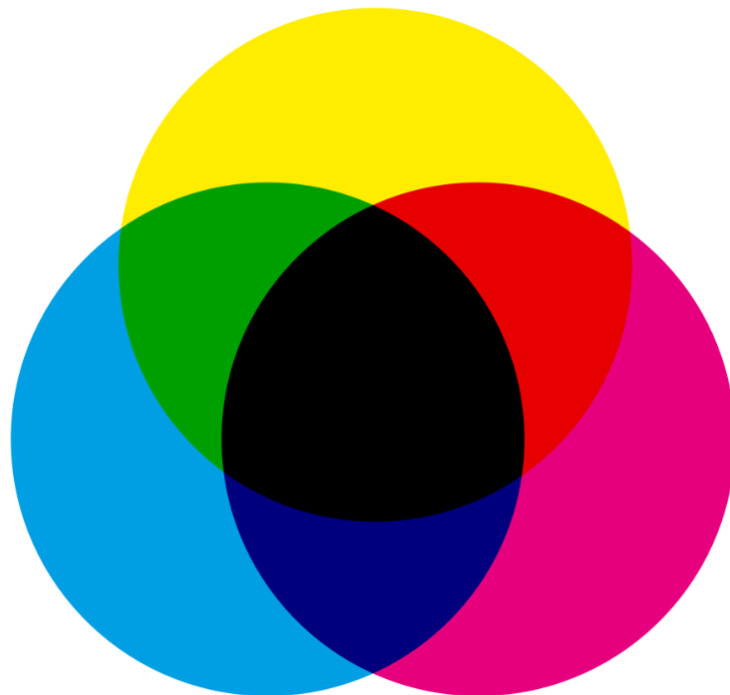




# Introduction to electroencephalography and its use in art installations

*Joep Dols*



# THE UTILITY AND LIMITATIONS OF UNIVERSAL EEG SETUPS IN ART INSTALLATIONS

One of the most versatile brain imaging techniques is electroencephalography, commonly abbreviated as EEG. The term electroencephalography literally translates to the "writing of the electrical activity of the brain." The analogy of "writing" is drawn from the initial methodology used in EEG recordings, where, akin to a seismometer, measurements were documented on paper. Electroencephalography captures the brain's electrical activity using electrodes positioned on the scalp. This monitoring of the brain's electrical activity is invaluable as it mirrors the communication dynamics of the neurons within the brain's intricate network, which interact through electrical impulses.

In terms of temporal precision, EEG excels. Cognitive, perceptual, emotional, linguistic, and motor processes are rapid, typically unfolding within tens to hundreds of milliseconds (far swifter than a simple eye blink). Events that stimulate these cognitive processes also have time frames ranging from hundreds of milliseconds to several seconds. Mirroring the capabilities of a high-speed camera, EEG's superior temporal resolution captures the physiological shifts underpinning these swift cognitive processes far more adeptly than other imaging methodologies, such as MRI or PET scanners.

There are compelling reasons, as outlined by Cohen (2011), that validate EEG's superiority for probing the neurocognitive processes steering human behaviour:

## *Direct Measurement*

EEG provides a direct evaluation of neural activity. Although the electrical activity emanating from our perpetually active brains is subtle, it is discernible with the right equipment. Over time, neuroscience research has yielded consistent results, establishing theories on how EEG signals correlate with processes like cognition, attention, and emotion. Conversely, while modalities like MRI offer superior spatial resolution, they measure neural activity indirectly, necessitating a profound comprehension of the correlation between the readings and cognitive processes.

## *Cost-Effectiveness & Portability*

MRI studies conducted in real-world settings, or "in the wild," are implausible due to the stationary nature of MRI equipment. In stark contrast, EEG systems, with their portability and light weight, offer the flexibility of data collection in diverse, real-world scenarios.

## *Monitoring without Behaviour*

Behaviour is the culmination of brain processes. In cases where the focus is on mental activities such as response inhibition, meditation, or creativity, the resultant behavioural manifestations might be subtle or even negligible. Yet, EEG can detect these processes due to the distinctive electrical brain activation patterns they produce.

Electroencephalography (EEG) serves as a profound tool in comprehending the intricate electrical dynamics of the human brain. Through electrode placements on the scalp, EEG measures the symphonic electrical patterns produced by synchronized neuronal activities. These patterns are reflective of various cognitive states and mental activities.

*Image 1.1: images of our EEG demonstration by project MARCH*



# OVERVIEW OF EEG DYNAMICS

EEG data manifests in several specific waveforms or 'brain waves', each correlating with different states of consciousness:

- Delta waves (1-4 Hz): Associated with deep sleep.
- Theta waves (4-7 Hz): Evident during drowsiness or initial sleep stages.
- Alpha waves (8-13 Hz): Indicative of relaxed yet alert states.
- Beta waves (13-30 Hz): Point towards active cognition and concentration.
- Gamma waves (30-100 Hz): Tied to complex cognitive operations, such as problem-solving or perception.

Beyond these waveforms, EEG has the capability to capture the brain's responses to specific stimuli, known as Event-Related Potentials (ERPs). Consistent stimulus presentations, coupled with EEG recordings, allow researchers to identify and study specific cognitive processes.

## CHALLENGES IN ARTISTIC INTEGRATIONS

However, integrating EEG into unconventional arenas like art installations presents a unique set of challenges, particularly when employing a universal setup that doesn't cater to individual calibrations. Such a generic setup might not account for individual differences in brain anatomy, scalp thickness, or hair density, all of which can influence EEG signal accuracy.

Despite these constraints, several aspects of EEG remain consistent across individuals:

1. Dominant Frequencies: These can help infer general brain states, such as relaxation or focus.
2. ERPs: Despite individual variations, consistent patterns can still be discerned, especially for strong, synchronized responses to stimuli.

## OPPORTUNITIES IN ART INSTALLATIONS

Universal EEG setups within art installations can foster innovative integrations:

1. Real-time Feedback Art: Artwork dynamically changes based on collective EEG data.
2. Collective Consciousness Visualization: Visualizations reflecting the averaged mental states of participants.
3. Interactive EEG Challenges: Encouraging participants to adjust their brain states to influence the installation.
4. Reflective Stations: Participants view their EEG data post-interaction, facilitating introspection.
5. Artistic Data Representations: EEG patterns artistically displayed, transcending traditional data presentations.

Ensuring consistent electrode placements and offering clear instructions can improve data uniformity. Additionally, post-processing tools can refine and standardise data.

## Conclusion

While non-calibrated EEG setups in art installations pose challenges regarding data specificity, they unveil a realm of possibilities for collective experiences. By marrying art with science, these setups create a nexus between aesthetics, cognition, and shared consciousness.

## ESSENTIAL ASPECTS OF EEG DATA PROCESSING

EEG data processing, with its inherent complexity, requires meticulousness. This section elucidates critical facets imperative for effective EEG data processing, encompassing:

1. Pilot Sessions: These ensure efficient system operation, accurate stimuli presentation, and participant comprehension.
2. Clean Data Collection: As underscored by Prof. Steve Luck, the quality of raw data is paramount. Corrections post data collection can never fully compensate for initial inaccuracies.
3. Informed Decision Making: Drawing upon widely referenced literature can guide decision-making regarding data analysis techniques.
4. Artifact Management: Strategies to identify and manage irrelevant data distortions.
5. Statistical Frameworks: The choice of statistical methodologies should resonate with the study's goals.

In summation, while EEG data processing can be intricate, rigorous planning, flawless data collection, and sensible decision-making can harness its full potential, especially in avant-garde contexts like art installations.

# INTRODUCTION TO IMOTIONS ELECTROENCEPHALOGRAPHY

## THE COMPLETE POCKET GUIDE

To this document the "iMotions Electroencephalography: The Complete Pocket Guide." Is attached. This is a comprehensive guide from iMotions.

"iMotions is the world's premier provider of human insights software. Across its desktop, online, and mobile applications, iMotions allow users to collect and analyse human behaviour data through eye tracking, galvanic skin response, facial expression analysis, EEG, EMG, and ECG on one convenient platform. Backed by science, this multi-modal software suite is the most comprehensive human insights tool currently available on the market."

This guide provides a deep dive into the fascinating world of electroencephalography (EEG) and its multifaceted applications. Whether you're a seasoned researcher, a student embarking on your first EEG project, or simply someone intrigued by the intricacies of the human brain, this guide is tailored for you.

Inside, you will uncover:

- An exploration into the relationship between the brain, mind, and behaviour.
- A breakdown of the foundational components that constitute the brain.
- A detailed overview of various brain regions and their associated functions, with a spotlight on Frontal Lobe Activity.
- Fundamental concepts such as voltage, current, resistance, frequency, power, and phase.
- An in-depth look into delta waves and typical studies associated with them.
- A step-by-step guide on collecting EEG data, ensuring its quality, understanding EEG electrodes, and best practices for electrode handling.
- A comprehensive introduction to the renowned 10-20 system of electrode placement.
- Recommendations on choosing the right sampling rate for your research.
- A thorough guide on EEG analysis, highlighting crucial metrics and features.
- And finally, insights to help you kick off your EEG research on the right foot.

Please note that the complete guide is attached to this document, allowing you to delve into each topic in detail at your own pace. This guide will hopefully prove to be an invaluable resource in building your understanding of EEG.