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Does my child know I'm here? EEG signatures of parental comfort for disorders of consciousness in critically ill children

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***Introduction**:* Every day in the Pediatric Intensive Care Unit (PICU), children suffering from severe brain diseases lie unconscious and comatose. Parents lie beside them, desperately wondering if their child will ever awaken. Many patients suffering from coma and related disorders of consciousness (DoC) show no clear physical behaviours of conscious awareness but have residual cognitive function. This cognitive-motor dissociation (CMD) can be seen by the presence of volitional brain activation to motor commands via EEG[1]. CMD occurs in up to 20% of adults with DoC[1], has high early prognostic value for predicting good outcome[1] and can be used by brain-computer interfaces (BCIs) to create simple communication ("Yes"/"No") systems for locked-in patients[2]. Despite such potential, children have been entirely neglected from CMD and BCI research[1,3]. Our group has shown that children (even those with severe brain disorders) can operate many BCI systems with comparable success to adults[2], including one built for DoC in adults[1,2]. Children's developing brains may also harbour unique, robust networks elicitable by simple stimuli not found in adult brains such as the response to parental comfort and affection[5]. Detecting the activation of such networks in comatose children whose parents are constantly caring for them at their bedside could reveal new brain activity markers. These may then predict clinical outcomes early on, and possibly allow families to communicate with their child in the most critical of circumstances. To explore this possibility, the present preliminary case study aimed to identify EEG signatures of parental comfort in a child with acute DoC.

***Material, Methods, and Results**:* 17 hours of video/EEG data was obtained via the Alberta Children's Hospital Neurocritical Care program for a 13-year-old female patient afflicted with DoC following traumatic brain injury (inclusion criteria searched: age 6mo-17yr; acute encephalopathy with Glasgow Coma Scale score < 6; 24+ hours of video/EEG monitoring). Blinded video review defined three clinical states: parental comfort (physical contact / talking to child), parent presence (in room only), and parent absence. Video states were time-locked with recorded EEG (bandpass-filtered [0.1 – 40 Hz], cleaned [removal of artefacts, periods of status epilepticus, etc.], downsampled [256 Hz]). The Highcuhi Fractal Dimension (HFD), a complexity measure recently reported as a sensitive discriminative marker of severity in EEG analysis for DoC[4], was computed for 1 sec. epochs and standard 20 channels. Results were clustered and visualized via K-Means / t-SNE, to identify the most dynamic sections of recorded EEG. Clusters were mapped to clinical states defined in the video (parent presence/absence).

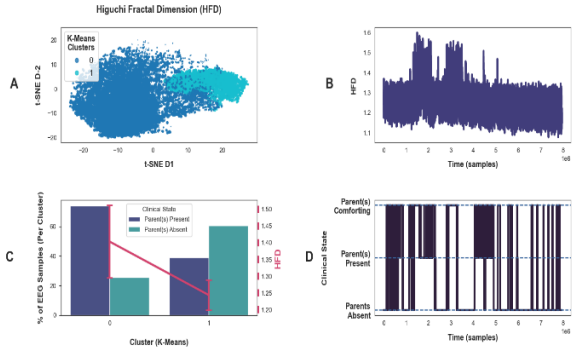

Fig.1. **A:** K-Means clustering indicated two clearly separable clusters of HFD values (Silhouette score = .54) – visualized via t-SNE. **B/D:** Visual comparison of HFD changes (**B**) with changes in video-defined states (**D**) over time suggested similar trends. **C:** Mapping the video labels (parental presence/absence) and mean HFD across channels to the two identified clusters indicated differences in both values; higher HFD (1.40 ± .11) and times of parental presence (74% of clustered points) were prevalent in cluster 0, whereas lower HFD (1.24 ± .05) and parental absence (61%) tended towards cluster 1.

***Discussion**:* Preliminary results suggest that parental comfort in the ICU may elicit detectable changes in EEG-measured brain activity of children with acute DoC, which may indicate some intact cognition and/or a potential marker for prognostication and building BCI-based communication systems in these contexts.

Significance: Developing biomarkers for DoC in children is essential for reconnecting them with their families; future studies can now test the HFD and other EEG features for prognostic and communicative utility in this context.