Can We Identify Individuals from Emotional EEG? A Comparative Analysis of Feature Extraction Methods

DREAMER Data Analysis Project

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Abstract

Research Question: The primary objective of this study is to determine whether individuals can be accurately identified based on their EEG responses during emotional stimulation. **Methods:** We analyzed the DREAMER dataset (23 subjects, 18 videos) to test two feature extraction approaches for biometric identification: (1) **Reactivity** (Δ = Stimulus − Baseline) and (2) **Raw State Concatenation** ([Stimulus, Baseline]). We employed a Random Forest classifier to test identifiability and Intraclass Correlation Coefficients (ICC) to measure feature stability. **Results:** The study found that the answer depends entirely on the feature extraction method. The standard "Reactivity" method yielded a poor identification accuracy of **47.34%**. However, the "Raw State" method achieved a remarkable accuracy of **95.89%**. Variance analysis confirmed that the raw EEG signal contains a highly stable "Neural Fingerprint" (ICC ≈ 0.70) that is inadvertently destroyed by the reactivity subtraction process. **Conclusion:** **Yes, individuals can be identified from emotional EEG with high precision (95%).** We conclude that contrary to common practice, preserving the raw baseline state is critical for accurate biometric identification.

1 Introduction

Biometric identification using brain signals ("Brainprint") is an emerging field with applications in security and personalized interfaces. However, a key challenge remains: does the emotional state of the user obscure their identity?

This study addresses the core question: **"Can we identify individuals from their EEG responses during emotional stimulation?"**

To answer this, we investigate whether the unique neural signature of a person persists even when they are experiencing strong emotions (fear, joy, etc.) induced by film clips. We compare two methods to see which one best captures this identity.

2 Methods

2.1 Data Preprocessing

We utilized the DREAMER dataset, comprising EEG recordings from 23 participants watching 18 emotional film clips. Signals were filtered (1–50 Hz) and decomposed into spectral bands (Alpha, Beta, Theta) and Frontal Alpha Asymmetry (FAA).

2.2 Experimental Design

To test identifiability, we extracted features using two competing paradigms:

1. **Method A: Reactivity (Δ).** We subtracted the baseline from the stimulus ($S - B$). This is the standard approach in emotion research.

2. **Method B: Raw States.** We concatenated the baseline and stimulus vectors ($[S, B]$). This preserves the absolute power levels.

3 Results

3.1 Identification Accuracy

We trained a Random Forest classifier to predict the **Subject ID**. The results provide a definitive answer to our research question.

Table 1: Biometric Identification Performance

Method	**Accuracy**	**Can we Identify?**
Statistical Chance	4.35%	No
Method A (Reactivity)	47.34%	Poorly
Method B (Raw States)	**95.89%**	**YES (High Precision)**

3.2 Why Method B Worked

To understand why the Raw States allowed for such high identification accuracy, we analyzed the stability of the signals using the Intraclass Correlation Coefficient (ICC).

We found that the **Raw FAA** (Frontal Alpha Asymmetry) had an ICC of **0.70**, meaning 70% of the signal variance was unique to the individual. In contrast, the **Reactivity FAA** had an ICC of only **0.10**. This proves that the subtraction step in Method A was deleting the very "fingerprint" we were trying to detect.

4 Discussion

The results confirm that EEG signals contain a robust biometric signature, even during emotional processing.

The significant performance gap between Method A (47%) and Method B (96

5 Conclusion

This study conclusively answers the research question: **Yes, we can identify individuals from emotional EEG.** By utilizing raw spectral states, we achieved a 96% identification rate. We recommend that future EEG biometric systems avoid baseline subtraction to preserve the stable neural traits that make each individual unique.