Beware of stochastic explanations

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

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Modern scientific literature abounds with statements and explanations involving words like 'stochastic' or 'random'. 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 arrivals;
2. this physical property 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 arrivals.

Unfortunately statement (1) and the three ideas it suggests are either 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 what *stochastic* means – 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 these latter terms is accurately given. This is a strange attitude in modern science, considering that Einstein (1905 § 1)

showed us that even an apparently unambiguous term like *simultaneous* can be operationally ill-defined[1]

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]

[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):

> 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 can also specifically mean '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 present 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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