Sensorimotor Laws, Mechanisms, and Representations

Alfredo Vernazzani (alfredo-vernazzani@daad-alumni.de)

Institut für Philosophie, Am Hof 1
53113 Bonn, Germany

Abstract

According to the sensorimotor account, vision does not imply the construction of internally generated representations of the environment, but it is the skillful exercise of the sensorimotor contingencies obeying sense-specific laws. In this short study, I focus on the notion of "sensorimotor law" and characterize the kind of explanation provided by the sensorimotor theory as a form of covering law model. I then question the nature of such sensorimotor laws and describe them as mechanisms. I show that a mechanistic interpretation provides a better account of the sensorimotor invariances, which fosters us to rebalance the explanatory burden of sensorimotor action and information. Finally, I show that the question of the role of representations within the sensorimotor theory should be reconsidered.

Keywords: Sensorimotor theory of vision; representations; mental mechanisms; explanation.

Introduction

In recent years we have witnessed the emergence of a new research paradigm in vision studies: the sensorimotor approach. First put forward in a paper written by Noë and O'Regan (2001), the sensorimotor account represents an attempt to explain vision and visual consciousness without relying on internally generated models of the external world. Against the Orthodox account of vision (the expression is due to Noë & Thompson 2005), which claims that to perceive something visually our brains construct complex and detailed representations of the external world, defenders of the sensorimotor account maintain that visual perception is constituted by the active exercise of our sensorimotor contingencies which obey a set of sense-specific laws.

In this study, I set out to examine which kind of explanation of visual consciousness is provided by the sensorimotor account. I will argue that the appeal to sensorimotor laws makes the deductive nomological model a perfect candidate. However, in contrast to the sensorimotor theorists, I argue that sensorimotor laws are better described in mechanistic terms. The dichotomy presented here between a "law" interpretation and a "mechanistic" interpretation of the sensorimotor invariances has several relevant consequences. I will argue that if we characterize such invariances as mechanisms, the role of the internal information processing and perhaps of representations has to be reconsidered.

In the following pages I will primarily refer to O'Regan & Noë (2001) as it is the main source for all subsequent developments of the sensorimotor account.

Outline of the Sensorimotor Theory

In overt contrast with traditional accounts of vision, defenders of the sensorimotor theory contend that the purpose of vision is not the construction of internal representations of the external world, but rather the exploration of the environment through the active exercise of the sensorimotor contingencies. Of course, representationalist thories of vision do not deny that representations are employed to guide the organism in the environment. The crucial difference between the two accounts is that the sensorimotor theorists identify the coding of vision exactly in the organism's sensorimotor response: it is precisely the exercise of the sensorimotor skills that constitute visual perception.

What the authors call "sensorimotor contingencies" are the motor actions exhibited by the organism and the associated changes in sensory input. What distinguishes the senses from one another, according to the sensorimotor theory, is therefore not some specific nerve energy (Gorea 1991) that accounts for the diversity of experiences in different sense modalities thanks to some intrinsic quality of the signal transmitted by the neurons. The senses are individuated by a set of rules that govern the sense-specific sensorimotor contingencies. The distinctive character of vision is the result of a very specific set of rules or "laws" (O'Regan & Noë 2001, p. 941) that modulate the motor actions triggered by the external objects.

There are two kinds or "categories" of sensorimotor contingencies. The first kind is that of the sensorimotor contingencies determined by the visual system, whereas the second kind is specific to the visual attributes such as shapes and colors. The distinction between two kinds of sensorimotor contingencies is roughly equivalent to the distinction between sensation and perception. In fact, the first kind is "independent of any characterization or interpretation of objects" (O'Regan & Noë 2001, p. 943) and can be considered as the fundamental level of visual sensation, whereas sensorimotor contingencies determined by visual attributes are specific to visual features at the higher perceptual level. Later, I will briefly discuss two examples of such sensorimotor laws.

Noë and O'Regan argue that, in order to perceive something visually, the organism must not only explore the environment through the two kinds of sensorimotor contingencies. The organism must also actively exercise "its mastery of these laws" (O'Regan & Noë 2001, p. 943). This implies that the organism must possess a distinctive know-how of the sensorimotor laws. Moreover, the sensorimotor

contingencies must be activated by an object in the external world (Noë 2005).

Obviously, the sensorimotor contingencies are not unknown to visual scientists: the theory's original claim is that the laws governing them constitute a representation-free code of visual perception. O'Regan and Noë do not exactly deny the existence of representations (2001, p. 1017), yet they seem to maintain that representations are not explanatory relevant for visual perception. Allegedly, this model sidesteps a number of problems summoned by the Orthodox view. Vision is not the construction of an internal representation of the world. This way of conceiving vision would be analogous to some version of Cartesian materialism (Dennett 1991). Cartesian materialism is not exactly a philosophical doctrine, but rather a way of conceptualizing the relation between representations and consciousness. According to this standpoint, representations would be conscious once they obtain access to some brain region(s) whose function is that of producing consciousness.

Sensorimotor theorists claim that the Orthodox standpoint would lead us to a conceptual dead-end when we try to explain consciousness and vision. Postulating the existence of functional regions in the brain that simply make the representations conscious does not contribute to explain visual consciousness and gives rise to an insurmountable explanatory gap.

A DN Model of Vision?

From the viewpoint of philosophy of science, there are several interesting questions. In this context, I focus my remarks on the notion of explanation, and ask what kind of explanation is provided by the sensorimotor theory.

Let us briefly recall the main features of this account: visual perception is the active exercise of the sensorimotor contingencies; sensorimotor contingencies obey a set of sense-specific laws; moreover, they must be activated by an object in the external world. Thus, perception is the action response triggered by an object and structured according to the sense-specific laws. Considering such features, it seems that the model of explanation which best fits the sensorimotor account is the covering law model.

The Covering Law Model

According to the covering law model, or more appropriately, the deductive-nomological (DN) model (Hempel & Oppenheim 1948; see also Salmon 1989), explanations are arguments from premises, the explanans, to a conclusion, the explanandum phenomenon, which is deductively entailed by the premises.

The DN model has its roots in the era of logical positivism, dominated by an anti-metaphysical standpoint. Hempel's model contributed to the clarification of the notion of scientific explanation by describing it as a purely logical relation. According to the DN model, the explanans is composed by at least a law of nature and a singular statement of antecedent condition (boundary condition). The explanandum phenomenon figures in the DN model as the conclusion of the argument, which ought to be deduced from the premises.

Let us focus on some key features of the DN model. In order to have a deductive-nomological explanation, the following criteria must be met: the explanation must be a valid deductive argument; the explanans must contain at least one general law; the explanans must have empirical content; the sentences in the explanans must be true.

The DN model is today widely considered untenable. In this context, I will only focus on one specific problem. The fact is that the explanatory power of the DN model crucially depends on distinguishing true laws of nature from accidental generalizations. Only laws of nature are explanatory, whereas accidental generalizations are not. Whilst the appeal to laws of nature in physics is rather common, the case of the special sciences, like psychology and biology, is quite different.

Cummins (2000) has persuasively argued that what psychologists sometimes call "laws" are in fact descriptions of effects: for instance, the Garcia effect, the McGurk effect, and others. Effects do not have any explanatory relevance: they merely describe a phenomenon which needs to be explained. If the sensorimotor theory provides DN explanations of vision, we need to verify the nature of the sensorimotor invariances and clarify whether they actually are laws.

Subsuming Vision under Sensorimotor Laws

Consider the sensorimotor theory's account of vision. According to this model, when an object is visually "given", it triggers the system in such a way that the motor actions exhibited constitute visual perception, and that such motor actions obey a set of specific laws.

A rough, albeit intuitive schema for the sensorimotor explanation could be the following:

> ⌜ Sensorimotor Law of Visual Perception
> ⌞ Target Object O
>
> → Visual Perception of O
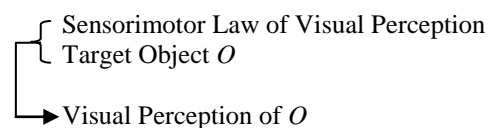
It is important to stress that neither Noë nor O'Regan have explicitly described the sensorimotor account as providing a covering-law explanation. Moreover, they have never spelled out the notion of 'law' clearly. But the similarity with the DN model is striking. From the fact that the motor actions triggered by the distal object O obey a set of sense-specific laws, it follows that the primary effort should be that of finding out and to describe the sensorimotor laws. Once we will have completely described the sensorimotor laws, we will also have a complete account of the structure of vision. However, one could rightly ask at this point: What are the sensorimotor laws?

The Nature of the Sensorimotor Laws

As I have explained above, it is a matter of debate whether there actually are laws in special sciences such as

biology and psychology. Clearly, if we want to explain vision through the sensorimotor laws, it is paramount to determine their nature. According to the DN model, the laws of nature are sentences, which, as we have seen, are used as premises of an argument. In this paragraph, I argue that what O'Regan and Noë call 'sensorimotor laws' are actually better described as mechanisms.

In their paper, O'Regan & Noë (2001) discuss some of such laws. As I have explained in the first paragraph, there are two kinds of sensorimotor contingencies: those determined by the visual system and those determined by the visual attributes. The first law that I will discuss is of the former kind, the second one belongs to the latter.

First Example: Eye Rotation

Rotation of the eye alters the stimulation on the retina in a way determined by the size of the eye movement, the shape of the retina, and the nature of ocular optics (O'Regan & Noë 2001, p. 941).
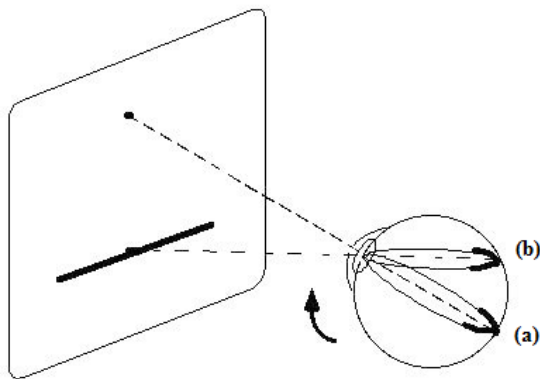

Figure 1: Eye Rotation (borrowed from O'Regan & Noë 2001)

As figure 1 shows, eye movement distorts the straight line in such a way as to describe a greater arc in (a) and a smaller one in (b). The alteration of the stimulus on the retina depends not only on the eye rotation, but also on the structure of the retina. The alteration of the stimulus on the retina is transmitted in such a way as to deliver different cortical representations.

O'Regan and Noë maintain that the alterations of the stimulus and consequent sensorimotor response would be constrained by different structural laws that are specific to the sense of vision. The task of the vision scientists, and the philosophers interested in visual perception, is that of describing the laws in order to understand how the organism exhibits a specific sensorimotor response.

Second Example: Visual Shape

The other example of sensorimotor law discussed by the authors is that of visual shape. As I have explained above, the second kind of sensorimotor contingencies is determined by visual attributes, which means by specific features of our

conscious visual phenomenology such as colors and shapes. This second kind of sensorimotor laws is related to visual perception whereas the former, as we have seen, are related to visual sensation.

According to the authors, shape perception would be "the set of all potential distortion that the shape undergoes" (O'Regan & Noë 2001, p. 942) when we move in relation to the object or when it is the object itself which moves in relation to us. From these movements, the brain abstracts a set of laws which code the shape perception.

That shape perception depends on the laws abstracted by the variances produced by body movements would be illustrated by patients who enjoyed restored visual perception after being born blind with congenital cataract. Clinical histories provide plenty of examples. Helmholtz (quoted in O'Regan & Noë 2001, p. 942) for instance cites the case of a patient who, after visual restoration, is surprised that the coin apparently changes its shape when rotated. According to O'Regan and Noë, the "surprise" this patient felt would be due to the fact that upon restoration of sight, the visual phenomenology is dramatically altered in such a way as to enable abstractions of specific laws previously inaccessible.

Sensorimotor Mechanisms

As I have said, according to the DN model propositions are sentences used as premises in an argument. Yet, the examples of sensorimotor laws just discussed do not seem to support this interpretation. I suspect that the appeal to 'laws' in the sensorimotor theory reveals the lingering tendency to provide covering law explanations. The phenomena just examined are better described as mechanisms.

The term 'mechanism' is often used by biologists and neuroscientists (Craver 2007), as well as by cognitive scientists (Bechtel 2008). But what is a mechanism? Bechtel (2008) defines mechanisms as structures performing a function in virtue of their component parts, operations, and their organizations. The way we characterize parts and operations crucially depends on the field of investigation and therefore the kind of phenomena studied. For instance, many fields of biology determine both the explanandum phenomenon and the operations as involving physical transformation of material substances. To provide a mechanistic explanation basically means to show how the joint interactions of the component parts and operations results in the production of the explanandum phenomenon. I will now consider again the two examples of sensorimotor law described above from the mechanistic standpoint.

Allegedly, the first 'sensorimotor law' accounts for the alterations of the signal on the retina and the consequent sensorimotor response through vision-specific structural laws. It is by describing the mechanics of the eye that we can explain the alteration of the stimulus on the retina. Yet, it is not clear how we should understand this claim. We could interpret this observing that eye movements obey the laws of mechanics. Yet, this interpretation would obviously

be trivial. Moreover, it would be an utter mystery why such laws should help us explain visual perception.

A better way to figure out how to explain the alterations of the signal on the retina would be to provide a mechanistic explanation of the eye's movements. In mechanistic terms, the different component parts are physical and the operations are their movements. The explanandum phenomenon, the alteration of the signal on the retina, can be explained by reconstructing the way the specific mechanism behaves without introducing the inaccurate notion of 'law'.

Consider now the second case. Visual shape perception would depend on 'laws' abstracted by the brain on the basis of the variances produced through bodily movements. The abstracted laws, as we have seen, define the set of all potential shape distortion. In this case it remains completely obscure why we should understand the potential distortions as 'laws', nor is it clear why such 'laws' should account for shape perception. Noë and O'Regan remain silent on this issue.

The case of shape perception is perhaps more tricky; yet, I think that this example, too, can be better described from the mechanistic standpoint. Even if we agree on the sensorimotor account of shape perception, it would still be required that the brain 'recognizes' and processes the information concerning the object's shape. But this would be better accounted from a mechanistic standpoint, as an example of a mental mechanism: the component parts are functional units processing information concerning visual shape. Accordingly, cases of restored vision could be reinterpreted as processing information previously inaccessible, without introducing any mysterious sensorimotor 'law'.

If my remarks are correct, I would propose a mechanistic reformulation of the sensorimotor theory: the sensorimotor laws are actually sensorimotor mechanisms. This reformulation of the sensorimotor theory has several implications that I will now explore.

Sensorimotor Mechanisms and Information: A Return of Representations?

The way we describe the phenomena considered here is not only a verbal dispute. Laws and mechanisms are explanatorily different. I contend that it is precisely the introduction of the notion of law, vague and never really clarified in the O'Regan and Noë's paper, that leads to the rejection of the explanatory power of representations. Yet, if we reject the 'law' interpretation of the phenomena we have described, a number of theoretical consequences follow. I will now consider some of them.

First, and most importantly, a mechanistic reading helps us solving a confusion within the sensorimotor theory concerning representations. As I have explained, the theory does not reject the existence of representation, but it undermines their explanatory power. It is not through representations that we can hope to explain vision, but through the two kinds of sensorimotor laws. Yet, in

O'Regan and Noë (2001) it is not exactly clear what role do representations play. Noë (2004, p. 22) claims that it is not possible to deny the existence of representations altogether. Similarly, in their response against criticisms, O'Regan and Noë agree that the visual system 'stores information' and that such information influences the perceiver (2001, p. 1017). If we hold a representational interpretation of the information processing, and this seems to be the authors' stance (O'Regan & Noë 2001, p. 1017), then the sensorimotor theory includes representations but deny that they have any explanatory power. After all, representations are repeatedly mentioned in their description of the sensorimotor laws: it is through the sensorimotor laws governing eye movement that the signal on the retina is altered thus producing different cortical representations.

The authors put the explanatory burden of vision entirely on the sensorimotor laws: it is precisely this that leads O'Regan and Noë to an unclear position concerning the role of representations. But if we interpret the sensorimotor laws as mechanisms, the role of representations in perception needs to be reconsidered.

According to the interpretation that I have laid out, we should distinguish between two kinds of mechanisms. The first one provides an example of a physical mechanism affecting the signal on the retina. The second one provides an example of a mental mechanism that process information. In both cases, the notion of information is central, counterbalancing the focus on the motor actions.

What remains to be questioned is the nature of such information being processed, and whether it can be defined as representational or not. In any case, switching the focus from the sensorimotor laws to the sensorimotor mechanisms prompts us to reconsider the role of the information processed in the explanation of vision and its representational interpretation.

Conclusion

My remarks are not meant to reject the sensorimotor theory. The crucial question is to understand the nature of sensorimotor laws, and therefore to understand which role they play within the sensorimotor account of vision. I have tried to show that such laws are actually better characterized as mechanisms. This has some relevant consequences, since the explanatory structure of the theory dramatically changes in the two interpretations.

According to the "law" interpretation, the purpose of vision research is to describe the laws governing the sensorimotor reactions without relying on representations. On the contrary, according to the mechanistic interpretation, the concept of information and, perhaps, of representation, returns as an important explanatory component.

Finally, there is still another important implication of the mechanistic interpretation of the sensorimotor theory: a more balanced account of the relations between action and perception that does not bind them too tight, but stresses the relevance of the sensorimotor action to the modulation of the information processing.

Acknowledgements

References

Bechtel, W. (2008). *Mental Mechanisms*. New York: Psychology Press.

Craver, C. (2007). *Explaining the Brain*. Oxford: Oxford University Press.

Cummins, R. (2000). "How does it work?" vs. "What are the laws?": Two conceptions of psychological explanations. In F. Keil & R.A. Wilson (Eds.), *Explanation and Cognition*, Cambridge, MA: MIT Press.

Dennett, D. C. (1991). *Consciousness Explained*. Boston: Little, Brown & co.

Gorea, A. (1991). Thoughts on the specific nerve energy. In A. Gorea (Ed.), *Representation of vision*, Cambridge: Cambridge University Press.

Hempel, C.G., & Oppenheim, P. (1948). Studies in the Logic of Explanation. *Philosophy of Science*, 15, 135-175.

Noë, A. & Thompson, E. (2005). Introduction. In A. Noë & E. Thompson (Eds.), *Vision and Mind*, Cambridge, MA: MIT Press.

Noë, A. (2004). *Action in Perception*. Cambridge, MA: MIT Press.

Noë, A. (2005). Real Presence. *Philosophical Topics*, 33, 235-264.

O'Regan, K.J., & Noë, A. (2001). A sensorimotor account of vision and visual consciousness. *Behavioral and Brain Sciences*, 24, 939-1031.

Salmon, W.C. (1989). *Four Decades of Scientific Explanation.* Minneapolis: Pittsburgh University Press.