Appendix B Existing power analysis methods

While hypothesis testing emerged in the literature nearly a century ago (Fisher, 1925), statistical power was not formally discussed until the late 1980s (reviewed in Huberty, 1993). Power analysis' relatively recent emergence has led to a number of misunderstandings and misuses (Hoenig and Heisey, 2001), an under-appreciation of its value (Hopkins and Batterham, 2016) and *ad hoc* effect definitions (Knudson, 2017).

Continuum-level approaches to statistical power first emerged in the 1990s (Friston et al., 1996) and currently three main categories of continuum-level power analysis exist (Fig.B.1): inflated variance, non-central random field theory (RFT), and numerical.

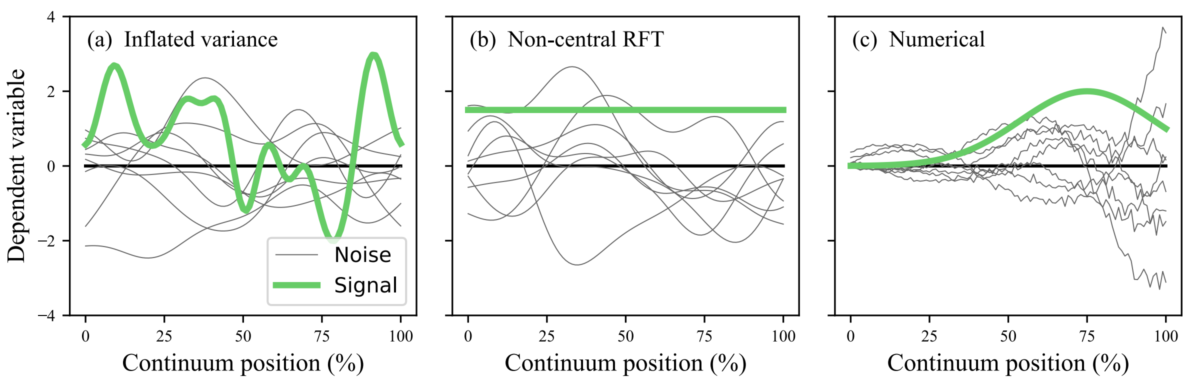

Figure B.1: Overview of existing continuum-level power analysis methods.

The inflated variance method (Friston et al., 1996) is based on (central) random field theory (RFT) (Adler and Hasofer, 1976; Adler and Taylor, 2007). RFT describes the probabilistic behavior of smooth Gaussian continua (see Fig.B.1a,b) and has been shown to accurately model the variance observed in a variety of 1D biomechanical datasets (Pataky et al., 2013). For power analysis this approach defines signal as a second Gaussian process with larger variance and potentially different smoothness (i.e. different frequency content), thereby representing a hypothesis for which the continuum location(s) and precise effect amplitudes are *a priori* unknown. In the context of joint angle trajectories, for example, this inflated variance signal implies that the approximate magnitude of a particular change is known (e.g. 10 deg) but not its location or extent in time. This interpretation of signal is useful for purely exploratory analysis in which precise effect predictions are not made. However, the method itself has low power because the signal prediction is imprecise Hayasaka et al. (2007). In other words, if there is a true signal which systematically occurs at the same point in time across subjects and/or trials, then the inflated variance method will predict far more subjects and/or trials than are actually needed to detect that signal.

The second approach to continuum-level power analysis is the non-central RFT method (Hayasaka et al., 2007; Mumford and Nichols, 2008). This method models signal as a constant shift (Fig.B.1b), possibly isolated to specific continuum regions. This signal represents, for example, a constant change of 5 deg from a reference joint angle trajectory. This type of signal is perfectly analogous to the classical definition of power, and since the signal is precise the non-central RFT method is more powerful than the inflated variance method (Hayasaka et al., 2007). Neverthless, its main limitation is that it defines signal in a binary sense: a continuum region either possesses constant signal or none. This is not very useful for biomechanics applications in which precise kinematic and dynamic trajectories can be predicted based on theory or musculoskeletal model optimization.

The third approach is a numerical method which iteratively simulates random 1D continua to compute power (Pataky, 2017). This method, while computationally intensive, overcomes the limitations of both aforementioned methods because it affords arbitrary modeling of both signal and noise (Fig.B.1c). This allows an investigator to generate a specific 1D signal of interest, to create 1D noise models to mimic theoretical or experimentally observed variance, and ultimately to compute the sample size required to robustly test arbitrary 1D signal predictions in their arbitrary noise environments. The numerical approach is the most general approach, flexibly implementing either of the two aforementioned approaches or arbitrary signal and noise (Pataky, 2017). Since it is most general the main manuscript uses only the numerical method.