if the subject has an adequate theory to guide his inferences. Thus, all observation must involve theorization and inference. From such a general viewpoint, the colloquial sense of "observation" can be characterized in terms of the stage of the causal chain being emphasized (proximal, but outside the human body) and the level of theorization being used (low and medium levels).

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2 Definitions

An *observation* is traditionally defined as an act of perception in which (i) one emphasizes a focus of attention, and which (ii) involves the acquisition of knowledge. In Torretti's words, it is "the attentive, deliberate, explicitly cognitive mode of perception."[1]

A perception may take place without there being a focus of attention, although it is difficult to express this linguistically or to recall this experience without choosing a focus. Nevertheless, one considers that an observation involves a focus of attention, and this feature will be important for the pluralist aspect of the metatheory[2] to be developed here.

Point (ii) above may be called the epistemic or cognitive aspect of observation. It may be expressed by the notion of acquisition of "information," present for example in the definition given by Shapere[3] of direct observation, which opens with the requirement that "information is received by an appropriate receptor." This is a satisfactory formulation, as long as the concept of information is suitably clarified, which would have to take into account the representation that the observer has of the world.[4]

As we observe something in the world, we carry expectations about what we will perceive. When such expectations are minimally articulated, one may speak of "theoretical expectations", which guide the focus of attention and influence any judgement about what we are observing. This judgement is part of point (ii) listed above, the epistemic aspect of observation.

In Shapere's words,[5] what counts as an observation "is a function of the current state of physical knowledge," while "prior information plays an extensive role in determining what counts as an 'observation'." We can only observe solar neutrinos if our scientific theory postulates their existence and provides many of their properties. In other words, in general, an observation is loaded with theoretical (epistemic) considerations. In science, the observation of an entity that is theoretically postulated (such as solar neutrinos) involves long causal chains that are uncovered by inference guided by the theories of the source, of the medium of transmission, of the scientific instrument, and of our perceptual apparatus. This is the "causal" aspect of the metatheory of observation being proposed here.

In the following sections, several aspects of the causal-pluralist metatheory of observation will be developed, leading to a condensed definition of the approach in the conclusions.

3 The Choice of a Focus of Observation

Observations involving vision and hearing may be readily analyzed in terms of a *source*, which emits light or sound; a *medium*, where the optical or acoustical signal is transmitted with partial absorption or the introduction of noise; what we will call an *obstruction*, which is anything that reflects or markedly modulates the signal (as opposed to the medium, which does this in a continuous way); and finally the *receptor*, which involves the sense organs and could also include a scientific instrument. Variations in any of these stages usually change the phenomenal features of the observation. We will call "vehicle" the type of radiation, wave, or piece of matter that carries information from the source, such as light or sound.

The term "obstruction" corresponds, in common situations involving vision, to the "objects" or things that we observe, such as a starfruit on the table. However, when one looks to the setting Sun, what is considered the object is the source of light. We will thus use the term "object" to refer to the stage of the chain of observation that we take as the focus of our attention. The present metatheory of observation is

1 Torretti, "Observation," 1.

2 We will use the term "metatheory" of observation to distinguish it from the theories that a conscious subject uses to interpret his observations.

3 Shapere, "The Concept of Observation," 492.

4 We have chosen to express the epistemic aspect of observation in terms of "knowledge", in a rather vague sense, because we don't have a detailed metatheory of how theories arise in the subjects's brain. The term "knowledge" is not to be understood as "justified true belief", but in a more pragmatic sense of statements that increase the effectiveness of action. Still, this part of the metatheory must be further developed.

5 Shapere, "The Concept of Observation," 492, 505.

termed "pluralist" just because it admits that any stage of the causal chain of observation may be considered the focus of attention, i.e. the observed object.

Observations involving the sense of smell have as their vehicle (outside the body) not a waveform (light or sound) but molecules of the odorant. Let us consider the example of the scent of vanilla, obtained from a bottled vanilla extract. Given our well-accepted theory of molecular chemistry, the "object" of observation might be considered the vanillin molecules, so that one may say that one is "observing the molecules of vanillin". However, given that the causal chain involving the molecules of vanillin originates in the open bottle of vanilla extract, one may consider that the scent of vanillin is the olfactory observation of the bottled vanilla extract.

As previously stressed, the focus of attention of an observation may be chosen by the observer, and may be the source, the medium, the obstruction, or even parts of the perceptual apparatus or scientific instrument. The manipulation of any of these may lead to perceptual changes (as in Reichenbach's "mark criterion" for causal relevance[6]), so any of these may be considered the object of observation. Let us give a few examples.

First consider the observation of a total eclipe of the Moon. We usually say we are observing the Moon, which is the obstruction (which reflects and absorbs sunlight), but if we focus our attention on the reddish hue of light acquired by the Moon, we will be observing the Earth's atmosphere (through which the solar rays pass and their unscattered portion reaches the Moon), which is part of the transmitting medium. We can also consider that we are observing the Sun, which is the source of light. Any marked change in the Sun or in the Earth's atmosphere would lead to a change in our observation of the eclipsed Moon. According to the causal-pluralist metatheory, we may even say that we are observing the light that falls on our eyes, or an image in our retinas or brain.

It is interesting that van Fraassen[7] explicitly denies that one may observe light: "Light is not observable". It is true that one can only observe a laser beam in the lab by the scattering of light off dust particles in its path, but if the beam is pointed at our eyes, we will surely see the light! For a causal theory of perception, it is unacceptable to claim that we don't observe the electromagnetic radiation located in front of our corneas and propagating to our pupils, since it is part of the causal chain between the object and the subjective observer. Such a region of the electromagnetic field can be manipulated experimentally, leading to changes in what we observe.

The causal-pluralist analysis may also be applied to the case of the rainbow. What do we observe when looking at a rainbow? Depending on the focus of attention, we may say we are observing the Sun, which is the source of light, water droplets, which are the obstructions, or even the atmospheric medium. We may also say that we are observing "colored bands", created somewhere within our perceptual apparatus. The difference between the observation of common objects such as a starfruit and this example of water droplets is that the latter reflect, refract and disperse light, while the starfruit only reflects and absorbs light (in different proportions, according to the wavelength of light).

Concerning the observation of the rainbow, van Fraassen[8] has considered it to be a "public hallucination," since there are no real colored bands floating in the humid landscape. The present approach rejects such an interpretation.

4 Reflections on Photographs and Drawings

According to the present causal-pluralist approach, as we look at a black and white picture of a person, we may consider that we are observing either a piece of white paper with black and gray spots (if we direct our focus to the material reality of the photographic paper), or the real person that is depicted (if this is our focus of attention).

6 Reichenbach, *The Direction of Time*, 198.
7 van Fraassen, "Constructive Empiricism Now," 151.
8 Ibid., 160.

In causal terms, light from a certain source was partially absorbed and reflected by the depicted person, and part of the reflected light entered the camera, ionizing a significant amount of halides in the emulsion, leading to silver specks which were later chemically developed and printed. The causal chain continued when light was reflected on the photographic paper before the observer, reaching his eyes. Any small change in the depicted person would have resulted in a change in observation. According to the criteria of the causal-pluralist metatheory, one is clearly observing a real person, even if he is now dead.

The criteria used for photographs also lead to the conclusion that a good drawing may be considered the observation of the depicted object, if the drawer attempted to reproduce faithfully what he saw. Hacking and Walton agree[9] that a photograph corresponds to an observation of the depicted object, but both disagree that a good drawing is an observation of the object, even if it is so precise to be indistinguishable from a photograph. The present approach arrives at a different conclusion.

As long as the artist drew what he was seeing, one may say that the drawing is an observation of the depicted person. If some part of the drawing is composed in a fictional way, then this part is not an observation of the depicted person. Both photographs and drawings have an intermediary causal stage involving an instrument: the one leading to a faithful drawing involves the "human apparatus" of the artist. In section 6, we will argue that we can focus our attention on the measuring instrument used in a scientific observation, so that the instrument is the object being observed; analogously, one can "observe the artist" as we study the strokes of his drawing (with the help of theoretical knowledge concerning the details of the artist and the scene being drawn).

5 Null-effect Observations

The observation of a red sunset is not a problem for any theory of observation. But according to our approach, it may also be considered the observation of the Earth's atmosphere, which scatters away the blue end of the visual spectrum arising from the Sun. Now what about the case in which sunlight is reflected in a mirror? The mirror is undoubtedly an obstruction, just like a common object such as a starfruit, but it has the property of not absorbing or scattering light, but only changing its direction of propagation. We usually know that the image is being reflected by the mirror, because we see the edges of the mirror, or due to other theoretical knowledge. We can therefore consider that the observation of the sun reflected in a perfect mirror is also an observation *of* the mirror, but in this case it approximates a "null-effect" observation, which is defined as the observation of an object that is indistinguishable from the situation in which the object is absent. The only way of visually distinguishing the two cases (with and without the mirror) is to analyze the direction of the incoming light and its parity (left- and right-handedness).

A better example of a null-effect measurement is to see the sun through a perfectly transparent glass, the borders of which are invisible to us. We assume that there is no visual difference between the presence and the absence of the glass. But, according to our present metatheory, we may consider that we *are* observing the transparent glass. First, any small change in the glass, such as a scratch, becomes visible (thus satisfying the mark criterion). The fact that we don't observe any scratch informs us about the properties of the obstruction. Secondly, our theoretical knowledge of the situation tells us that there is an invisible glass before us. If such knowledge is true, then it is true that we are observing the transparent glass, in the sense of a null-effect observation.[10]

The claim that "we observe our retina" may also be considered a null-effect observation: only when the ophthalmologist pokes our retina do we visually note its presence.

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9 Hacking, *Representing and Intervening*, 207-8; Walton, "Transparent Pictures."

10 A somewhat similar situation arises in atomic physics, in the so-called "negative-result experiment", in which information about a quantum-mechanical object is obtained without any transfer of energy to the measurement apparatus. See Jammer, *The Philosophy of Quantum Mechanics*, 495-96.

6 The Issue of Neutral Observations

One important issue concerning observations is whether they are always loaded with theoretical assumptions or whether there can be a "neutral" observation, i.e. neutral in respect to different theories. The empiricist ideal of an observation that is objective and neutral with respect to theories is well represented by John Stuart Mill, in his debate with William Whewell.[11] For Mill, facts are independent of theories, while for Whewell "every fact involves ideas", i.e. every fact is grasped under a certain theoretical perspective. Whewell's position is known as the "theory-ladenness of observations", and has been put forward by several philosophers of science, such as Pierre Duhem, Karl Popper, and Carl Hempel, besides many others. Norwood Russell Hanson[12] posed the following question: "Do Kepler and Tycho see the same thing in the east at dawn?" For the Millian empiricist, both receive the same sense-data – the sun and the horizon moving relatively apart – but they *interpret* it in different ways: for the first it is the Earth that is spinning, for the latter it is the sun that moves. Hanson may agree that the sensations of both are similar, but stresses than "observation" is more than sensation, since it involves a linguistic dimension, expressed by the construction "one observes that …". Thus, Kepler and Tycho Brahe observe different things at dawn: the first observes *that* the Earth spins, the second *that* the sun rises.

Besides the two different choices illustrated by Hanson of how astronomical theory may guide observation, the empiricist approach is to try to avoid the guidance of any high-level scientific theory during observation. Whether this is possible is a matter of dispute (see the debate between Fodor and Churchland[13]), but there is a sense in which both positions may be reconciled. One can accept that what the empiricist calls a "neutral observation" is an observation which is not loaded with high-level scientific theories, but loaded only with lower-level theories that guide his observation. In a preliminary way, one may speak of "high level" theorization, as in mature science, "medium-level" theorization, as in common sense and folk psychology, and "low-level" theorization, which is implicit in the working of our perceptual apparatus.

Consider an example taken from ancient Greek science, of an observation that may be considered free from theoretical considerations. When the Greek philosopher Strato wanted to show that in the free fall of ponderable bodies there is acceleration, he compared the sound produced on the ground when the body fell from a small height with the sound produced after it fell from a higher position.[14] The auditory observations clearly indicated that, in the second case, the loudness of the sound was higher. Is such an observation loaded with theory?

It is true that the *preparation* of the experiment was guided by scientific-theoretical considerations of a reasonably high level, as well as its *interpretation*. But the observation itself was not influenced by the validity or not of the Aristotelian theory of natural motion, which was at stake. Now, even if we accept that the auditory observation of the sounds is not loaded with higher-level theory, one may argue that in this case there is "low-level theorization". First, the focus of attention is directed to the loudness of the sound. Even if this point is irrelevant for the Millian, the second point is more important: the comparison between different volumes of sound involves a previous conception of the distinction between "more loud" and "less loud". The association of these concepts to different subjectively perceived sounds is an example of *low-level theorization*. The acceptance of this category of theorization allows one to reconcile the empiricist ideal of neutral observation with the thesis that all observation is theory-laden. An observation only loaded with low-level theorization may be considered "neutral".

The notion of "low-level theorization" is to be understood in the sense of the "unconscious inferences" proposed in the literature of psychology of perception. In 1867, Hermann von Helmholtz described the "unconscious conclusions" that accompany acts of perception, including those of optical illusions, which lead to incorrect inferences. Two classic examples associated with unconscious inferences are:

11 Mill, *A System of Logic*, bk. III, ch. II, §4; Whewell, *Philosophy of the Inductive Sciences*, v. II, 213-14.

12 Hanson, *Patterns of Discovery*, 5.

13 Fodor, "Observation Reconsidered"; Churchland, "Perceptual Plasticity"; Fodor, "A Reply to Churchland".

14 Cohen & Drabkin, *Source Book in Greek Science*, 211-12.

(*i*) the constancy of the evaluation of heights of objects and people, by unconsciously multiplying their apparent height by their distance from the observer; and (*ii*) the constancy of colors under different illuminations.[15] Irvin Rock has classified such low-level theorizations into four types of cognitive operations in perception.[16]

The distinction that the logical empiricists drew between "observation terms" and "theoretical terms"[17] may be analyzed according the conception proposed here. An observation term refers to a situation of neutral observation – neutral in relation to scientific theories, but not neutral in relation to low and medium level theorizations. When observing an image of elementary particles in a bubble chamber, the layman will only identify curved lines, and will probably not say that he is "observing particles". The concept of "curved line" involves only medium-level theorization, and thus may be considered an observational term. On the other hand, a theoretical physicist may identify a neutrino, even where there is no trace of a line, and state that she "has observed a muon neutrino". This observation depends on sophisticated high-level theorization, so it is justified to consider the "muon neutrino" a theoretical term.

7 Observations Mediated by Instruments

Scientific observations are generally mediated by instruments, built according to some theory or even by trial and error. For the last half century, experimental data has been registered and processed by computers, before being analyzed by scientists. Torretti and Mosterín[18] call these situations of data processing without conscious awareness "impersonal" observations, as opposed to the "personal" observation involving a causal chain that ends with a human observer. Thus, according to their definition, if an artificial satellite collects data on gamma rays, this amounts to an impersonal observation, even if it explodes before sending the information to Earth. In the present approach, however, the mere registration of a scientific measurement will not be considered an "observation", while it is not perceived by a conscious being. In other words, impersonal observations will not be considered observations.[19]

In observations involving a vehicle that propagates in space (such as electromagnetic radiation or pressure waves), the instrument is an artificial medium that modulates, amplifies, or transforms in some other way the signal coming from the source. It does not seem reasonable, as suggested by van Fraassen[20], to restrict the term "observation" only to situations that either don't involve instruments or involve instruments that give information that can be directly checked by unaided observation, such as is the case of the telescope, but not of the microscope. In the present approach, we will consider as observation most of what scientists call "observation" (as long as perceived by a conscious being), such as the images obtained by electronic microscopes and scanning tunneling microscopes, even if data processing guided by theory is intense, as in the controversial images of "electronic orbitals" (understood as electronic density), which led to protests from some philosophers of chemistry.[21] The images produced are not merely an abstract

15 Hatfield, "Perception as Unconscious Inference", 116-19.

16 Rock, *The Logic of Perception*. Low-level theorization isn't simply an issue involving linguistic conventions. In the example from Strato, the distinction between 'more loud' and 'less loud' does involve a linguistic convention, related to the words used, but the low-level theorization involved also seems to establish an intuitive ordering for the percepts of loudness. The general issue of how language differences affect perception is quite important, but outside the scope of this paper. Further work might clarify how linguistic differences map onto low-level or medium-level theorizations, and maybe these levels of theorization could be further refined.

17 Carnap, *An Introduction*, 225-31.

18 Torretti, "Observation"; Mosterín, "Technology-Mediated Observation."

19 One drawback of extending the definition of "observation" to include "impersonal" ones is that it is not so simple to come up with a criterion for establishing when such an impersonal observation is completed. One could stipulate that this would occur when a macroscopic registration of a numerical value associated to an external magnitude is obtained, but that would exclude human observation, which usually does not involve numerical values. I would rather call "impersonal observations" simply "measurement, data processing and storage", which could be done without resulting in numerical values, in an analog way.

20 van Fraassen, "Constructive Empiricism Now."

21 See Scerri, "Have Orbitals Really Been Observed?"

theoretical representation, but capture information of the system being observed, such that small variations or marks in the object lead to variations in the resulting observation.

Would a computer simulation of a physical or chemical process amount to an observation? Torretti[22] (1986, 7) has stressed that "the observer grasps the object as a particular instance of a universal", where the association with a universal is part of the epistemic aspect of observation. The computer simulation may be considered a description in terms of universals (kinds), without denoting a particular object.[23] For example, two gold nuclei are made to collide in an accelerator; the computer model which represents this collision and the production of pions, kaons and other particles is not an observation of that particular collision in the lab, since there is no causal chain connecting the particular collision and the model (the mark criterion would not apply).

Another example of observation mediated by a scientific instrument is the first "observation" of a neutrino obtained in 1970 at the Argonne National Laboratory, an image in which the particle does not leave a visible path, but produces three other visible particle trajectories. According to the standard model of elementary particles, the only explanation for the appearance of these trajectories is the collision of a neutrino with a proton. According to the causal-pluralist metatheory, this clearly constitutes an observation of a neutrino, albeit strongly loaded with theory. As previously emphasized, the identification of such an object could be wrong, if the theory used were false.

The fact that the neutrino leaves no visible trajectory is irrelevant. In the case of the proton, what is more directly observed are the ionizations it caused, not the proton itself. The same reasoning applies to a football we see in a stadium: what we observe more directly is the light scattered from the ball. The only difference between the three cases is the length of the causal chain connecting object and observer, and the degree of confirmation of the theories involved.

Another point to be stressed, in an observation mediated by scientific instruments, are the so-called "artifacts" that may be produced. A typical case is the appearance of rings and peaks of diffraction in reflecting telescopes, surrounding the images of stars. According to the causal-pluralist metatheory, if the focus of attention is the stars, then such artifacts should be ignored. However, the artifacts exist, and are caused by parts of the equipment (the four radial peaks separated by 90° surrounding the images of stars are due to the diffraction arising in four supports of the secondary mirror of the telescope). If the focus of attention is the artifacts, then this corresponds to the observation of details of the instrument itself.

8 Analogy Between Perceptual Apparatus and Measuring Instrument

Every observation is mediated by the perceptual apparatus. Our perceptual apparatus is analogous to a scientific instrument, the only difference being its biological constitution and the fact that it evolved biologically. Just as there is a theory underlying a scientific instrument, there is also a theory explaining the perceptual apparatus. We may call this neurobiological theory, which describes the workings of the relevant parts of the brain, the "theory of the perceptual apparatus".

Furthermore, our perceptual apparatus shapes the sensations according to its neurobiological structure, and one may argue that this process is equivalent to the implicit adoption of a theory. This may be called the "theory generated by the perceptual apparatus": the structure of the perceptual apparatus organizes the sensations, resulting in a low-level theory about the world.

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22 Torretti, "Observation," 7.

23 This issue deserves further analysis, to be attempted in future work. What is one observing when looking at a computer simulation? What does it mean to observe a representation? At least two cases may be considered: a simulation of a particular, such as the continental drift on Earth through millions of years, and a simulation of a general case, such as the example given of a collision of two nuclei. The role of universals in the later case should be clarified, including the issue of whether one can "observe" a universal.

For example, consider a luminous rectangular panel of 323 diode lamps. Suppose that a single diode turns on and off after a second, and then another diode next to it blinks in the same manner, and then its neighbor, successively. As we observe this phenomenon, we have the tendency of identifying a *thing* moving against the background, as a distant airplane moves in the sky. But, in reality, there is no such thing moving in the screen, only diodes blinking in succession. This illusion happens because the theory generated by the perceptual apparatus, a low-level theorization, assumes the world is made of things that maintain their identity through time and can move through space.[24] There are good reasons, of course, to assume that such a theory is a good one, reasons originating from biological evolution, but in certain circumstances, such as in the observation of a large diode screen, it can lead to errors of prediction. Under these circumstances, one can neutralize the influence of the spontaneous theory (that the luminous dots are things that move) imagining an alternative theoretical scenario (according to which the bright dots don't actually move, but blink in succession).

The thesis that our nervous system instantiates a "theory generated by the perceptual apparatus" may be extended (by analogy) to scientific instruments. This is different from the usual statement that scientific instruments *presuppose* a scientific theory *about* how they work. The suggestion being made here is that the way in which instruments are built ends up emphasizing certain aspects of the object of observation, rather than others, and that this "theory generated by the instrument" contributes to the establishment of an ontology of the observed object (in an analogous way as our brain establishes low-level theoretical presuppositions). For example, different optical instruments may emphasize different aspects of a same physical thing, such its spatial location or its reflectance spectrum.

9 Observations of the Brain

Consider the situation in which someone hits his own head and has the visual sensation of a bright luminous flash, or "phosphene". Is this an observation? Yes, since there is a causal chain and we obtain information about the occurrence of an event in our skull (the blow) and also in our brain (stimulation of the visual cortex). The flash is not generated by light, and there may not be a corresponding pattern in the retina, but neuroscientific theory confirms that the flash corresponds to a specific process in the brain, which we perceive as a flash. It is therefore an observation of the blow in the skull or, changing the focus, of an event in the visual cortex. An analogous analysis applies to the subjective visual images (aura) that precede certain types of migraine.

How about an optical illusion? Consider the case of the Hermann-Hering illusion, that is seen in a grid of black squares separated by white lines: in the intersection between the white lines, faint black dots appear, although they are not physically present in the figure. Are such ghost dots "observed"? Yes, undoubtedly they are. But where are they? In the pattern of paint on the paper? Clearly not. This illusion consists of an observation *of the retina*. Such illusions are analogous to the artifacts of observation generated within scientific instruments, with the difference that now the artifacts are generated within our perceptual apparatus.

How about a *hallucination*? Let us start with pseudo-hallucinations, in which the subject is aware that the perceptions do not correspond to real entities. The visions in the Charles Bonnet syndrome may be considered an observation of a specific region of the cortex, in this case the fusiform gyrus in the ventral occipital lobe,[25] where specific neural patterns of faces and textures are produced.

Hallucinations in epilepsy of the temporal lobe, which may lead the subject to recall specific events in the past (Penfield's "experiential seizures"), are full of meaning, feeling and familiarity.[26] In this case, memory registers are present in the regions that are the source of the causal chain which produces the hallucinatory observation. Such a source may be a small stroke, in which case one may say that the subject is observing the stroke, but he may interpret the endogenous sensation with a (medium-level) theory that

24 One may explain this psychological phenomenon in different ways; for example, that it arises from an interpretational custom of the mind. What is being done here is describing the phenomenon in terms of the causal-pluralist metatheory of observation.

25 See ffytche et al., "The Anatomy of Conscious Vision."

26 Sacks, *Hallucinations*, chapter 8.

does not make reference to the stroke, but to the past event that is registered in his memory and has come to consciousness. If he wishes, he may claim that he is observing again the past event, which originated the causal chain leading to his hallucination.

A third type of hallucination is the psychotic form in schizophrenia. The subject may see children without faces, for instance, and have a clear delusion that they are real. Certain regions of the brain are activated and observed, but these activations are interpreted (with medium-level theorization) as being objects of the external world (which is false). It is plausible to assume that the endogenous source of the observation, once interpreted in a certain way, receives a feedback stimulus from areas responsible for the theorization, in such a way that the endogenously created sensation becomes similar to the theoretical expectation. In this case, considering the "circular" causal processes involved, we can say that, in psychotic hallucinations, theorization acts as one of the causes of the sensation, as a source of the stimulus. In this case, it seems plausible to conclude that one cannot separate the observer from the observed object.

10 Observational Materialism

We have seen that, according to the causal-pluralist metatheory of observation, any stage of the causal process leading to subjective perception may be considered the object of observation. We have followed such causal process all the way to the eye (in the case of visual observations) and claimed that one may consider that we observe the pattern of activation of our retinas, even if it is a null-effect observation. But the causal chain continues inside our brain, and we may claim that we likewise observe a pattern in visual area V4 (which when damaged leads to cerebral achromatopsy). Where does this causal chain end? What is the most proximal cause of the subjective visual sensation of a rainbow? What is the immediate brain correlate of visual consciousness?

There is a debate in neuroscience on whether the immediate neural correlate of each sense modality is localized in a relatively small region of the brain, or whether it emerges in a holistic manner from a large volume of the nervous system. The localizationist views are divided between those that believe that it is a region of the neocortex, such as a "hot zone" in the posterior cortex, and those that claim that it is located in some subcortical region, such as the thalamus.

We will adopt a localizationist view and call the *immediate* correlate of the conscious perception the "perceptual sensorium". The view that the most direct form of observation involves activity in the sensorium will be called "observational materialism", also known as "Cartesian materialism".[27] In other words, observation only happens when information (i.e. flowing patterns of energy and matter) arising elsewhere enters the perceptual sensorium. The details of this hypothetical process is, of course, still an open problem for science and philosophy. We adopt the view that the subjective qualities that arise in perception, known as "qualia", are identical to electrochemical processes in the sensorium.

The most direct form of observation involves events in the sensorium. A yellow quale is postulated to be an event in the sensorium, caused by a chain of electrochemical spikes generated elsewhere. In this case, subject and object seem to be identical. It is better here to speak of "self-observation", not in the sense of "observation of the self", but in the sense of a subjective event arising in the sensorium (and which a future high-level theory will describe more appropriately).

We have mentioned in section 9 another instance in which the separation between subject and object breaks down, when theorization acts as one of the causes of sensation in psychotic hallucinations.

11 Conclusions

The causal-pluralist metatheory of observation presented here has extended the definition of observation in order to encompass the usage of the term in the physical sciences and in neuropsychology. Since the

27 This latter term was used derogatorily by Dennett, *Consciousness Explained*, 207. An exploration of the mind-body problem associated with this view is outside the scope of this paper, but the interested reader may refer to Pessoa, "How to measure a quale".

object of observation is taken to be any stage of the causal chain that produces the subjective experience, the identification of this object requires a theoretical account, which in science usually involves high-level theories, but in everyday life is given by common sense medium-level theories.

The materialist approach of the present account emphasizes the analogy between the human perceptual apparatus and scientific instruments. Humans of course have consciousness, but the manner in which the perceptual apparatus organizes the causal chains originating elsewhere amounts to unconscious inferences or low-level theorization, evolutionarily important in our adaptation to the environment. Scientific observation is perception guided by high-level theorization; perception is sensation formatted by low-level theorization.

The distinction between high, medium, and low-level theorization has also been used to reconcile the sides in the debate on the theory-ladenness of observations. What the Millian empiricist calls a "neutral" observation is an observation not loaded with high-level scientific theories, but loaded only with low-level or medium-level theorizations that guide his observation.

In a nutshell, the "causal-pluralist metatheory of observation" considers that the object of observation is any stage in the causal process leading to conscious perception, a perception that is guided by theoretical considerations that can be high, middle or low-level. This approach allows for the observation of invisible entities (such as neutrinos), for null-effect observations (for example, a transparent glass), for the observation of instrumental artifacts, for observations of parts of the brain outside the sensorium (including illusions and pseudo-hallucinations), and for the self-observation of qualia.

An important criticism against the present extension of the definition of observation is that it is too wide in scope: almost anything would count as an observation, so the definition would tend to be vacuous. So let us mention some processes that are not considered to be an observation.

First, we have restricted the definition to the presence of a conscious being in the causal chain, so that Torretti and Mosterín's "impersonal" observation (section 7) is not considered an observation.

Second, any process or event that is outside of the causal chain leading to a certain subjective perception cannot be an object of observation associated to that perception. This automatically excludes any future processes or events, or events space-like separated from the observer. Causal processes that are "washed away" before arriving at the subject, or otherwise preempted by other causal processes, are also excluded from the scope of an observational process.

Third, the statement that someone is observing a certain object, such as a starfruit, is either true or false, depending on the truth or falsity of the theoretical inference being assumed. I might judge erroneously that a yellow flower is a starfruit, so I am not observing the starfruit. On the other hand, if what I have in front of me is a high quality hologram of a starfruit, and the causal process used to generate it involved photographs of a real starfruit, then I am observing a starfruit, although it is not located where I judge it to be and at this time.

One may say that Galileo, Lalande, and John Herschel in fact observed Neptune through the telecope, although they interpreted it as a star. While their theory led them to interpret the luminous object as a star, such theoretical consideration is false. In day-by-day examples of observation, humans share basically the same low-level and medium-level theories, so the observation ("I saw a bear eating the berries") brings by itself evidential support for the associated claim ("The bear ate the berries"). But in the extension of the concept of observation to domains far removed from daily life, the validity of the observational claim will depend crucially on the veracity of the high-level theory being used.

Given that all causal chains started in the Big Bang, could I say that I am observing the Big Bang right now, while looking at a campfire? Assuming that such causal chains are deterministic and have not been washed away, the causal-pluralist metatheory would say yes, although our ignorance of the detailed causal history of the Universe would not allow our science to discern interesting features of the Big Bang from the direct observation of the campfire.

Fourth, in section 7 we argued that a detailed theoretical model or computer simulation of a nuclear collision is not an observation of a real collision occurring in an accelerator. However, the computer model was constructed upon a large amount of data, from past collisions, so according to our metatheory such a model is in part an observation of such collisions (which take part in the causal process generating the

model), although the process of averaging and the random choice of initial conditions of the simulation eliminate a large part of the features of each individual collision. This seems to be relevant for a nominalist analysis of the philosophical difference between particulars and universals.

We have followed the traditional separation between subject and object of observation, and extended it to observations of objects within the brain. However, in the case of psychotic hallucinations, the subject's theorization actively influences the production of the object of observation, disrupting the separation between subject and object. Furthermore, we adopted "observational materialism", which postulates that there is a region inside the brain, the perceptual sensorium, in which the occurrence of an event is identical to the experience of qualia. In this case, one might speak of self-observation, which is the most direct observation.

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28 Previous versions of parts of the paper have been published in Portuguese. See Pessoa, "Uma Teoria Causal-Pluralista da Observação," and "Conciliando a Neutralidade e a Carga Teórica das Observações."