CQFT–HBP Integration: A Reproducible Framework for Quantifying Consciousness Across EEG and fMRI

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Abstract. The *Consciousness Quantified Field Theory* (CQFT) is the quantized extension of the deterministic *Principled Consciousness Field Theory* (PCFT), formalizing consciousness as a measurable, integrative field obeying physical and informational symmetries. CQFT defines four canonical observables—Ψ, K, Λ, and Δ—corresponding respectively to spatial integration, algorithmic complexity, temporal coherence, and causal structure. This document outlines a reproducible protocol to map these theoretical quantities onto neural observables within the Human Brain Project (HBP) and EBRAINS infrastructure using open EEG and fMRI data. The objective is to test whether CQFT metrics systematically discriminate conscious from unconscious states across modalities and datasets.

1. Conceptual Mapping

CQFT Variable	Interpretation	Empirical Proxies and Computation
Ψ	Spatial Integration / Field Amplitude	EEG global field power; fMRI global BOLD; graph-theoretic network integration (global efficiency, participation coefficient).
K	Algorithmic Complexity	Lempel–Ziv complexity, multiscale entropy, PCI when available; derived from broadband EEG or fMRI voxel time-series.
Λ	Temporal Coherence	Phase-locking value, cross-frequency coupling, spectral slope of $1/f$ component; computed per frequency band and time window.
Δ	Directed Causality	Granger causality, transfer entropy, dynamic causal modelling; applied to source-level EEG and fMRI effective connectivity.

2. Minimal Experimental Framework

Public datasets (e.g., Sleep-EDF, LEMON, Human Connectome Project) will be reprocessed using open-source pipelines (`MNE-Python`, `Nilearn`, `NetworkX`). Each dataset yields time-resolved $\Psi(t)$, $K(t)$, $\Lambda(t)$, and $\Delta(t)$ series. Conscious versus unconscious states will be classified via logistic or SVM models using these metrics. Performance (AUC, sensitivity, specificity) will be benchmarked against standard spectral and connectivity

measures.

3. Expected Outcomes

A successful test would show: (i) CQFT metrics reliably differentiate conscious and unconscious states (AUC ≥ 0.8), (ii) cross-modal consistency between EEG and fMRI observables, and (iii) reproducible code and data release under an open scientific license. The work aims to establish a bridge between field-theoretic formulations of consciousness (PCFT/CQFT) and the empirically grounded frameworks of the HBP.

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