Antireduction

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Abstract

This document summarises the reductionist problem in biological sciences and outlines a methodology which may begin to address them. It then goes on to describe how this methodology can be investigated.

1 Introduction

This document summarises the problems with the classic *reductionist* approach to science in biology, and outlines one way that they may be addressed in some situations. The nature of *understanding* is described in section 2, and this also serves as a general introduction to the particular problems that biological systems pose in comparison to other scientific problems of understanding. Section 3 and section 4 describes some ways we can understand things, and these lead into section 5, which summarises a project and suggests some avenues for progress.

2 What Is Understanding?

Science is concerned with the problem of understanding systems. When a system is understood its behaviour can be predicted in different situations, and the effect of changes to the system can also be predicted.

2.1 Reductionist Understanding

Classically, a system was understood by reducing it. A reduction explains a system in terms of its components, their properties, and how the components interact. In effect, reductionism "looks down".

For example, a molecule can be understood, reconstructed and predicted by the properties of the atoms which make it up. In turn, these can be predicted and understood by the properties of the electrons, photons, neutrons and electromagnetic waves. Again in turn, these can be understood in terms of the properties of subatomic components such as quarks.

Similarly, the state of a solar system can be predicted if the mass, relative position and velocity of each planet is known. By specifying these components we understand the solar system.

2.2 Understanding Understanding and the Reductionist Problem

However, the reductionist approach fails in many biological and social situations. Even though a system may be reducible to some components, their properties and interactions, it is not immediately obvious how one goes about reconstructing the state of the original, unreduced system from its components.

Examples of systems which reductionism is insufficient for include cells and social structures. In general, it seems that reductionism is appropriate and sufficient only in the hard sciences.

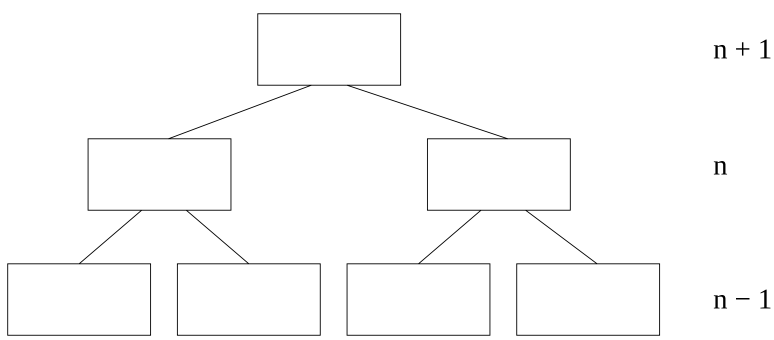

Figure 1: A hierarchical conceptualisation of understanding.

The context and source of this problem can be understood as follows. Figure 1 gives a hierarchical conceptualisation of understanding. Classic understanding looks down. An individual system at level n can be completely understood, predicted and reconstructed just by specifying the relevant (connected) components at level $n-1$.

Understanding other components at level n is unnecessary, and it is also unnecessary to couch the explanation in the context of any super-system at level $n+1$. This independence is one of the great strengths and appeals of reductionism. Just as a molecule is understood in terms of its components, an atom can be understood solely in terms of its components. Knowledge of other atoms or of chemistry is unnecessary.

On the other hand, understanding a biological or social component at the level n requires some conception of its role or function, and this is defined only at the next level up, $n+1$. Therefore to fully understand such a component, an explanation must "look up" as well. Just looking down does not answer many of the "why" questions that we pose.

2.3 Systems Which Can't Just Be Reduced

Specific examples of systems which demand a combined reductionist and *antireductionist* explanation include cells and sports teams.

A cell is made up of a wide range of components, and it can be understood by defining the components and the way in which they interact. However you cannot understand the components unless you understand the role that they play in the greater context of the cell itself.

A sports team is made up on individuals. Each individual will have immediate and personal goals such as "move the ball forward" or "go wide" to "stop Bob from tackling Jim". However these goals can only be understood in the context of the goals of the team as a whole, which would be something like "score a goal", "gain posession of the ball" or "win the game". For this reason, a reduction of a team to its members and the rules of the game does not give you a complete understanding of either the members or the team itself.

In summary, a reductionist explanation is an explanation in terms of a systems components, the components' properties and their interactions. An antireductionist explanation is an explanation in terms of a system's relationship with other systems and the way the system and its relationships create some higher level or more abstract super-system.

2.4 Analysis and Miscellania

Several important facts emerge from this analysis. Firstly, note that our description is an object-centred description. The focus is on objects (components), and they are what have relationships. The converse (relationships which are made up of objects) is also possible. Such an analysis would be reinterpretation of classic reductionist science and may be fruitful.

Secondly, these objects form hierarchies. Generally, interactions and understanding do not need to cross hierarchies except as described above. However, in some other situations hierarchies may still be crossed. A cell's state may change due to the presence of independent sub-cellular components. Although these components (e.g. proteins) are normally associated with other cells they are not necessarily so.

Finally, note a potential category mistake that may occur here. If the system which is being reduced is not philosophically real then it may be impossible to rigourously reconstruct it from any decomposition of it. This will be the case even if the components have been accurately specified. In effect, the road back up is a dead end.

For example, take the concept of "race" (such as African, Cuban, European, and so forth). This concept could be decomposed into historic, cultural and national components. However, if the original concept is poorly defined (race as a concept is hotly debated in philosophy) then the components may bear very little regular relationship to each other or to the purported system they are reduced from. The Churchlands' philosophical eliminativism of folk psychology is motivated by this sort of concern.

3 Models

As outlined in section 2, understanding must go both up and down in order to be complete. When moving up or down we use models to represent the other level in terms of the first. One commonly used reductionist model is a set of *ordinary differential equations*[1; 2] (ODEs).

However, it is difficult to see how such a model could be used to give an antireductionist explanation. An ODE specifies the state of a component in relation to the state of other components. The state of a system it is a component of is invisibly implicit in the states of the components.

Similarly, while human emotions could be reduced to a chemical description of neural activity, it is not clear that such a description would help us understand them any more completely. We speculate that emotions may be subject to the kind of category mistake outlined in subsection 2.4.

In summary, many of the most useful and common reductionist models may be inappropriate for antireduction. Although they have invisibly and implicitly served a dual role in the hard sciences it may be necessary to use a different or more flexible model, and it may be necessary to use a different model to go up and to go down. In the next section we outline a single model that is flexible enough that, with augmentation, may be sufficient to sometimes travel in both directions.

4 Agent-Based Models

One model that has historically been used in to reduce is the agent-based model[3]. In this model, a system is described by characterising the componets which make it up as agents, and each agent has *beliefs*, *desires* and *intentions* (abbreviated BDI). An agents beliefs represent its knowledge (accurate or inaccurate) about the state of the *world*, where the world is made up of other agents. Its desires are its goals, and its intentions are its plans and strategies for achieving its goals given its beliefs. Werner[3] formalised a logical model of agents with BDI and their communication and cooperation.

On initial inspection, this is a reductionist model. A molecule can be understood by ascribing (loosely) BDI to the atoms which make it up. However, a molecule itself can also be characterised as an agent with BDI. Similarly, just as a sports team is made up of agents, the team itself can be characterised as a super-agent. This prompts the question: can an agent-based model be antireduced? We will outline this possibility in the final section.

5 Project Summary and Discussion

As outlined in section 4, all four of a system, its components, its peers, and any associated super-system can be characterised as an agent.

One way that the problem of antireduction could be addressed would be to develop a methodology to translate from component agents and peers to the original system. Such an approach would neatly solve the antireduction problem in some situations.

However, it is important that the translation is robust, rigourous and does not implicitly contain the understanding it is trying to provide. Guaranteeing that these conditions are met is very difficult.

Therefore, the next step in this project would be to develop a set of techniques for antireducing in 2 or 3 similar situations. An example set would be to use Werner's [3] BDI agents to model the players in a basketball team, the players in a cricket team and a bridge partnership. A general method which can reconstruct a team super-agent with reasonable BDI of its own (given the rules of the game and states of the team members) would be a useful demonstration of the practical utility of this approach.

References

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