The Ordinal Complexity of EEG: A Neural Correlate of Consciousness?

Sebastian Berger, Dipl.-Ing.

TUM ICS Research Seminar
March 23, 2018

Abstract. Detecting changes in a person's state of consciousness by quantitative analysis of the electroencephalogram (EEG) is an active field of research, with new approaches towards the problem being frequently reported on.

General anaesthesia, as performed to facilitate medical surgery, provides an interesting setting for studying this subject: by medication, anaesthesiologists are able to modulate human consciousness on very short timescales. In addition, the surgical environment also constitutes a relevant field of application for techniques of monitoring consciousness: medical complications—such as intraoperative awareness and postoperative cognitive dysfunction—may in part be related to inadequate dosages of anaesthetic drugs, which can in turn be caused by ambiguities in current anaesthesia monitoring. Thus, patients undergoing general anaesthesia could directly benefit from advances in monitoring human consciousness.

In a broader context, progress in this field of research may eventually contribute to answering one of the big questions of mankind: what is consciousness? Against this backdrop, a particular set of techniques in EEG analysis is receiving increasing attention: measures based on ordinal pattern analysis, most notably permutation entropy [1], correlate remarkably with the clinical assessment of consciousness. An hypothesis that builds upon dynamic systems theory implies that such ordinal measures reflected the varying complexity of the underlying brain dynamics—rendering them neural correlates of consciousness.

In the upcoming talk, an introduction to ordinal pattern-based EEG analysis shall be provided by the example of permutation entropy. Recent results in ordinal pattern-based EEG analysis—as obtained in the course of the speaker's doctoral studies—will be presented, and discussed in the light of the aforementioned hypothesis on the ordinal complexity of human brain dynamics [2].

About the Speaker. Sebastian Berger is an electrical and computer engineer who graduated from TUM in 2013. His primary focus is on signal processing. Having worked as a software engineer for the aerospace industry, he has a strong background in writing and optimising low-level code—and claims to enjoy it.

Currently a doctoral candidate and research assistant at TUM Department of Anaesthesiology, Berger's interest lies in quantitative EEG analysis. In particular, he studies the relations between states of human consciousness and the signal characteristics of EEG.

---

[1] Christoph Bandt and Bernd Pompe. Permutation Entropy: A Natural Complexity Measure for Time Series. *Physical Review Letters*, 88(17):174102:1–174102:4, 2002.

[2] Sebastian Berger, Gerhard Schneider, Eberhard F Kochs, and Denis Jordan. Permutation Entropy: Too Complex a Measure for EEG Time Series? *Entropy*, 19(12):692, 2017.