Ready TransInformation-based Assessment of Neurocognitive Salience level Electrophysiologically

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Introduction

- The assessment of neurocognitive salience is vital in both clinical and high-stress work environments.
- Advancements in high-resolution, cost-effective telemetric dermal-patch leads have enabled exploration of characteristic biopotential signals from electrocorticographic/ electroencephalographic frameworks.
- Neurophysiologically, the transinformation interaction flow (in hartleys/bits) is a key parameter for characterizing stimulus-response relationships within the neurophysiological system.
- Previous research successfully employed transinformation measures to predict neural system responses in animal models, establishing a fundamental neurocomputational understanding of neural information transmission

Objectives

- This study aims to investigate the applicability of transinformation parameters for delineating neurocognitive salience levels across diverse clinical scenarios.

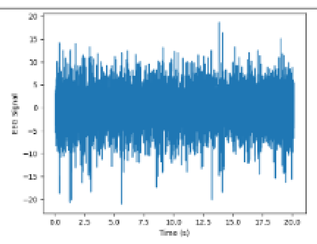
Methodology

Following steps were taken to perform TransInformation based assessment of Neurocognitive Salience level. The Data can be taken up by any measuring instrument taking all the contributing factors into consideration for measuring results.

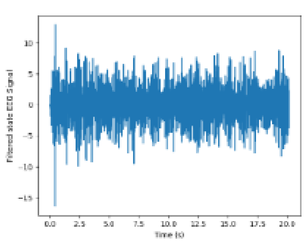
DataSet Selection

Alzheimer Study [2]
36 AD - 28 CN
Anesthesia Study [3]
25 Pre - 25 Post
Cognitive Load [4]
10 Task - 10 Baseline

MultiChannel EEG Signals



Processing & Denoising



Bandpass filter
(for **δ-θ-α-β** brain waves)

Choose different frequency bands for different cases

Fourier Transform

$$X(f_i) = \sum_{t_i} x(t_i) e^{-i2\pi f_i t_i}$$

Power Spectrum Density

$$P(f_i) = X(f_i) * X^{\wedge}(f_i),$$

Normalization

$$\sum_{f_i=f_1}^{f_2} P_n(f_i) = C_n \sum_{f_i=f_1}^{f_2} P(f_i) = 1$$

Shannon Function

$$S_N[f_1, f_2] = \frac{1}{\log(N[f_1, f_2])} P_n(f_i) \log\left(\frac{1}{P_n(f_i)}\right)$$

Statistical Comparison

Trans-Info. comparison using T-Test for obtaining **p-Value**

* **p-Values** obtained can be done using a paired or unpaired T-Test depending on whether we are making comparison between the independent classes or not.

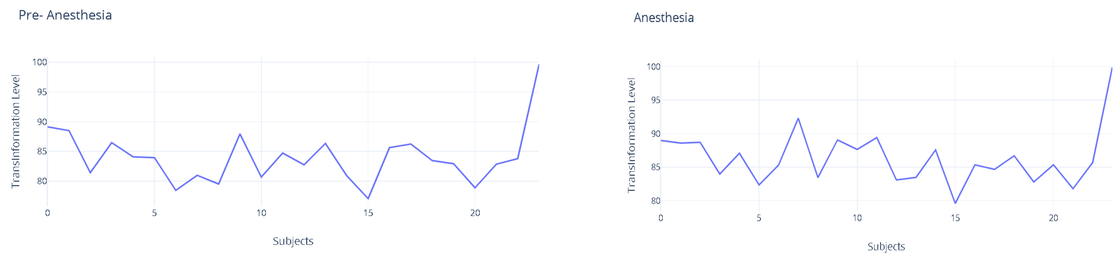
Results

The neurocognitive salience level for all the states are normalized to be within 100.

- We found that all the different neurocognitive conditions could be distinguished by the transinformation index with strong significance-level (t-test, p≤0.01), namely as:

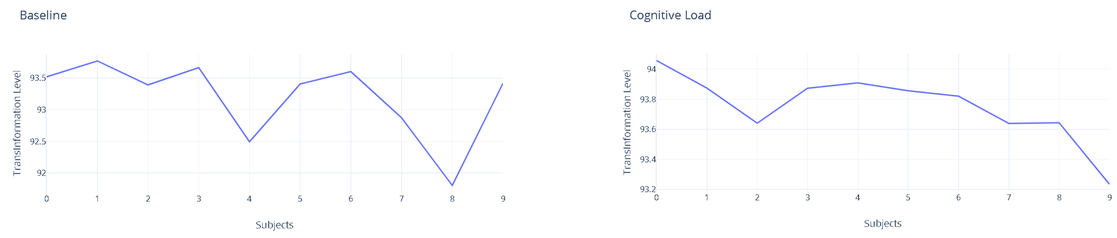
<u>Anaesthesia versus Awakefulness</u>

Global spectrum δ-θ-α-β band: **p= 0.0051**.



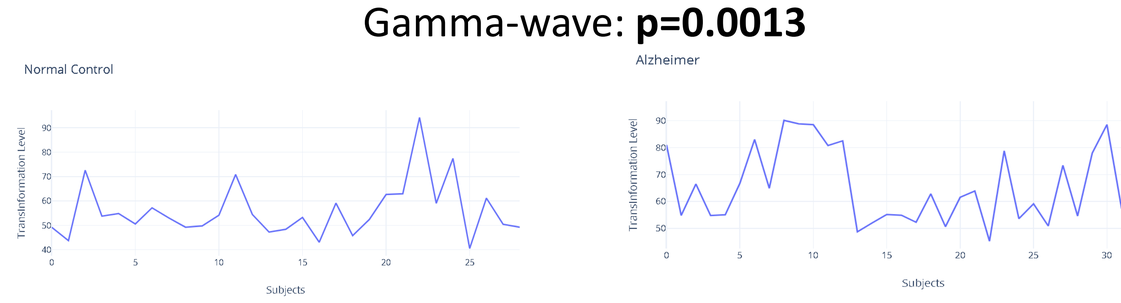
<u>Relaxation versus Cognitive Load (Stroop Test)</u>

Theta-wave**: p=0.0117**; Alpha-wave**: p=0.0193**.



<u>Dementia subjects (Alzheimer's disease) versus Normals</u>

Gamma-wave: **p=0.0013**



Conclusion

- Our approach for measuring neurocognitive salience on a scale of 100 units effectively distinguishes between different clinical conditions ($p \leq 0.01$), highlighting potential usage as a diagnostic tool.
- The developed methodology can be adapted for real-time monitoring of neurocognitive states like anesthesia, wakefulness, cognitive load, relaxation, dementia, and normal states using patch-contacts on the body or headbands.
- Our study showed that transinformation spectral analysis may be a promising tool for assessing and monitoring neurocognitive resilience in challenging clinical or work situations.

References

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