Window in the Brain (WiB): Developing a novel brain connectivity-based seizure detection algorithm for future paediatric critical care use

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Introduction

- Delayed seizure detection and treatment worsen paediatric critical care (PCC) patients' recovery.[1]
- Gold standard seizure detection using multi-channels EEG requires 24/7 availability of:
  - Expert neurologists;
  - Highly specialised clinical physiologists.

Unmet clinical need: Accurate seizure detection tool independent of specialists' input.

- Brain connectivity (Fig. 1) changes before and during seizures.[2]
- Phase Synchrony (PS) is a measure of brain connectivity changes.[3]
- Previous PS-based seizure detection required expert placement of >19 EEG channels, limiting its clinical use.

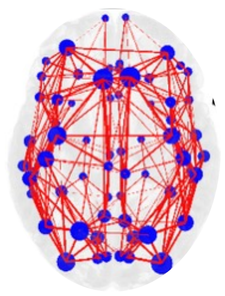

Figure 1. Schematic diagram of a brain connectivity map.

Aim

- To determine the feasibility of seizure detection with a PS-based algorithm using **less than 19 EEG channels.**

Methods

- An MRC CiC funded single centre data-informatics feasibility study.
- Routine clinical EEG (n = 40) with expert identified seizure markings (i.e. gold-standard) were extracted and fully anonymised.
- From a standard 10-20 EEG electrode system, a montage with four channels (Fig. 2) was selected, because:
  - ✓ It was a configuration already in use by PCC bedside team;
  - ✓ It included central electrodes coverage.

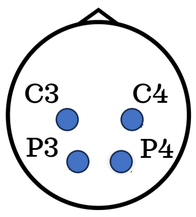

Figure 2. The selected 4-channels configuration.

- The BrainsView algorithm was refined to produce WiB algorithm (Fig. 3) and to improve seizure detection performance (assessed by comparing with gold-standard seizure markings).[4]

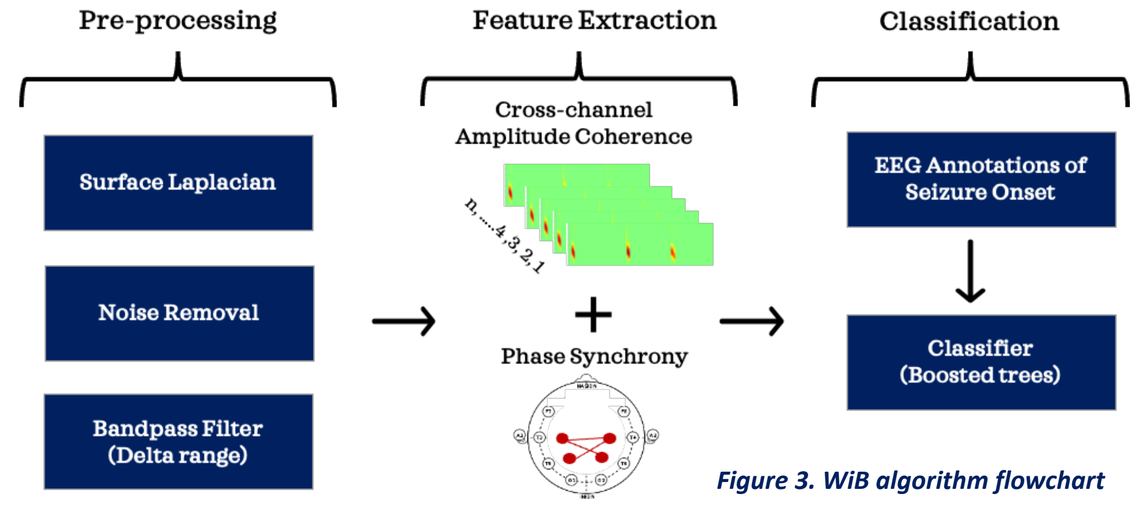

Figure 3. WiB algorithm flowchart

Results: Data

- Total duration: 38.5 hours. (n=40; Fig. 4)
- 236 seizures marking- all expert neurologist identified.
- Seizure types: 50% generalised and 50% focal.
- Aetiologies: Generic Generalised Epilepsy, Mesial Temporal Sclerosis, Battens Disease, etc.
- Age: 1 month to 12 years.

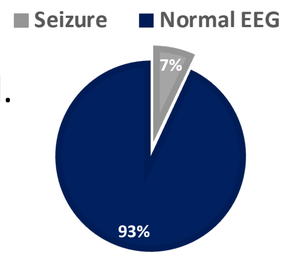

Figure 4. Proportions of EEG recordings with or without seizures.

Results: Seizure detection algorithm's performance

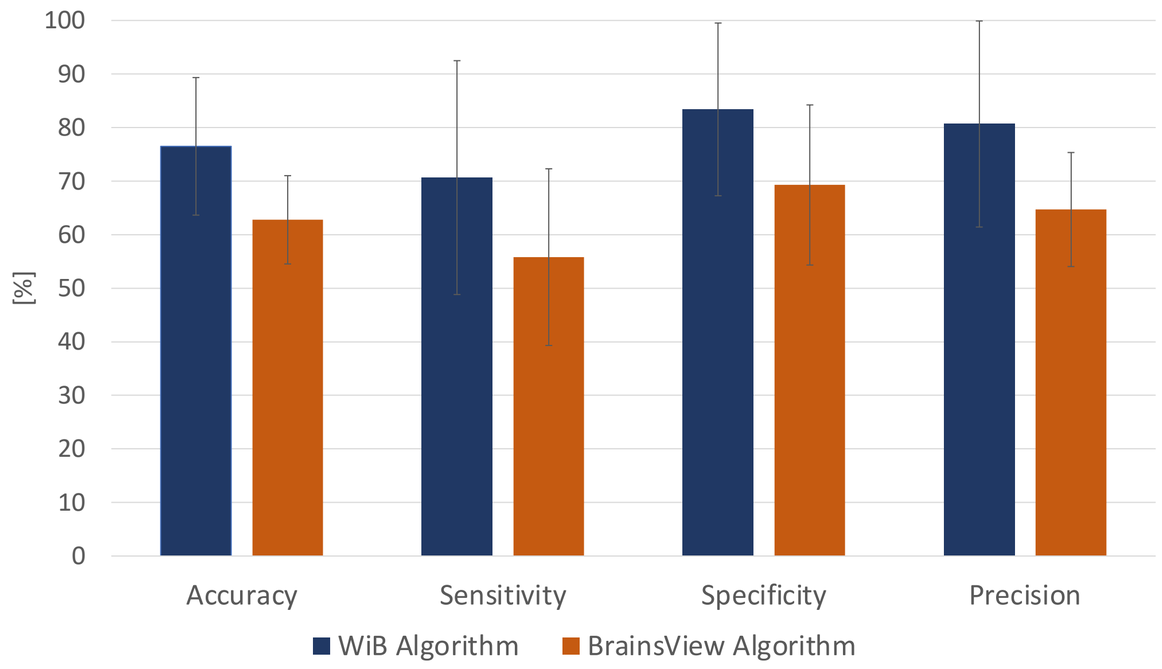

Figure 5. Average seizure detection performance in 40 samples.

- The addition of cross-channels amplitude coherence to the algorithm (Fig. 3) enhanced its seizure detection performance by 12 % in all seizure types. (Fig. 5)

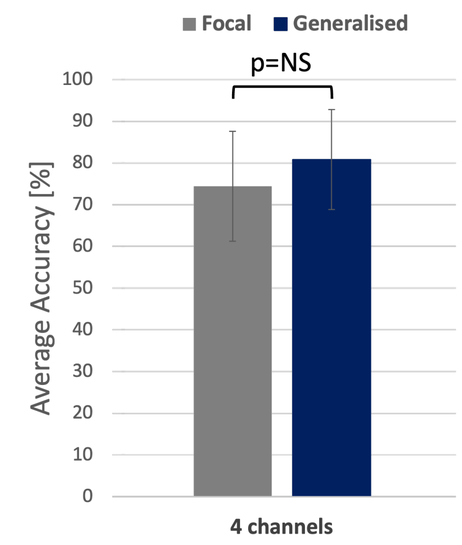

Figure 6. Comparison of seizure detection in focal and generalised samples.

- The WiB algorithm performed better in detecting generalised seizures (p=NS). (Fig. 6)
- Common misclassification causes :
  - Movement artefacts;
  - Seizure durations < 3 seconds.

Future work

A CSO-funded follow-on **multi-centre study** is underway to ascertain WiB algorithm's generic compatibility which is essential for **future global clinical uptake** and **commercialisation**.

Take-home message

We are the first to demonstrate brain connectivity-based seizure detection is feasible with as few as 4-EEG channels. This is a configuration that the PCC bedside teams are already using without expert input, thereby facilitating future clinical translations of our algorithm.

References:
1- Payne E., et al. *Brain* (2014) ; 137 (5) :1429-1438
2- Das A., et al. *Neural Comput* (2019); 31 (7): 1271–1326
3- Guevara J. et al. *Neuroinformatics* (2005); 3 (4) : 301-313
4- Abdullateef S., et al., *44th Ann Int Conf EMBC Proc (2022)* :259-262

Please scan the QR code for more information about the project.

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