

Utilizing BrainScope™ EEG to Detect Blast Overpressure (BOP) Effects in Heavy Weapons Training

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Background: Subconcussive blast exposure (SBE) is a recognized contributor to neurophysiologic dysfunction in military personnel, but objective field-deployable biomarkers remain limited. EEG offers high temporal resolution to capture shifts in neural network dynamics following traumatic brain stress, and EEG complexity is linked to altered brain function across neurologic disorders.

INVICTA used BrainScope™ EEG complexity metrics to detect neurophysiologic changes after SBE in heavy weapons training. Participants, including blast-exposed Special Operators, Range Safety Officers, and two different control groups, completed brief recordings at multiple time points. For each 10-minute recording, the participants were placed in a dark environment and sat still with eyes closed while wearing a single-use BrainScope headset.

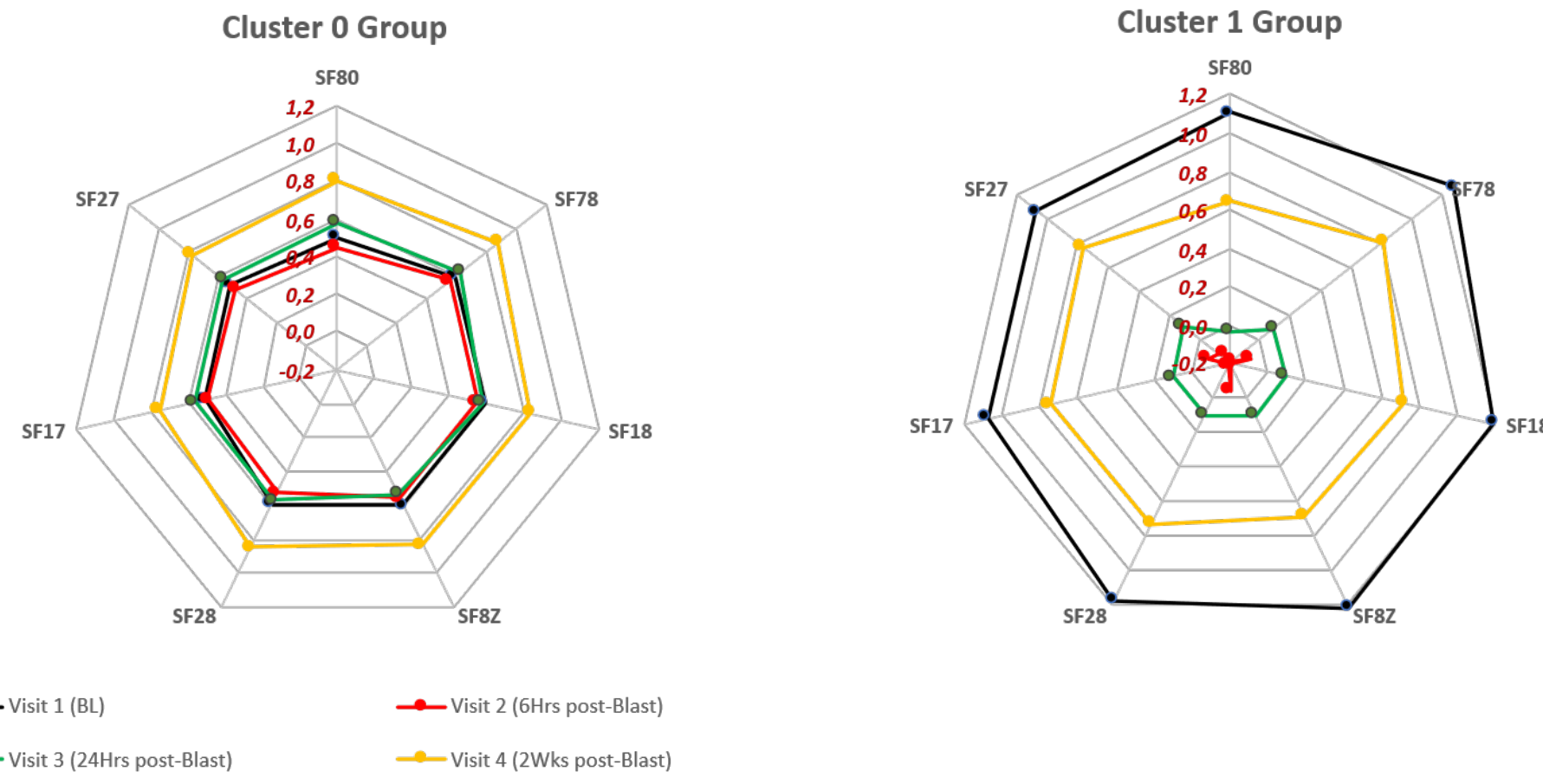
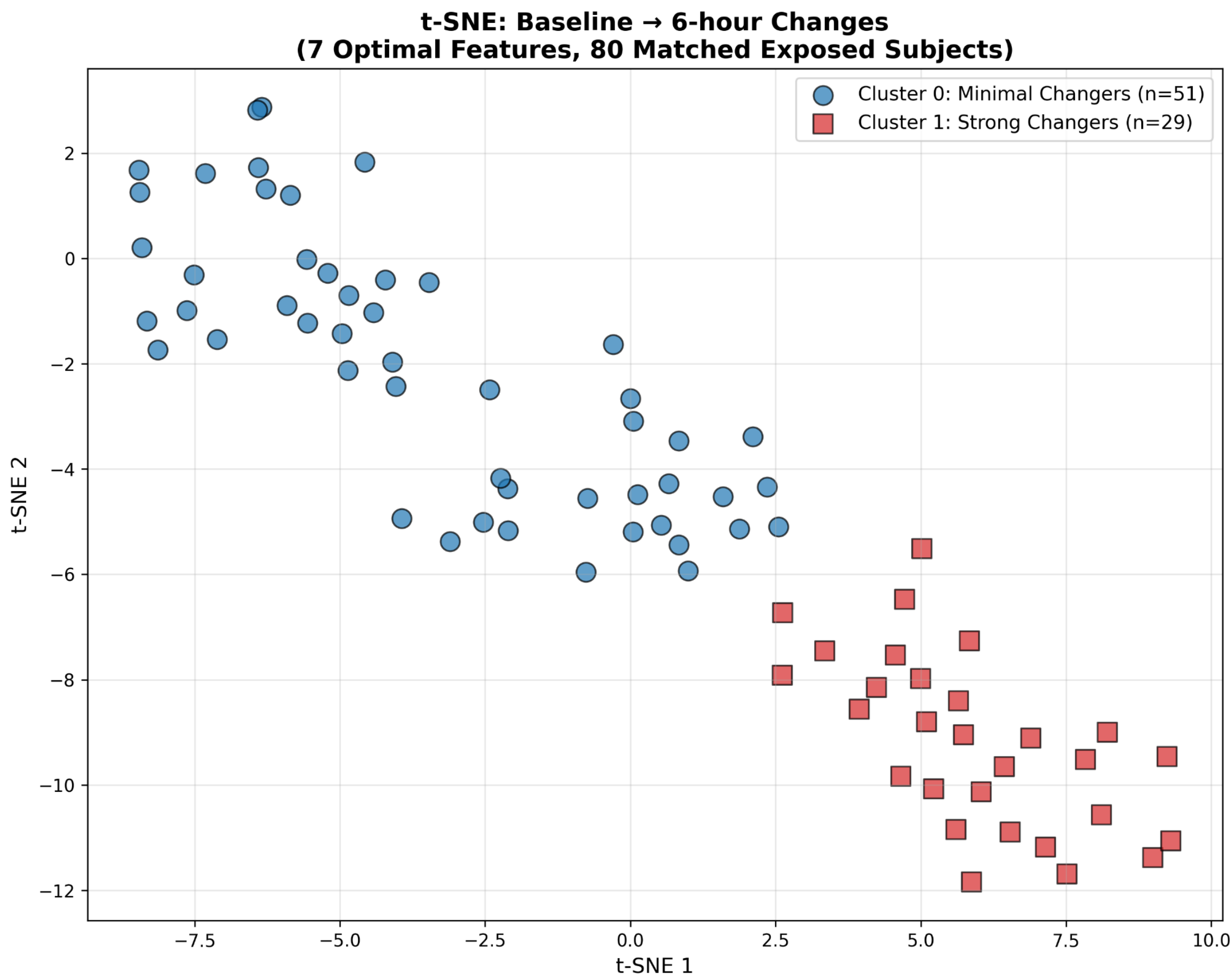


Methods: The dataset included 1,034 longitudinal EEG sessions at five intervals (baseline, 6 and 24 hours, 2 weeks, 3 months post-exposure). Cohorts consisted of blast-exposed personnel (n=92), Range Safety Officers (n=34), and training (n=42) and naïve (n=35) controls. Two minutes of artifact free EEG data were analyzed for scale-free complexity features across frontal and DLPFC channel pairs. Within-group and between-group comparisons were performed using paired tests and Wilcoxon statistics with false discovery rate correction. Clustering and dimensionality-reduction analyses (t-SNE) were used to identify response phenotypes among exposed participants.

Results: BE participants showed significant, acute shifts in EEG complexity (frontal–DLPFC) vs. controls. Neurophysiologic differences were noted between baseline and 6 & 24 hours post-exposure across multiple complexity features (p ≤ 0.0033), while controls demonstrated no comparable changes. Intra-group analysis identified 18 feature alterations in BE personnel (effect sizes: –0.8 to 0.7). Unsupervised clustering revealed two phenotypes: a minimal-change subgroup (64%) and a strong-change subgroup (36%) with large effect sizes (|d|=1.5–2.2) at 6 hours. Further analyses showed partial normalization of complexity measures by 2 weeks to 3 months post-exposure.

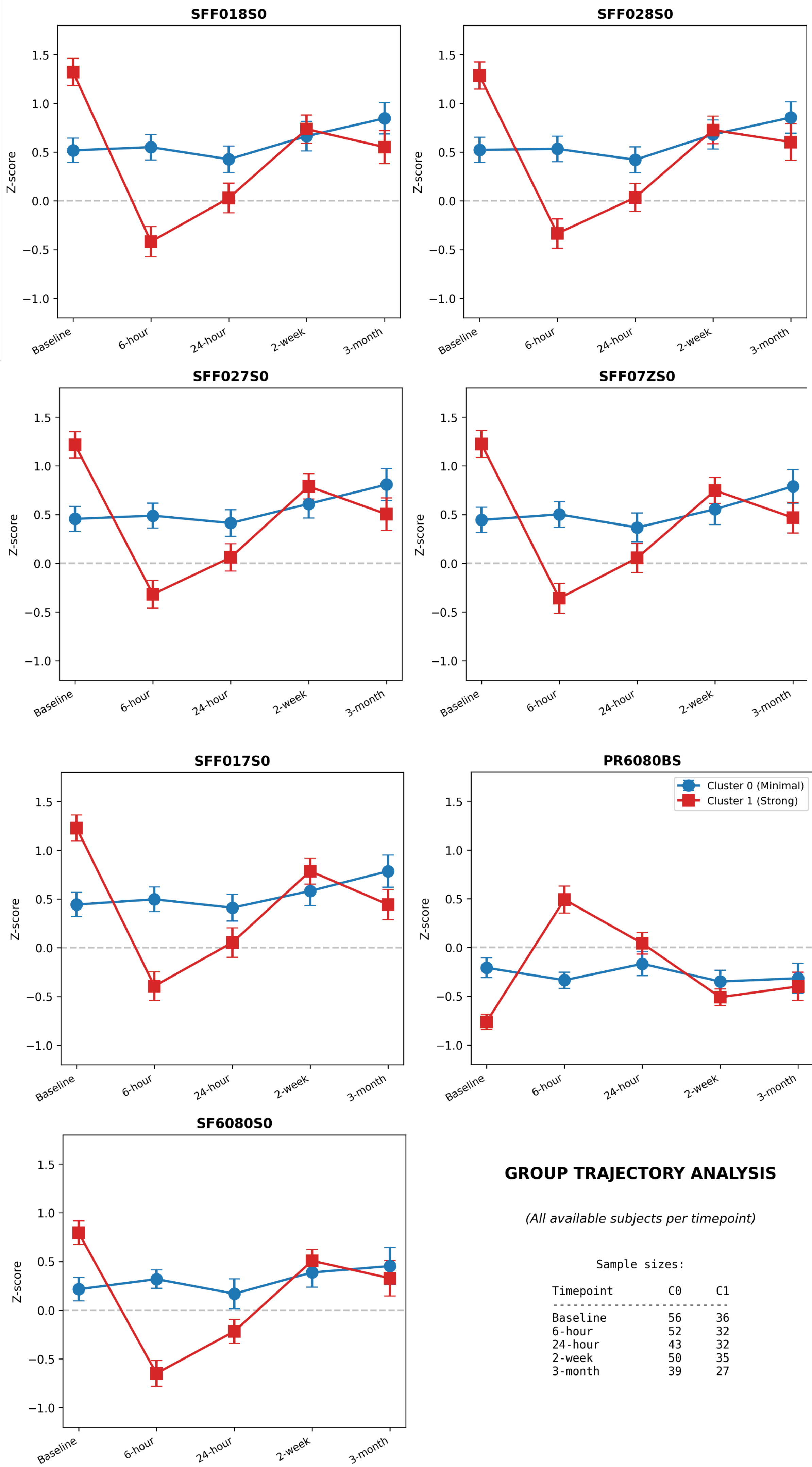
1. Exposed Operators (n = 94)			
EEG Metric	Pre-Blast vs. 6 Hours	Pre-Blast vs. 24 Hours	Pre-Blast vs. 2 Weeks
SF78	0.0003	0.0033	0.813
SF17	0.0006	0.02	0.9644
SF27	0.0005	0.0148	0.9128

2. Training Controls (n = 45)			
EEG Metric	Pre-Blast vs. 6 Hours	Pre-Blast vs. 24 Hours	Pre-Blast vs. 2 Weeks
SF78	0.3774	0.9239	0.4739
SF17	0.3455	0.9529	0.3455
SF27	0.5335	0.9964	0.6186



CLUSTER 0 GROUP (n=51)	Pre-Blast vs 6 hrs Post	Pre-Blast vs 24 hrs Post	Pre-Blast vs 2 wks Post Blast
SF78	0.8234	0.9044	0.3928
SF17	0.9302	0.8455	0.5033
SF27	0.8906	0.8906	0.4367

CLUSTER 1 GROUP (n=29)	Pre-Blast vs 6 hrs Post	Pre-Blast vs 24 hrs Post	Pre-Blast vs 2 wks Post Blast
SF78	0.000000815	0.00000709	0.07543
SF17	0.000000253	0.0002	0.1336
SF27	0.000000517	0.0001	0.1774



Conclusions: EEG complexity metrics derived from BrainScope™ detect acute and heterogeneous neurophysiologic responses to SBE. These findings support EEG-based complexity measures as promising objective biomarkers for monitoring brain effects of SBE, identifying individuals with heightened sensitivity. Such tools may enable operational monitoring and improved risk stratification in military training environments

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