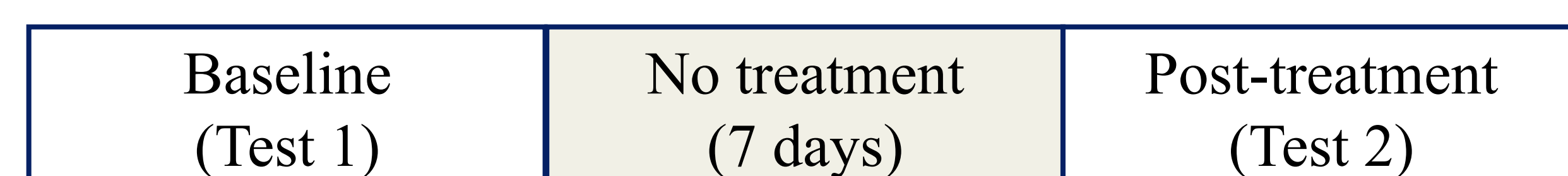


## Introduction

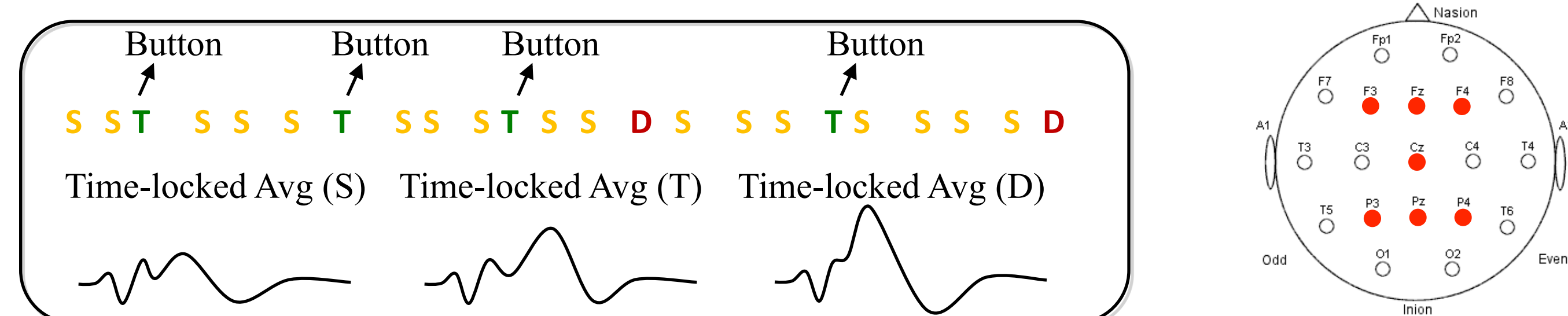
Popularity of energy drinks (EDs) has dramatically increased among college students in recent years. However, their effects on cognition have not been extensively characterized. Event-related potentials (ERP) and quantitative EEG (qEEG) are cutting edge technologies that provide objective measures of cognitive function. In this study, we are using ERP and qEEG to quantify the pro-cognitive effects of EDs. We are investigating: 1) patterns of consumption of EDs in college students; 2) college student's perception of ED effects; 3) ED effects on ERP and qEEG measures; and 4) contribution of sugars to the cognitive effects associated to ED.

## Material and Methods



- Survey (40 questions)
- 2 deviant auditory oddball
- 3 min resting EEG
- ED classic (8.4 oz.)
- ED sugar free (8.4 oz.)
- Placebo

• **Experimental Paradigm:** Research participants were tested using a two-deviant, active, auditory oddball paradigm as described by Cecchi et al. (2015).



• **Testing Procedures:** Electroencephalographic (EEG) activity was recorded from 7 electrode sites (Fz, Cz, Pz, F3, P3, F4, and P4) of the international 10-20 system using a COGNISION™ Headset (Neuronetrix). ERP and EEG data were analyzed using the COGNISION™ Software.

## Results

1

### Caffeine consumption

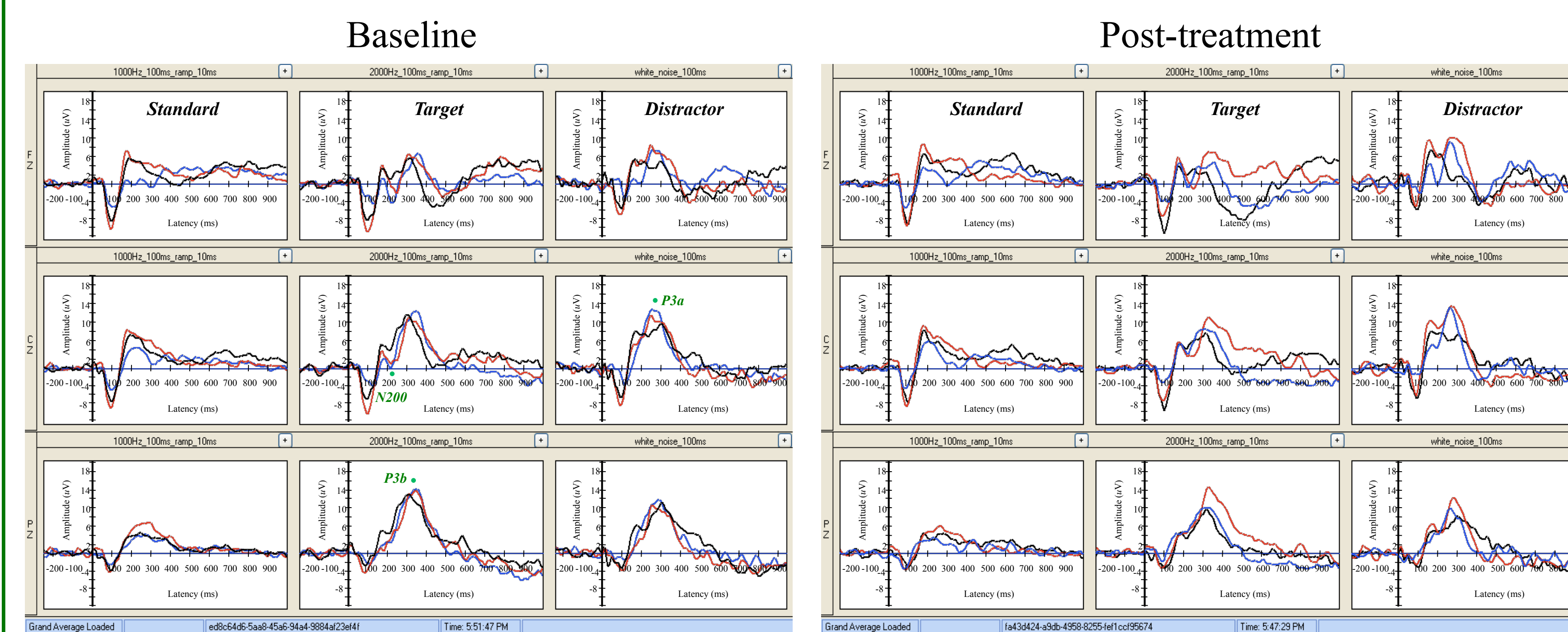
**Participants.** Sixteen African American college students (2 males, 14 females), 19-24 years of age, were surveyed about their pattern of consumption and perception of popular caffeinated beverages.

	Consumption
Caffeinated drinks (such as sodas, energy drinks, teas, etc.)	70,6%
Energy drinks	35%
Consumption during Exams period	53%

	Caffeine content (mg)	Perceived caffeine content
Coca-cola (12 oz.)	34.5	5 times higher
Diet coke (12 oz.)	45	3 times higher
Red Bull (8.4 oz.)	80	3 times higher
Cocaine energy drink (8.4 oz.)	280	comparable
Green tea (8 oz.)	25	4 higher

2

### Grand Average ERP waves before and after treatment

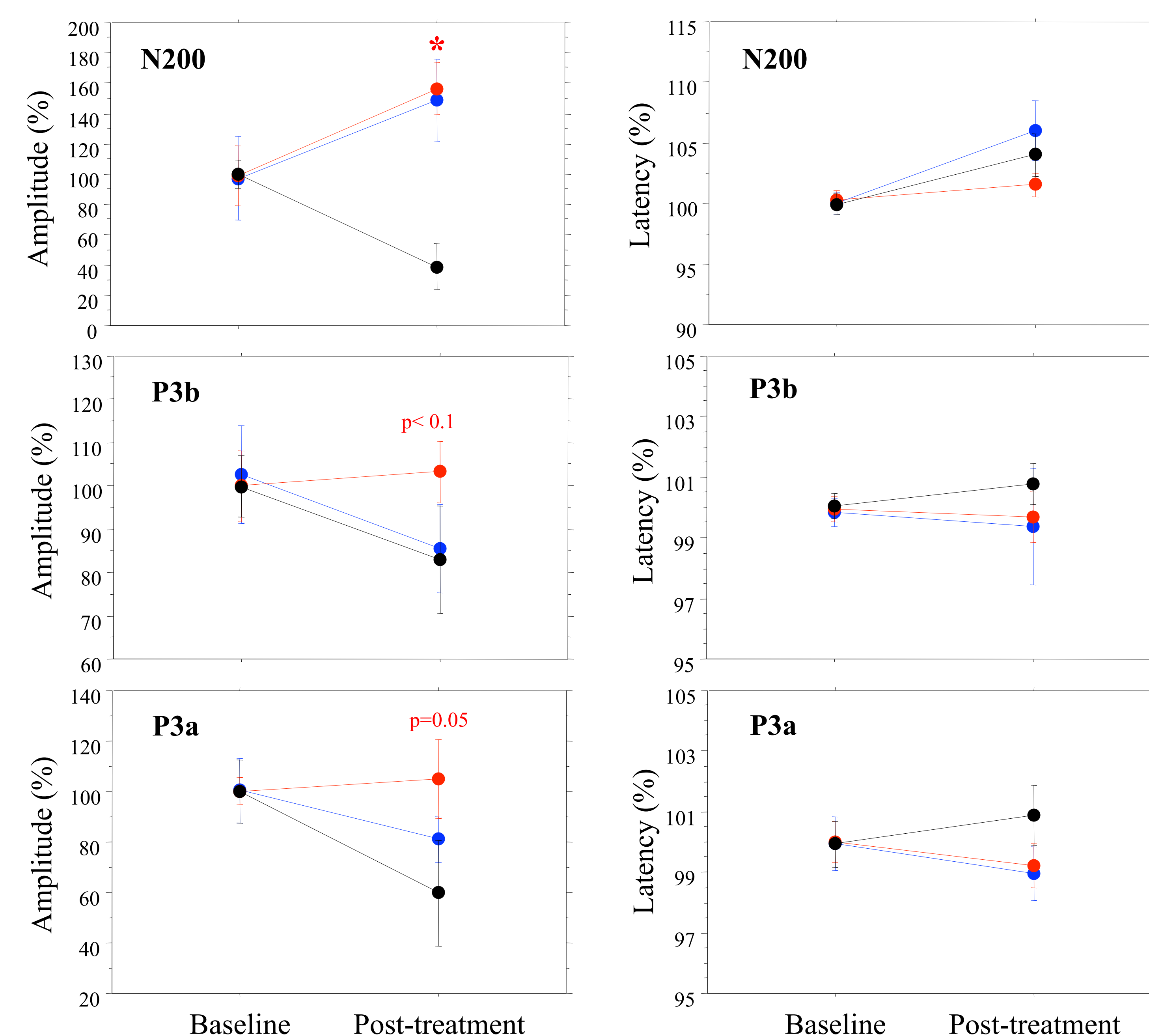


- ED classic
- ED sugar free
- Placebo

Grand average ERP for standard, target, and distractor stimuli in subjects treated with ED classic, ED sugar free, or placebo. ERP features for each stimulus are shown at the electrode site where they were found to be more prominent. (n=4-6 per group)

3

### ERP features in energy drink-treated subjects



- ED classic
- ED sugar free
- Placebo

Effects of energy drinks on the ERP features N200, P3b, and P3a. Lines represent percent change relative to baseline (Mean ± SEM) (n=4-6 per group). \* significantly different from placebo-treated group (p<0.05) (Fisher Post-Hoc test).

4

### Performance in the target detection task

Button Press Accuracy (%)	Baseline	Treatment
ED classic	99.0 ± 0.4	99.0 ± 0.6
ED sugar free	99.5 ± 0.5	97.3 ± 1.5
Placebo	93.0 ± 7	95.2 ± 4.4

False Alarms (%)	Baseline	Treatment
ED classic	0.5 ± 0.3	0.4 ± 0.1
ED sugar free	0.5 ± 0.2	0.6 ± 0.2
Placebo	1.5 ± 1.3	1.0 ± 0.8

Mean Reaction Time (ms)	Baseline	Treatment
ED classic	442 ± 48.9	450 ± 69.2
ED sugar free	410 ± 46.7	422 ± 38.1
Placebo	469 ± 52.3	472 ± 55.4

Performance in the target detection task of the ERP test after treatment with ED classic, ED sugar free, or placebo. Accuracy was calculated as a percent of correct responses to target tones, while false alarms indicated button presses to non-targets. Reaction time was calculated as the time from stimulus onset to button press. Data are presented as Mean ± SEM (n=4-6 per group).

5

### Peak Alpha Frequency

Latency (ms)	Baseline	Treatment
Energy Drink classic	9.3 ± 0.4	9.1 ± 0.4
Energy Drink sugar free	10.3 ± 0.1	10.5 ± 0.4
Placebo	9.9 ± 0.3	9.8 ± 0.3

Peak alpha frequency from the qEEG after treatment with ED classic, ED sugar free, or placebo. (Mean ± SEM) (n=4-6 per group).

## Conclusions

Our preliminary data show that:

1. College students perceive most caffeinated drinks as having 3-5 times more caffeine than they actually have.
2. Consumption ED, either classic or sugar free, significantly improved the peak amplitude of N200, a feature associated to the cognitive processes of stimulus identification and distinction.
3. ED classic, but not ED sugar free, altered the peak amplitude of P3a as compared to placebo. This ERP feature is a measure of focal attention and executive functions. The analysis of the peak amplitude of P300 (P3b), a measure of working memory, showed a similar trend.

Overall, current results provide evidence of neural correlates that may underlie the behavioral effects attributed to energy drinks. To our knowledge, this is one of the first studies investigating energy drinks-related cognitive effects by using ERP technology.

### References

- Cecchi et al. (2015). A clinical trial to validate ERP markers of Alzheimer's disease in outpatient settings. *Alzheimer's & Dementia. DADM* (In press).
- Luck (2012). Introduction to the event-related potential technique. 2<sup>nd</sup> ed., MIT press.

### Acknowledgments

This study was supported by the COGNISION™ System Grant Program (Neuronetrix).