

# EMG rectification has inconsistent effects on coherence analysis even in single motor unit studies

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TO THE EDITOR: We read with interest the article by Ward et al. (2013). Several groups question the use of electromyogram (EMG) rectification in calculating corticomuscular coherence (McClelland et al. 2012; Neto and Christou 2010; Stegeman et al. 2010), and Farina et al. (2013) demonstrate the inconsistent effects of rectification across different levels of muscle activation, relating to amplitude cancellation. Ward et al. (2013) now reanalyze data from a previous study (Halliday et al. 1999) using partial coherence to determine whether rectified or unrectified EMG better accounts for coherence between pairs of single motor units (MUs).

There are several problems with their article.

1) The study was not designed to investigate the effect of rectification at different levels of contraction. Recordings with increased force were restricted to those in which single MUs could still be discerned (Halliday et al. 1999). Thus this study reflects a specific circumstance in which little if any amplitude cancellation is present in the surface EMG. Farina et al. (2013) show that, in this situation, rectification may indeed enhance coherence detection but that, with increasing levels of muscle activation with recruitment of more MUs, EMG rectification decreases coherence. Therefore, the analysis by Ward et al. (2013) cannot be extrapolated to other studies.

2) Combining data from each loading level (5–40 g) into one group for analysis masks the trend evident in Table 2 that rectified EMG is less effective at enhancing coherence at loads >15 g. Nevertheless, for this combined loaded condition, there is no significant difference between raw and rectified EMG in predicting the frequency components of MU synchronization. Thus, even with this modest increase in muscle activity, the ability of rectification to enhance coherence detection disappears.

3) The authors focus on the observation that the spectrum of rectified surface EMG is closer than that of the unrectified EMG to the MU spectrum. This is irrelevant. Coherence is a measure of the coupling between signals and not simply a measure of their power. Correlated frequency components are not necessarily seen as peaks in the spectra of the signals (Brovelli et al. 2004; Bruce and Goldman 1983).

4) The authors interpret the observation that rectification fails to detect coherence at a known common frequency, 50-Hz mains artifact, as evidence that rectification emphasizes the modulatory drive at the expense of action potential shape. This

is an oversimplified view. High-frequency information is not just “suppressed” but is transposed elsewhere within the rectified spectrum. Rectification produces a complex interaction between noise and EMG rendering its effect on coherence analysis inconsistent (McClelland et al. 2012, 2014).

The authors seek to determine whether rectified or unrectified EMG shows “greater fidelity” in detecting the common drive to MUs. To show fidelity in representing the underlying physiological process, a method must be consistent across experimental conditions. The data presented here reflect a specific single MU study and are not generalizable. In contrast, analysis with raw EMG produces a stable estimate of coherence irrespective of the level of muscle activation (Farina et al. 2013), making it a more appropriate choice for analysis.

## DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

## AUTHOR CONTRIBUTIONS

V.M.M. drafted manuscript; V.M.M., Z.C., and K.R.M. edited and revised manuscript; V.M.M., Z.C., and K.R.M. approved final version of manuscript.

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