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Soft Drink Effects on Brain Computer Interface Online Performance and Resting-State Arousal

John Mundahl[1], Jianjun Meng[1], Jeffrey He[2] and Bin He[1*]
[1]Dept. of Biomedical Engineering, University of Minnesota, MN, USA; [2]Mounds View High School, MN, USA
*E-mail: binhe@umn.edu

Introduction: Studies show that mind-body awareness, motivations, and other factors can affect online BCI performance [1, 2]. Since caffeine is the most commonly consumed stimulant and soft drinks represent a substantial portion of caffeine intake, this work studied the effect of soft drinks on BCI performance and resting state brain signals used in BCI. Relative to a control soft drink, the sugary soft drink caused negligible difference in resting state alpha power and BCI performance. A caffeine soft drink decreased resting state alpha power, but maintained BCI performance.

Material, Methods and Results: Noninvasive electroencephalography (EEG) data were recorded for six subjects via a 64 channel Neuroscan cap. Electrodes over left (C3) and right (C4) motor cortex recorded control signals for online BCI. Each subject came in for three sessions. All sessions started with two runs of left or right (LR) virtual cursor control with 30 trials in each run. Then the subject drank a Coca-Cola variant with either caffeine, sugar, or neither substance (considered control). The drink selected for each session was randomized across subjects to use all six drink order permutations. The subjects were blinded to the Coca-Cola variant and consumed the 12 oz. drink in five minutes. Then 32 minutes of resting state data were collected by alternating between eyes open and eyes closed for two minutes segments. Finally, subjects performed two more runs of LR cursor control. The power activities in the upper mu frequency band over left and right hemisphere were linearly mapped to the position of the virtual cursor. To minimize the residual effects, subjects did not consume sugar nor caffeine at least four hours before the experiments. We performed experiments between 1:00 PM and 6:00 PM.

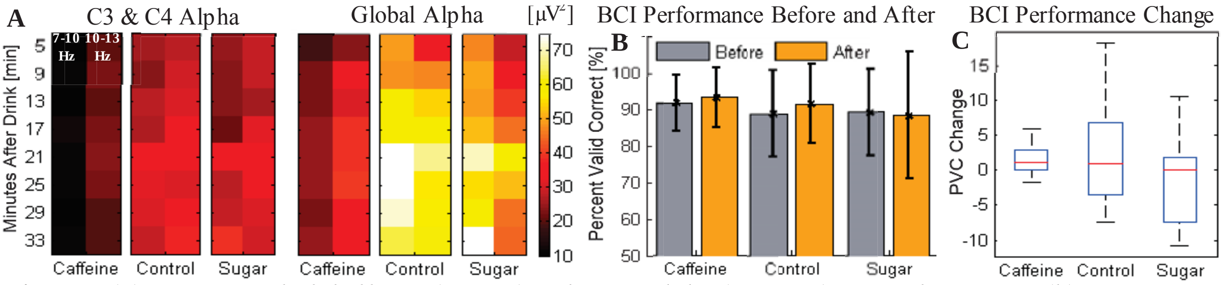

Figure 1. *(a) C3 & C4 and Global lower (7-10Hz) and upper alpha (10-13Hz) power during rest. (b) LR BCI PVC before and after each drink, error bars are standard deviation. (c) PVC change after consumption of each drink.*

The global power of lower and upper alpha frequency bands for three conditions and channels C3 and C4 throughout resting state is shown in **Fig. 1a**. For both C3 & C4 and global, note the similarity between control and sugar consumption in the power of alpha band. Caffeine consumption causes alpha power to decrease substantially from control. Group average percent valid correct (PVC) of all subjects is shown before and after each type of drink in **Fig. 1b**. BCI performance increases slightly after caffeine and control drinks. Sugary drinks cause average PVC to decrease and cause the largest standard deviation of performance. The change of PVC after consumption of each drink is displayed in **Fig. 1c**. Caffeine consumption shows slightly higher improvement of PVC than the control, while the sugar consumption leads to a decrease of PVC. Caffeine consumption also causes the smallest deviation among drinks, while the sugary drink mostly decreases the PVC.

Discussion: The sugary drink seems to have no effect on C3 and C4 alpha power relative to the control. For caffeine, both upper and lower alpha power decreased in C3 and C4, which is consistent with previous literature and global results, where caffeine caused a decrease in global alpha power [3]. Since upper alpha power of C3 and C4 are directly utilized to control virtual cursor movement, this alpha power decrease at rest due to caffeine might lead to a weaker control signal with smaller dynamic range. However, caffeine is also known to increase attention and reduce fatigue [4], which may reduce performance deviation and improve BCI performance. The results show caffeine consumption does not improve BCI performance relative to the control drink. The BCI performance effects due to resting state alpha power decrease, increased attention, and reduced fatigue seem to cancel out one another. Sugar consumption caused a slight decrease in average BCI performance. All postulations should be confirmed with a larger sample size.

Significance: With the prevalence of soft drinks and caffeine, their effects on BCI performance are worth investigating. Caffeine seems to have negative frequency effects and positive attention effects that combine to cause negligible changes in BCI performance, while sugary drinks may decrease BCI performance relative to the control condition. As researchers push the boundaries of non-invasive BCI with quadcopters, robotic arms, and cars, these results shed light on how the world's most popular stimulant, caffeine, affects BCI performance.

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