

The Return of Causal Powers?

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1. Introduction

Powers, capacities and dispositions (in what follows I will use these terms synonymously) have become prominent in recent debates in metaphysics, philosophy of science and other areas of philosophy. In this paper I will analyse in some detail a well-known argument from scientific practice to the existence of powers/capacities/dispositions. According to this argument the practice of extrapolating scientific knowledge from one kind of situation to a different kind of situation requires a specific interpretation of laws of nature, namely as attributing dispositions to systems. My main interest will be to discuss what characteristics these dispositions need to have in order to account for the scientific practice in question. I will furthermore assess whether the introduction of dispositions in the context of the extrapolation argument can be described as a ‘revitalization’ or as a ‘return’ to those notions repudiated by early modern philosophers. More particularly I will argue for the following claims:

- I. In repudiating scholastic terminology, including substantial forms with their causal powers, post-cartesian philosophers focussed on a concept of causation that was much stronger than 21st century conceptions of causation. For this reason alone, whatever ‘causal’ is supposed to mean in today’s causal powers, embracing causal powers is not a simple return to a pre-cartesian notion.
- II. The dispositions presupposed in scientific practice need not (and should not) be construed in causal terms (whether strong or weak).
- III. While some early modern philosophers contrasted the characterisation of the natural world in terms of substantial forms (and their causal powers) on the one hand and a mathematical characterization on the other and suggested that these approaches are incompatible, the

dispositions postulated by the extrapolation argument to account for scientific practice are themselves characterized in mathematical terms. More precisely: The behaviour the systems are disposed to display is – at least in physics – often characterized in mathematical terms.

- IV. The dispositions assumed in the law-statements in scientific practice are determinable rather than determinate properties.

In what follows I will first have a brief look at the repudiation of substantial forms and their associated causal powers in early modern philosophy in order to argue for claim (I) (section 2). I will then analyse the role laws of nature play in explanation, prediction and other features of scientific practice. It will turn out that this role can best be understood by assuming that law-statements attribute a specific kind of dispositional properties to objects or systems. In this context I will argue for claims (II) to (IV) (section 3).

2. The rejection of substantial forms and causal powers

In a letter to Morin in 1638, Descartes argues that his assumption that matter is composed of extended parts explains a lot more than alternative conceptions of how bodies are constituted: “You must remember that in the whole history of physics up to now people have only tried to imagine some causes to explain the phenomena of nature, with virtually no success. Compare my assumptions with the assumption of others. Compare all their real qualities, their substantial forms, their elements and countless other such things with my single assumption that all bodies are composed out of parts. [...] All that I add to this is that the parts of certain kinds of bodies are of one shape rather than another. [...] Compare the deductions I have made from my assumption – about vision, salt, winds, clouds, snow, thunder, the rainbow and so on – with what the others have derived from their assumptions on the same topics [...]. I hope this will be enough to convince

anyone unbiased that the effects which I explain have no other causes than the ones from which I have deduced them.” (Letter to Morin July 13, 1638: Descartes 1991,107)

Descartes contrasts two characterizations of nature: one in terms of scholastic terminology and substantial forms in particular, another in terms of matter conceived of as extended. The rejection of substantial forms became to be viewed as giving way to a mathematical characterization of the behavior of bodies. Thus, Newton – obviously appealing to a widely shared assessment – opens the Author’s Preface to the Reader of the *Principia* by describing the ‘modern philosophers’ as those philosophers who, after “[...] rejecting substantial forms and occult qualities, have undertaken to reduce the phenomena of nature to mathematical laws, [...].” (Newton 1999, 381)

The important point that I will come back to later is this: Characterizing nature in terms of substantial forms (and their causal powers) was seen as a distinct and presumably incompatible approach to the modern approach of characterizing the phenomena in terms of mathematical laws.

So the repudiation of (among other things) substantial forms and their causal powers allowed for a mathematical physics to be developed. Another consequence of the repudiation of substantial forms, however, pertains the notion of causation. The active powers of substances were supposed to be grounded in and unified by their substantial form (see Des Chene 1996, 157ff for the discussion of some views on the exact relation between substantial form and active powers). The rejection of substantial forms and active (or causal) powers thus meant that the very concepts in terms of which causation was explicated were no longer available. While Descartes nowhere explicitly discusses this implication, post-cartesian philosophers acknowledged it – either by down-playing its significance (La Forge, Cordemoy) or embracing it somewhat enthusiastically for theological reasons (Malebranche).

This discussion of the implication of the repudiation of substantial forms is interesting because it indicates that the concept of causation that was at stake cannot easily be equated with anything we

conceive today. One initial piece of evidence is provided by the well-known fact that Malebranche assumes that between a cause and an effect a necessary connection has to obtain. This assumption was not made up by Malebranche to attack a strawman (as it is sometimes assumed) but rather refers back to a notion of causation as explicated e.g. by Suárez (see Ott 2009 for discussion)). Suárez is interested in whether “there are causes that act necessarily once the things required for acting are present” and explains:

“This question is easy and so one should assert succinctly, that among created substances there are many that operate necessarily once all the things they require for operating are present. This is obvious from experience and from a simple induction. For the sun illuminates necessarily, and fire produces warmth necessarily, and so on for the others. The reason for this must stem from the intrinsic and determination of [the agent’s] nature [...]“ (Suárez, 1994, 270)

“Lastly one can infer from this that the necessity in question is so strong that neither the intrinsic power of the faculty itself nor any other natural cause whatsoever is able to remove it or to prevent it from issuing in an act. To be sure, natural causes can, as we have explained, impede one another through resistance or through contrary action, and in this way they are capable of removing all the things that are required for acting. But once those things are posited, natural causes cannot prevent the action of a necessary agent, since they do not have the power either to change the nature of things or to remove wholly intrinsic properties. [...] even God himself does not seem to be able to bring it about [...] that a cause which by its nature acts necessarily should fail to act, once all the things required for acting are posited. ” (Suárez, 1994, 281)

Given that Malebranche – in disputing the causal efficacy of created substances in his *The Search after Truth* – refers to Suárez quite frequently (e.g. at least five times in Elucidation 15 on the efficacy of secondary causes) it is interesting to note that Suárez relies on a concept of causation that is presumably influenced by neo-platonic thought. Suárez defines the concept of causation (which is meant to comprise all for Aristotelian causes) as follows:

“a cause is a principle per se inflowing being to something else” (Causa est Principium per se influens esse in aliud, DM 12.2.) This characterisation had the explicit purpose not only of unifying the various Aristotelian notions of causation but also of bringing causation and creation under a common heading (see Schnepf 2006, chapter 2). With this background and the explicit characterisation (to inflow being (*esse*) into something else) in mind, it is maybe not completely surprising why Malebranche concluded that if we allow the causal efficacy of secondary substances “we therefore admit something divine in all the bodies around us when we posit forms, faculties, qualities, virtues, or real beings capable producing certain effects through the force of their nature.” (Malebranche 1997, 446)

Given the strong concept of causation as *inflowing being (esse) into something else*, to cause something may indeed appear to be a divine activity.

Further evidence for the claim that we cannot simply equate the notion of causation (and a fortiori that of a causal power) that came under attack in early modern philosophy with contemporary notions can be gained from a passage in Louis de la Forge. La Forge, while not referring back to Suárez explicitly, argues, just as Malebranche, that strictly speaking only God is able to cause effects in other substances.

“However you should not say that it is God who does everything and that the body and mind do not really act on each other. For if the body had not had such a movement, the mind would never have had such a thought, and if the mind had not had such a thought the body might also never have had such a movement.” (La Forge 1997, 150)

For La Forge, the rejection of causation in a strict or strong sense among created substances is compatible with a weaker notion of cause. According to Specht, La Forge allows for “quasi-causation” (Specht 1966, 140). This weak notion of causation (quasi-causation) can quite naturally be construed as a counterfactual conception of causation. So what was at stake when the traditional causal terminology was rejected by early modern philosophers wasn’t one of our contemporary

conceptions of a causation.¹ In rejecting substantial forms and their causal powers early modern philosophers attacked a notion of causation that was much stronger than any of ours, namely of causation as the inflow of being into something else. The rejection of causation in this strong (traditional) sense is compatible with the obtaining of counterfactual relations, which might be taken to be causal relations in our sense of causation. As a consequence, whatever the “causal” in “causal powers” may mean exactly, the ‘revitalization’ of causal powers should not be viewed as a simple return to the very conception that was rejected by post-cartesian philosophers because these causal powers were conceived of as being instrumental in “inflowing being to something else”.

3. The Role of Laws and Dispositions Scientific Practice

I take the ‘resurgence’ of dispositions, powers or capacities in recent years to consist in their acceptance as real and irreducible properties. This resurgence has been due to various kinds of developments: Attempts to reduce talk about dispositions to talk about occurrences or categorical properties failed (see Mumford 1998, Schrenk 2016, McKittrick this volume). While this on itself is not yet a positive argument for assuming dispositions to exist, there have been proposed various such arguments (Shoemaker 1979/1984; Mumford 1998, Ellis 2001, Molnar 2003, Bird 2007; for a classification see Bird 2016).

I will focus on what I take to be the most convincing argument for dispositions: an argument that appeals to the role of laws of nature in scientific practice, namely in extrapolation. It is with respect

¹ I think it can be easily argued that a regularity account of causation is compatible with the absence of strong causation too. Even the transfer of conserved quantities as conceived in transfer theories of causation can be explicated in terms of the continuous recreation of amounts of energy at different places in space and is thus compatible with occasionalist views. La Forge and Malebranche had different aims in defending occasionalist positions. While La Forge tended to downplay counterintuitive implications of Cartesianism Malebranche welcomed e.g. the passivity of created substances. While La Forge endorsed quasi-causation Malebranche presumably would not have liked to do the same. However, it seems that causation according to a counterfactual account, according to a regularity account and even according to a transfer theory account is compatible with his position.

to dispositions as introduced by this argument that I will – in section 4 – consider the question whether the introduction can be described as a ‘revitalization’ or as a ‘return’ to those notions repudiated by early modern philosophers.

3.1. Law-statements and Generalizations

The argument from extrapolation to the existence of dispositions analyses the role law-statements play in this context. It is thus important to start with a clear understanding of what laws of nature (law-statements) are.

Let me start with Galileo’s law. What is Galileo’s law? Is Galileo’s law to be equated with the equation: $s = \frac{1}{2} g t^2$ (with s : distance covered, t : time, g : constant)?

I will assume that laws or law-statements are those (maybe complex) generalizations that play a role in extrapolation, confirmation, explanation and other aspects of scientific practice. With this characterisation of a law-statement as a starting point we arrive at the following consequence: If a law-statement is what is confirmed or disconfirmed in trials (or used in the contexts of explanation, prediction or manipulation), the above equation on its own cannot be an example of a law(-statement). As a matter of fact, nobody takes Galileo’s law to be disconfirmed by balls uniformly rolling on a horizontal plane or by stones lying on the ground. What is missing is a claim about *the kinds of systems* that are meant to be represented by the equation. Galileo’s law is not simply a mathematical equation but the claim that the behaviour of a certain class of systems can be represented by the above equation. A full statement of Galileo’s law might thus be something like the following:

Free falling bodies behave according to the equation $s = \frac{1}{2} g t^2$.

Similarly, $F = ma$ is merely a mathematical equation. It becomes a law-statement once it is asserted that this equation is meant to represent the behaviour of physical systems (in this case: of all physical systems whatsoever). And again, the Schrödinger equation with the Coulomb-potential on

its own does not qualify as a law-statement, i.e., it is not what we confirm or disconfirm. By contrast, the claim: “*Hydrogen-atoms* behave according to the Schrödinger-equation with the Coulomb-potential” is a law-statement in this sense.

The fact that equations such as $s = \frac{1}{2} gt^2$ come along with a domain of systems for which they are meant to be relevant has been noted by others e.g. within the semantic account of theories. Thus, van Fraassen, referring to Ronald Giere, defines a *theory* (not a law²) as consisting of

- (a) the *theoretical definition*, which defines a certain class of systems; and
- (b) a *theoretical hypothesis*, which asserts that certain (sorts of) real systems are among (or related in some way to) members of that class. (van Fraassen [1987], p. 222.)

A preliminary general characterisation of law statements might thus be the following:

(A) “All systems of a certain kind K behave according to Σ ”

Here “ Σ ” typically stands for an equation or a set of equations. The expression “of a certain kind K” may refer to all physical systems whatsoever, as it does in the case of Newton’s second law or in the case of the bare Schrödinger-equation. Or it refers to more circumscribed classes of systems such as free falling bodies, hydrogen atoms etc., thus giving rise to what to so-called *system laws*.³

² In fact, Giere and van Fraassen deny that there are laws of nature (van Fraassen 1989, 183ff). According to my reconstruction what Giere and van Fraassen call a “theoretical hypothesis” should be taken to be a law-statement.

³ One might worry about the exact characterisation of the system to which Σ is attributed. The worry is that one needs Σ to individuate the systems in question. That of course would make the law statement come out as an analytical truth and thus devoid of empirical content. It has to be assumed that the relevant class has been individuated antecedently, for example in terms of experimental procedures (“free falling bodies”), or by other means that do not depend on Σ .

Furthermore: Euclidean geometry on its own is a mathematical theory without any empirical import. We get an empirically testable claim (a law) if we attribute of a certain class of systems (space-times) that they are adequately characterised in terms of Euclidean geometry.⁴

Law-statements as just characterized do not only play a prominent role in physics but in other disciplines too. Thus, the Lotka-Volterra equations describe the temporal development of a biological system consisting of two populations of different species – one predator, one prey. The relevant equations for prey-predator-populations are (1) $dx/dt = x(a - by)$ and (2) $dy/dt = -y(c - gx)$, where x represents the number of prey and y the number of some kind of predator; a , b , c , and g are constants. Again we can distinguish between the system to which the equations apply on the one hand and the equations or the description of the behaviour on the other. Even in cases in which the behaviour in question is not represented mathematically it is possible to distinguish the behaviour that is attributed to a system on the one hand and the systems to which is attributed on the other: Protein folding may serve as an example. On the one hand we have amino-acid chains (the systems) on the other we have a qualitative description of what they do, i.e. of how they fold to become functional proteins (the behaviour).

Characterising law-statements in terms of (A) allows me to draw attention to an important distinction between different kinds of generalisations. Even though there are often no explicit quantifiers law statements often involve at least *two different kinds* of generalisations. In Galileo's law, for example, we can distinguish one form of generalisation that pertains to the values of the variables s and t that appear in the equation and another generalisation that pertains to the objects to which a certain kind of behaviour is attributed.

More generally we can distinguish the following two kinds of generalizations (see Scheibe (1991) for this distinction)⁵:

⁴ This point was famously observed by Einstein: "As far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality". Einstein's own view is fairly close to what has been suggested here (Einstein 1954).

- (1) *System internal generalisations*: Generalisations concerning the values of variables: for instance s, t in the case of Galileo's law : The equation may hold either for all values of the variables or for all values within a certain range.
- (2) *System external generalisation*: A generalisation concerning different systems: The equation pertains to all systems of a certain kind (e.g.: free falling bodies).

In the case of the Lotka-Volterra equations the internal generalizations concern the variables x (number of prey) and y (number of predators), while the external generalizations concern biological systems consisting of prey and predator populations.

Another illustration: When we claim that hydrogen atoms can be characterised in terms of the Schrödinger equation with the Coulomb potential the " Σ " in our canonical statements "All systems of a certain kind K behave according to Σ " comprises the conceptual apparatus of quantum mechanics. So when we say that hydrogen atoms behave according to Schrödinger equation with the Coulomb potential, we say that it behaves according to quantum mechanics in which the Schrödinger equation is concretized via the Coulomb potential. The essential point is that law-statements attribute predicates to systems of a certain kind and these predicates are typically involving a highly complex mathematical apparatus. This complexity becomes invisible if we are operating with examples of the "All ravens are black" sort.

With this preliminary characterisation of law-statements I can now turn to the argument for dispositions.

3.2. Dispositions

⁵ Hitchcock and Woodward (2003, 189) - though not in these terms - draw attention to this distinction when they remark with respect to explanation that "the nomothetic approach has focused on a particular kind of generality: generality with respect to objects or systems other than the one whose properties are being explained". By contrast their own account of explanations relies on generalizations that pertain to the values of variables.

Braveness, fragility and solubility are usually considered to be dispositional properties. By contrast, squareness and other geometrical properties are often considered to be the paradigmatic candidates for categorical properties. It has turned out to be notoriously difficult to draw a distinction between dispositional and categorical properties (see Mumford 1998 and Fara & Choi 2012). In this chapter I will try to get along with assumptions about dispositional and categorical properties that are fairly uncontroversial.

A useful starting point is Mathew Tugby's recent characterization of dispositionalism and dispositions:

“According to dispositionalism, dispositions (or what are sometimes called ‘causal powers’) are taken to be real properties of concrete things, and properties which cannot be reduced to any more basic kind of entity. But what, precisely, does it mean to say that a property is irreducibly dispositional in nature? Roughly, it means that the property is characterized in terms of the causal behaviour which things instantiating that property are apt to display. This is to say, in other words, that irreducibly dispositional properties are by their very nature orientated towards certain causal manifestations. To illustrate: in order to explain what it means for, say, a particle to have the property of being charged, the dispositionalists will point out for example that charged particles accelerate when placed in an electro-static field. In explaining this feature of charge, dispositionalists take themselves to have said something about the essential nature of charge. In short, then, dispositionalists see properties as properties for something else: their causal manifestations.” (Tugby 2013, 452).

This is a useful starting point because it allows me to start with a disagreement: There is no need to consider the relation between a disposition and its manifestation as causal. While “causal” appears in Tugby's *abstract* characterisation of dispositions (“irreducibly dispositional properties are by their very nature orientated towards certain causal manifestations”), the example for a disposition (charge), by contrast, is characterised without relying on causal terminology: An object has the

property of being charged, if – when placed in an electro-static field – it accelerates in the right way. It seems to me that the three occurrences of the word “causal” in the above quote can be skipped without loss of content. I will, thus, work with a notion of a disposition that does not explicitly built causation into it. Assumptions about causation are additional assumption and there is no need to built them into a characterization of dispositions (There is a further reason for this approach: As I argued elsewhere (Hüttemann 2013) causation can be explicated in terms of dispositions. For this to be non-circular dispositions should better be explicable without recourse to causal terminology.)

As a consequence I start with a slightly modified version of Tugby’s characterization: A dispositional property is characterized in terms of the behaviour which things instantiating that property are apt to display. Dispositional properties thus allow for a distinction to be drawn between a property being instantiated and a property being manifest, while non-dispositional or categorical properties do not allow for this distinction. Dispositional properties allow for this distinction because they are “oriented towards their manifestation”, as Tugby notes, which implies that the manifestation need not be displayed.⁶ Thus a person can be brave without actually displaying brave behaviour. By contrast a piece of paper cannot instantiate the property of squareness without displaying squareness. It seems inappropriate to consider such a distinction in the case of squareness. If we furthermore assume that the distinction between categorical and dispositional properties is exhaustive we can derive a simple and fairly uncontroversial sufficient condition for the ascription of dispositional properties: If the ascription of a property assumes that the property in

⁶ While I think that this way of talking is fairly common, some authors (Molnar 2003, 195; Mumford 2009, 104) argue that dispositions *contribute to effects*. According to these authors dispositions *always* contribute and furthermore the contributions remain the same (though the effects may differ, provided different dispositions contribute to an effect). These contributions are then identified as the dispositions’ manifestation, and as a consequence these dispositions are always manifest (for discussion see McKittrick 2010). However, this does not undermine the above criterion, for Molnar and Mumford would agree that a disposition ascription allows for a disposition to be instantiated but *the effect* to which the disposition tends not occurring. Thus, with respect to our criterion these differences are largely terminological.

question can be instantiated without the manifestation being displayed it is a dispositional property. Whatever the exact nature of dispositions may be, this criterion will allow us to identify some dispositions. It is all we need for the conclusions of this paper.

3.3. The problem of extrapolation

In a recent book Nancy Cartwright and Jeremy Hardie discuss the following question: A project carried out in Tennessee in the 1980ies showed – according to an empirical evaluation – that students in smaller classes did better than students in larger classes and that this applies in particular to minority students. In the mid 1990ies California intended to apply a class size reduction program to its state-schools. Will what has worked in Tennessee work in California too? This question concerns the issue whether evidence gained in one case is relevant for a distinct case in another context. (Cartwright, Hardie 2012, 4).

The problem Cartwright and Hardie are concerned with is the question of finding evidence for whether or not we can infer from one case to the other. However, there is a further issue: Assume that the inference works. In virtue of what does it work? The problem of extrapolation, as discussed in this paper, consists in the challenge to explain why generalisations that we have found to hold under specific circumstances hold under different circumstances too. (See Steel (2008, 3) for examples and a slightly different characterisation of the problem).

The problem of extrapolation is not only relevant for social policy or in medical research but also in very simple examples from physics to which I will turn now. Take Galileo's law again. It describes the behaviour of free falling bodies, it describes the behaviour of a body falling in a vacuum. What about falling bodies in a medium? As a matter of fact, we consider the vacuum case to be relevant for the other cases too: We take the vacuum case as the basis of our theoretical treatment of the other cases and add further influences (further terms). So, as a matter of fact we are assuming that

what we know about one kind of - in some way ideal - case is relevant for other less ideal cases, for other cases with different contexts. Why can we extrapolate from one case to the other?

Cartwright in another publication suggested the following explanation of what is going on in extrapolation:

“When [...] disturbances are absent the factor manifests its power explicitly in its behaviour. When nothing else is going on, you can see what tendencies a factor has by looking at what it does. This tells you something about what will happen in very different, mixed circumstances – but only if you assume that the factor has a fixed capacity that it carries with it from situation to situation.”

(Cartwright 1989, 191)

In my terminology (see Hüttemann 2014 for what follows) Cartwright argues that we need dispositions to understand why extrapolation works. With respect to Galileo’s law the problem for a non-dispositionalist reading of laws can be formulated as follows: In the case we hold that Galileo’s law applies to the vacuum case only (that is how we have reconstructed the law up to this point by restricting it to *free* falling bodies) we cannot explain, why it also used for accounting for the behaviour of falling bodies outside the vacuum/the laboratory. If we assume that Galileo’s law applies to falling bodies in general (we drop the “free” in “free falling bodies”), we might seem to be in a better situation because it is now clear why the law is relevant both in and outside the laboratory/vacuum. However, the problem is that for falling bodies outside the vacuum it is false that they fall according to the equation $s = \frac{1}{2} gt^2$. On a non-dispositionalist reading Galileo’s law is either irrelevant for falling bodies outside the vacuum or false.

Cartwright way out is the way out that has already been suggested by Mill:

“There are not a *law* and an *exception* to that law – the law acting in ninety-nine cases, and the exception in one. There are two laws, each possibly acting in the whole hundred cases, and bringing about a common effect by their *conjunct operation* [my italics, A.H.]. [...] Thus if it were stated to

be a law of nature, that all heavy bodies fall to the ground, it would probably be said that the resistance of the atmosphere, which prevents a balloon from falling, constitutes the balloon as an exception to that pretended law of nature. But the real law is that all heavy bodies *tend* to fall [...]”. (Mill 1836 quoted after Mill 2008, p. 56, original emphasis)

To return to the case of extrapolation: When – in a successful case of extrapolation – we consider Galileo’s law (‘nothing else is going on, disturbances are absent’) to be relevant for a falling body in a medium (different context, ‘mixed circumstances’), we assume that something carries over from the first (ideal) situation to the second situation – a property that is (completely) manifest in the first situation but fails to be (completely) manifest in the second (though instantiated in both situations).

If we consider the fall in the vacuum to be, e.g., explanatorily relevant for the fall in the medium we rely on how the body would behave if it were isolated, i.e. on how the falling stone would behave in the absence of the medium. But the body – in this case – is not isolated. The behaviour to which the body is disposed is not (completely) manifest due to the presence of the medium – however, the body and the medium *contribute*⁷ to the behaviour of the compound and the respective dispositions are thus *partially* manifest (I will say a few more words about partial manifestation below).

So the claim is, that if we take the external generalisations to be attributing dispositions (capacities) we understand why the law statement can be extrapolated, e.g., to systems in non-ideal situations, i.e., in the presence of further factors. Something (a dispositional property) is present in both situations. The fact that we are dealing with a property (a universal), accounts for the fact that what we know in the one situation is relevant for the other situation too. The fact that the property is

⁷ This notion of contribution needs to be distinguished from the notion introduced by Molnar or Mumford (see fn. 6). According to the terminology used here a disposition can be either completely manifest (if the context is ideal) or it may be partially manifest. In the latter case it is said to contribute to the behaviour that is due to various factors or dispositions. So contributions are not conceived of as additional ontological entities mediating between disposition and effect/manifestation.

dispositional has to be assumed because in (at least) one of these cases the property isn't (completely) manifest.⁸

But how *exactly* does the ascription of dispositions help to explain why we may extrapolate for example from an ideal case to a less ideal case? The worry is that citing a disposition might not explain the *actual* behaviour of a system. Earman and Roberts for example inquire:

“Thus if what one wants explained is the actual pattern, how does citing a tendency – which for all we know may or may not be dominant and, thus, by itself may or may not produce something like the actually observed pattern – serve to explain this pattern?” (Earman & Roberts 1999, 451f)

The fact that something (the disposition) *carries over* does not tell us enough as long as it isn't clear *how* the disposition contributes to the phenomenon in question/the behaviour that arises in new contexts in which (further) interfering factors are present.

However, if we know how to handle interfering factors the claim that dispositions contribute to the 'actual pattern' or the observed behaviour can be made precise. Consider again the simple case of a falling body. Within Newtonian mechanics we can describe what is going on in a system consisting of the earth's gravitational field and the body within this field. It might be argued that knowledge about how this system (and the body as part of it) would behave if it were on its own does not tell us anything about how it actually behaves in the presence of other factors, for example a medium. For all we know, it might be argued, the other factors might or might not be dominant. But things are not as gloomy as this objection implies. We know how to determine what is happening in such cases. We have the means to determine *how (to what extent) the various factors add up or contribute*. When we are considering a falling body in a medium we have to add e.g. an extra force

⁸ It should be noted that while the usual examples of dispositions such as fragility and solubility need positive triggering conditions to become manifest, in our case the manifestation conditions for complete manifestation are negative. It is required that the system in question (free falling body) is isolated or on its own. (This would be different if we were considering examples from biology or social policy. In these cases we would have to hold a lot of features constant (rather than absent).)

term into Newton's second law, which represents buoyancy. The essential point is that there are laws or rules that allow us to quantitatively determine how different factors or tendencies contribute to the actual behaviour that we want to explain.

These laws of composition also allow us to make the notion of partial manifestation precise: A disposition is *partially* (as opposed to *completely*) manifest if it contributes to some behavior given the presence of other contributing dispositions. Laws of composition tell us what happens if various dispositions are present and thus 'partial contribution' can be explicated and made quantitatively precise.

Earman's and Roberts' worry is unwarranted as long as there are laws of composition that allow us to estimate the contribution of various factors. In physics there are various quantitatively precise generalisations for this purpose, such as those describing the vector-addition of forces, or more generally rules that describe how to represent compound systems in terms of subsystems by way of laws (rules) of composition (see Hüttemann 2004 and 2015).

Let me summarize: When we successfully extrapolate from one situation to a qualitatively different situation, we assume something, a property of the system in question, to be present in both situations that accounts for the extrapolation. However, this property needs to be dispositional because if the situations are qualitatively different in the sense that the observed behaviour that is to be explained is different, then in at least one of the cases the property is not (completely) manifest. *A fortiori* the properties that account for extrapolation are dispositional properties according to the criterion discussed in section 3.2.

This result has consequences for how law-statements should be understood. Those law-statements that describe the behaviour of systems which may or may not be completely manifest should be taken to attribute dispositions to systems. In the case of falling bodies we should reconstruct Galileo's law as follows:

“Falling bodies *are disposed to behave* according to the equation $s = \frac{1}{2} gt^2$.”

More generally, to account for the role law-statements play in scientific practice we should reconstruct them as making the following claim:

“All physical systems of a certain kind *are disposed to behave* according to Σ ”

4. Revitalization

So, dispositions should be accepted as real and irreducible. Is this a return to or a revitalization of concepts that have been repudiated in early modern times? Given the foregoing consideration we see a return of dispositions, i.e. of properties that allow for a distinction between being instantiated and being manifest. But it is not a return to a conception of causal powers that were renounced e.g. by occasionalists.

(1) The notion of causation at play in the rejection of causal powers and substantial forms was considerably stronger than any of our contemporary notions. Causation was conceived of as the inflow of being into something else. There is no evidence that contemporary authors who characterise dispositions in causal terms think of causation in these terms. A fortiori even if there were a return not only of dispositions but also of causal powers it would still be no return to early modern conceptions of causal powers which were understood in terms of the strong notion of causation.

My main focus, however, was on dispositions that account for the practice of extrapolation. The question is how dispositions introduced in this context compare to those items repudiated by early modern philosophers.

(2) While I have given no positive characterisation of the relation of a disposition to its manifestation, the argument from scientific practice I looked at, provides no reason to take this

relation to be a *causal* relation. There is no need to conceive the dispositions that account for extrapolation in causal terms. It is a return of powers, not of causal powers.

(3) What the disposition is disposed to, its manifestation, is – at least in physics – typically characterised in terms of mathematics; in simple cases such as Galileo’s law in terms of a single equation – in more complex cases in terms of Maxwell’s equations or in terms of the Einstein-equations. While some early modern authors suggested that a characterisation of nature in terms of substantial forms and causal powers is incompatible with a characterisation in terms of mathematics, the dispositions introduced in the context of the above argument are typically disposed towards the display of a behaviour that is characterized in terms of mathematics.

(4) Let me add a further and final point that shows, why we should hesitate to describe the return of dispositions as a simple revitalization of older notions.

Law-statements as we have seen attribute dispositions to systems. In contrast to, say the power to generate fire or the power to illuminate, these dispositions are typically infinitely multi-track. In virtue of the internal generalisations, a law-statement like ”Ideal gases behave according to the equation $pV=vRT$ ” implies an infinite number of regularity-statements for every single system:

For every ideal gas: If $p=p_0$ and $V=V_0$, there will be a value T_0 for T such that $p_0V_0= vRT_0$

For every ideal gas: If $p=p_1$ and $V=V_1$, there will be a value T_1 for T such that $p_1V_1= vRT_1$

For every ideal gas: If $p=p_2$ and $V=V_2$, there will be a value T_2 for T such that $p_2V_2= vRT_2$

And so on.

In virtue of the fact that laws such as the ideal gas law are formulated in terms of functional dependencies (and the internal generalisations that come along with them) the dispositions in question are explicitly multi-track. There are some discussions about how such a feature, which might either be characterized as *multi-track* or as *determinable*, should be understood and whether it is fundamental (Bird 2007, Armstrong 2010, Wilson 2012). Still, while the characterisation of a *power to illuminate* may be vague and thus implicitly allow for different ways of illuminating, the

characterization of a disposition in terms of variables and functional dependencies is *explicitly* multi-track.

To conclude: The fact that law-statements attribute *determinable* or *infinitely multi-track* dispositions to systems is a further reason to be wary to take contemporary reference to dispositions to be a return to those notions repudiated in early modern philosophy.

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