Neuromodulatory Effects of Shiftwave Technology:

An Exploratory Pilot Study of EEG Biomarkers

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Executive Summary

This pilot study investigates the neuromodulatory effects of Shiftwave technology through EEG-based biomarkers—over 20 days.

Participants participated in daily Shiftwave sessions and were assessed via EEG at baseline, after an initial session, and after 20 sessions. EEG markers included spectral neural oscillations, whole-brain neural entropy, and frontal alpha asymmetry (FAA).

Findings reveal a consistent bimodal shift in brainwave activity over time, with increases in delta, theta, and gamma bands and a reduction in alpha activity, patterns linked to relaxation, cognitive alertness, and reduced mental noise.

The study also observed decreased neural entropy across sessions, suggesting a shift toward a more stable and relaxed neural state.

The findings showed an increase in frontal alpha asymmetry (FAA) in 2 of 3 participants, indicating a shift toward positive affect and approach-oriented behaviors, which are beneficial for resilience and emotional regulation.

Further research is recommended to confirm these neuromodulatory effects and explore broader applications.

These preliminary results underscore the neuromodulatory potential of Shiftwave technology for supporting cognitive readiness and stress reduction, particularly for individuals in high-performance roles.

Introduction

Shiftwave technology introduces psychophysiologically validated patterns of pulsed pressure into the body to affect the musculoskeletal, cardiovascular, lymphatic, and autonomic nervous systems, promoting relaxation, enhancing physical recovery, and reducing stress and pain in users.

These pulsed pressure waves activate mechanoreceptors, influencing sympathetic (SNS) and parasympathetic (PNS) activity.

This repetitive stimulation leverages SNS activation, as seen via electrodermal activity, to facilitate targeted autonomic regulation (Boucsein 2012).

Increased heart rate variability (HRV) during and after sessions illustrates Shiftwave's capacity to balance the autonomic nervous system (ANS), reducing stress and promoting recovery.

High-stress roles, such as professional sports and military service, frequently demand rapid shifts between calm and focus, challenging the ANS's regulatory capacity.

Because the ANS state also affects central nervous system (CNS) processes linked to resilience, cognitive performance, and emotional regulation (Thayer 2010), this exploratory study was conducted to assess changes in EEG-based CNS biomarkers due to Shiftwave use.

Study Design and Methodology

Participants and Protocol

Three male adult participants, who underwent 20 daily Shiftwave sessions at Aspen Neuro in Colorado (www.aspen-neuro.com), were assessed across three-time points to evaluate neurophysiological changes in conjunction with Shiftwave use.

1. **Baseline (T1):** Initial measurement prior to Shiftwave use.
2. **Immediate Post-Session (T2):** Measurements following the first session.
3. **Post-20 Sessions (T3):** Final measurements to assess cumulative effects.

EEG data were collected at three intervals for two participants (T1, T2, T3) and at two intervals for the third participant (T1, T3).

Data Processing

The methods employed in the Shiftwave EEG analysis adhere to standard methods of EEG signal processing.

Dehan Elcin, a Ph.D. candidate at Tulane University, conducted the analysis. Initially, raw data was uploaded into EEGLab (Swartz Center for Computational Neuroscience, UC San Diego).

Following established EEG processing protocols, artifacts (e.g., eye blinks and muscle movements) were removed manually, and data channels with noise were excluded to ensure signal accuracy.

Independent Component Analysis (ICA) was employed to isolate brain activity from non-neuronal signals, maintaining the integrity of the data (Hyvarinen & Oja, 2000).

ICA is a common and rigorous method for EEG data processing, aiming to separate the brain's electrical activity from extraneous sources mathematically.

Components showing an 80% or higher likelihood of originating from non-neuronal sources were eliminated.

This meticulous artifact rejection step of data suspected to be non-brain signals ensures that the data used in the analysis reflects genuine brain activity. For example, in the case of participant JT, particular challenges were noted due to high noise levels across several EEG channels, which may affect certain interpretations of JT's EEG data.

The filtered and cleaned data then proceeded to further analyses. Then, the remaining data was processed using FieldTrip (Donders Institute for Brain, Cognition, and Behaviour).

The data underwent a high-pass filter set at 1 Hz and a low-pass filter at 50 Hz to isolate the frequency range most relevant to EEG analysis.

Subsequently, the EEG signals were re-referenced to the average, allowing for a baseline that mitigates the influence of individual electrode placement discrepancies.

EEG data were subsequently introduced into the following analyses:

Oscillatory Power Analysis

To assess the contributions of oscillatory and fractal (1/f) components to spectral power, we decomposed the signal using the Irregularly Resampled AutoSpectral Analysis (IRASA) algorithm as outlined by Wen and Liu (2016). The spectra resulting from both the IRASA and conventional analyses were then segmented into the following frequency bands: EEG data were captured across five primary frequency bands:

- **Delta (1-4 Hz):** Associated with deep relaxation (Sterman 2006).
- **Theta (4-8 Hz):** Linked to meditative states and creativity (Boynton 2001).
- **Alpha (8-13 Hz):** Reflects wakeful relaxation (Klimesch 1999).
- **Beta (13-30 Hz):** Associated with active concentration (Ray 1985).
- **Gamma (30-50 Hz):** Connected to complex cognitive processing (Jensen 2007)

Figures were generated for subtractive differences in values across time points.

Frontal Alpha Asymmetry (FAA):

FAA is a measure of hemispheric asymmetry of alpha wave power in the right prefrontal cortex vs the left, calculated between F3 and F4 channels.

Examining lateralization in alpha power, FAA is a proxy for approach vs. avoidance behaviors and a potential biomarker of mood effects (Davidson 2000).

Neural Entropy

A marker for neural complexity, higher entropy indicates increased brain signal variability across the whole brain.

Calculated using Lempel-Ziv complexity, this quantifies the degree of EEG complexity, reflecting states of focus, meditation, or level of consciousness (Vyšata 2014).

Key Findings

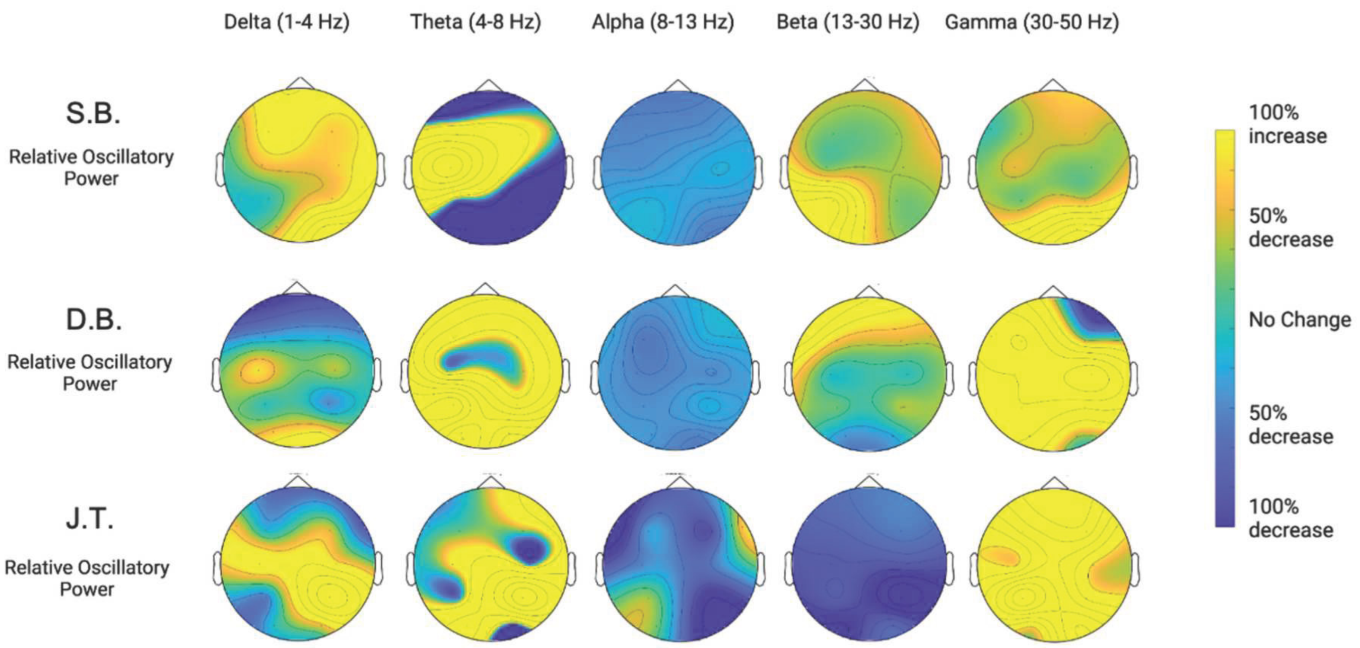
1. Oscillatory Power Shifts: Enhanced Relaxation and Cognitive Readiness

After 20 sessions, participants displayed increased delta and theta power, decreased alpha power, and increased gamma power. These changes form a distinctive bimodal pattern often termed the "disco smile effect" in audio engineering and equalization contexts.

It refers to a frequency equalization profile that boosts the low and high frequencies while reducing midrange frequencies, creating a "smile" shape on a graphic equalizer display.

Of note, this pattern of change is directionally similar to EEG studies in psychedelics, characterized by elevated lower (delta/theta) and upper (gamma) bands with decreased alpha activity (Carhart-Harris 2014).

- **Delta & Theta Increases:** Observed increases in low-frequency bands (delta, theta) indicate a relaxed physiological state, commonly associated with calmness and reduced arousal states such as meditation (Hinterberger 2014).
- **Alpha Decrease:** Across participants, alpha oscillations decreased, potentially reflecting reduced inhibition and greater sensory openness, and reduced internal distraction, often described as "quieting the mind" (Benwell 2017).
- **Gamma Increase:** Gamma band power increases, particularly in the posterior regions, suggest heightened attentional or cognitive processing, reflecting heightened readiness without sedative effects (Kaiser 2005).

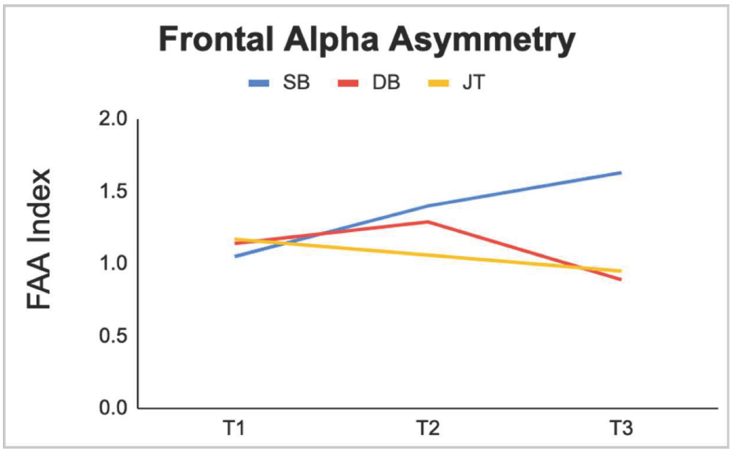


2. Frontal Alpha Asymmetry (FAA): Positive Affect and Approach Behaviors

FAA, a measure of hemispheric lateralization of alpha waves, was calculated between F3 and F4 channels, showing a leftward shift after sessions in two participants.

This leftward shift is commonly associated with positive affective states and approach-oriented behaviors.

Shiftwave may support adaptive emotional responses, including those crucial for resilience in demanding environments (Coan 2004).



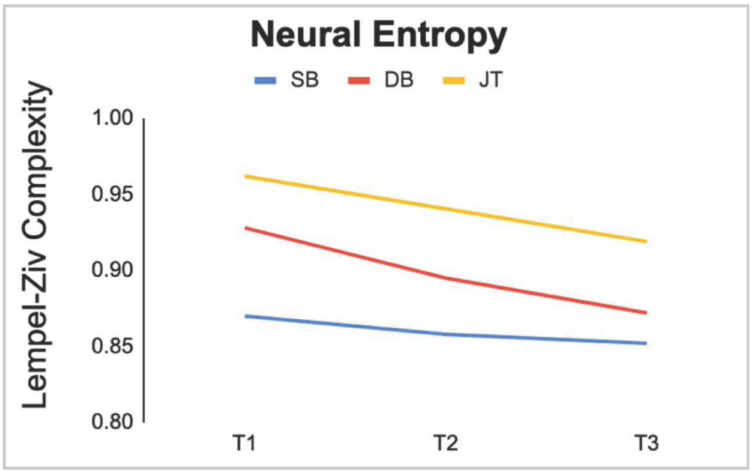
Values >1 indicate leftward asymmetry.
Values <1 indicate rightward asymmetry

3. Neural Entropy Reduction: Stability Without Sedation

Reflecting signal complexity, neural entropy decreased consistently from baseline to final sessions, indicating improved stability and relaxation over time.

Lower entropy aligns with reduced neural complexity and a calmer physiological state, supporting relaxation without diminishing mental clarity—a potential key benefit for users in high-stakes roles where calmness and cognitive readiness are critical.

This reduction in neural entropy is also a pattern seen in meditation practitioners (Madl 2024).



Conclusion and Future Directions

With longitudinal use of Shiftwave, this EEG analysis revealed notable power increases in the delta, theta, and gamma bands, along with reductions in neural entropy and enhanced frontal alpha asymmetry. These shifts suggest a balanced neuromodulatory effect, enhancing cognitive stability while fostering relaxation.

The results of this preliminary study demonstrate that Shiftwave shows significant potential as a neuromodulatory device, a neurocognitive performance enhancement tool that promotes a state of calm readiness.

The limited sample size is a clear constraint of this study, as it restricts the generalizability of the findings and prohibits more rigorous statistical analysis. Additionally, the uncontrolled setting introduces potential variability that could affect EEG interpretations. These limitations underscore the need for further research with more robust design parameters, including sham or placebo interventions.

Future studies should include larger, more diverse participant cohorts to validate these findings and explore Shiftwave's broader therapeutic potential. Incorporating multiple EEG assessments during the trial would help assess the time course of EEG changes, and post-intervention follow-up data collection would help to understand the durability of these effects over time.

Furthermore, integrating the collection of additional affective, neurocognitive, and ANS data are essential for characterizing how the observed neurophysiological changes with psychological, cognitive, and autonomic effects.

Shiftwave's neurocognitive effects show promising potential applications across high-performance settings, particularly in enhancing focus, resilience, and recovery in sports, military, and clinical contexts.

By modulating delta, theta, and gamma waves, Shiftwave may aid athletes in both recovery post-exertion and pre-competition mental preparation, aligning with parasympathetic recovery mechanisms supporting tissue repair and stress reduction (Cheron 2016). In military and defense environments, its ability to reduce neural entropy and promote balanced frontal alpha asymmetry (FAA) supports cognitive clarity and resilience, which are crucial in high-stress, high-alert situations.

Regular sessions could increase baseline stress tolerance during training, with post-mission sessions facilitating faster mental recovery. Also, gamma band power has been shown in battlefield scenarios to enable effective cognitive control and attentional processes (Ko 2016). Clinically, with appropriate studies and regulatory approval, Shiftwave's neuromodulatory properties may benefit individuals experiencing stress-related or cognitive disorders by supporting autonomic and emotional regulation (Porges 2011), and cognitive control.

In summary, Shiftwave presents a promising non-pharmacological approach to autonomic nervous system (ANS) regulation and neuromodulation.

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