BRAIN CONNECTIVITY INVESTIGATION DURING SEIZURES IN THE INTENSIVE CARE UNIT

Supervising staff

Antoine Nonclercq (antoine.nonclercq@ulb.be), Nicolas Gaspard (Head of Department of Neurology, nicolas.gaspard@hubruxelles.be), Lise Cottin (lise.cottin@ulb.be).

Context

This project will be performed in collaboration and with the help of the Department of Neurology at the CUB Hôpital Erasme.

Epilepsy is a disorder of the brain characterized by an enduring predisposition to generate epileptic seizures and by the neurobiologic, cognitive, psychological, and social consequences of this condition (Fisher et al. 2005). Epilepsy has variable etiologies, may affect both children and adults, and has an annual incidence of 4–8/1000. In about a third of epileptic patients, seizures do not respond to conventional anti-epileptic drugs.

Management of epileptic patients in the Intensive Care Unit (ICU) is challenging. The ability to anticipate an upcoming seizure would be valuable both for patient management and as a predictor of treatment adequacy.

Recently, a technique has gradually gained prominence in forecasting epileptic seizures: the investigation of brain connectivity, characterizing how highly specialized brain regions communicate with each other (Ismail and Karwowski 2020). Indeed, epilepsy is widely believed to result from disrupting healthy brain network properties (van Mierlo et al. 2014). By modeling the brain as a connectivity graph, the interactions between its regions can be studied formally, allowing quantitative characterization and interpretation of the specific patterns observed (Farahani, Karwowski, and Lighthall 2019; van Diessen et al. 2015).

Although brain connectivity has been increasingly studied in recent years in epilepsy, the organizational changes in the brain network around a seizure are not yet clear, and the literature shows great discrepancies between articles. It is commonly accepted that the brain is organized in a small-world structure, characterized by a larger number of smaller and denser clusters of connected nodes. When the occurrence of a seizure disrupts this structure, this efficient organization for information transfer tends towards more random or ordered patterns (Ponten, Bartolomei, and Stam 2007; Kramer, Kolaczyk, and Kirsch 2008; Schindler et al. 2008; Srinivas et al. 2007; Kramer et al. 2010; Wu, Li, and Guan 2006; Percha et al. 2005; Christodoulakis et al. 2012). Those structures are illustrated in Figure 1. An explanation for these disagreements is that most of the studies focused on small and specific patient groups, for which conclusions were consistent but difficult to compare since they were obtained under different conditions (van Mierlo et al. 2014). They also show the need for a deeper investigation of the connectivity mechanisms present in epilepsy.

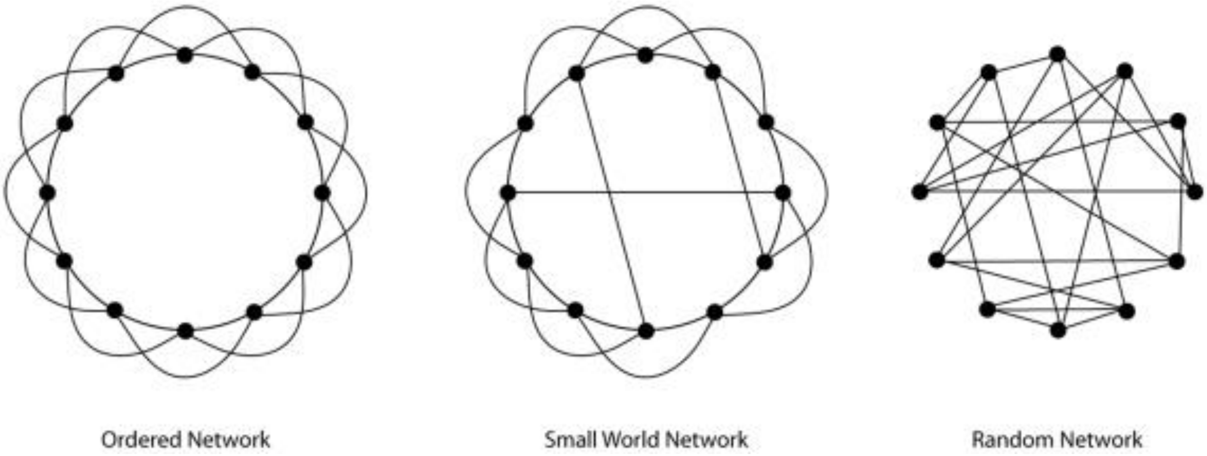

Figure 1. Network structures (Ismail and Karwowski 2020). *Random networks have both small characteristic path length and clustering coefficient, reflecting efficient information transfer but no robustness. In contrast, ordered networks have high clustering coefficients and path length, reflecting robustness but inefficient information transfer. The small-world networks lie between the two, with relatively short path lengths, similar to a random network, and higher clustering coefficients with respect to the regular lattice. This organization is considered near-optimal in terms of segregation, integration, cost, and performance, promoting information processing.*

Work

This work aims to investigate the organizational features of brain connectivity during seizures to understand the pathological mechanisms underlying epilepsy better. The evolution of the connectivity in that framework will be evaluated. In that regard, these patients' connectivity will be investigated during background activity, just before, during, and after a seizure. Besides, if results are conclusive, a comparison of the analysis on EEG from these patients with the one on EEG from epileptic patients (i.e., characterized by recurrent – rather than isolated – seizures) is also considered.

Recording of electroencephalographic signals (EEG) from patients in the Intensive Care Unit (ICU) will be provided.

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