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Conceptions of Mechanisms and Insensitivity of Causation

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ABSTRACT: Conceptions of mechanisms due to Glennan (1996; 2002), Machamer, Darden, and Craver (2000), Bechtel and Abrahamsen (2005) have developed in opposition to the nomological approach to explanation. It is less emphasized, however, that these conceptions have also developed as alternatives to the causal perspective on explanation. In this paper, I argue that despite their distancing from the topic of causation, the mechanistic conceptions need to incorporate in their definitions of mechanisms the notion of insensitivity of causal relations that was examined by Woodward (2006).
KEYWORDS: mechanism; causation; insensitivity.

1. Insensitivity of Causation

Woodward (2006) claims that a causal relationship '*C* causes *E*' is sensitive if it holds in the actual background circumstances *Bi*, but fails to hold in the circumstances *Bii-n* that depart in various ways from the actual circumstances. A causal relationship is less sensitive, *i.e.*, more insensitive or stable, if it holds over a broader range of circumstances that depart in various ways from the actual ones. Suppose Suzy throws a rock at a glass bottle and it shatters. The causal relationship between Suzy throwing the rock and the bottle shattering is insensitive to various changes in the background conditions in the sense that it will continue to hold even if the throwing and the shattering occur in Boston while someone sneezes in Chicago, regardless of the color of Suzy's blouse and despite variations in environmental conditions (temperature, wind speed, etc.). The bottle would have shattered had Suzy thrown the rock earlier or later, or from a different angle. If departures from actuality alter the time and place of the causal relationship, this may affect the identity of causal relata such that instead of a *C*-event and an *E*-event there will be a *C*-like and an *E*- like event (Woodward 2006). This would probably translate into a case involving Jenny in Chicago, instead of Suzy in Boston, throwing a metallic object, instead of a rock, at the bottle that subsequently shatters.

Woodward's proposal can be examined more specifically to suggest three types of insensitivity to changes in the structure of a causal relation and two types of background conditions. *Componential insensitivity* of a causal relationship obtains when the relationship is not affected by

changes in its relata. Suzy might throw a rock, or a brick, or a metallic object at the bottle and it will break, preserving thereby the causal relationship. *Organizational insensitivity* characterizes the causal relationship that is not altered by changes in the arrangement of its relata. Suzy might throw the rock from various distances or under various angles, but the relationship will be preserved, since the bottle will break. *Interactional insensitivity* characterizes the case when changes in how the relata interact do not impact the causal relationship. Suzy could throw the rock more or less forcefully, but this will not affect the relationship as long as the bottle breaks. However, if Suzy throws the rock with a too small force and the rock does not reach the bottle, the relationship breaks. It is sensitive to a throw executed with a small force.

The color of Suzy's blouse and the Dow index are background conditions that *do not and cannot* affect the causal relationship rock throwing – bottle breaking. Because of that, exploring them will not provide important information about the relationship. By contrast, wind is an example of background conditions that *do not*, but *can* affect the causal relationship. If wind blows with, say, a 65 km/h speed, it can blow away the bottle, influence the trajectory of the rock, but the rock will nevertheless strike the bottle. This illustrates background conditions that *affect* a causal relationship, yet it still occurs, or is insensitive to influences from such conditions. Due to their potential to influence causal relations, background conditions of the latter two types are relevant for investigating causal relations.

2. Conceptions of Mechanisms and Insensitivity of Mechanisms

In light of the foregoing consideration of insensitivity, I turn now to examining the notions of mechanisms and the examples of mechanisms that Machamer et al (2000), Glennan (2002), Bechtel and Abrahamsen (2005) use to explain their conceptions of mechanisms and mechanistic explanation.

Machamer et al claim that "[m]echanisms are regular in that they work always or for the most part in the same way under the same conditions" (2000, 3). Yet they do not clarify in what respects the conditions are the same. Their claim could be interpreted as indicating insensitivity of mechanisms under background conditions that (a) do not change, or (b) change without affecting the functioning of the mechanism. Version (a) does not seem to do justice to some mechanisms and is, hence, problematic. Version (b) might mean that conditions could be the same in the sense that conditions *Bii* of one neuron differ only by a small degree from conditions *Bi* of another neuron, or even if they differ by a greater degree, they do not contain factors that might affect the mechanism functioning. Conditions *Bi* and *Bii* could be the same in the sense that they both contain the same

ions of Ca, Na, and Mg, but in different quantities. Moreover, the claim does not suggest whether the conditions affect in any way the functioning of the mechanism. If my reading of "the same" is correct, Machamer et al leave out the situation when the conditions are *different*. For example, *Bii* could contain factors, say, molecules of Methylenedioxymethamphetamine, that *Bi* does not, and these factors influence the production of phenomenon, but do not block it. Such cases show that their description of background conditions is incomplete. That "[t]he organization of ... entities and activities determines the ways in which they produce the phenomenon" (Machamer et al 2000, 3) suggests that the phenomenon production is sensitive to changes in the organization of component activities and entities, but they do not consider the case of organizational insensitivity, *i.e.*, when a mechanism produces a phenomenon despite changes in its organization. It seems, however, that they admit componential insensitivity. Along this line could be read the claim "Activities usually require that entities have specific types of properties" (Machamer et al 2000, 3), which leaves open the possibility that any type of entity that has the relevant properties can execute the activity. The examination by Machamer et al of mechanisms does not seem to engage interactional insensitivity.

The mechanisms of chemical transmission at synapses and depolarization illustrate the view of Machamer et al on mechanisms. Examination of these mechanisms shows that they exhibit multiple kinds of insensitivity and the characterization of mechanisms by Machamer et al should explicitly consider them. The following analysis of these mechanisms is based on Levitan and Kaczmarek (1997).

Calcium channels illustrate insensitivity to the influence of background conditions that *affect* casual relations, as well as componential insensitivity. A subunit, α_1, and one, or several, smaller subunits β, γ, α_2, and δ constitute calcium channels. α_1 is sufficient to make a functional voltage-dependent calcium channel. The smaller subunits are not necessary for channel activity, yet they interact with the α_1-subunit and modulate the kinetic properties of the channel. β subunit, when expressed with α_1-subunit, increases the rate of inactivation of the channel. Although the channel inactivates at a faster rate, the β subunit does not block its functioning. The functioning of the channel is thus insensitive to the presence of this subunit. The latter modulates the channel functioning, but does not break it. Another case of insensitivity refers to the interaction between neurotransmitters and receptors. Virtually every neurotransmitter interacts with more than a single class of receptors (Levitan and Kaczmarek 1997, 236). Acetylcholine interacts with nicotinic as well as muscarinic receptors. The insensitivity of the relationship between neurotransmitter and receptors is limited; it breaks if the receptor is a different one, *e.g.*, NMDA. Yet it is insensitive because receptors do not interact with just one type of neurotransmitters. Sensitivity can be found in

the relationship between transporter proteins and a particular neurotransmitter. The mechanisms of neurotransmitter uptake involve distinct transporter proteins that are specific because they transport a particular neurotransmitter (Levitan and Kaczmarek 1997, 220). The relationship between transporter proteins as part of the mechanism of neurotransmitter uptake and neurotransmitters is highly sensitive to the identity of the component neurotransmitter that it is supposed to transport. Change the neurotransmitter, and the transporter protein does not take the neurotransmitter and the uptake mechanism does not function.

Modulation of patterns of electric activity of cells due to the presence of certain chemicals in the cell environment further illustrates insensitivity to changes in background conditions that affect a causal relationship. Action potentials result from the activity of a population of ion channels. Calcium channels contribute to the depolarizing phase of the action potential, while potassium channels underlie the repolarization phase and contribute to determining the action potential shape. The calcium and potassium channels, the ions, the cell membrane are the key components of the mechanism responsible for action potential. The environment of the neuron comprises the background conditions. A variety of neurotransmitters might be present in it. The neurotransmitters might decrease the calcium or sodium currents, narrowing as a result the action potential, as it happens for instance in the neurons of the chick dorsal root ganglion. Alternatively, introduction of noradrenaline, or of other similar agonists, in the environment of cardiac muscle cells increases the activity of calcium channels, which in turn prolongs significantly the cardiac action potential. The neurotransmitters and the noradrenaline modulate the action potentials. The latter would have occurred even if those substances were not present in the cell environment. Given that neurotransmitters and noradrenaline do not break the relationship between ion channels and action potentials, but modify it, the relationship is insensitive. The neurotransmitters and the noradrenaline make up the background conditions that can change a causal relationship, and the relationship holds despite changes in these conditions.

The foregoing neurobiological example does not illustrate organizational insensitivity, yet Machamer et al need to consider it for their account of mechanism to be general.

Bechtel and Abrahamsen have recently offered this characterization of mechanisms:

> A mechanism is a structure performing a function in virtue of its component parts, component operations, and their organization. The orchestrated functioning of the mechanism, **manifested in patterns of change over time in properties of its parts and operations,** is responsible for one or more phenomena (Bechtel and Abrahamsen 2010, 323).

The phrase in boldface is an augmentation of their earlier (Bechtel and Abrahamsen 2005, Bechtel 2006) characterization of mechanisms. The purpose of augmentation is to extend the mechanistic explanation to accounts of dynamics of mechanisms by means of computational modeling. Neither the older nor the recent characterizations consider the behavior of mechanisms when there is change in their background conditions or in their structure. However, Bechtel and Abrahamsen's discussion of homeostatic or autopoietic organization of organisms can be interpreted as insensitivity to background conditions that can or do affect the mechanism. Homeostatic or autopoietic organization occurs in living systems that "resist those environmental forces that threaten them," as well as in systems that simply maintain themselves even if not threatened by environmental forces (Bechtel 2006, 45). These systems are insensitive to influences from background conditions that can affect them. Bechtel and Abrahamsen do not examine mechanisms that do not have the specific homeostatic or autopoietic organization and yet resist "environmental forces that threaten them," nor do they examine the case of insensitivity to structural changes. The heart example that they use to illustrate their conception of mechanisms presents however sufficient instances of insensitivity to changes in its structure and in its background conditions.

Hearts have features that escape Bechtel and Abrahamsen's characterization of mechanisms. The heart mechanism undergoes changes over time and yet its operations are stable and they produce the phenomenon of blood circulation. The fetal heart shows a rate of 120 to 160 beats per minute, that of an infant presents a rate of 120 beats per minute. The rate slows to 90 rates per minute when the child is seven years old, and stabilizes at 70 rates per minute at age 18. Depending on which activities one engages in, the heart rate would increase or decrease. If rate is an aspect of organization, we have here an instance when the mechanism is insensitive to changes in its organization. The mechanism does not break although the organization changes. Moreover, rate changes mean differences in how components interact, suggesting interactional insensitivity. The heart mechanism is also insensitive to a number of significant changes in its components. Until the heart becomes of an adult, it is of a fetus, infant, toddler, child, and teenager. The components of the heart change; they grow. There are also macromolecular changes in the heart tissue from birth to adulthood. For example, there are changes in the expressed proteins, which affect muscle contractility (Martinsen and Lohr 2005). Thus, the heart is developmentally insensitive to modifications in its structure that occur over long and short periods of time.

A more radical change in the components of hearts presents replacement of defective valves with mechanical ones (from titanium or ceramic), or biological ones (from human, porcine or bovine tissue). Similarly, blocked arteries in some hearts are replaced with coronary bypass grafts.

The functioning of the heart mechanism is insensitive to such changes in its components and organization, and it produces the blood circulation phenomenon.

Transplanted hearts show insensitivity to changes in background conditions. Some of these conditions in the recipient patient, like the thorax, do not affect the functioning of the heart and it is insensitive to changes in thoraxes. Others, for example the immune system of the receiving organism, can and do affect it by rejecting the donated organ. The functioning of the heart mechanism can be, at least for some time, insensitive to changes in immune systems from donor to recipient and to adverse reaction of the latter.

Fetal hearts present a different departure from the adult heart prototype. The interatrial septum of a fetal heart contains the *foramen ovale* valve that allows the blood to be shunned from the right (pulmonary) side to the left (systemic) side. The ligament of the inferior vena cava aids this flow and the duct of the artery connects the left pulmonary artery and the aortic artery. These specific features of the components of fetal hearts are required because fetal blood flows through umbilical atria and arteries, and oxygenation occurs in placenta, as opposed to in the lungs. At birth, the *foramen ovale* closes and the heart chambers are septated, the duct ceases its function, and blood circulates as in adults (Weinhaus and Roberts 2005). In Woodward's terminology, fetal blood circulation is *like* adult blood circulation. Correspondingly, the structure of the fetal heart is *like* that of an adult. Except for the *foramen ovale*, the ligament, the duct and the blood flow, the heart mechanism is insensitive to changes from fetal phase to adult phase. Bechtel and Abrahamsen (2005) somewhat capture this particular aspect of insensitivity when they claim that a mechanism presents *variations* relative to a prototype, their focus being on componential insensitivity, but not on the other types of insensitivity. What does not vary between the prototype and the variant is an insensitive structure.

Glennan's characterization of mechanisms does not show an explicit acceptance of any version of insensitivity:

> A mechanism for a behavior is a complex system that produces that behavior by the interaction of a number of parts, where the interaction between parts can be characterized by direct, invariant, change-relating generalizations (2002, S344).

An important feature of mechanisms is that the arrangement of their parts is stable. Glennan explains first stability of parts: "in the absence of interventions, their properties must remain relatively stable" (Glennan 2002, S345). Stability in this sense is rather similar to the insensitivity of Suzy's throw and the shattering of the bottle given the color of her blouse. The relationship between the throw and the shattering is stable because the blouse does not affect it. By contrast, the

properties of parts could remain stable *despite* interventions, but Glennan does not consider such a case. Watches, cells, organisms and social groups are mechanisms "consisting of stable arrangements of parts" (Glennan 2002, S345). Given the foregoing clarification of "stable," mechanisms turn out to be stable because nothing intervenes on them. However, the mechanisms that Glennan gives as examples suggest a different understanding of stability. A social group is subject to social influences, a watch is subject to various mechanical stresses, and the immune system of the recipient patient affects the heart, and yet all three maintain their stability, which would amount to insensitivity to background changes that affect the mechanism. Since Glennan uses the heart and cell examples as illustrations of his conceptions, the findings concerning these mechanisms that I outlined above hold here as well. For the sake of brevity, I will not repeat them here, but I will remind that they show that causal relations and mechanisms are insensitive to changes in their components, interactions between them and their organization.

Glennan also states that the behaviors of these mechanisms "can manifest themselves at more than one time and place"(2002, S345). This would be a case of insensitivity to changes in the background conditions time and space. However, if the two conditions are not accompanied by other conditions that can affect the functioning of the mechanism, then the capacity of a mechanism to manifest its behavior at various times and places is a rather weak form of insensitivity.

Conclusion

The foregoing examination has shown that insensitivity is implicit to various degrees in the conceptions of Machamer et al, Glennan, Bechtel and Abrahamsen. Their examples of mechanisms are insensitive in many important ways and to different degrees. To account for these cases, their conceptions of mechanisms need to incorporate the notion of insensitivity to structural changes and to background conditions.

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