Levels: What Are They and What Are They Good For?

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PLAN

- Begin with a typology of some different notions of level.
- Then focus on one of these notions that is particularly important in science. This is tied to issues about the choice of variables that are most useful or appropriate for causal explanation or causal analysis of some system of interest.
- I will then explore the implications of some of these ideas for how we should think about causation between levels and in particular “downward causation”.
- I will conclude, time permitting , with some additional remarks about criteria for variable choice and how these relate to notions of “level”.

BACKGROUND

Talk of “levels” (of organization, explanation etc.) is common in many areas of science

But many also complain that such talk is unclear and problematic in many ways.

Part of the problem with level talk is that researchers operate with many different understandings of level and cognate notions.

This can lead to confusion: researchers mistakenly attribute features associated with one notion of level to other notions where they do not apply. This is part of my motivation for beginning by sorting out different understandings of “level”.

Some More Background

- Common and correct observation that different systems are best understood at different levels of analysis (or perhaps in terms of some combination of levels)—where this means that the systems are more appropriately analyzed or understood in terms of certain explanatory or causal variables rather than others.

- On my view which level or levels are most appropriate is always an empirical matter, dependent on the details of the behavior of the systems we are trying to understand. Sometimes “lower” or more fine grained levels of analysis will be most appropriate and sometimes more “upper level” variables will be most appropriate. In particular it is a mistake to suppose that we always improve the quality of an explanation or causal analysis by invoking lower level variables

- The considerations that figure in variable choice will sometimes lead us to accounts which include (in a single model) variables are at different “levels” on some understandings of that notion—so-called multi-level or mixed level models. Thus another related theme is the contrast between such multi-level models and theories/models that appeal to variables that are at least for the most part at a single level. Multi-level theories, which include many theories in psychiatry, have a number of distinctive features and face certain distinctive problems.

Some Different Notions of "Level"

- Levels as Compositional
- Levels as Involving Realization or Implementation
- Levels Individuated in Terms of Disciplinary Subject Matters
- Levels Related to Abstractness and Coarse Graining
- Interactionist Conceptions of Level
- Levels as Related to Variable Choice

Levels as Compositional

- Objects at a higher level are composed or "made up of" (are spatial parts of) objects at lower levels in a way that generates a hierarchy. Nucleons, atoms, molecules, cells, organisms.

Levels as Involving Realization or Implementation.

- Here levels are understood in terms of a "realization" or "implementation" relationship of some kind with realizers or implementers being at a "lower level" than what they implement.
- Marr's levels as an illustration: the specification of a computation that some cognitive structure is executing is regarded as at a higher level than the algorithm that implements the computation which is in turn at a higher level than the "hardware" that executes the algorithm and computation.

Levels Individuated in Terms of Disciplinary Subject Matters.

- Notion of levels linked to the present organization of disciplines—what is at the "psychological level" is whatever psychologists study, the "biological" level" consists of whatever biologists study and so on. Obviously this is not a very principled or stable notion of level, but I think it clearly influences how researchers think about levels.

Levels Related to Abstractness and Coarse Graining

- Variables that are more fine-grained or specific are at a "lower level" than variables that are related to them by some sort of coarsening operation. "Coarsening" can take many different forms but often the idea is that the lower level more fine grained variables are related to the more coarse grained upper level variables via some many-to-one function– e.g. many brain states correspond to the same psychological state.
- Statistical mechanics and thermodynamics as another illustration.

Interactionist Conceptions of Level

- Tied to claims about the extent to which objects and properties causally interact (or fail to interact) with each other. Systems which interact are at the same level.

- Often tied to ideas about the role of considerations having to do with "scales"—spatial, temporal and energetic – in constructing theories and models: sometimes when nature is kind we have "separation" or near separation of scales, so that what happens at one length or energy scale can be understood largely independently of what happens at other scales.

- This in turn leads us to think of interactions at one scale as at a different level than interactions at other scales.

- Important that “scale” matters in this sort of framework because and to the extent that it bears on degree of interaction—that is, size or the difference between longer and shorter distances or times do not matter in themselves but only because (or to the extent that) they are thought to be related to strength of interaction.

Illustrations

- Fundamental forces

- Biology: both length and temporal scales are important. Some biological variables may change so slowly with respect to others and to explananda of interest that the former can be effectively treated as constants – variations in them make effectively no difference for the problem at hand. Other variables may reach an equilibrium so quickly that they can also be treated as non-varying. Again, this can justify ignoring or greatly simplifying interactions involving those variables.

- Note that this basis for level talk (which interactions are important and which can be ignored) is distinct the from the issues about composition or size that figure in the first notion of level distinguished above. Whether one object X is part of another Y is obviously a distinct question from whether one can safely ignore features of X in explaining the behavior of Y

- Put differently strength of interaction considerations are only very imperfectly related to size differences or to compositional relationships. More generally, notions of level according to which objects are at higher level than what they are composed of and notions of level that are centered on notions of what interacts with what are very imperfectly aligned.

- Interaction- based conceptions of level based on the assignment of objects (systems etc.) to the same level to the extent that they interact strongly with one another can sometimes lead to the identification of distinct regimes or "protectorates". We are able to identify a set of phenomena all of which can be explained in terms of some relatively small set of explanatory factors that interact primarily with one another.

- We sometimes find this sort of pattern in physics but not for certain other areas of investigation. In case of many mental illnesses such as depression, many different causal factors—social or environmental factors, factors having to do with personality type, as well as genes and brain structure seem relevant -- and we do not have, as we do in the case of the nuclear and electromagnetic forces, strong general arguments that certain factors could not possibly be relevant (or at least any general arguments of this sort are much weaker than they are in the physics case.)

This can lead to confusion, especially if we are not clear about what is meant by “level”

- Consider the causal influence of environmental factors such as environmental stressors on gene expression and mental illness. Assuming that such influences are real, what do they imply about levels? If we adopt a purely interaction based conception of level, there seems to be no puzzle. Stressors and gene expression are at the same level to the extent that there is interaction.

- However, we usually think about environmental events like stress as at a "higher level" than gene expression. Such judgments must reflect the influence of other conceptions of level besides a purely interaction based conception: perhaps we are thinking that genes are parts of organisms, that environmental stressors involve in various ways whole organisms, hence that the stressors must be a "higher level" than genes.

A Recipe for Confusion

- Suppose we try to retain the idea that objects and systems at the same level interact preferentially or even exclusively with each other *and* combine this with a notion of level based on something other than interaction (e. g., a size or composition based notion, as above). Now we have a recipe for confusion: on the one hand, the occurrence of environmental stressors is a higher level event (based on size and composition considerations) than genes; on the other hand factors at different levels are not supposed to interact (much) with one another. Thus it can seem problematic that environmental events can influence genes (so that some special story* needs to be told about how to analyze the appearance of such influence.)

Inter-level Causation?

- Accordingly one finds, both in the philosophical literature and elsewhere, a number of arguments to the effect that objects and systems at different levels cannot interact with one another (or that such interaction is problematic and needs to reinterpreted in a way that makes it philosophically respectable). In other words, the claim is that, strictly speaking, there is no such thing inter-level causation or causation from upper to lower levels.

- Advocates of this position are illegitimately combining expectations that come from an interactionist view of levels with conceptions of level that are based on other sorts of considerations such as part/ whole relations

Levels as a Matter of Variable Choice

- Finding the right “level” (of description or explanation) for modeling or theorizing about some set of phenomena is often crucial to success.

- “It should perhaps be noted that the choice of variables in terms of which a given problem is formulated, while a seemingly innocuous step, is often the most crucial step in the solution”. (Callen, 1985, p. 465)

- Issues about choice of variables are in my opinion among the most important methodological and philosophical issues raised by level talk. Thus an important question for the philosopher or methodologist of science has to do with the principles or considerations (if any) that guide such choices – what do we mean by finding the “right” variables or level of analysis and what criteria guide such choices.

An Interventionist Account of Causation.

(**M**) X causes Y in background conditions B if and only if under some intervention that changes the value of X in B, the value of Y will change.

- This is a natural notion of causation to go along with an interactionist conception of levels. Note that on this account of causation, causal claims relate *variables*– magnitudes or properties such as mass or charge or suffering from depression or not. Causal claims do not relate things or objects like atoms or cells or people. The latter, however, are what stand in compositional relationships.

- Note that (**M**) by itself imposes no constraints connecting causal claims with the various non-interactionist notions of level. As far as (**M**) is concerned, a variable that is identified as "upper level" according to some criterion like composition or abstractness—e.g., a variable like environmentally induced stress S -- can cause a lower level variable having to do with a certain pattern of gene expression G as long as it true that under the right sort of wiggling of S, G would change.

Who Would Have Thought Otherwise?

- A common argument against “downward causation” is that this involves causation running from a whole to its parts.
- This is claimed to be incoherent; often because it is thought that wholes and parts are not suitably distinct to stand in causal relationships. Those who make this complaint appear to be assuming some version of a compositional conception of level so that what makes a putative causal relationship a case of downward or cross level causation is that the candidate cause and its effect stand in a whole/ part relationship.

- Within an interventionist framework, this objection to downward causation is wrong-headed.
- To begin with, within that framework things or thing-like entities (which are what wholes and parts are) don't stand in causal relationships to begin with—instead causal relata are always *variables* (or more precisely, whatever in the world variables describe.)

- Suppose that W is a whole and P one of its parts. If V1 is a variable describing some property or feature of W and V2 a variable describing some property or feature of P, V1 will often be sufficiently distinct from V2 to stand in an interventionist causal relationship to it. In particular even if P is a part of W, V2 may not be a "part" of V1 —indeed in many cases it does not make sense to think of one variable as a "part" of another.

- An example: in the Hodgkin-Huxley model of the action potential the potential difference V across the cell membrane is a cause of the opening and closing of the ion channels in the cell membrane and of the ionic currents I_i (where I_i is a measure of the magnitude of the ith current) that flow through those channels.
- The ion channels are literally part of the cell membrane and thus on a compositional conception of levels, at a lower level than the cell membrane.

- So on a compositional conception one might think of the causal influence of the membrane potential on the ion channels as a matter of upper to lower or "downward" causation, which indeed is how it is often described. But notice that although the ion channels are part of the membrane it makes no sense to describe the ionic currents I_i as "part" of the membrane potential V, so we can't object to the claim that V causes I_i on the grounds that they stand in a whole/part relation. That is, I_i and V can be (and in fact are) distinct in whatever way is required for them to stand in causal relations even if the ion channels are part of the membrane.

- Although the example involves “downward” causation it does not involve causation from a whole to its parts and thus avoids whatever is thought to be objectionable about that idea.
- Downward causation ≠ Whole→ Part Causation

- In fact, the $V \rightarrow I_i$ relation straightforwardly satisfies the interventionist criterion for causation; if one intervenes on the membrane potential the ionic currents will change. Indeed, Hodgkin and Huxley actually did this experiment with the then new device of a voltage clamp which allowed them to impose different potentials across the cell membrane and measure the resulting changes in the ionic currents.

Some Criteria for Variable Choice

- Invariance – choose variables that allow for the formulation of causal relationships that are relatively invariant
- Specificity-- choose variables that allow for the formulation of causal relationships that are relatively specific.
- Conditional Independence

- Standard inference techniques in causal modeling and model selection criteria assume you start with a stock of variables– they don't have much to say about whether one choice of variables is better than another.

Invariance

- Does relationship continue to hold as other conditions (e.g. in the background) change.
- David Lewis
- Genes for reading?
- Sometimes by changing variables we can find more invariant relationships– endophenotypes.

Conditional Independence

- Suppose there is a set of fine grained variables Yj which are causally relevant to some set of explananda Ek characterizing system S (where causal relevance is understood in terms of **M**). Suppose also that there is some other set of variables X_i which also characterize S, which correspond to a coarsening of the Yj (they are of lower dimensionality than the Yj) and which have the following properties; (i) the Xi are also causally relevant to the Ek and (ii) conditional on the values of the Xi the Yj are irrelevant to (independent of) the Ek

- Then it will often make sense to use the coarser –grained Xi variables rather than the finer-grained Yj variables. All of the explanatory “oomph” of the Y variables is absorbed into the X variables. The X variables are at the right “level” to explain the EK.