Beware of stochastic explanations

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Note: Dear Reader & Peer, this manuscript is being peer-reviewed by you. Thank you.

Modern scientific literature abounds with statements and explanations involving the terms 'stochastic', 'random', and similar ones. Here is a recent example from the neuroscientific literature:

> *stochastic spike arrival in the input can lead to a broad interspike interval distribution in the output of a neuron.* (1)

I won't give the source of this statement because my discussion concerns this kind of statements in general, not just this particular one; and I consider its source an otherwise excellent work.

The statement above is grammatically correct. It contains several technical terms and seems to have a meaning. It also suggests the following ideas:

1. stochasticity is a possible physical property of spike arrival;

2. the stochasticity of spike arrival can be the cause of a broad interspike-interval distribution; hence,

3. if a broad interspike-interval distribution is observed, a possible cause is the stochasticity of the spike arrival.

Unfortunately statement (1) and the three ideas it suggests are false or meaningless – 'not even wrong', as Pauli would say (Peierls 1960). Let's analyse it.

We must first ask: what does *stochastic* mean? Scientific works that try to explain this term – and not all do – define it in terms that are just as vague, such as *randomness* or *chance*. I can't recall any work in which the meaning of the latter terms is accurately given. This nonchalant attitude is unexpected in modern science, considering that Einstein (1905 § 1) showed that even an apparently unambiguous term like *simultaneous* can be operationally ill-defined[1]

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[1]The scientific community felt shock and shame at Einstein's *semantic* findings, as can be sensed in this passage by Bridgman (1958 p. 1):

Since scientific texts don't help us, let us consult a dictionary. The Concise Oxford English Dictionary (2004) defines *stochastic* in terms of *random*, and *random* as 'made, done, or happening without method or conscious decision'.[2] I'd like to refine this definition by saying 'without *apparent* method', since there could be a method but we aren't aware of it.

Statement (1) is therefore equivalent to this:

> *spike arrival that happens without apparent method in the input can lead to a broad interspike interval distribution in the output of a neuron.*   (1′)

If you want to argue against the equivalence of the two statements, then you first owe me an accurate, non-circular definition of *stochastic*, *random*, and similar words.

The rephrased statement (1′) is trivial and empty. Sure, spikes arriving without apparent method might lead to a broad interspike-interval distribution. And then again they just might not. Likewise for spikes arriving *with* apparent method: they might or might not. The ideas suggested by the first formulation of the statement are therefore false:

(1′) the absence of apparent method is not a physical property of spike arrivals, but just our state of knowledge about them;

(2′) there isn't any causal or explanatory relationship between the apparent absence of method in spike arrival and a broad interspike-interval distribution; hence

(3′) if a broad interspike-interval distribution is observed, we can't say whether the was an apparent method in spike arrival or not.

So there isn't any causal or explanatory relationship between the apparent absence of method in spike arrival and a broad interspike-interval distribution.

It was a great shock to discover that classical concepts, accepted unquestioningly, were inadequate to meet the actual situation, and the shock of this discovery has resulted in a critical attitude toward our whole conceptual structure which must at least in part be permanent. Reflection on the situation after the event shows that it should not have needed the new experimental facts which led to relativity to convince us of the inadequacy of our previous concepts, but that a sufficiently shrewd analysis should have prepared us for at least the possibility of what Einstein did.

[2]It also gives the more specific meaning 'governed by or involving equal chances for each item', but this circular definition (what's *chance*?) is not usually associated with *stochastic*. Originally, *random* roughly meant 'fast', a meaning still visible in 'random-access memory'.

Bibliography

('de *X*' is listed under D, 'van *X*' under V, and so on, regardless of national conventions.)

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