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**Presentation Title: Emulating Conventional Disc Electrode with Middle Ring or Central Disc of Tripolar Concentric Ring Electrode on Human Electroencephalogram Data**

**Research Focus: Biomedical Engineering**

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**Student or Faculty Member: Student**

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**Abstract:**

Some noninvasive electrophysiological measurement applications benefit from simultaneous collection of data both conventional disc electrodes and via tripolar concentric ring electrodes (TCREs), so an emulation of the former by the outer ring of the latter was previously proposed and since adopted widely. Its effectiveness was validated using linear time and frequency domain signal synchrony measures (cross-correlation and coherence, respectively) [1], [2]. This approach represents an alternative to recording from both electrode modalities concurrently, which may involve two recording systems and potential synchronization issues with signals not recorded at exact same locations.

However, recent application of a nonlinear signal synchrony measure, normalized mutual information (NMI), resulted in mean values of less than 0.7 between outer ring of a TCRE and the disc electrode on both phantom model and human electroencephalogram (EEG) datasets, indicating outer ring of a TCRE may not be as suitable as an emulation of the disc electrode as previously suggested in [1], [2]. Therefore, in this study, alternative options such as the central disc or the middle ring of a TCRE were assessed on the resting EEG data from six human subjects from [1], [2]. Middle ring and central disc channels were not recorded directly in this dataset, and were obtained through addition and subtraction of other monopolar and bipolar channels (e.g. subtraction of the outer ring monopolar channel and the bipolar channel corresponding to the outer ring minus the central disc allowed assessing the data corresponding to the central disc). Because of that, all the channels compared were normalized once to zero mean and unit standard deviation. NMI expresses the mutual dependence based on Shannon's entropy between two random variables and was used in several EEG applications.

Average NMI values obtained for middle ring and central disc versus the disc electrode were equal to 0.589 ± 0.0997 and 0.587 ± 0.0725, respectively. Lower NMI values suggest that neither middle ring nor central disc of a TCRE are a more effective emulation of the conventional disc electrode than currently used outer ring. Their consistent NMI values may still be high enough to offer an alternative emulation option if needed. Research significance of this study stems from assessing middle ring and central disc as emulations for disc electrode for the first time.

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[1] O. Makeyev, Y. Boudria, Zhenghan Zhu, T. Lennon, and W. G. Besio, "Emulating conventional disc electrode with the outer ring of the tripolar concentric ring electrode in phantom and human electroencephalogram data," in *2013 IEEE Signal Processing in Medicine and Biology Symposium (SPMB)*, Brooklyn, NY, USA: IEEE, Dec. 2013, pp. 1–4. doi: 10.1109/SPMB.2013.6736778.

[2] O. Makeyev, T. Lennon, Y. Boudria, Z. Zhu, and W. G. Besio, "Frequency domain synchrony between signals from the conventional disc electrode and the outer ring of the tripolar concentric ring electrode in human electroencephalogram data," in *2014 40th Annual Northeast Bioengineering Conference (NEBEC)*, Boston, MA, USA: IEEE, Apr. 2014, pp. 1–2. doi: 10.1109/NEBEC.2014.6972865.