

Real-Time Neurologic Monitoring for mTBI Triage in Austere Combat and En Route Environments

Mark H Myers, PhD

NeuroDyne Inc.



Working with:
24th Special Operations Wing & 59th Medical Wing



Abstract

Introduction - Mild Traumatic Brain Injury (mTBI) remains a significant readiness challenge in operational environments, where it is frequently underdiagnosed due to reliance on subjective assessments and the lack of rapid, objective, field-deployable diagnostic tools.

Capability Description: NeuroDyne has developed a machine learning-powered, wireless EEG platform, SeizureSenz™, that enables real-time neurologic monitoring and triage for TBI in operational environments. The system uses proprietary dry electrodes to capture objective brain activity, replacing subjective assessments with data-driven decision support.

Materials/Technical Approach - EEG signals were acquired using a wireless, dry-electrode platform and processed using machine learning-based signal analysis to identify patterns associated with neurologic impairment. Pilot data from several colleges within the Memphis, TN area provided 35 mTBI subjects that featured TBI injuries from football, soccer and cheerleading activities, and 35 non-injured controls were collected in clinical lab settings to evaluate the system's ability to detect differences in neural activity compared to non-injured control cohorts and TBI cohorts who had gone through rehabilitation.

Results - Measurable differences in neurologic signals between mTBI patients and non-injured controls provided an approximate 5 μ V separation between cohort means. These findings indicate that mTBI is associated with detectable changes in neural activity, including low-frequency shifts and increased cortical amplitude, supporting real-time identification of neurologic impairment. The platform also demonstrated rapid assessment capability, reducing evaluation time by approximately 67% compared to MACE2 protocols (5 minutes vs. 15+ minutes).

Applicability to Medical Roles of Care: The platform supports Role 1 by enabling rapid, objective neurologic assessment to inform triage in austere environments. During en route care, it enables continuous monitoring and status tracking across the continuum of care. At Role 2, it provides objective data to support clinical decision-making and improve readiness for intervention.

Impact to the Warfighter: The platform's mobile algorithms process EEG signals in real-time provides alerts within 5 minutes (Figure 1). NeuroDyne's AI detects subtle neurological patterns that precede clinical systems.



Figure 1. Rapid triage of TBI incidents can bring fast assessment for the Warrior.

Introduction

Based on feedback from neurologists, removing myogenic movement such as head and arm artifacts from EEG is extremely important in a mobile system. A miniaturized electrode PCB using a dry comb electrode provides initial amplification and buffering to the EEG signal before it is applied to the biopotential amplifier. High band-pass filtering and notch filtering are added to remove any artifacts from each EEG electrode. The active electrode is mounted on top of EEG cap and attaches to EEG prong electrodes that attach to scalp on other side of the EEG scalp.



Figure 2. Neurodyne's sensor technology provides EEG data acquisition in the most challenging environments.

Methodology

- AI implementation of **signal filtering** and Signal to Noise Ratio
- Data amplification and **filtering at each electrode**
- High-fidelity dry-electrode signal acquisition by **removing noise from movement and interference**
- Reference and ground connections applied within a **single cap solution**

The active electrode chipset has been revised to enable the following (Figure 3):

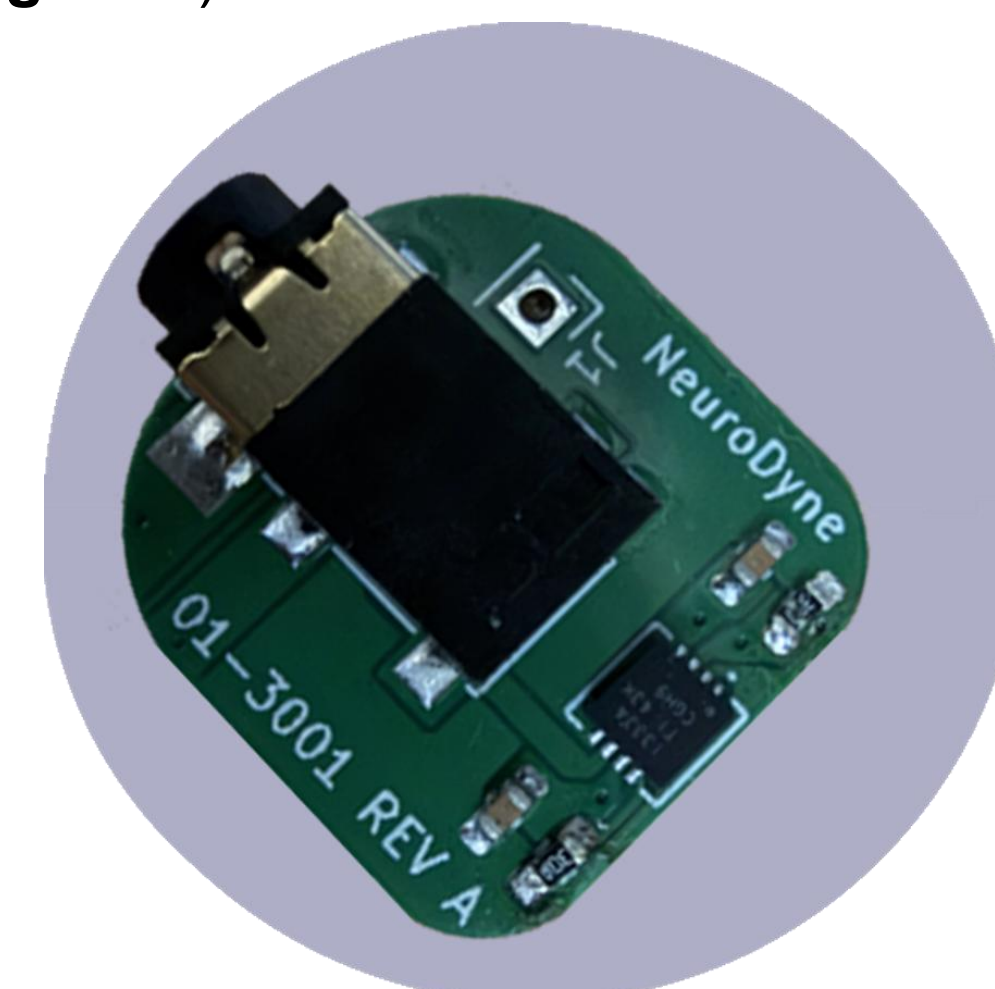


Figure 3. NeuroDyne's active electrode chipset enables real-time signal filtering in order to provide precise location of the EEG signal.

Neural Network Kalman filter for electrodes for noisy environments.

The Kalman Filter enables the estimate of observable and unobservable parameters with great accuracy in real-time. The inputs to the filter are noisy and sometimes inaccurate measurements. The outputs are less noisy and sometimes more accurate estimates. The estimates can be system state parameters that were not measured or observed. Estimates with high accuracy are used to make precise predictions and decisions. For these reasons, Kalman Filters are used in robotics and real-time systems that need reliable information.

We will extend our previous work, which utilized g.tec's dry electrode, to a flexible polymer that maintains scalp contact and compression flexibility. This consists of 7mm conductive coated polymers with 8 probes that attach to our active electrode chip configuration via a clip connector outside of the cap (Figure 4).

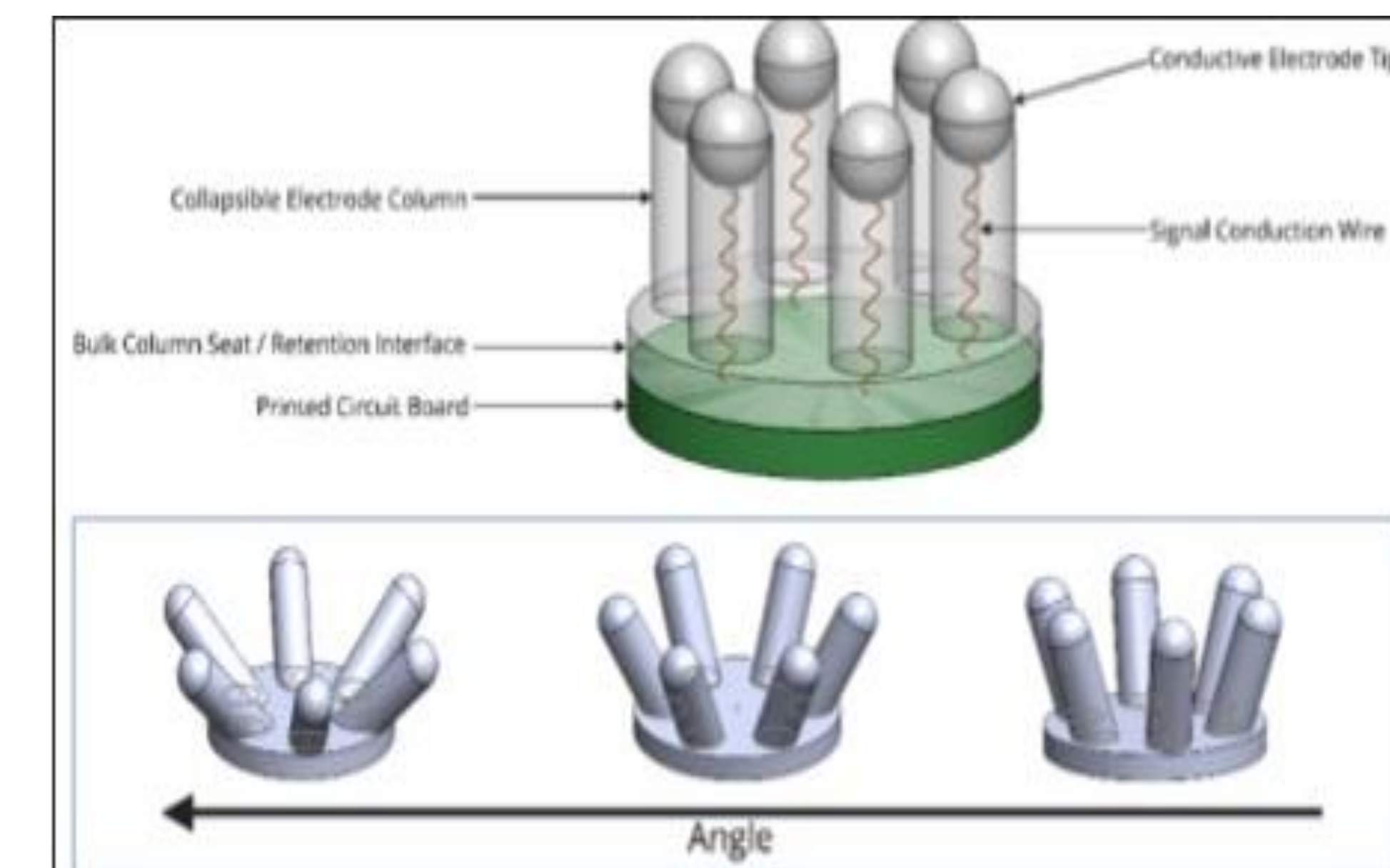


Figure 4. Scalp facing electrode that is collapsable while maintaining scalp connection.

Results

The active electrodes contains an amplifier and buffer circuits integrated to electrodes to provide for NN Kalman filtering thereby enabling greater signal fidelity & signal to noise ratios (SNR). Another example features a comparison between two types of task-based responses where frontal lobe theta activity is compared against g.tec's g.Sahara (dry) electrodes and NN Kalman filter implementation. **NeuroDyne's NN Kalman Filter demonstrated a $\pm 5\%$ power difference from the g.tec dry electrodes (Figure 4).**

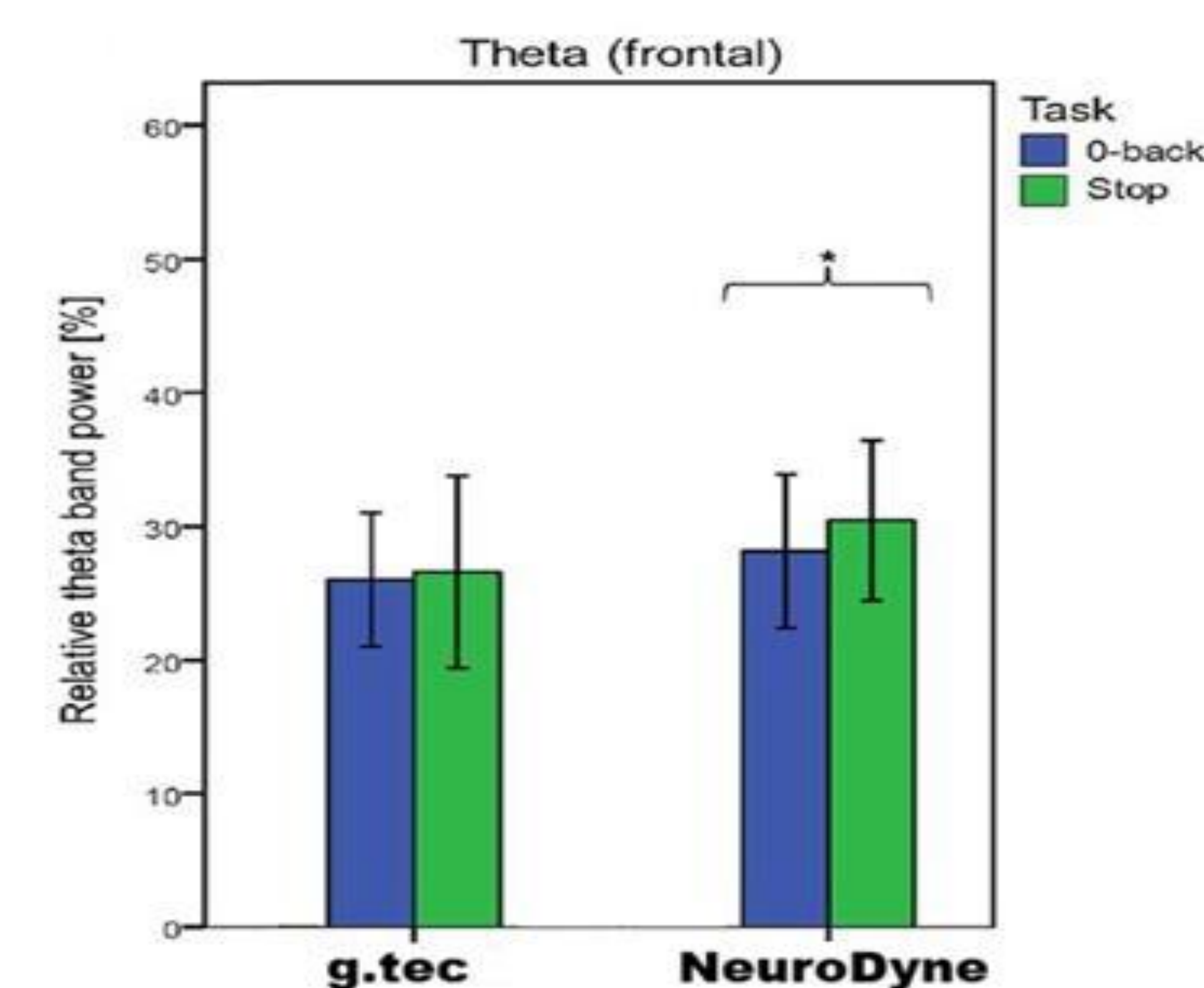


Figure 4. Theta band power responses from frontal lobe with respect to two stimuli types. The g.tec's g.Sahara (dry) and NeuroDyne's electrodes show $\pm 5\%$ power differences: * 0.001 < p $\leq$ 0.01.

We will see additional improvement in signal to noise ration (SnR) and wearability with the implementation of NeuroDyne's scalp facing electrode. The greatest advantage with a flexible scalp facing electrode is real time monitoring in the battlefield to enable rapid triage and assessment.

Conclusion

NeuroDyne's TBI Platform directly addresses this gap through an AI-powered electroencephalographic (EEG) monitoring system that detects TBI by analyzing real-time brain wave activity rather than basing diagnosis solely on clinical assessment (Figures 5 and 6).



Figure 5. Specifications: Inches: 20.22 x 16.38 x 6.1", Weight: 8 lbs.

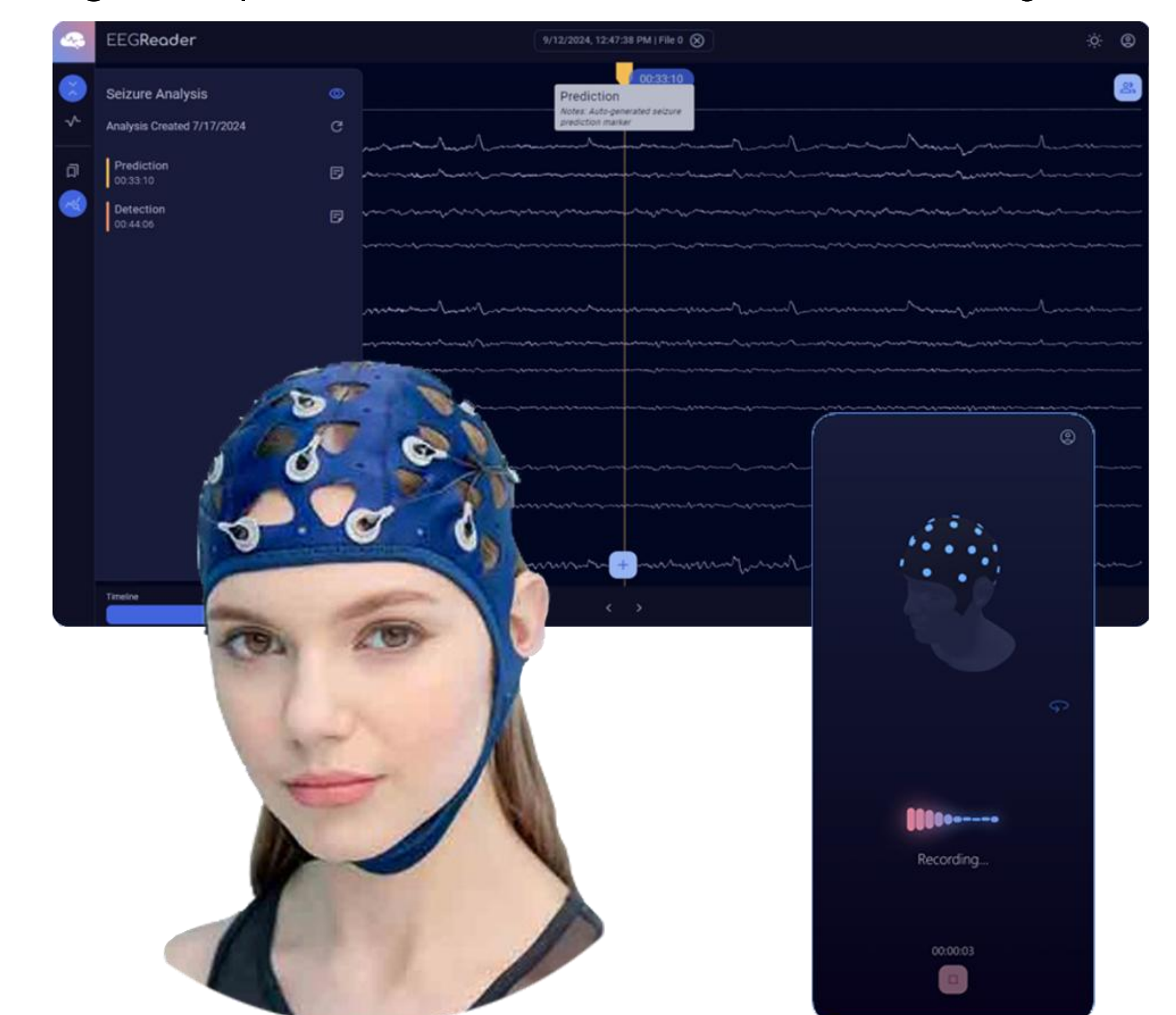


Figure 6. NeuroDyne TBIdeTECT™ AI-Powered EEG Monitoring Platform. The system integrates a wearable dry-electrode EEG cap (left) with a mobile recording interface (right) and cloud-based analytics dashboard (top). The active electrode array enables high-fidelity neural signal acquisition without conductive gels, while the companion mobile app manages real-time data streaming, signal quality monitoring, and secure transfer to NeuroDyne's cloud AI engine for automated event detection and clinical review.