Psychological Explanation and Noise in Modeling

Comments on Whit Schonbein's "Cognition and the Power of Continuous Dynamical Systems"

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I.

I find myself ambivalent with respect to the line of argument that Schonbein offers. I certainly want to acknowledge and emphasize at the outset that Schonbein's discussion has brought to the fore a number of central, compelling and intriguing issues regarding the nature of the dynamical approach to cognition. Though there is much that seems right in this essay, perhaps my view is that the paper invites more questions than it answers. My remarks here then are in the spirit of scouting some of the surrounding terrain in order to see just what Schonbein's claim is and what arguments or options may be open to the dynamicist.

II.

Schonbein rehearses several themes in computational and dynamical approaches to cognition in order to lead up to three criticisms of the dynamicist's view. He rejects the first two criticism — the argument from representation and the argument from measurement — but these lead to the argument from noise, which Schonbein approves of. This argument claims that the extra precision afforded by an analog artificial neural network (AANNs) is rendered irrelevant by noise. Consequently, any such AANN is going to be intelligible and modelable, and may as well be actually modeled, using traditional Turing machine computationalism (p. 13). The infinite precision of the values contained in the AANN are "irrelevant in explaining cognition" (p. 15).

III.

The central strand of argument from noise is clear enough, but what, precisely, is the target of the argument? In order to answer that question, it may be helpful to distinguish between at least the following four claims that Schonbein might conceive as his primary dialectical adversary (the target physical system in this case is the human cognition):[1]

- i) Infinitely precise values matter to the behavior of the target physical system
- ii) Infinitely precise values matter in achieving a correct abstract mathematical characterization of the target physical system.
- iii) Infinitely precise values matter in the behavior of the physical system that is used to concretely simulate the target physical system.
- iv) Infinitely precise values matter in achieving a correct concrete simulation of the target physical system.

[1] Discussion of closely related distinctions can be found in van Gelder (1998) and Giunti (1995).

As a start, we can note that the first and third claims are metaphysical, while the second and fourth claims are epistemological. Schonbein's emphasis on explanation suggests that he has in mind one of the epistemological theses, so, if any of these are in the ballpark, (ii) and (iv) appear the likeliest candidates. Let's proceed more slowly, though.

I offer (i) as a claim that I can imagine someone making, but I do not see as how it makes much sense. Take a physical system such as our solar system.[2] I presume that we are loath to say that its behavior is determined by the interaction of infinitely precise values. Our reluctance no doubt comes from the view that the operation of the solar system *does not rely on values at all*. The solar system does what it does, and there are no values or computations or mathematical operations of any sort that it appeals to in order to determine what to do. I gather than Schonbein accepts this, as his argument against the argument from measurement (in section 4.2) appeals to just this sort of distinction between epistemology and metaphysics. That suggests that the argument from noise is not primarily aimed at (i).

Now, as far as our *understanding* of a physical system such as our solar system, we would say that we can characterize its operation by deploying some mathematical framework or, if we prefer, by developing a concrete simulation of the solar system. I take it that these latter two epistemic enterprises are themselves distinct, and of either or

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[2] Norton (1995) suggests that the solar system is historically the most important instance of a system that has been investigated using dynamical approaches.

both of these two possibilities we might urge that they require values of infinite precision. (These two possibilities correspond to my (ii) and (iv), above.)

On (ii), a correct abstract mathematical characterization of a physical system may very well include infinitely precise values, depending on whether the characterization falls within the framework of discrete math or not. This is not the sort of characterization, though, where noise is an issue. For the abstract mathematical characterization, there can be no noise. It is certainly not the case that abstract mathematical frameworks are "…physical systems [that] are inherently noisy…" (to put the argument in Schonbein's words (p. 15)). So, Schonbein is not arguing against (ii).

Hadley's argument from measurement is an instance of an argument aimed at (iii). Schonbein maintains that the argument is unsuccessful, and I agree with him. Thus, the argument from noise is not aimed at (iii).

(iv) claims that a correct concrete simulation of a physical system will need to incorporate values of infinite precision. Prima facie, this claim does not seem very promising. After all, a concrete simulation — in the sense of, say, a computer program that can be manipulated in order to predict future states of the solar system — can not include infinitely precise variables because the representational medium used by the model will not allow it. For instance, the machine we are using to create the simulation limits the number of decimal places that our variables can expand out to in a LISP program. This is right but too hasty. Another kind of model, e.g., a really sophisticated orrery, will no more rely on the mathematical manipulation of values for its operation than will the physical system that it is a model of.[3] Therefore, if the concrete model is a physical system that stands in for the target physical system, it may not make sense to ask whether it offers infinite precision in its values.

This goes to show that the difference between abstract mathematical characterizations and concrete simulations does not seem to be simply a consequence of the model being physical rather than abstract. The correct way to characterize the difference is that questions about infinitely precise values track *how* one is modeling the target physical system. If we are using explicitly represented variables in order to capture an abstract mathematical characterization (e.g., a computer model), the kind of media used to represent the parameters of the target physical system will inevitably impose an upper bound to the precision that can be achieved. If instead we are using the subparts of one physical system as representations of the subparts of the target physical system, then questions concerning value precision are inappropriate.[4]

It seems to me that Schonbein is arguing against (iv) in its first reading where explicit representations are involved. His claim is that a correct model of the human

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[3] At the limit, one can imagine sophisticated alien beings whose strategy for predicting future states of our solar system involves going to a different part of the universe and *arranging the matter found there* into a model of our system to see what it does. Admittedly this would be a seemingly inefficient and curious technique.

[4] Of course one can ask how precise the model is in the sense of asking *how accurately do the physical subparts of the model mimic the behavior of the physical subparts of the target system.*

cognitive system will not have to contain values of infinite precision because any such model (or, at least, AANNs) will exhibit inter-node noise. That noise will make it so that the extra computational power of the AANN will be irrelevant.

The question, then, is whether the dynamicist is defending (iv). I would have thought that the heart of the dynamicist thesis is a version of (ii), namely that infinite precision matters in the abstract mathematical characterization of the human cognitive system. (ii), while an epistemological thesis, does not mention concrete simulations of the target physical system. If I am right about what the dynamicist is claiming, she is not offering (iv), which is a thesis about simulations nor is she offering (i) or (iii) which are metaphysical theses about physical systems. Of course, I'm prepared to be corrected on this reading of what the dynamicist has in mind. Some small evidence in favor of my view comes from two of the dynamicists that Schonbein concentrates on. What Horgan says in the quotation that Schonbein offers us is this: "at the mathematical level of description the alternative approach would invoke some form of mathematics more powerful than the discrete mathematics of computation theory" (p. 19). And van Gelder emphasizes the dynamicist "conceptual framework." I gather that the mention of a conceptual framework is an appeal to the abstract mathematical framework involved in dynamical approaches to cognition.

Where does this leave us? If I am right, then Schonbein is arguing against a claim different from the one that the dynamicist makes. I should confess that I am not completely comfortable in attributing this mistake to Schonbein. This is because noise is found in the biological systems that analog artificial neural networks are aimed at simulating. This is not irrelevant, but it is not completely clear how Schonbein understands this relationship between a model and a noisy target physical system. If the simulation of a physical system is going to be faithful to the physical system itself, one would expect the simulation to contain the same noise that the physical system contains. There is an important caveat here, though: the simulation might idealize away from the noise if the noise is deemed to be explanatorily irrelevant at the level the researcher is attempting to understand the physical system. We are then faced with another crucial question, namely, *is noise relevant to cognition*? In a footnote, Schonbein suggests that it is not. He protests that,

> …There are many problems with this proposal [that noise is relevant to cognition]. For example, keeping in mind that we are trying to explain cognitive behavior, it seems to imply that every action, every inference, every rational thought, is based in some part on noise, since every (cognitive) state has some relevant noise component. …Furthermore, if we identify thoughts with network states, it implies that 'having the same thought' is a predicate rarely if ever satisfied: For two individuals to have the same thought, it would have to be the case that each state agreed in all decimal places (p. 15, fn. 13).

There are two arguments here, but I am not fully sympathetic to either of them. The first argument claims that it is not credible that the interaction between cognitive states involves noise. What Schonbein appears to have in mind is that an inference like the application of the practical syllogism is best understood in terms of discrete chunks. But this risks begging the question against the dynamicist. It is true that when we conduct our cognitive science in terms of our folk psychological categories (and refinements thereof), noise seems irrelevant. The dynamicist may offer the counter claim, however, that that is a problem for our folk psychological categories, not for a correct understanding of the phenomenon of cognition. The debate would then seem to be over the status of eliminativism as a co-commitment of dynamicism.

The second argument claims that, if noise is an essential part of any cognitive states, then no two people will likely never be in the same cognitive state. This, presumably, would make lawful generalizations in psychology difficult to come by.[5] Evidently, Schonbein would have to persuade us that a theory of sameness of psychological states can only get off the ground if the values that express that state have less than infinite precision. But that would tell against sameness of state in any science whose entities are captured by values of infinite precision. If Schonbein were right, generalizations of astrophysics would be just as suspect as generalizations of cognitive psychology because the particular entities of a system would contain values of infinite precision.

[5] Due to pressure from Fodor (e.g. 1986), an analogous criticism of meaning holism has precipitated a vast literature. There is no space here to reconstruct that discussion.

IV.

Finally, there is one more (related) issue on which I, for one, would like Schonbein to say a little more. He claims that the computational power of AANN's will be reduced as a result of noise. The inference that we are invited to draw is that the reduction will be so great that there will be no advantage in modeling cognition within the dynamicist's computational framework. The evidence for this inference is the results achieved by Maas and his co-authors and by Casey that AANNs subjected to analog noise are reduced to finite automata, and often less. This is indeed suggestive, but one outstanding issue that needs to be addressed is whether the sort of analog noise introduced into those systems is similar to analog noise that can be found in *cognitive* systems. It is not enough for Schonbein to persuade us that noise in a neural system reduces the computational power of AANN's, since the AANN's are not being used to model neural systems (that would be a different and interesting project), but they are being used to model cognitive systems. So there would need to be noise at the level of the entities and processes relevant to cognition for us to be persuaded that the noise reduces the computational power of AANN's. I am not here suggesting that there is *no* noise at the cognitive level in naturally occurring systems. But whether there is enough to bring the computation down to Turing status has, it seems, yet to be shown.

References

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