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Comment

Change is time
A comment on "Physiologic time: A hypothesis"

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Before Einstein imagined bending a beam of light, he understood that ultimately time is relative and the interval is the proper measure of the space–time continuum. The physiological time hypothesis offers a similar proposal for biological systems. It views state transitions as dependent on rate-limiting relational transactions, rather than a system-independent timekeeper. The target article proposes a scaling distribution to characterize body mass fluctuations. Moreover, the section of West and West [1] on *Stochastic Ontogenetic Mass Growth* (SMOG) represents a very general entry point into many biological, social, and other so-called "open" systems. The SOMG model falls squarely into a class of stochastic "birth–death" models described by the following equation:

$$\frac{dv}{dt} = c_1 v^{1-\gamma} - c_2 v + c_3 v \, dB$$

where v can alternatively stand for such *additive* quantities as the typical mass of a species, wealth [2], variance of market volatility [3], and perhaps even the degree of neurophysiological activation in processes governing human cognitive activity [4,5].

The first term $(c_1 v^{1-\gamma})$ may alternatively describe metabolic resource consumption, wealth acquisition arising in economic exchanges, or perhaps excitatory neurophysiological exchanges. Ordinarily, it can be argued that $0 \leqslant \gamma \leqslant 1$. In SOMG, for instance, the consensus is that $0 \leqslant \gamma \leqslant \frac{1}{3}$ in general, and that $\gamma \approx \frac{1}{4}$ for larger mammals.

The second term in the equation $(-c_2 v)$ describes an exponentially fast decay, such as the loss of body mass or wealth due to an agent's use of his or her own resources. Similarly, it might represent reduction in market volatility in absence of multiple information inputs, or inhibitory neurophysiological exchanges in an abstract biological or

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cognitive system. The third term is a stochastic term. It transforms the otherwise deterministic function into a system with outcomes that vary in terms of a probabilistic distribution.

The steady state distribution of this system is a Generalized Inverse Gamma (GIGa). It has a power law tail and belongs to a large family of parametrically related distributions, such as the lognormal and gamma, that can all be generated from the normal distribution. Other power law distributions can be obtained via convolutions of faster decaying distributions with the GIGa.

Just as the wealth model has microscopic underpinnings in a network model of economic exchange, [2] it is quite likely that SOMG [1] could be described by analogous network model based on capillary exchange. A general recipe for self-similarity and complex system dynamics is iteration in the context of relative balance among competing constraints—all in the face of stochastic perturbation [6]. This basic recipe implies a potential for variable, but lawful scaling behavior in complex biological and social systems, and convergent interdisciplinary explanatory frameworks.

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