Target-Related Alpha Attenuation in a Brain-Computer Interface (BCI) Rapid Serial Visual Presentation (RSVP) Calibration Task

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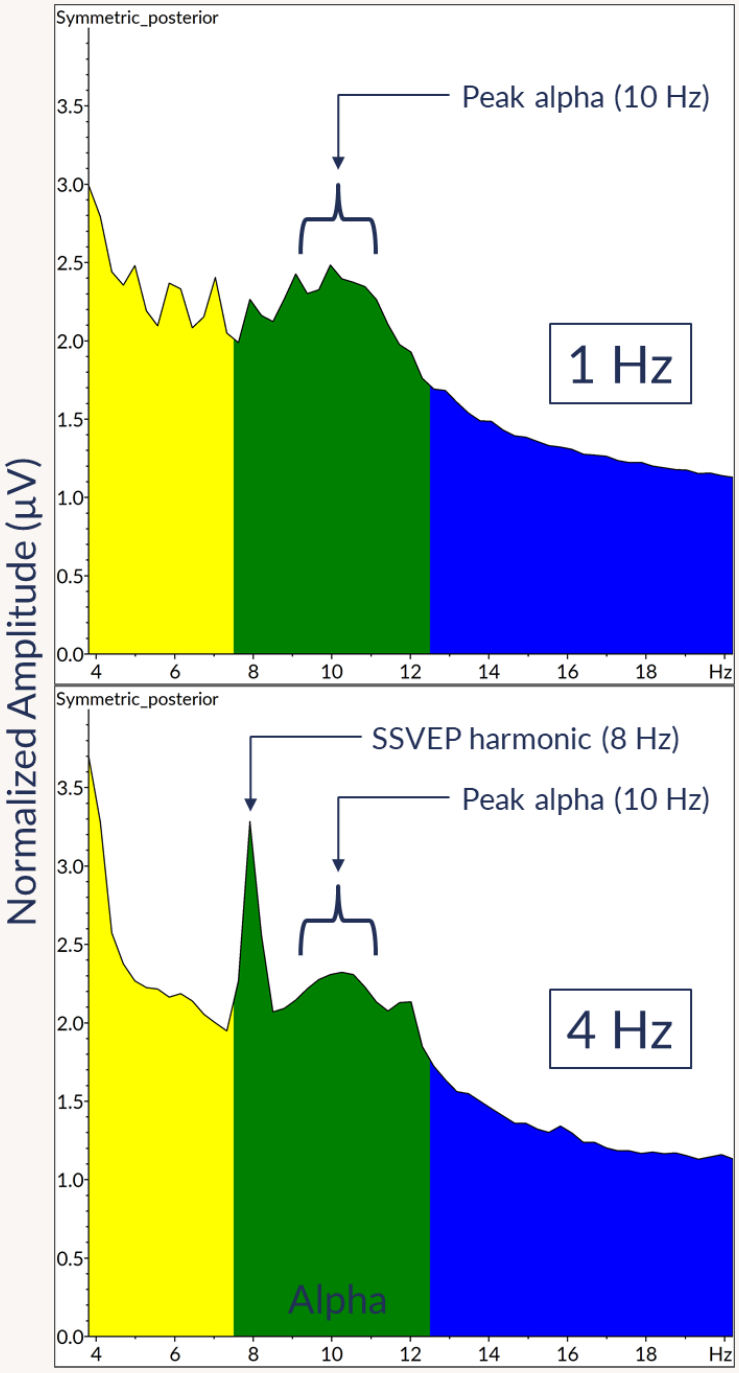
Background

- BCI systems assist users with communication and movement
- BciPy RSVP Keyboard uses ERP data for spelling (Memmott et al., 2021; Oken et al., 2014)
- Posterior alpha is a well-studied brain oscillation and amplitude is sensitive to visual attention effects (Feldmann-Wüstefeld & Awh, 2020; Klimesch, 1999; Silas et al., 2019)
- Posterior alpha rhythms not commonly integrated with RSVP speller systems, which often utilize ERPs, SSEPs, and motor imagery (Rezeika et al., 2018)

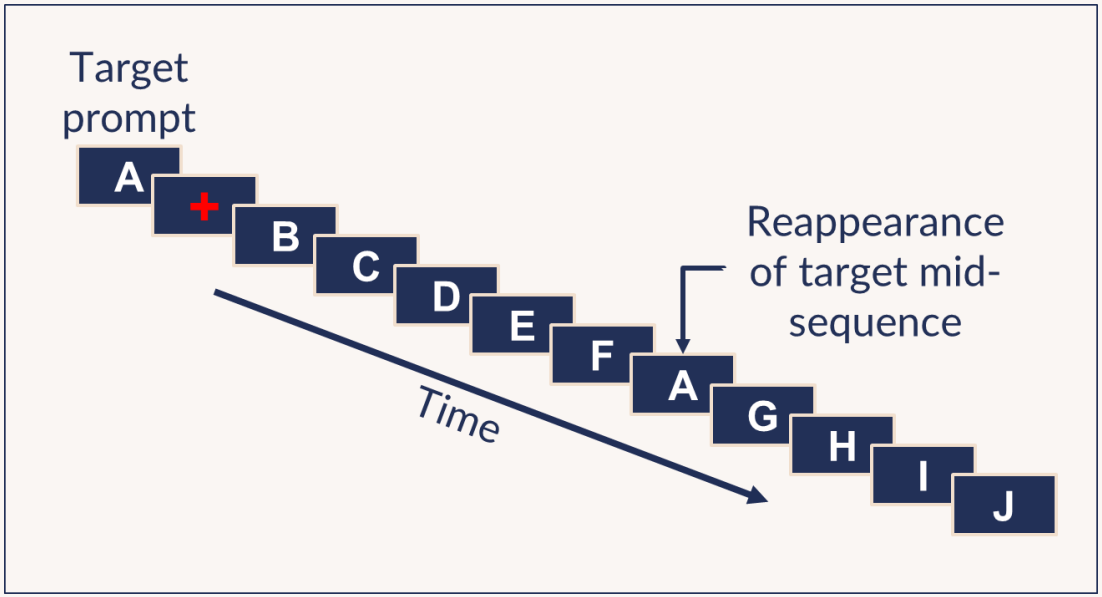
Research Questions

- Are posterior alpha attention effects measurable in RSVP?
- Does presentation rate affect alpha attention effect?
- To what extent do alpha attention effects correlate with coincident ERP changes?
- Can alpha effects be used for target/non-target classification?



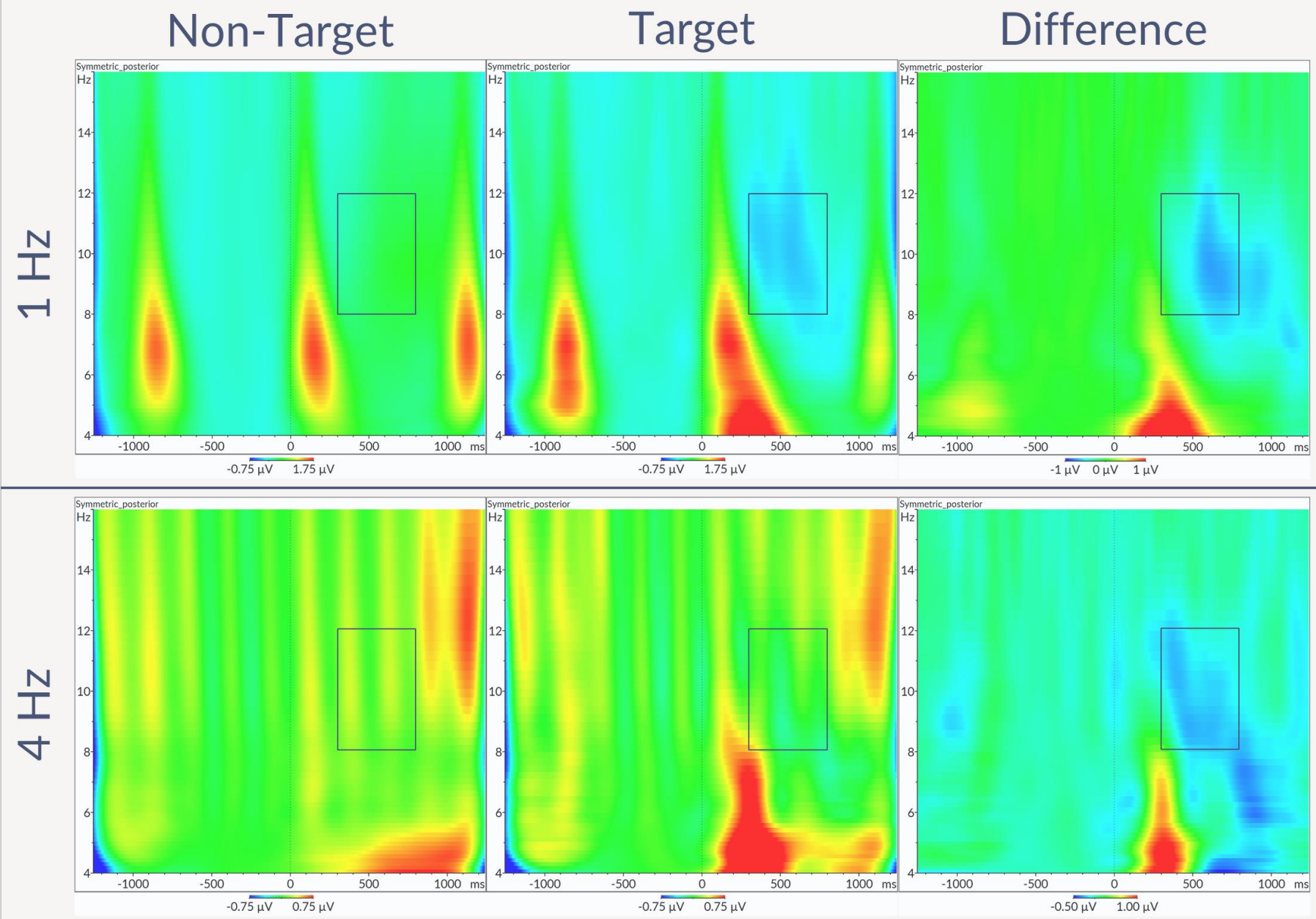
Methods

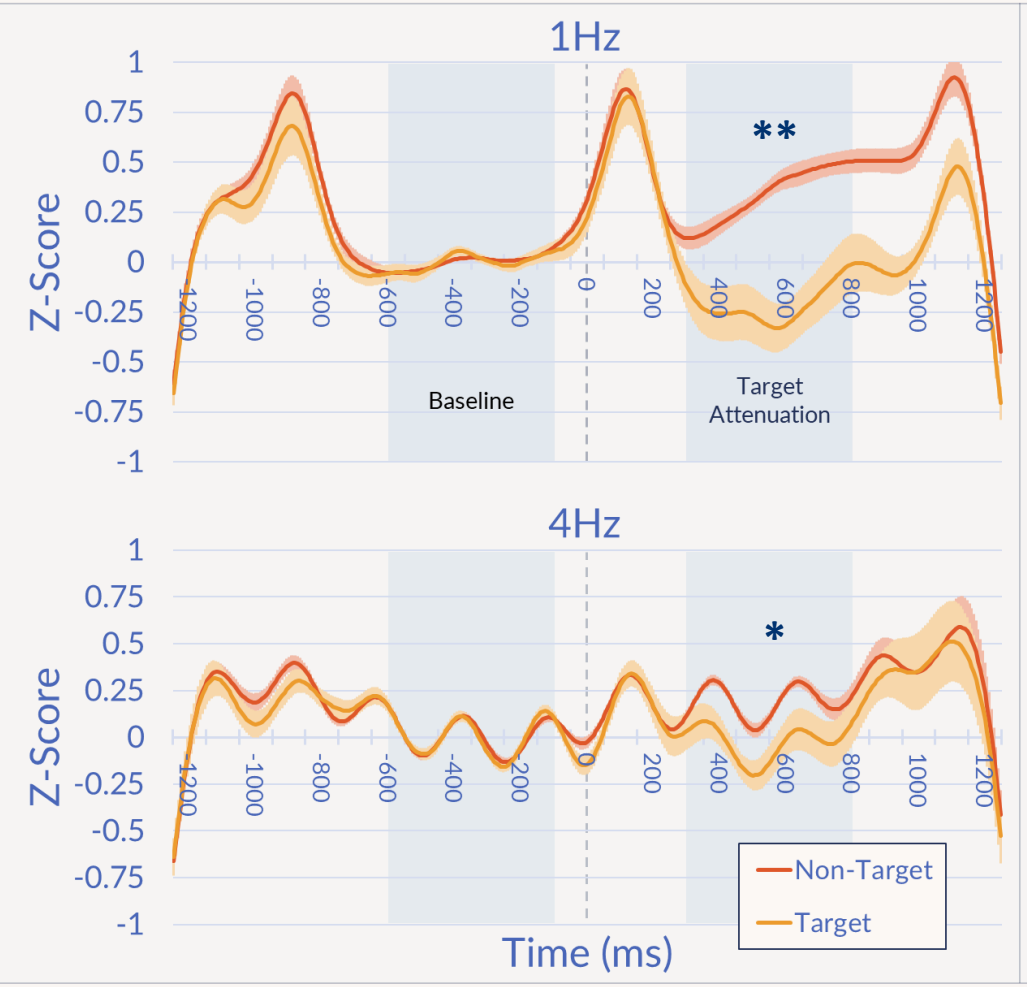
- n = 12 generally healthy adults
- RSVP presented at 1 Hz and 4 Hz
- EEG from dry-electrode VR-300 (Wearable Sensing)
  - fs = 300 Hz; filter 1-45 Hz (w/ 60 Hz notch) and downsampled to 150 Hz; pooled Pz, Oz, PO7, and PO8

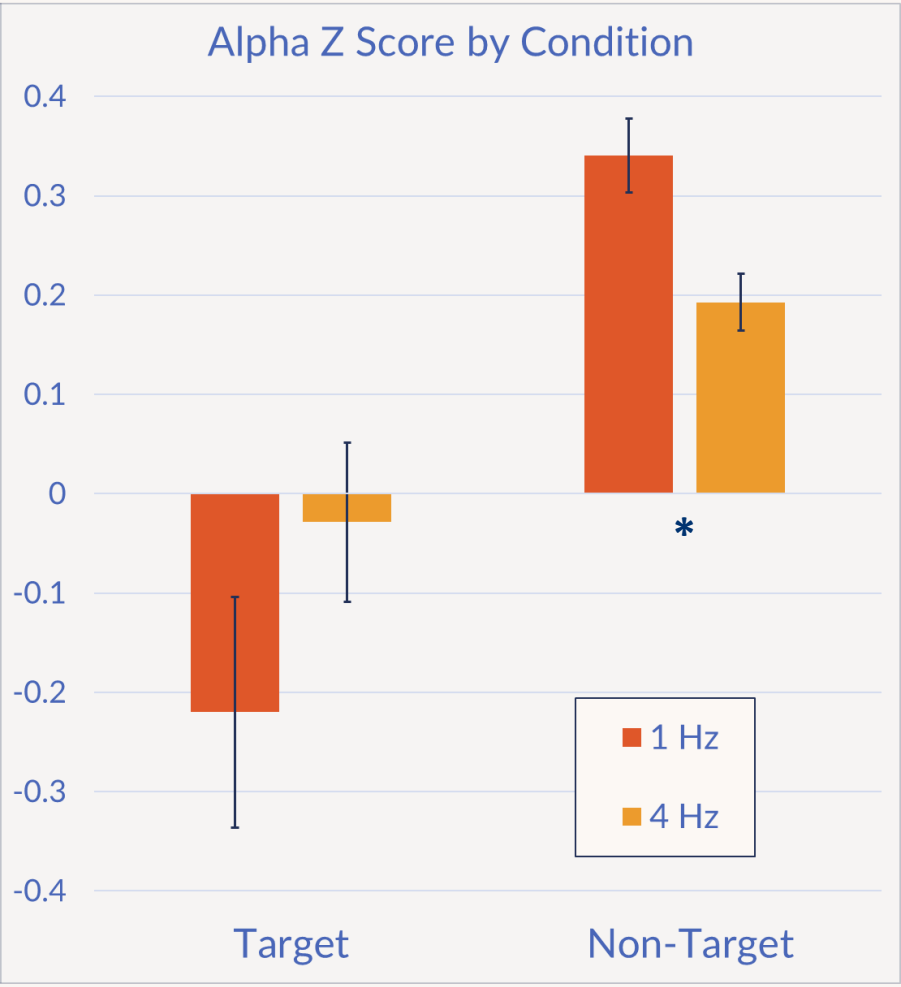


RSVP Keyboard Calibration

EEG Alpha Attenuation



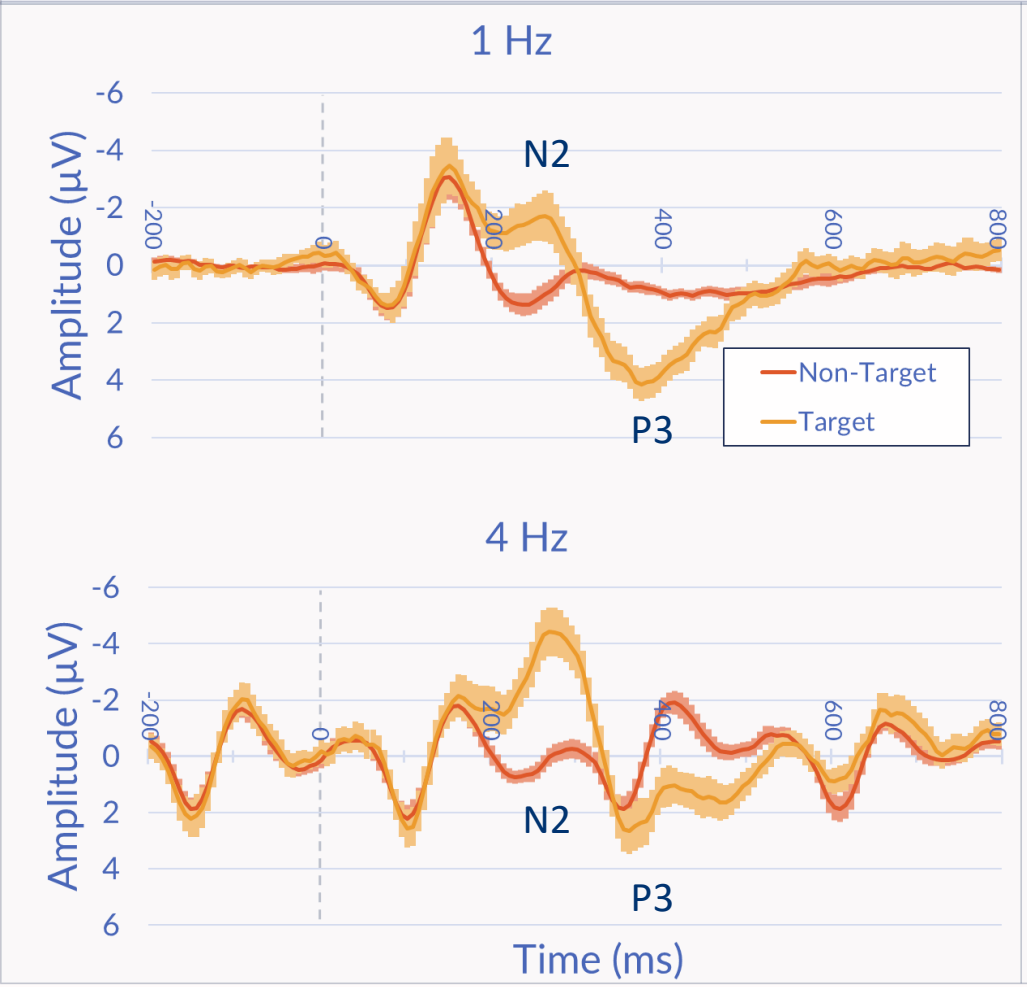


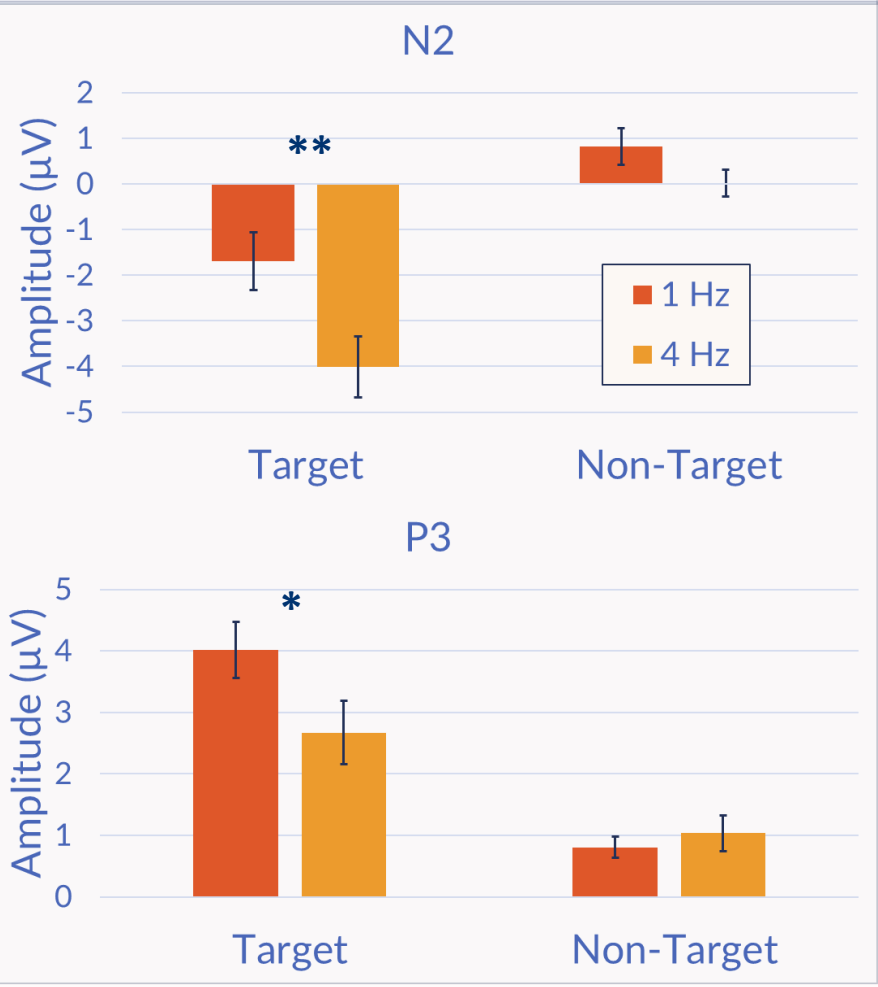


- Within-participant effects were significant for 6/12 sessions at 1 Hz, and 4/12 sessions at 4 Hz
  - 2 trending at 1 Hz ($p < .10$), but one showed alpha *increase* for target stimuli
  - 3 trending at 4 Hz ($p < .10$) all correct direction of effect)

*$p < .05$
**$p \leq .001$

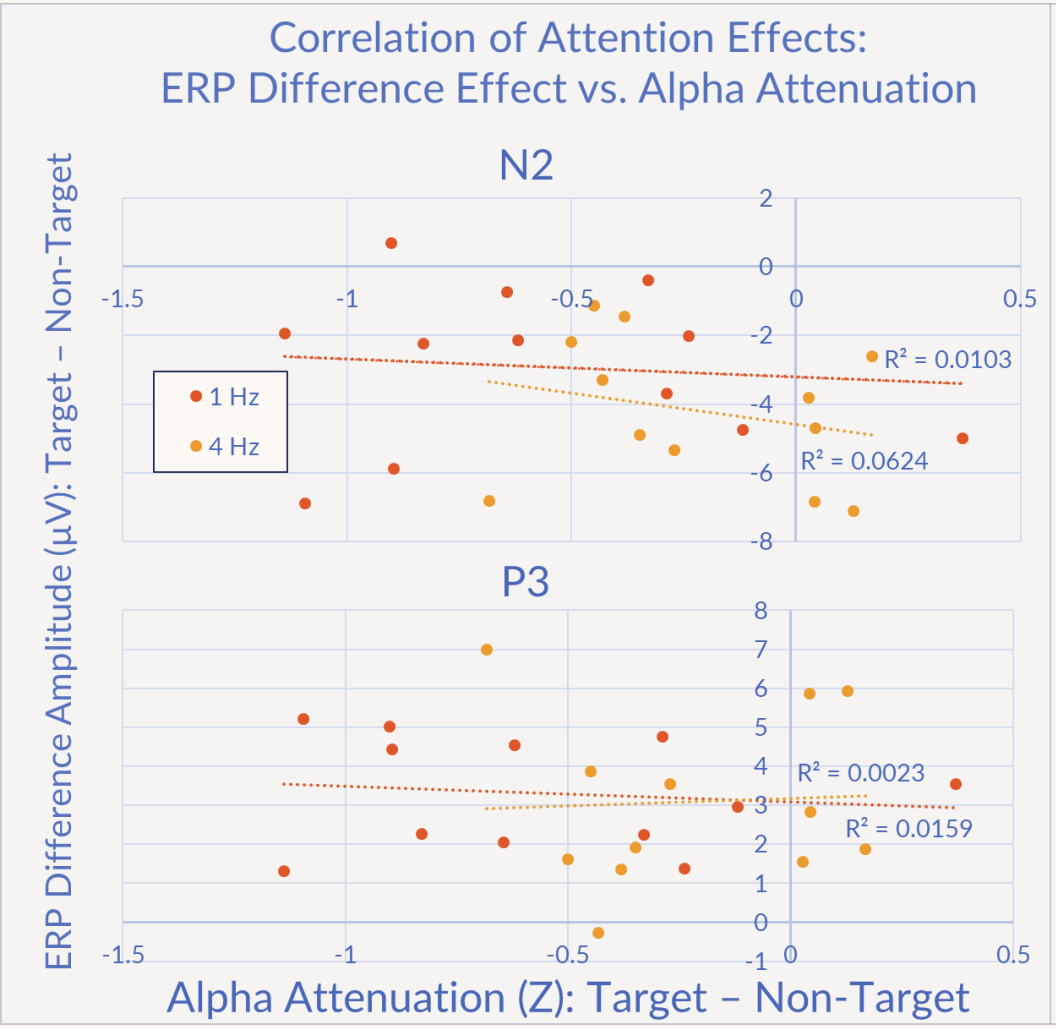
ERPs

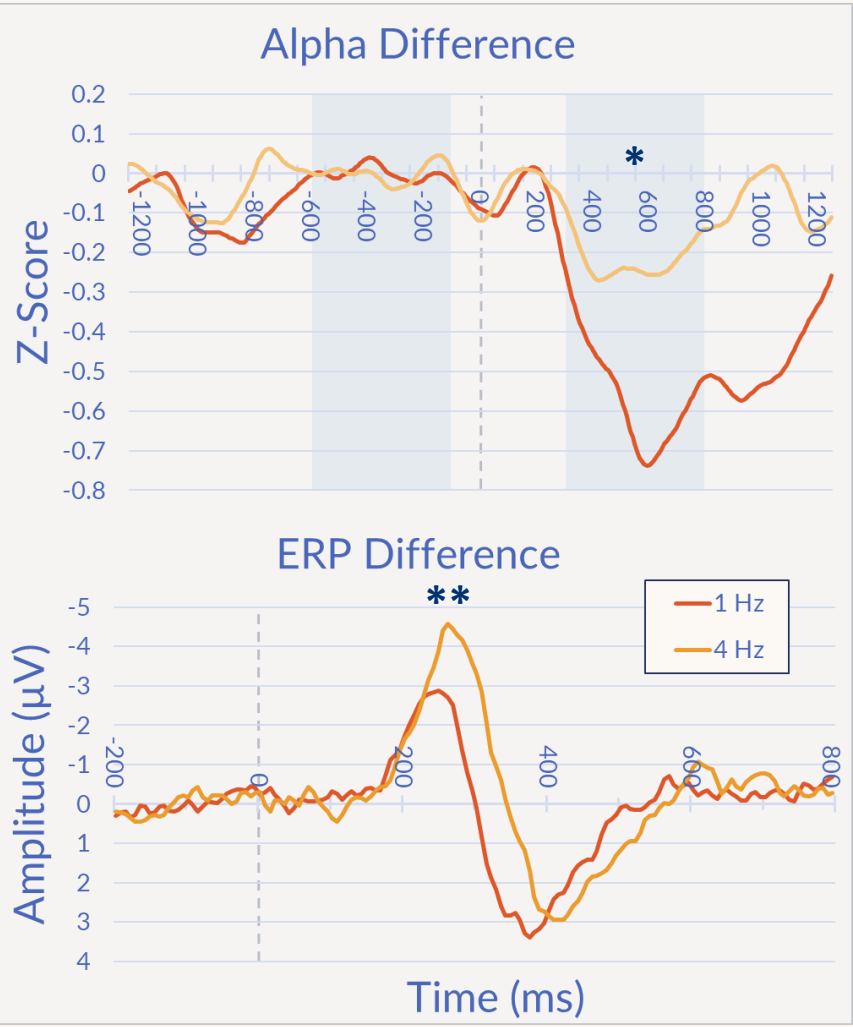




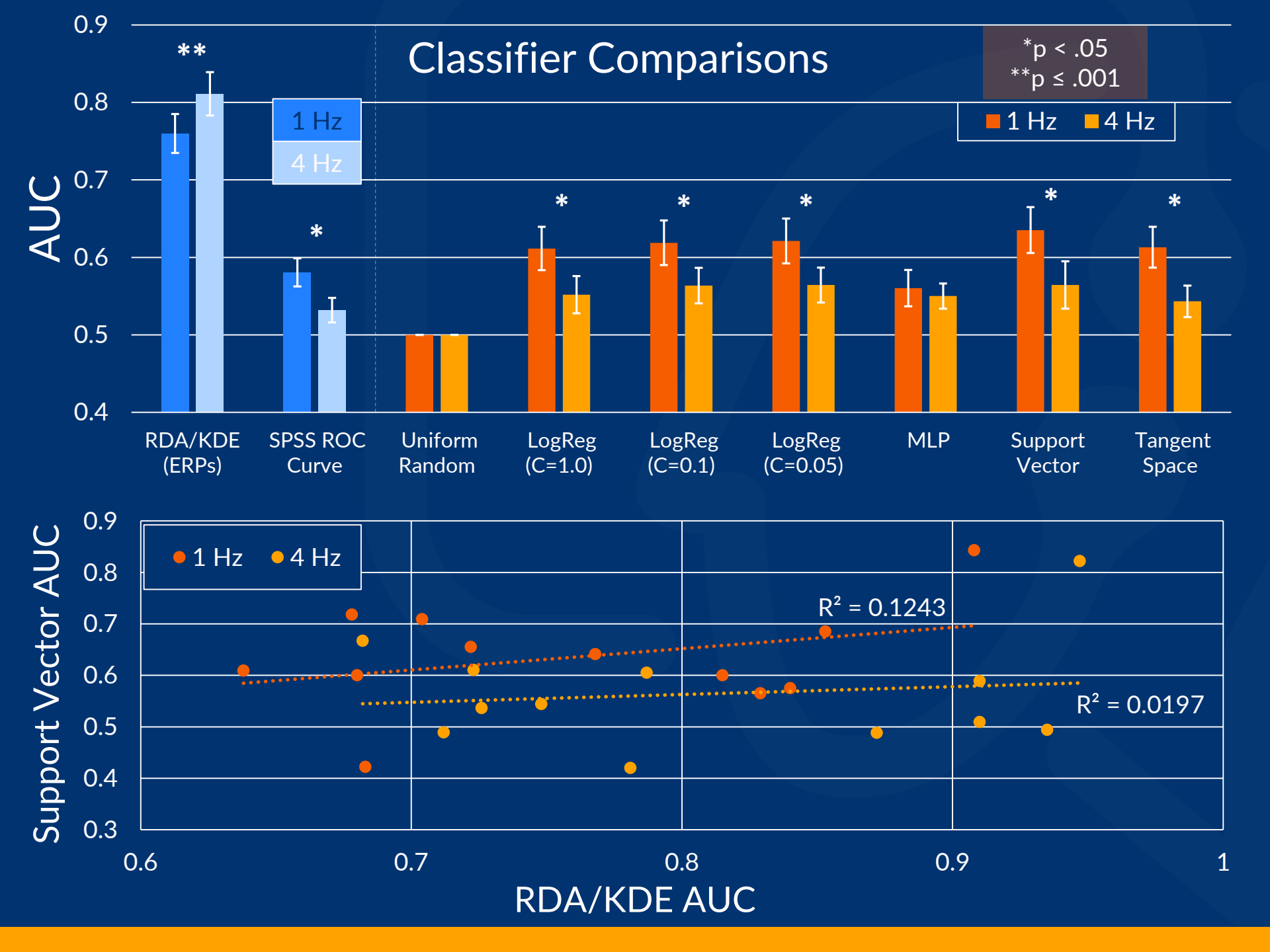
*p < .05
**p ≤ .001

Comparison of Attention Effects





*p < .05
**p ≤ .001


Classifier Comparisons
*p < .05
**p ≤ .001
1 Hz
4 Hz
AUC
0.9
0.8
0.7
0.6
0.5
0.4
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*
*
*
*
*
*
RDA/KDE (ERPs)
SPSS ROC Curve
Uniform Random
LogReg (C=1.0)
LogReg (C=0.1)
LogReg (C=0.05)
MLP
Support Vector
Tangent Space
Support Vector AUC
0.9
0.8
0.7
0.6
0.5
0.4
0.3
R² = 0.1243
R² = 0.0197
0.6
0.7
0.8
0.9
1
RDA/KDE AUC

Conclusions

- Alpha ERD effect is measurable across and within-individuals for target vs. non-target letters in RSVP and is sensitive to stimuli presentation rate
- N2 & P3 ERP attention effects are unrelated to attentional alpha ERD effects
- Target/Non-Target classification of alpha changes is poor in isolation when compared to classification of ERP time-series data, possibly due in part to individual differences in the time course of target-related alpha attenuation
- Future investigations should pursue optimization and individualization of alpha ERD classification and also integration of alpha with ERP signals

Thank You!

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