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The Covering Law Model Applied to Dynamical Cognitive Science: A Comment on Joel Walmsley

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Abstract In a 2008 paper, Walmsley argued that the explanations employed in the dynamical approach to cognitive science, as exemplified by the Haken, Kelso and Bunz model of rhythmic finger movement, and the model of infant preservative reaching developed by Esther Thelen and her colleagues, conform to Carl Hempel and Paul Oppenheim's deductive-nomological model of explanation (also known as the covering law model). Although we think Walmsley's approach is methodologically sound in that it starts with an analysis of scientific practice rather than a general philosophical framework, we nevertheless feel that there are two problems with his paper. First, he focuses only on the deductivenomological model and so neglects the important fact that explanations are causal. Second, the explanations offered by the dynamical approach do not take the deductive-nomological format, because they do not deduce the explananda from exceptionless laws. Because of these two points, Walmsley makes the dynamical explanations in cognitive science appear problematic, while in fact they are not.

Keywords Explanation · Covering law · Dynamical cognitive science · Cognition · Causal asymmetry · Dynamicism

Introduction

In Walmsley (2008), it has been argued that the explanations employed in the dynamical approach to cognitive science, as exemplified by the HKB model of rhythmic finger movement (Haken et al. 1985) and the model of infant preservative reaching developed by Esther Thelen and her colleagues (Thelen et al. 2001), conform to Carl Hempel's and Paul Oppenheim's deductive-nomological model

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(D-N model) of explanation (also known as the covering law model). While we are sympathetic to the idea of approaching explanation 'bottom up', i.e. by analyzing examples from scientific practice, there are two problems with Walmsley's paper:

(1) By characterizing explanations in dynamical cognitive science as deductive-nomological Walmsley neglects an important property of the explanations, viz. that they are causal.[1] In this way he suggests that they are problematic, while they are not.
(2) Not all explanations in dynamical cognitive science are deductive-nomological. At least some of them fit a non-deductive variant of the covering law model, which uses so-called default rules instead of strict, exceptionless laws.

The structure of this comment is straightforward: we briefly sketch Walmsley's position, and then discuss these two problems.

Walmsley's claim

Why does Walmsley think that "dynamical explanations are covering law explanations" (2008: p. 346)? He draws on two separate strands of evidence to support this claim.

The first strand of evidence comes from scientific practice; two models used in dynamical cognitive science are discussed. The first model, the so-called HKB model of rhythmic finger tapping, attempts to explain the curious observation that test subjects, having placed their hands palm-down on a table, can oscillate both index fingers in 'phase motion' (to the left and right at the same time) reliably across higher frequencies than they can oscillate them in 'antiphase motion' (to the left with one finger while to the right with the other). Dynamical systems theory explains this fact by capturing the rate of change of relative phase, the periodic function of current relative phase and the frequency of oscillation in a mathematical equation. Thus, the dynamicist is able not only to describe behaviour that has already been observed, but also to predict behaviour that can be (and indeed, has been) confirmed by subsequent experiments. The second model Walmsley considers is Thelen et al.'s model of infant preservative reaching. This model is meant to explain the 'A-not-B error': a child between seven and 12 months old is presented with two boxes. When an adult comes in and hides a toy or piece of candy under one of the boxes, the child will reach for the correct box. But if the adult repeats this procedure several times and then suddenly hides the toy under the other box, the child will still reach for the first box, even though it has observed the adult hiding the toy under the other box. Dynamical systems theory explains this fact by means of an equation, relating the current state of the movement planning field, general and specific aspects of the task, etc. Walmsley notes that a particular pattern of behaviour in this kind of experimental setup follows as a mathematical and

[1] Throughout this article, we will assume an interventionist account of causality along the lines of Woodward (2003): rather than the underlying causal mechanisms, we are concerned with causes as *difference-makers* that we can manipulate.

deductive consequence of the equation in conjunction with the initial states, and has the same logical form as the prediction of that event would have taken.

The features of these explanations (explanandum as a logical consequence of the explanans, equivalence of explanation and prediction) put them squarely in the covering law model. From this Walmsley draws the conclusion that "…some dynamical models provide covering law explanations" (2008: p. 342).

The second strand of evidence is meant to support the conclusion that dynamical cognitive scientific explanation *is* covering law explanation. This evidence is drawn from a consideration of the *goals* of dynamical cognitive science. Here, Walmsley does little more than quote a number of eminent theorists and philosophers who concur that the aim of dynamical modelling is to provide explanations that deduce the explanantia from mathematical rules and certain given parameters, and contends that "…these quotations, coupled with the lack of an alternative metatheoretical stance toward dynamical explanation, are sufficient to establish that the explanatory goal of dynamical cognitive scientists is to provide covering law explanations…" (2008: p. 343).

Hausman's adaptation of the covering law model

As is common knowledge among philosophers of science, Hempel's model is fraught with difficulties. One such difficulty is that it fails to distinguish between relevant and irrelevant premises. This has spawned a number of well known counterexamples. Does a sample of 'hexed' table salt dissolve in water because it is hexed and all samples of hexed table salt dissolve? Did John fail to get pregnant because he took birth control pills, and people who take birth control pills do not get pregnant?[2] We will forgo the particulars of these and other counterexamples. Suffice to say they hinge on the fact that one can always add a premise to a deductive argument: it will still remain a deductive argument. However, an argument containing irrelevant premises hardly constitutes an explanation, as the examples just mentioned clearly show.

Another problem with Hempel's model is the asymmetry of explanation. Arguments can be reversed, but explanations cannot. Again we are faced with counterexamples. We will restrict ourselves to one familiar example:

Question 1: Why does the flagpole have a shadow of 10 metres long?
Answer 1: The flagpole is 10 metres high. The sun is at a 45° angle above the earth. Light moves in a straight line, so we can derive that the shadow is 10 metres long.
Question 2: Why is the flagpole 10 metres high?
Answer 2 : Its shadow measures 10 metres in length. The sun is at a 45° angle above the earth. Light moves in a straight line, so we can derive that the flagpole is 10 metres high.

[2] Walmsley mentions these and some other counterexamples we will consider in notes 33 and 34 of his 2008 article.

The arguments in both answers fit the Hempelian model, but intuitively it is clear that only one constitutes a genuine explanation. Of course, from the length of the flagpole, the Pythagorean Theorem together with information about the behaviour of light and the elevation of the sun, we can derive the length of the shadow, and this results in a successful D-N explanation. But as far as deduction is concerned, from the very same Pythagorean Theorem and the very same information about the physics of light, in conjunction with the length of the shadow, we can derive the length of the flagpole. Intuitively, this is not a sound explanation; yet from a logical point of view, the deductive inference is perfectly valid. If you know two of the variables, you can work out the third.

Of course there have been attempts to avoid these and other counterexamples; here, we will focus on Hausman's analysis, because it is concise and because it can provide us with the resources to account for the examples of dynamical cognitive explanations that Walmsley discusses. How does Hausman tackle these problems? His analysis is straightforward enough. In cases like the height of the flagpole versus the length of its shadow, the arguments do not derive their conclusions from causes, but from effects. Only causal derivations yield explanations (Hausman 1998, p. 167). To distinguish cases of causal derivations from non-causal ones, Hausman proposes the *criterion of independent alterability*, which states that the variables characterising the explanans must be independently variable, where independently variable is defined as:

For every pair of variables, *X* and *Y,* whose values are specified in a derivation, if the value of *X* were changed by intervention, then the value of *Y* would be unchanged. (1998, p. 167).

Thus, Hausman adds an extra requirement to the covering law model. Explanations are arguments, but only arguments whose premises refer to the actual causes of the explanandum are explanations.

Hausman's modified covering law model represents a clear advancement over Hempel's original version. For one, it avoids those nasty counterexamples (Hausman 1998: p. 170–2).[3] More importantly for our present purposes however, are the *pragmatic* benefits accepting Hausman's causal requirement brings with it. In the special sciences particularly, we typically want not only to explain phenomena, but also to control and manipulate them. In dynamical cognitive science, we are interested in explanations because they enable us to control and manipulate behaviour to e.g. enhance our educational methods, to develop new drugs, etc.[4] If we desire to put dynamical cognitive science to good use for

[3] Returning to the example of the flagpole, if we change the angle of elevation of the sun, then this leaves the height of the flagpole unchanged: these two variables are independent from each other, hence, according to the principle of independent alterability, the genuine explanation is the one with the length of the shadow as explanans. However, the reverse no longer holds: having changed the angle of elevation of the sun, we can no longer work out the length of the flagpole, for the length of the shadow changes with the intervention and so we are missing a key element in the derivation. These two variables are not independent; therefore, the second case does not constitute a genuine explanation.

[4] Again, this point extends beyond dynamical cognitive science to all special sciences (perhaps even to physics). Here is a quote from Carl Craver making the same point about neuroscience: "Neuroscience is driven by two goals. One goal […] is explanation […] The second goal of neuroscience is to control the brain and the central nervous system. Neuroscience is driven in large part by the desire to diagnose and

humanity, then we should make sure that these explanations pick out the real causes; i.e. allow us to manipulate, control and predict (see note 2).

The explanations presented by the authors discussed by Walmsley, satisfy this additional criterion. Thelen et al.'s model of infant preservative reaching explains an infant's reaching behaviour as a mathematical consequence of an equation with a number of values for the parameters and variables, including the current state of the movement field, the general specific and memory inputs to the system and a function integrating competing inputs. From the perspective of the traditional covering law model, there is nothing against reversing the order of the argument: from the equation, parameters and variables, together with the reaching behaviour of the child, we might deduce (hence 'explain') under which box the researcher has hidden the toy! Surely, this kind of argument has to be ruled out as an explanation. And what is important for us: Thelen et al. do not claim that such arguments are explanations. They only claim that the argument which starts from the causes and has the effect as conclusion is an explanation. Similarly, the authors of the HKB model do not claim that effects can explain their causes. Of course, no one expects practicing scientists to explicitly adhere to one or the other model of explanation. Like Walmsley himself, we are simply trying to reconstruct the formats their explanations assume, and it is in this context that the absence of non-causal explanations in their work is relevant.

The upshot of this is that we can give a more precise characterisation of the examples: they fit the "causal-deductive-nomological model" of Hausman. This is important because, if they would not fit this model, dynamical cognitive science could have been accused of providing pseudo-explanations (like the one in which the height of a flagpole is explained by the length of its shadow) instead of genuine explanations. Walmsley acknowledges the validity of the counterexamples raised against the traditional covering law model. In his view they "…show […] that explanations in dynamical cognitive science will be the subject to the same set of criticisms, in virtue of the form they take" (2008, p. 344). This conclusion is not correct: the explanations have a more specific form than Walmsley claims, and therefore do *not* share the problems of Hempel's D-N model.

Non-deductive explanations

In Hempel and Oppenheim's 1948 paper, "covering law explanation" and "deductive-nomological explanation" are used as synonyms. Later on Hempel distinguished between deductive-nomological explanations and inductive-statistical explanations (see Hempel 1965). Walmsley does not consider the latter type of explanations. He only discusses Hempel's D-N model (2008, p. 338-340) and claims that the explanations of dynamical cognitive science fit this model. He explicitly says that in the explanations of Thelen et al. and in the HKB explanations

Footnote 4 continued
treat diseases, to repair brain damage, to enhance brain function, and to prevent the brain's decay" (2007, p. 1).

the explanandum is a *deductive* consequence of the explanans (pp. 340–341). This is strange, because his paper also contains information from which it follows that this claim is not correct. When describing the effect explained by Thelen et al., he mentions that it is “enormously sensitive to slight changes in the experimental conditions, such as the delay between viewing and reaching, the way the scene is viewed, the number of trials, the presence of distracting stimuli, and so on” (p. 335). The model of Thelen et al. is superior to previous models because it can take into account many of these contextual subtleties. However, as long as the model cannot cope with *all* contextual variation, it cannot produce deductive-nomological explanations. The reason is that, if the model cannot account for all contextual variation, the law we can derive from it has the form “If initial conditions C_1, C_2, …, C_N are satisfied, then *usually* E happens”. In order to have a deductive-nomological explanation, we need “always” in the law instead of “usually”: D-N explanations need strict, exceptionless laws of the form “If initial conditions C_1, C_2, … C_N are satisfied, then E *always* happens”.

The law we actually can derive from Thelen et al.’s model has the format of a default rule. Default rules (e.g. “Birds usually fly”) differ from universal generalizations in that they allow exceptions (e.g. “Penguins don’t fly”). Default rules also differ from probability statements in that they do not specify the relative frequency of the exceptions and “normal” cases (“usually” can mean anything fairly close to probability 1). Another important characteristic of default rules is that we can formulate them without knowing where the exceptions lie (we can say “birds usually fly” and have good evidence for that claim without knowing which species or individuals are the exceptions).

In our view the best way to characterize the explanations given by Thelen et al. is: they are non-deductive, causal covering law explanations using a default rule. They are causal, as established in the previous section. They use a covering law and have the form of an argument (this has been shown by Walmsley). But the covering laws they use have exceptions, so the explanations are not deductive. This means that they either use a default rule (as we suggest) or a probability statement (and are thus what Hempel calls inductive-statistical explanations). The latter presupposes that we can give a precise relative frequency of “normal cases” and “exceptions”. This does not seem the case in the explanations of Thelen et al., so they should be seen as explanations using default rules. As Walmsey himself acknowledges (p. 344), exceptionless generalizations have been hard to find in psychology. So there are reasons to suppose that explanations using default rules are the rule, rather than the exception.

Conclusion

In this paper, we have examined Walmsley’s claim that the explanations in dynamical cognitive science conform to the Hempelian covering law model of explanation, more precisely his deductive-nomological model. We have shown that this claim is misleading because the explanations of dynamical cognitive science are causal, so they are not as problematic as Walmsley suggests. Furthermore, we have shown that not all explanations in dynamical cognitive science are deductive-nomological. At least some of them (and presumably most of them) fit a non-deductive variant of the covering law model, which uses so-called default rules instead of strict, exceptionless laws.

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References

Craver, C. F. (2007). *Explaining the brain*. Oxford: Clarendon Press.

Haken, H., Kelso, J. A. S., & Bunz, H. (1985). A theoretical model of phase transitions in human hand movements. *Biological Cybernetics, 51*, 347–356.

Hausman, D. M. (1998). *Causal asymmetries*. Cambridge: Cambridge University Press.

Hempel, C. G. (1965). *Aspects of scientific explanation and other essays in the philosophy of science*. New York: Free Press.

Hempel, C. G., & Oppenheim, P. (1948). Studies in the logic of explanation. *Philosophy of Science, 15*, 135–175.

Thelen, E., Schôner, G., Scheier, C., & Smith, L. B. (2001). The dynamics of embodiment: A field theory of infant preservative reaching. *Behavioral and Brain Sciences, 24*, 1–86.

Walmsley, J. (2008). Explanation in dynamical cognitive science. *Minds and Machines, 18*, 331–348.

Woodward, J. (2003). *Making things happen. A theory of causal explanation*. Oxford: Oxford University Press.