Moment-to-moment signal variability in the human brain can inform models of stochastic facilitation now

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In their recent Opinion article (The benefits of noise in neural systems: bridging theory and experiment. *Nature Rev. Neurosci.* **12**, 415–425 (2011))[1], McDonnell and Ward make several compelling arguments highlighting the benefits of 'noise' in neural systems, and in particular, they offer a thoughtful framework that outlines how best to examine such benefits. We agree that the proposed term 'stochastic facilitation' is useful to encompass events in which neural computations benefit from the presence of noise, and is a noteworthy improvement on the more restrictive definition of stochastic resonance.

The authors also argue that a vital piece to understanding the 'noise' puzzle requires examining and theorizing about noise *in vivo*, rather than only through artificial, exogenous applications. They suggest that it would be "worthwhile to at least consider whether observations of random noise or background fluctuations may be evidence of a source of biological randomness that is potentially exploited *in vivo* for stochastic facilitation". It is important to note that the study of the functional consequences of moment-to-moment brain signal variability in the absence of exogenously applied noise sources is already a growing research focus in human functional neuroimaging[2–8]. The overarching trend from these studies is that young, high performing adults exhibit greater signal variability relative to younger children or older adults across a host of different task types. Work on various disease states (for example, mesial temporal lobe epilepsy[7] and traumatic brain injury[9]) also supports the functional benefits of greater brain signal variability. Approaches to measuring signal variability (for example, variance-based measures or multiscale entropy[2–4] using functional MRI, electroencephalography (EEG) or magnetoencephalography (MEG)) have differed across recent studies, but findings remain largely convergent; greater *in vivo* variability is beneficial for neural systems.

Importantly, this work reveals several unexpected effects that may further inform future models of stochastic facilitation. For example, not only is human brain signal variability spatially specific[2,3,5,8], variability-based spatial patterns do not closely resemble typical mean-based patterns[2,3]. This suggests that the functional benefits of variability are not equivalent across all brain areas, and that those regions that do signal functional benefits may not be the same regions that 'activate' according to mean signals. Furthermore, work on ageing that increased variability in several subcortical regions correlates with poorer cognitive performance and older age[3,8], thus highlighting that variability can sometimes be detrimental in the same neural system in which broad-scale cortical variability confers clear funtional benefits[3]. It is these unique *in vivo* effects that may prove most useful for informing future models of the crucial elements and bounds of stochastic facilitation, particularly in the context of larger network models. We applaud the authors' efforts to expand and discuss the benefits of noise under the framework of stochastic facilitation; in combination with extant and ongoing *in vivo* research, theoretical, computational and experimental work on stochastic facilitation can only improve.

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