Mechanistic stance: An epistemic norm among scientists

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Over the last two decades, some philosophers of science have enthusiastically advocated "mechanistic philosophy" (e.g., Machamer et al. 2000; Bechtel and Abrahamsen 2005; Glennan 1996, 2002), arguing that to describe or provide mechanisms is important to scientific explanation. Although it has been suggested that this claim could be applied to some examples (e.g., Baker 2005; Bechtel 2011), there has been also raised some serious problems.

The aim of this paper is to clarify the claim and defend mechanistic philosophy against the problems. We argue that these problems are not serious if we construe the claim of mechanistic philosophy in terms of scientists' "mechanistic stance": In (probably not all but) many cases, scientists actually search and try to describe mechanism-like systems even if they are not or cannot be defined so strictly, and this is one of the norms that scientists actually conform to even if should not. So in this sense, mechanistic philosophy correctly captures such mechanistic stance of scientists.

We will proceed as follows: Section 1 summarizes the basic claims of mechanistic philosophy. Section 2 points out some serious problems with mechanistic philosophy. Section 3 briefly describes "mechanistic stance", and responses to the problems we point out in Section 2.

A brief summary of mechanistic philosophy

Although the claims of "mechanistic philosophy" somewhat depend on each philosopher, what is commonly assumed among them is, first, that to describe or provide mechanisms in the target phenomena is very important for decent scientific explanations at least in some scientific disciplines. For example, Machamer et al. (2000, p. 2) argue that "in many fields of science what is taken to be a satisfactory explanation requires providing a description of a mechanism". Bechtel and Abrahamsen (2005, p. 422), referring to biological literature, also argue that "it quickly becomes clear that the term biologists most frequently invoke in explanatory contexts is mechanisms". As evidence of the assumption, Machamer et al. (2000, p. 2) and Bechtel and Abrahamsen (2005, p. 422) point out that the concept of mechanisms have been extensively used in philosophy and science, and argue that providing mechanism is actually important for many cases of scientific explanations. For instance, the number of the papers including "mechanism" in the titles and abstracts published from 1992 to 1997 is 597 in *Nature* and its supplementary journals, and 205 in the papers registered in the Philosophers' Index during the same period (Machamer et al. 2000, p. 2); the number of the papers including "mechanisms" and "synthesis" in the title is 302 (Bechtel and Abrahamsen 2005, p. 422) [1] .

However, even though mechanism is a quite important concept for understanding scientific explanations, many mechanistic philosophers have complained that "there is no adequate analysis of what mechanisms are and how they work in science" (Machamer et al. 2000, p.2). Glenann (2002, S343), though he agrees with Salmon's (1984) arguments on causal explanation, also argues that Salmon's view on mechanisms depends on "an inadequate analysis of the nature of causal mechanisms" and in this paper, he tries "to provide an improved analysis of mechanisms". Thus mechanistic philosophy has a common agenda, i.e., to clarify the concept of mechanism and the way it is used in actual scientific explanations.

As we will see in the next section, what mechanisms are depends on each philosopher. However, as an example, let us see a characterization of mechanism by Machamer et al. (2000). Analyzing some examples such as neurobiology and molecular biology, they characterize mechanisms as follows. (1) Mechanisms are 'entities and activities organized such that they are productive of regular changes from start or setup to finish or termination conditions' (p.3). The activities in mechanisms are the producers of change, and the entities are what engage in those activities. (2) There must be a 'productive continuity' (p.3) between each step. Mechanisms consist of a series of steps that go from start to finish whenever the preconditions are obtained. According to them, the phenomenon to be explained delimits the mechanisms to be described.

Let us elaborate the characterization by applying it to an actual example. Consider the mechanism by which a neuron releases neurotransmitters (see also Machamer et al. 2000, figure 1). A presynaptic neuron transmits a signal to a post-synaptic neuron by releasing neurotransmitter molecules that diffuse across the synaptic cleft, bind to receptors, and so depolarize the post-synaptic cell. In this example, (1) entities and activities are specified: entities are pre-synaptic neuron, post-synaptic-neuron, neurotransmitter, and so on; activities are depolarization, Ca influx, and so on. Moreover, (2) there is a 'productive continuity' (Ibid., p.3) between each step: the process of neurotransmission can be reduced to order. They also argue that providing the mechanism of neurotransmission could lead to explanation of why neurotransmission happens.

Some problems of mechanistic philosophy

This section points out some problems with mechanistic philosophy, i.e., (1) the definition problem, (2) the application problem, and (3) the norm problem. Let us look at them respectively.

The definition problem

Although the concept of mechanism is what mechanistic philosophy should clarify in many different contexts, and actually many philosophers have tried to do that, unfortunately, there are any consensus on what mechanisms are yet (see Hedström and Ylikoski 2010, table 1). Worse, they are not compatible to some degree. For example, Skipper and Millstein (2005, p. 334) draw out the following three key differences between conceptions of Glennan (2002) and Machamer et al. (2000). (1) While Glennan explicitly distinguishes between systems-mechanisms and process-mechanisms, Machamer et al. (2000) offer a univocal conception. (2) Though Glennan relies on the notion of interaction to account for productive continuity through mechanisms, Machamer et al. (2000) reject the interactionist perspective for their dualistic approach emphasizing entities and activities of mechanisms to account for productive continuity. (3) Glennan uses direct, invariant, change-relating generalizations to characterize the regularity of mechanisms (cf. Glennan 1997 on stochastic mechanisms). On the other hand, Machamer et al. (2000) hold to an apparently looser notion of regularity, in which mechanisms are regular if they work always or for the most part in the same way under the same conditions (Machamer et al. 2000, p. 3).

How should we respond to the problem? One may be able to modify these definitions and create a unique definition of mechanisms. For example, Torres (2009) tries to modify Machamer et al.'s and Glennan's definition and create a single definition of mechanisms. Even if his attempt is successful, however, it should be noted that we have further alternatives as shown in Table 1 of Hedström and Ylikoski (2010). Moreover, like many other scientific concepts used in science such as species (e.g., Ereshefsky 2001) and scientific models (e.g., Giere 1999; Morgan and Morrison 1999), it is possible that the concept of mechanism is a kind of folk concepts and that we are able to get a necessary and sufficient definition of mechanism (e.g., Moss 2012). This paper, however, argues that even if so, this problem is not serious for mechanistic philosophy because defining mechanism is not crucial for it.

The application problem

Let us turn to the second problem, i.e., the application problem. Like Machamer et al. (2000), many philosophers have considered whether the mechanisms defined by Machamer et al. (2000) can be applied to scientific explanations in other fields. For example, Skipper and Millstein (2005) focus on natural selection because regarding natural selection as a mechanism looks pervasive in biology literature. For example, Roughgarden (1996), when discussing Darwin's work in her well-known textbook of population genetics, argues that one of the Darwin's propositions is that the mechanism (or driving force) of evolution is natural selection. Futuyma (1986), in his introductory book of evolutionary biology, says that the several mechanisms of evolution include natural selection, which accounts for the diverse adaptations of organisms to different environments, and so on (Skipper and Milstein 2005, p. 328). From these discussions, it seems apparently clear that they are talking about natural selection as mechanism, and that mechanistic explanations are central in evolutionary biology.

In fact, natural selection might be best explained in terms of the mechanism defined by Machamer et al. (2000). Skipper and Milstein consider this possibility by looking at a familiar case of Darwin's finches. In this case, the entities are the name of some organism, some determinable organismic trait, the description of the environment of organism, and the description of a critical factor in environment. The activities are to interact with environment, to obtain seeds, and so on. Given the initial conditions and the causal interaction between the environment and the finches, we could expect various effects, i.e., finches with large beaks would have more offspring than finches with small beaks in rainy season, and so on. So it might be possible that the explanation of natural selection of Darwin finches clearly describes or provides the mechanism defined by Machamer et al. (2000).

Skipper and Millstein and others, however, have pointed out that the concept of mechanism defined by Machamer et al. (2000) or Glennan (1996) does not correctly capture explanations by natural selection. Here, for the sake of space, we focus on the following two problems. First, the problem of the organizations of mechanisms. For example, according to Machamer et al. (2000, p. 3, emphasis added), "[e]ntities often must be *appropriately located, structured, and oriented*, and the activities in which they engage must have a *temporal order, rate, and duration*". The case of finch shows, however, that (1) "organisms need not be found in any *particular location*" (e.g., geographical areas where finches do live depend on each year, individual, and so on), and that (2) "the activities of organisms do not occur at any *particular rate*"(e.g., the rate of clutch production is faster at some times and places than at others) (Skipper and Milstein 2005, p. 338) and so on. Second, explanations of natural selection do not meet the condition of regularity, i.e., they can be probabilistic. Machamer et al. (2000, p. 3) argue that "mechanisms are regular in that they work *always or for the most part* in the same way under the same conditions". However, natural selection can be seen as stochastic. So "the probabilistic regularity is a far cry from a mechanism that works always or for the most part in the same way under the same conditions" (Skipper and Milstein 2005, p. 343). Thus natural selection, though it is one of the most promising candidates for mechanistic explanation, we face the problem that the concept of mechanism defined by Machamer et al. (2000) is inapplicable to it.

This point is still controversial: Some have responded to Skipper and Milstein

(2005) and argued that natural selection can be seen as a clear example of mechanistic explanation (e.g., Barros 2008) while others also countered this argument (e.g., Havstad 2011). We think, however, that this controversy is not so productive since we do not have a single and unique definition of mechanism yet, and as we have already argued, it is possible that such definition will be unavailable forever. Rather, we will suggest an alternative resolution to this problem in the last section.

The norm problem

Third serious problem is the norm problem. Some mechanistic philosophers claim that providing mechanisms is a necessary condition and normative requirement for scientific explanations. For instance, Craver (2006, p.368) argues: "Models are explanatory when they describe mechanisms. Perhaps not all explanations are mechanistic. In many cases, however, the distinction between explanatory and non-explanatory models is that the latter, and not the former, describe mechanisms. (Craver 2006, p. 367; Moss 2012, p. 167). However, Moss (2012) argues that providing mechanisms is not a norm that scientists should confirm to. He says, "there is not, nor can there be, any universal normative gold standard for the right form of a mechanism-based explanatory model anymore than there can be a plausible hope of exhausting the entire possibility space of embodied human physical intuitions, which will vary both historically with different cultural lifeworld experience and individually with variant personal developmental patterns even within the same cultural space" (p. 166). Moreover, according to Moss, providing mechanisms is only the first step of scientific searches or normative touchpoints. He argues: "…[A mechanism] provides a platform for subsequent studies but it tells us nothing about the difference between a fungus and an elephant. The very idea that there could be stages in the unfolding of mechanism-based research in which the founding exemplars, and normative touchpoints of explanatory mechanism undergo transformation and replacement as biological/biomedical research agendas develop and advance is as yet virgin territory within the ambit of the philosophical discourse of the 'new mechanism' community" (p. 169). So if Moss (2012) is right, Craver's claim on normativity should be too strong and what mechanistic philosophy has tried to capture might be insignificant and unnecessary to understand scientific explanations.

Although we agree with Moss (2012) in that providing mechanisms cannot be a normative requirement we should impose on scientific explanations, we partially disagree with him because mechanistic philosophy correctly captures what scientists actually conform to and try to describe in scientific explanations. We will call this "mechanistic stance". We will briefly describe it in the next section, and show some of its merits by responding to the three problems in terms of the stance.

A brief description of mechanistic stance and its merits

Although describing or providing mechanisms might be just a first step of, and not be sufficient or necessary conditions for decent scientific explanations, it should be noted that many scientists actually try to describe mechanisms in their explanations of the phenomena, which is clear from Machamer et al. (2000) and Abrahamsen and Bechtel (2011) showing the number of the articles including "mechanism" in the title and abstract, and Skipper and Milstein (2005) referring to the important textbooks in evolutionary biology by Roughgarden (1996) and Futuyma (1986). Thus in (probably not all but at least) many cases, scientists actually search and try to describe mechanism or mechanism-like systems even if they are not or cannot be defined so strictly (e.g., Bechtel and Richardson 2010; Levy 2012; Matthewson and Calcott 2011). So in this sense, mechanistic philosophy correctly captures such "mechanistic stance" of scientists, and can reply to the three problems.

Brandon (1996) developed a similar argument. First, a definition of mechanisms should not be provided a priori. Brandon (1996) argued that "it can give no exhaustive list of such mechanisms, nor can it give a complete characterization of just what counts as a mechanism". According to him, this is not a problem rather a "virtue" because "it is the business of science to discover the mechanisms at work in nature" (pp. 192-193). Second, mechanistic stance is a norm among scientists: "[M]echanism plays a normative role in contemporary biology, in particular in evolutionary biology...the distinction between mechanistic and nonmechanistic work is recognized and...this is oftentimes the basis of criticism of certain approaches" (p. 196). Thus Brandon properly points out that scientists often have controversies on whether some hypotheses are mechanistic or not, and that scientists require identifying mechanisms for good exaplanations.

If we can construe the claim and agenda of mechanistic philosophy in terms of mechanistic stance, and mechanistic philosophy clarifies how such mechanistic stance is adopted in many different contexts, it can reasonably reply to the three problems. Let us consider them respectively in terms of mechanistic stance.

First, the definition problem is a bit misguided. We should not mind a definition of mechanisms before examining how they are used in actual contexts. As Brandon (1996) argues, a necessary and sufficient definition of mechanisms should not be provided a priori. Even if we may not be able to find such definition forever, like scientific models or biological species, it is possible that the concept of mechanism can function as a useful concept in scientific explanations. Thus mechanistic philosophy reconstructed in terms of mechanistic stance does not need to give a conclusive definition. Rather the aim is to clarify and examine different uses in each context.

Second, the application problem is also not serious for mechanistic philosophy. It is not important to think whether a definition of mechanisms can be applied or not, but rather we should clarify how different types mechanisms are provided or described in each area, which may reveal, for example, the difference of explanations in neurobiology and natural selection. In this sense, natural selection is a very good example. As we have already seen, although natural selection may not be a mechanism defined by Machamer et al. (2000), scientists like Roughgarden and Futuyma clearly aimed to describe "mechanism" in some sense, which may reflect some difference in explanations between evolutionary biology and other fields. Thus mechanistic philosophy standing on mechanistic stance can reveal variations of scientific explanations by explicating how "mechanisms" are provided or described in each context.

Finally, on the norm problem. We do no think that to describe mechanisms should be a requirement for decent scientific explanations. However, as we have already seen, many scientists actually have tried to describe and provide mechanisms in each fields, and Moss (2012)'s accusation of mechanistic philosophy is too haste. Mechanistic philosophy correctly represents scientists' actual norms and practices, and we should interpret mechanistic philosophy as an attempt to analyze "mechanistic stance" in different contexts and fields. Although scientists do not explicitly define mechanisms, it is clear that they try to discover mechanisms in several phenomena. Brandon (1996) properly guides the direction mechanistic philosophy should follow while Moss (2012) unfairly misses this point.

Conclusion

Mechanistic philosophy has faced some serious problems and criticisms. However, they derive from a mischaracterization of the aim of mechanistic philosophy, and mechanistic philosophy, if correctly interpreted, i.e., interpreted in terms of "mechanistic stance", can avoid the criticisms properly.

Notes

1. They do not specify the period when the papers were published.

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