Minds & Machines (2007) 17:357–360
DOI 10.1007/s11023-007-9076-0

Kenneth Aizawa, The Systematicity Arguments, Studies in Brain and Mind

Dordrecht, The Netherlands, Kluwer Academic Publishers, 2002, xiii+255, euro 100.00, ISBN 1-4020-7271-6

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Published online: 1 September 2007

Introduction

The systematicity arguments are part of a larger debate over the nature of the fundamental components of cognitive systems. That it requires an entire book to cover just a part of these arguments is a reflection of the complexity of the issues surrounding systematicity. Time and again, Connectionists claimed to have met Fodor and Pylyshyn's (1988) challenge by demonstrating neural network models that exhibit some form of generalization interpreted as being systematic. But, Aizawa argues, all these claims miss Fodor and Pylyshyn's central point, which is not to show how systematicity is *possible* within connectionist theorizing, but to explain why systematicity is a *necessary* consequence given assumptions of that theory. Aizawa's arguments raise a number of questions concerning what constitutes a suitable explanation. But, his main point is clear—there is more to theory development than just fitting data. If you think otherwise, then I suggest you read his book.

Systematicity refers to a particular distribution of cognitive capacities. The systematicity arguments concern what this distribution of capacities implies for the underlying cognitive architecture (i.e., the set of mental processes that produce our cognitive behaviour). To illustrate, suppose you asked people how much money do they currently have on them. After questioning dozens of people you find that in each case the amounts of money are grouped by multiples of five. Starting with this observation, you infer that the smallest denomination is five cents. The systematicity argument is similar in that you start with the observation that cognitive capabilities are grouped in a certain way and you end with the inference that cognitive architecture is based on symbolic processes. The grouping is supposed to be

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organized around structural commonality, and Classical theories explain systematic organization by assuming processes that are sensitive to that structure. For example, suppose we are given a process that takes the symbol *Sentence* and produces the symbols *Subject loves Object*; a process that takes the symbol *Subject* and produces either the symbol *John*, or *Mary*; and a process that takes the symbol *Object* and produces either *John*, or *Mary*. Then, the set of sentences that can be generated include "John loves Mary", and "Mary loves John"; but not "John Mary loves". The *Subject loves Object* generating process binds the capacity to generate these two sentences, so that you can't have one without being able to have the other. In this way, Classical theories are said to explain systematicity as a necessary consequence of structure sensitive processes.

Over the years, the focus of the systematicity argument has shifted in a number of ways from denying that human cognition is systematic; to accepting that it's systematic, but denying that connectionist models are not; to accepting connectionist models are systematic, but denying they are anything other than implementations of classical symbolic models; to accepting they are implementations of symbolic models, but denying they are of no further theoretical importance. With all that has been written about systematicity, one may wonder what there is left to say. What Aizawa says is that for the most part the arguments surrounding systematicity have failed to address the core issue, which is to provide an explanation for systematicity, rather than just a demonstration of it. The task Aizawa has set, then, is to establish the explanatory standard for systematicity, and evaluate competing Connectionist and Classicist proposals against that standard.

The explanatory standard

In this regard, the book really begins with Chapter 2. (Chapter 1 provides the background motivation for the systematicity arguments in terms of desire/belief psychology. Although interesting in its own right, it is not essential to the systematicity arguments.) When two different theories explain the same data, how do we determine which is the better theory? In this chapter, Aizawa draws on two historical examples—geocentric (Ptolemy) versus heliocentric (Copernicus) explanations of the motions of the planets, and creationist versus evolutionist (Darwin) explanations for speciation—as paradigms for Connectionist versus Classicist explanations of systematicity. The reason the latter two explanations are preferred is due to the ad hoc nature of the auxiliary hypotheses needed by the former to support accounts of the same data.

Ad hoc auxiliary hypotheses are characteristically additional assumptions unconnected to the rest of theory and data, and motivated only by the need to account for data not explained by the original theory. To account for the apparent retrograde motion of the planets, geocentric theories were modified to include the additional hypothesis that the planets also moved in a circular path relative to an imaginary point that moved along a circular path relative to the Earth. (To picture this situation, imagine looking at the moon from the Sun. As the moon moves around the Earth the apparent motion viewed from the Sun would look like sequences of three steps forward and two steps back.) Aizawa explains that this additional assumption is ad hoc in that there was no independent motivation for its introduction. For heliocentric theories, by contrast, retrograde motion is a natural, logical consequence of the relative positions of the Earth, Sun and planets. A planet will appear to move in one direction when it and the Earth are on the same side of the Sun, and in the reverse direction when the planet and the Earth are on opposite sides. In this case, retrograde motion is a necessary consequence of assuming all planets including the Earth move in a circular motion around the Sun.

The concept of an ad hoc hypothesis forms the basis of what Aizawa believes to be a suitable explanatory standard for systematicity. With this standard, he proceeds to re-examine the four properties to be explained (productivity of thought; systematicity of inference; systematicity of representation; and compositionality of representation) and the Classical explanation in chapters 3–6, and three supposedly alternative Connectionist explanations in chapters 7–9. Aizawa concludes (Chapter 11) that the Connectionist accounts do not explain systematicity; but, surprisingly, neither does Classicism. Both cases fail to meet the explanatory standard established in Chapter 2. (Chapter 10 is not directly related to the systematicity arguments, but is included as a cautionary note to those expecting to find answers through neuroscience.)

By Aizawa's standard, neither Connectionist nor Classicist theories fare very well. For Connectionism, if you assume that cognitive architecture consists of a connected graph of processes then, of itself, there is nothing that constrains cognitive capacity to be systematic, or unsystematic. Suppose, for illustration, all even graphs (even number of nodes) are systematic, and all odd graphs are not. Now, if the observation is that all cognitive systems are systematic, then the connectionist theory fails to explain that observation, because the theory implies that some systems will be systematic and some will not, just because some graphs will be even and some will not. However, the connectionist theory can be made compatible with the observation by including an auxiliary hypothesis that constrains all graphs to be even. But, compatibility is not sufficient as an explanation of systematicity. This was part of the original problem Fodor and Pylyshyn raised against Connectionism. What Aizawa has done is to argue that subsequent revisions to Connectionist models fail to meet the explanatory standard established in Chapter 2. That is, the auxiliary hypotheses introduced into subsequent Connectionist theory are ad hoc in nature. Ironically, though, Aizawa argues that Fodor and Pylyshyn's Classical explanation also has this problem, just because structure sensitive grammars can also be devised that do not support systematicity. Therefore, if your Classical theory assumes structure sensitive grammatical processes then, of itself, it cannot explain systematicity.

It seems, then, that good theories are in very short supply. But are the issues raised by Aizawa specifically a problem for these theories, or for defining an appropriate standard of explanation? I expect modellers and theoreticians will argue that the problem lies with the latter. Aizawa warns throughout the book (e.g., p. 35 and p. 167) that philosophers cannot say what defines an appropriate explanatory standard. Hence, the only strategy available is by analogy to historical examples, such as competing theories of planetary motion. While this example is excellent for exposing one type of scientific explanation, it may not be suited to cognitive science. If that is the case, what then are the alternatives?

In Chapter 2, Aizawa briefly mentions four other types of scientific explanations and the possibility of more. They are: (1) explanations for events (e.g., extinction of the dinosaurs); (2) explanations based on substructure (e.g., water freezing); (3) explanations of processes (e.g., the making of proteins); and (4) explanations for what things are (e.g., what constitutes a planet). One possibility not explicitly canvassed is a hybrid theory that draws on both Classical and Connectionist theories as complementary components that together overcome their individual limitations. Aizawa alludes to this type of explanation in reference to Karmiloff-Smith's theory of micro-domains in language acquisition—rather than a theory of word acquisition, there are theories of noun acquisition, verb acquisition, and so on. He warns, though, that the flexibility afforded by this type of theory raises the explanatory standard. Not only must a theory explain each of the components, but it must also explain why it is split that way. Much of the book has been concerned with an explanatory standard for competing theories, because much of the debate has been framed in terms of Classicism versus Connectionism. One way forward may be to establish an explanatory standard for a complementary theory, where the issue is framed in terms of Classicism and Connectionism.

Summary

This book is perhaps most importantly a lesson in the philosophy of science and how philosophy can and should inform the rest of the cognitive sciences. Through meticulous detail, Aizawa has accomplished what he set out to achieve, which was to clear away the confusion that has dogged much of the systematicity debate. In doing so, he has revitalized the debate with a new set of questions.

References

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