Can Teams Develop Inter-Brain Coordination While Resolving Uncertainty?

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Introduction

Team members co-regulate their activities and move together at the collective level of behavior while coordinating their actions toward shared goals. In parallel with these team processes team members also need to resolve their individual uncertainties arising from the changing environment.

The tension between resolving individual uncertainty and participating in collaborative processes has not been explored at the neurodynamic level. We compared the neurodynamics of team member uncertainty with their long-duration inter-brain coherence during healthcare simulation training. The data indicate that it is difficult for team members to maintain inter-brain coherence while simultaneously resolving their individual uncertainties.

Methods

Teams

Three three-person teams performed simulated patient ventilation scenarios while wearing electroencephalogram (EEG) headsets [1] in a simulation center environment [2] (110 minutes total containing briefings, scenarios, and debriefings). Three additional two person teams managed pediatric bronchiolotis simulations (112 min. total scenario time) in an emergency helicopter setting.

Neurodynamic Correlates of Uncertainty

Neurodynamic correlates of uncertainty are based on the information content of EEG rhythms [3-6]. The measure, Neurodynamic Information (*NI*), temporally bridges the gap between low level neural processes and the organizations associated with verbalized uncertainty and the hesitations and pauses associated with them [4,7].

The symbolic modeling process generated a quantitative scale with the information content of a single symbol (i.e. 0), as the lower bound, and an upper bound of the maximum information of the symbols used for modeling. *NI* can be directly compared across team members and teams, or across scalp / sensor regions, or across the 1-40 Hz EEG spectrum. Similar comparisons can be made across individuals and teams with different levels of expertise, training segments such as briefings scenarios and debriefings, or when comparing across critical healthcare events like ventilating a patient [5]. Observed precipitating causes of elevated uncertainty included a) a fire in the operating room; b) acute anesthesia-induced malignant hyperthermia; c) failure of BPAP breathing machine; d) benzodiazepine withdrawal.

Inter-brain Coherence

Inter-brain coherence (IBC) are patterns of brain activity arising from two or more team members engaged in joint tasks. Unlike the neuronal events of speech exchanges that occur over hundreds of milliseconds [8-10], periods of IBC can last minutes or more in the form of temporal receptive windows (TRW) that capture the context over time [11]. Descriptions of TRW often relate to watching movies or reading text, but likely apply to team situation awareness or task sharing during teamwork. The IBC are calculated by correlating the cross power spectral densities (PSD) between-subject pairs at the same (or other) EEG channel using 60s moving windows updated each second. The IBC of 3x randomized PSD were subtracted before reporting

Results

An example analysis of the temporal IBC and *NI* dynamics are shown in Figure 1 for an experienced anesthesiologist and nurse who had previously worked together. There were several periods of increased IBC with significant correlations greater than r = 0.5, and durations of 50-120s. These were temporally and spatially restricted to a limited number of sensors; T3, Cz and P7 during the simulation Scenario and F4, C3, Cz, C4 and Pz during the Debriefing (Fig. 1A).

The elevated *NI*, representing periods of uncertainty, were also discrete, and showed a different temporal and sensor profile than the IBC with activities at the Fz, T4, P7 & P3 sensors (default mode network) as well as the C3 & C4 (sensorimotor) and O1 & O2 sensors (Fig. 1B). The correlation between the IBC and the *NI* of TM-1 was 0.08, and IBC and *NI* of TM-2 was 0.02 (Fig.1C).

Elevated *NI* predominated during active management of a patient with acute malignant hyperthermia brought on by the anesthetic (*Patient Management*). The IBC predominated while the team ventilated the patient (*Intubation*), and during the *Patient Review* when the team discussed the patient, the operation, and possible complications. There was also elevated IBC between the anesthesiologist and the nurse during the debriefing when they discussed the uncertainty of the situation and the mutual support needed when managing the patient. Similar results were obtained from the other five teams.

The results indicate that inter-brain coordination often occurs among team members when performing realistic tasks and that these periods may relate to a co-understanding of the situation. The results also suggest that it may be difficult for team members to coordinate with other team members when they are preoccupied reducing the uncertainty of their individual tasks.

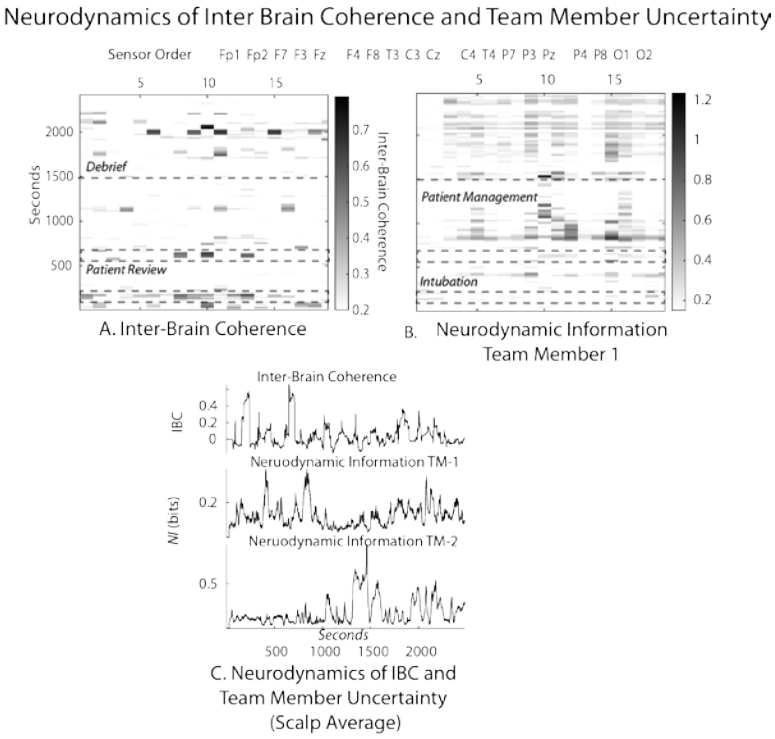

Figure 1. EEG was collected from an experienced operating room dyad while they performed required simulation training. *Intubation* = Ventilation of the patient; *Patient Review* = Patient and surgical procedure review by all team members; *Debrief* = After-action review. (A) The sensor-specific power spectral density values for two team members were correlated with each other over a 60s moving window that was updated each second. (B) The sensor-specific *NI* for Team Members 1 and 2 (not shown) were calculated each second over a 60s moving window. (C) The dynamics of the scalp-averaged IBC and the *NI* of TM1 and TM2 were aligned and displayed.

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