Can Motor Noise Account for Force Variability?

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Involuntary force variability is an inherent property of motor behavior. When exacerbated, it is a key contributor to performance errors and a feature of several neurological conditions. Some propose that involuntary force variability arises primarily through the conversion of motoneuron firing patterns into muscle force, i.e. “motor noise.” This mechanism has been tested using a model of recruitment and rate coding developed by Fuglevand et al. (1993). However, this model has several drawbacks that limit its ability to simulate force variability. First, it does not explicitly model the fusion of force twitches with increases in firing rate and concomitant saturation of calcium binding to troponin. Second, the model lacks a series elastic element (i.e., tendon), which damps out the effects of fluctuations of motoneurone firing by changing its length and, thereby, the velocity of the muscle fibers in an externally isometric system. We addressed these limitations by combining some elements of the Fuglevand model with physiological and mechanical features from a model by Song et al. (2008). This new model has improved predictions of force and force variability. Upon close inspection, we show the amplitude and spectral features of force variability are significantly influenced by the viscoelastic properties of musculotendons. This model of motor units produces a lower amplitude of force variability than previous models. Also, spectral features of this new model resemble more closely what has been observed experimentally. These results question current thinking attributing the majority of involuntary force variability to peripheral motor noise, and highlight the importance of closed-loop behavior including afferent feedback and error corrections.