Cognitive Activity and Surgical Capability: Impact of Cognitive Load on Simulated Cholecystectomy Performance

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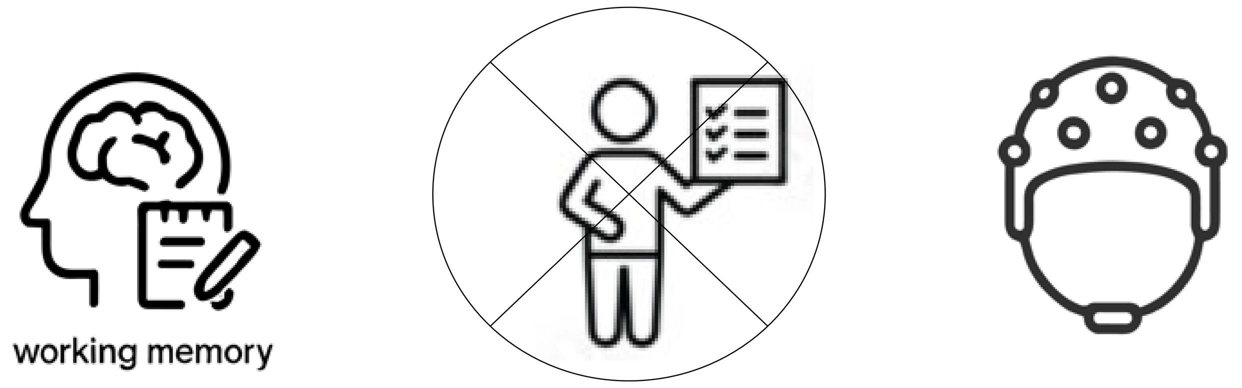
BACKGROUND



- Cognitive load (CL) refers to the information demands on working memory.[1]
- When excessive, CL can degrade surgical performance.[2]
- Self-report CL measures have important limitations in objectively capturing impact of CL on surgical performance.
- Physiological sensors like electroencephalogram (EEG) or heart rate monitors could objectively capture indices of surgeons' CL.[3]
- **Study Objective:** Determine whether objective CL sensing modalities are associated with surgical performance.

METHODS

- Surgical novices and experienced surgeons participated.
- Performed cholecystectomy procedures on explanted porcine livers laparoscopically and robotically.
- A heart rate monitor, mobile eye tracker, and 14-lead saline-based EEG measured CL during performance.
- Spare attentional capacity (i.e., available working memory) was measured with a secondary visuospatial task superimposed on the viewing monitor. Participants used a foot pedal when they detected a particular pattern.
- Performance videos were evaluated by two blinded raters using the Global Operative Assessment of Laparoscopic Skills (GOALS and the Global Evaluate Assessment of Robotic Skills (GEARS), respectively.
- Performance differences between groups and surgical modalities and correlations were analyzed non-parametrically.

RESULTS

- Thirteen participants (62% Female, 46% experienced, 100% right-handed).
- **Weighted Kappa revealed high inter-rater reliability (ranging from 0.78 to 0.96 across GOALS/GEARS domains).**
- **Experienced surgeons had significantly better depth perception and efficiency than novices laparoscopically and had significantly better performance robotically in all GEARS domains ($p < 0.05$).**
- **Experienced surgeons had significantly better secondary task performance than novices on both platforms ($p < 0.05$).**
- There were no significant differences in performance or CL between laparoscopic and robotic cholecystectomies.
- Heart rate and eye tracking metrics were not correlated with performance.
- **EEG-measured cortical activation (reflective of CL) in the prefrontal, premotor, motor, occipital, and parietal cortices negatively correlated with surgical performance ($p < 0.05$).**
- **The number of correct identifications in the secondary task positively correlated with performance ($R = 0.58$, $p = 0.003$) while the number of missed identifications negatively correlated ($R = -0.5$, $p = 0.01$).**

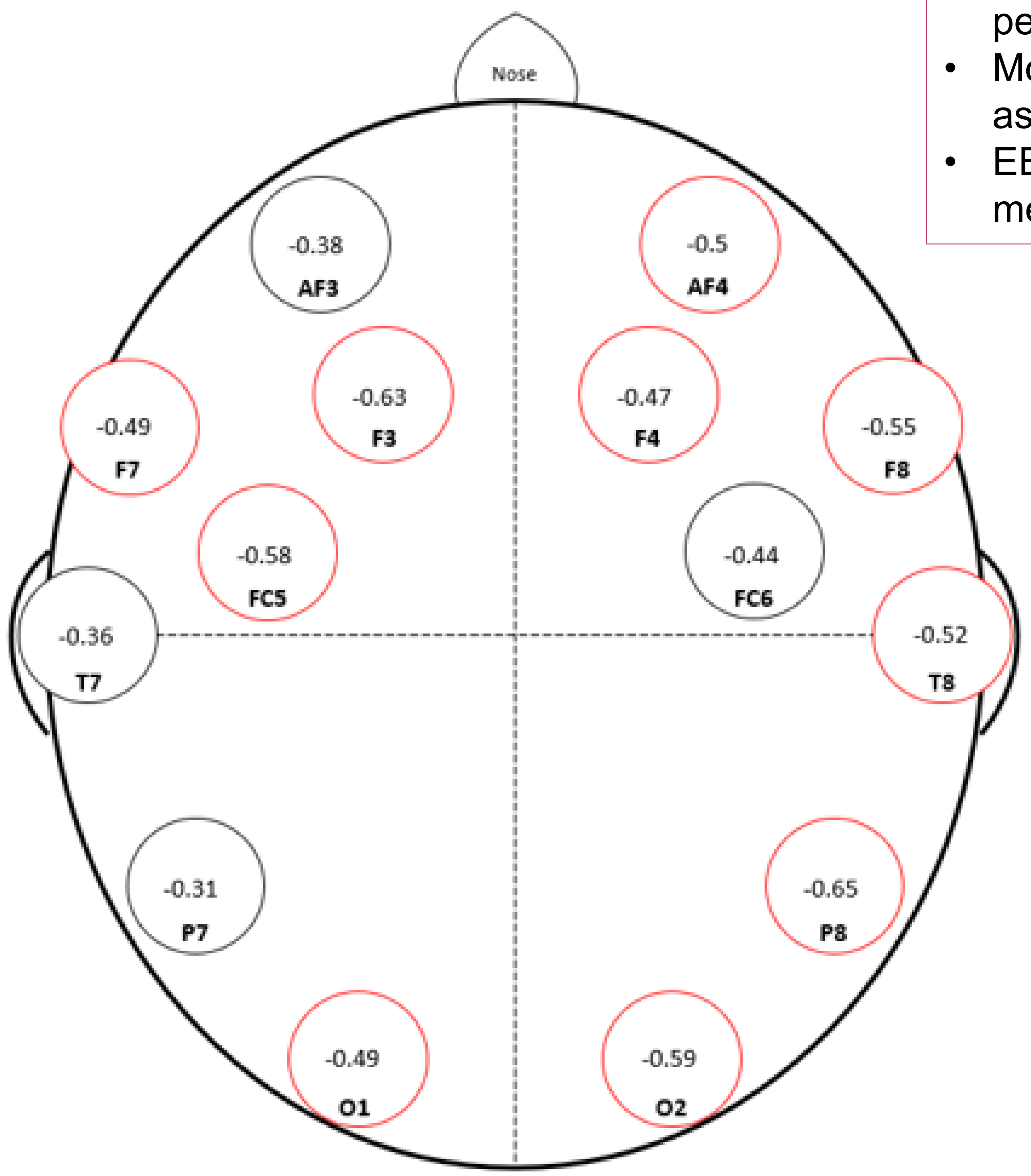


Figure 1. Correlations Between Theta Activation and Total GOALS/GEARS Score. Values reflect Spearman's Rho Coefficients. Red circle indicates $p < 0.05$.

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CONCLUSIONS

- Across simulated laparoscopic and robotic cholecystectomies, greater theta band cortical activity, which indicates heightened cognitive load, was associated with poorer surgical performance.
- More spare attentional capacity, indicating less CL, was associated with better surgical performance.
- EEG and secondary task measures show promise in objectively measuring CL during surgical performance.

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