Does Sudafed® Improve Performance on Cognitive Tasks?

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Introduction:

What if a simple, over-the-counter, drug could help increase your performance? Currently there is a wide range of supplements and herbal nutrients that claim that they have beneficial effects in improving performance, cognitively or physically. Although Sudafed® is primarily used as a decongestant there are alternative ways that people could use the drug. In a current television series, *Glee*, a school nurse administers decongestants to help stimulate a group of students for a competition. Media expression of alternate use of over-the-counter drugs leads the public to question the validity of such ideas. Do decongestants work to enhance performance? Can they improve cognitive functioning?

Decongestants, such as Sudafed®, are used to relieve nasal congestion, stuffy nose. A stuffy nose is a common symptom of having the flu or allergies. Congestion results when membranes lining the nose become swollen. The active ingredient in decongestants, Pseudoephedrine (PSE), relieves the swelling by constricting blood vessels that supply the nose. However, the side effects of orally ingesting PSE include nervousness, restlessness, and excitability ("Pseudoephedrine", 2011). It is also reported that decongestants may cause increased blood pressure and fast and irregular heartbeat, which are similar to the effects of taking stimulants. While not all decongestant brands contain PSE, it is the active ingredient that the current study investigates, Sudafed®. Pseudoephedrine is a readily available over-the-counter nasal decongestant which is structurally similar to amphetamine and is included

on the International Olympic Committee's list of banned substances. Pseudoephedrine works by mimicking the sympathetic nervous system, which could enhance performance in competitions, such as the Olympics. Drugs that mimic the sympathetic nervous system are considered sympathomimetic drugs, which increase systolic and diastolic blood pressure, heart rate, peripheral vascular tone, respiratory stimulation, bronchial tube dilation, pupillary dilation, relaxation of the smooth muscles of the gastrointestinal tract, and promote vasoconstriction of cutaneous blood vessels, and increases blood supply to working muscles (Gill et al, 2000).

A study conducted by Gill et al. (2000), investigated whether a 180 mg dose of PSE ingested 45 minutes prior to exercise enhanced short-term maximal performance and/or altered related physiological variables. By performing a double-blind pre- and post-drug test, their results revealed that performance enhancement can be induced in some performance tasks following the ingestion of 180 mg of PSE. Investigators observed the greatest difference in performance for exercises that involved muscle torque, in which muscle activation also significantly differed. Gill et al. (2000) also revealed a significant difference in peak power and increased lung function.

While studies have supported that PSE can improve performance in physical exercise, little research has been conducted investigating the cognitive effects PSE can have on performance. The purpose of the current study is to investigate whether Sudafed® improves cognitive functioning in a series of cognitive tasks. By measuring brain activity (EEG), reaction time, and accuracy, pre- and post-drug it is hypothesized that the presence of PSE will increase performance based on the notion that PSE is a sympathomimetic. Since sympathomimetic drugs mimic the sympathetic system, it is expected that there will be quicker reaction time during Go/No-go tasks and increased accuracy.

Subjects:

Participants were 10 undergraduate students from Wofford College between the ages of 19-22. Data from one participant was discarded due to technical complications regarding data acquisition. Participants were entered into a drawing to win a $25 gift card to Pizza Hut.

Method:

The aim of the current study is to investigate the effects Sudafed® on performance during various cognitive tasks by measuring EEG activity, reaction time, and accuracy before and after the consumption of Sudafed®. The present study measured performance using four different cognitive tasks. After collecting 2 minutes of baseline EEG data the participant endured a series of four pre-drug cognitive tasks: a visual Go/No-go, an auditory Go/No-go task, a working memory 2-back task, and a working memory 4-back task. After completing pre-drug cognitive tasks the participant then consumed two tablets of Sudafed® , the instructed dosage and waited 45 minutes before collecting post-drug EEG data. After 45 minutes, baseline EEG data was collected again and the participant then proceeded to post-drug cognitive tasks, which included the same tasks as the pre-drug period. A within subject design repeated measures ANOVA test was used to identify significant differences of $P < .05$. A T-test was also used.

Visual Go/No-go task:

This task as a stimulus needs to be responded to, as well as one that should not be responded to. Response to the alternate stimulus needs to be inhibited. During this task, the participant was instructed to responding by clicking on the screen with the mouse if the stimulus that appeared was a solid green dot, Go. However, the participant was instructed to refrain from responding when the stimulus presented was a patterned dot, No-go. This task is a measure of reaction time and accuracy.

Auditory Go/No-go task:

This task required the participant to listen to two tones per trial. A baseline tone was first presented and depending on the instructions provided on the screen, the participant was to respond, by clicking the mouse on the screen, when the second tone was either higher than the baseline tone or lower than the baseline tone. Instructions switched periodically therefore altering the Go and No-go stimulus. The Auditory Go/No-go task required the inhibition of certain stimuli. This task is a measure of reaction time and accuracy.

Working Memory 2-Back

A variant of the “n-back” test required the participant to hold a continuous series of images in their working memory. The participant was instructed to respond, by clicking on the screen, when the current image was a repetition of an image they saw two images ago. This task is a measure of accuracy.

Working Memory 4-Back

A variant of the “n-back” test required the participant to hold a continuous series of images in their working memory. The participant was instructed to respond, by clicking on the screen, when the current image was a repetition of an image they saw four images ago. This task is a measure of accuracy.

Results:

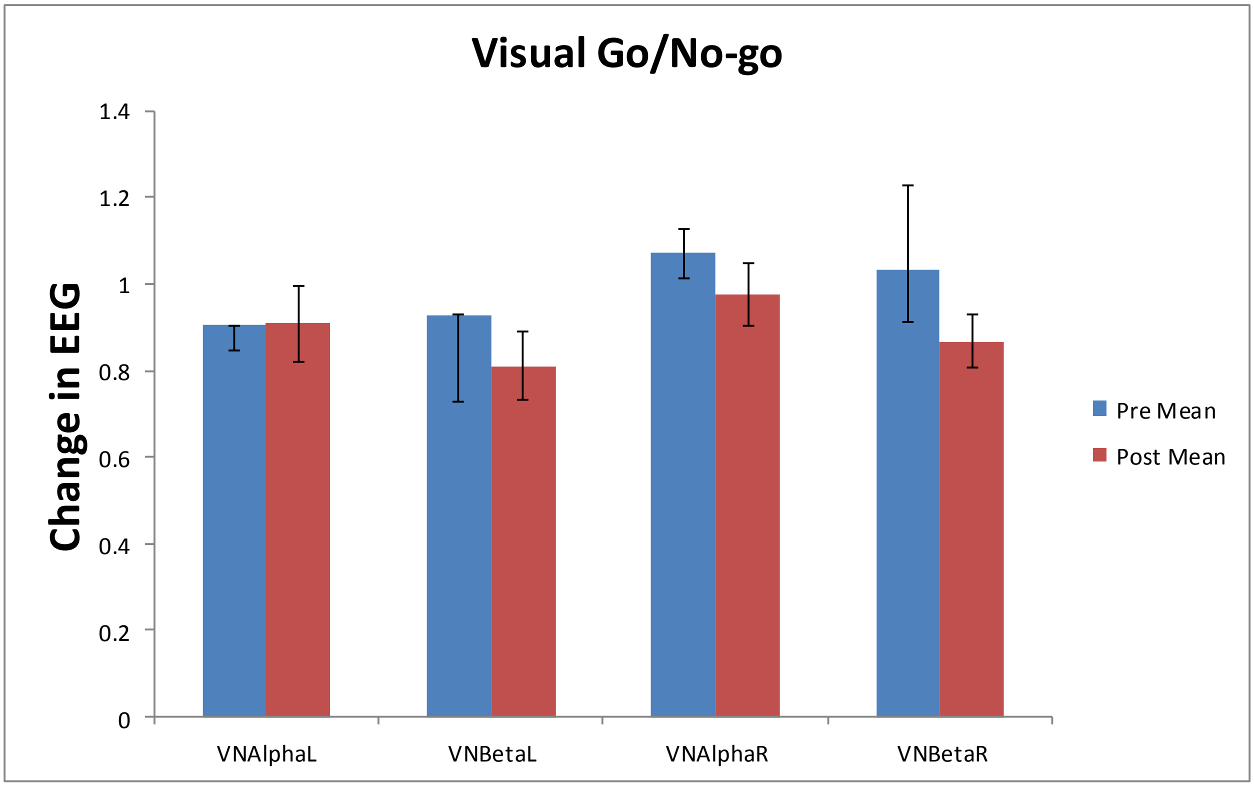

Figure 1. Compares Alpha and Beta waves of the left and right hemisphere during the Visual Go/No-go cognitive task.

There was no significant effect of drug on brain activity when comparing alpha and beta waves of the left and right hemisphere. This indicates that the presence of PSE did not affect the resting state or attention state since alpha waves are a measure of the resting state while beta waves are a measure of focused attention. The figure also demonstrates that there was not a significant difference in EEG activity when comparing the left hemisphere to the right hemisphere.

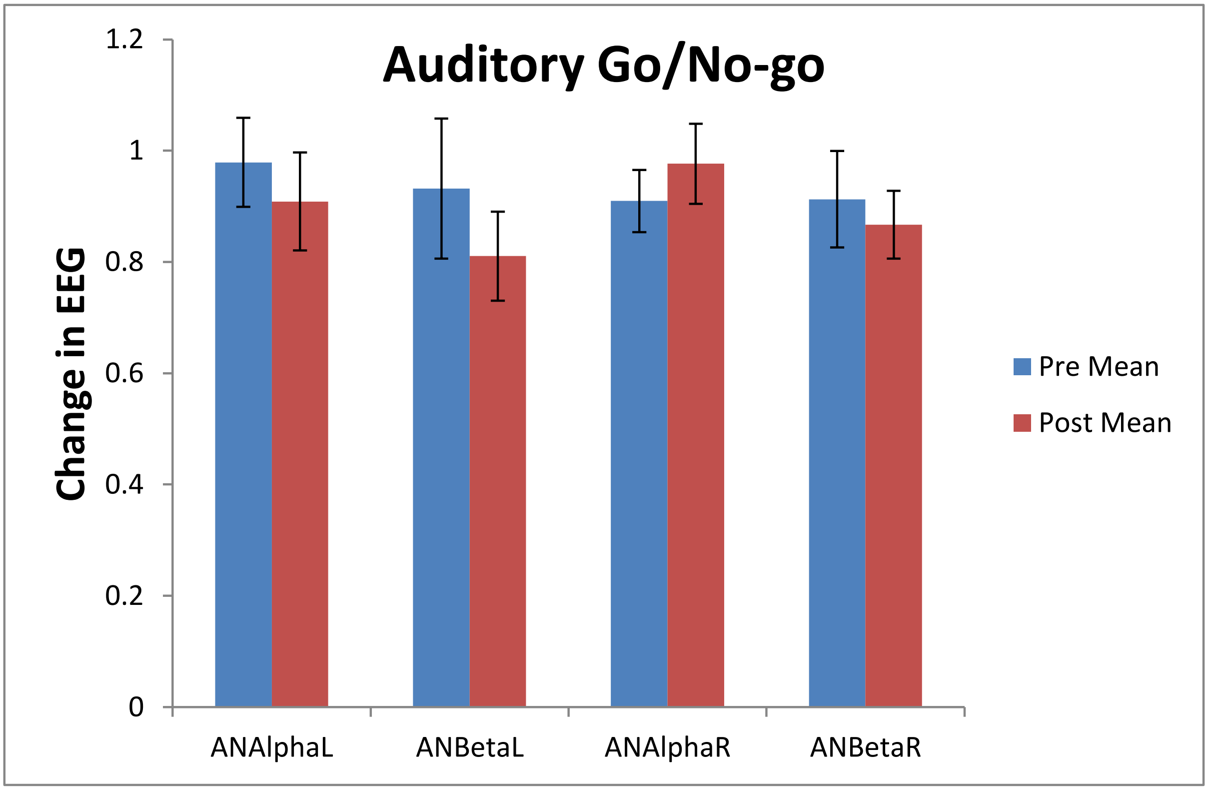

Figure 2. Compares alpha and beta waves of the left and right hemisphere during the Auditory Go/No-go cognitive task.

There was no significant effect of drug on brain activity when comparing alpha and beta waves of the left and right hemisphere during an auditory go/no-go task. This indicates that the presence of PSE did not affect the resting state or attention state since alpha waves are a measure of the resting state while beta waves are a measure of focused attention. A significant interaction of drug*hemisphere was approached, although it did not reach significance. This indicates that there may be an effect of PSE on hemispheric activity.

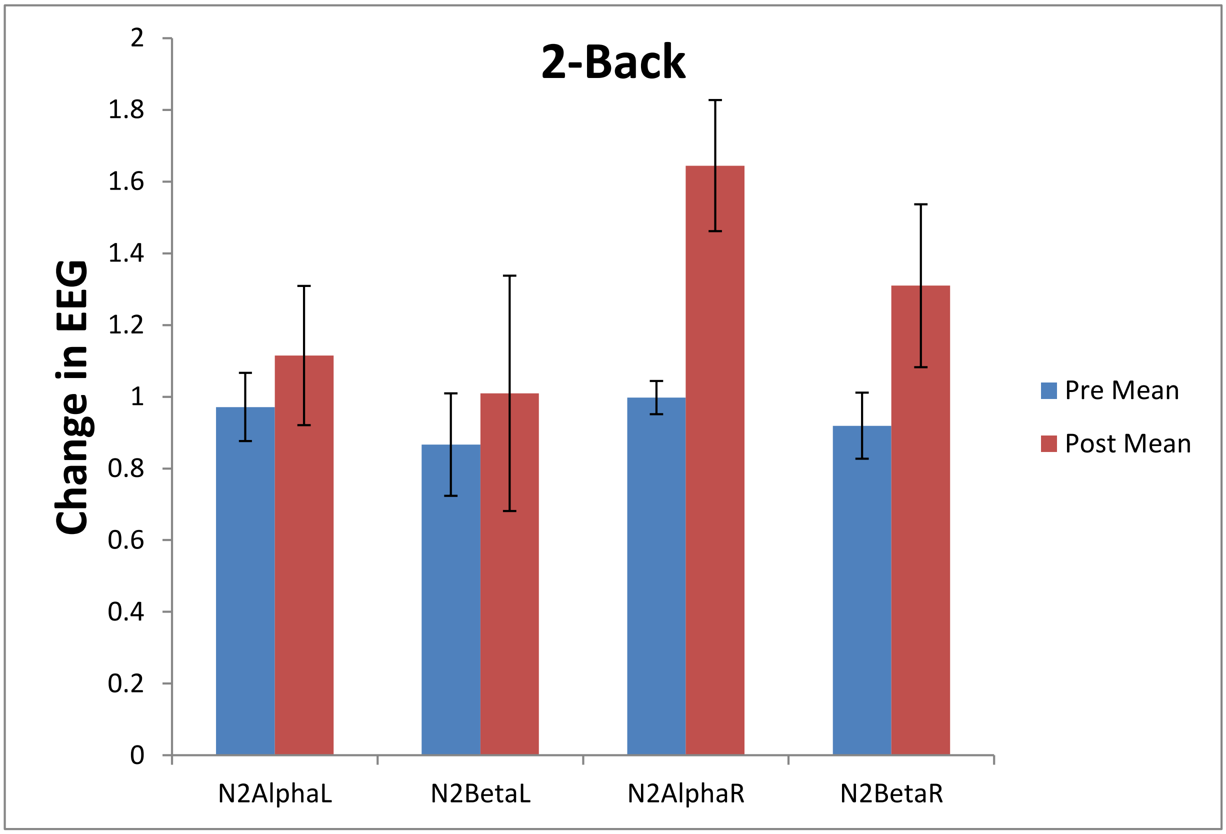

Figure 3. Compares alpha and beta waves of the left and right hemisphere during the 2-Back working memory task.

There was a significant effect of PSE on waves [$F_{(1,9)}$=.022, P<0.05]. This indicates that the presence of PSE increased the mean alpha and beta waves during the post-drug cognitive tasks. The average recorded alpha waves during the pre-drug test were .984, compared to 1.32 during the post-drug tests. The average recorded beta waves during pre-drug test were .89, compared to 1.16 during the post-drug cognitive test. However, there was no significant difference observed when comparing EEG across hemispheres.

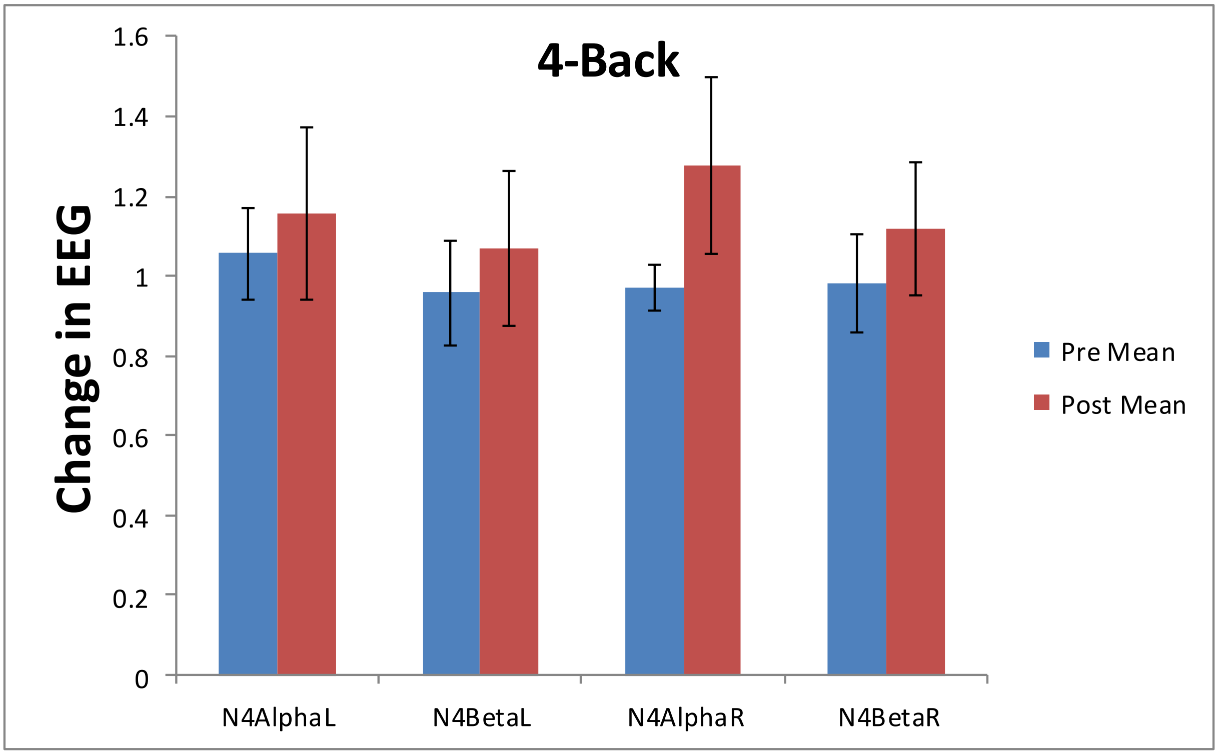

Figure 3. Compares alpha and beta waves of the left and right hemisphere during the 4-Back working memory task**.**

No significant effect was revealed when comparing EEG of the alpha and beta waves and the left and right hemisphere across pre- and post-drug cognitive testing. This means that there was no increase in focused attention during a more difficult working memory task. This also indicates that there was no significant hemispheric difference during the 4-back working memory task.

However, there was an significant interaction of drug and task [$F_{(1,9)}$,=.048, p <.05]. This indicates that PSE has an effect on performance during the 2-back working memory task. Although a significant interaction was revealed for performance during the 2-back test, no significant interaction was found during the 4-back working memory task.

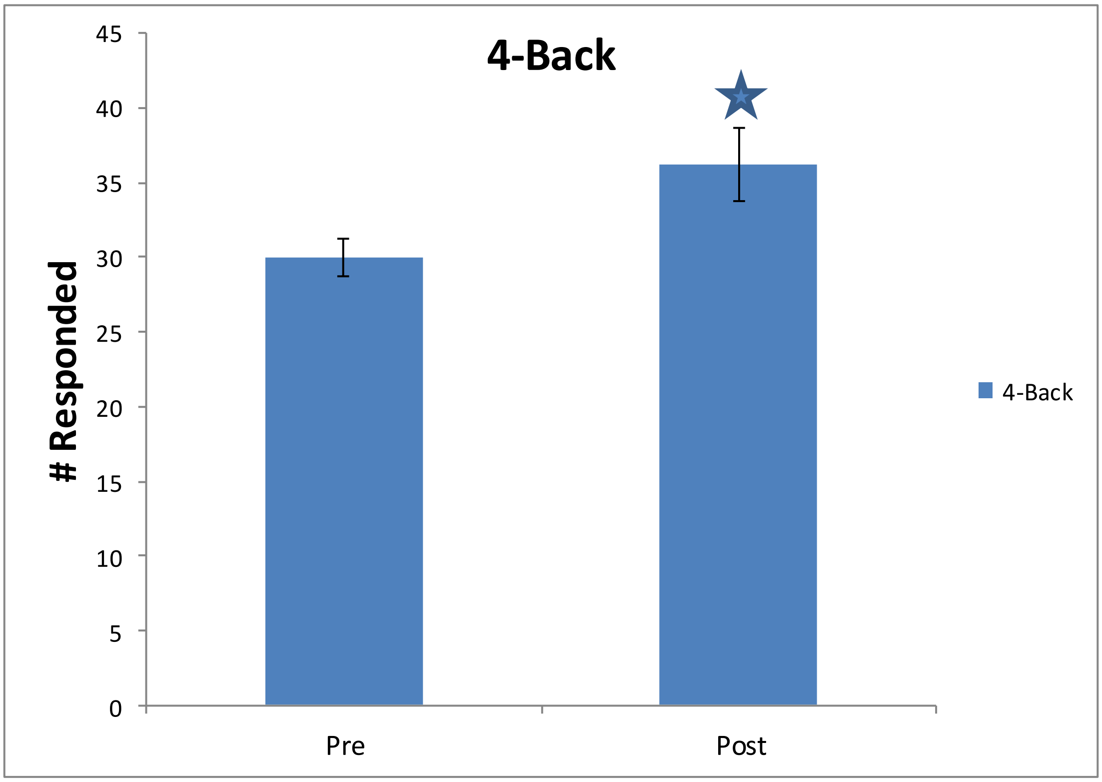

Figure 4. Compares the number of repeated images the participant correctly responded to during the pre- and post-drug 4-back working memory task. A star indicate a significant difference.

A significant difference of the number of correct responses during the 4-back working memory task was revealed [$T_{(9)}$=.026 , $P< 0.05$]. This indicates that there was an increase in accuracy during the post-drug testing of the 4-back working memory task. During the pre-drug 4-back working memory task the average number of correct responses was 30 trials, while during the post-drug test there was an average of 36.2.

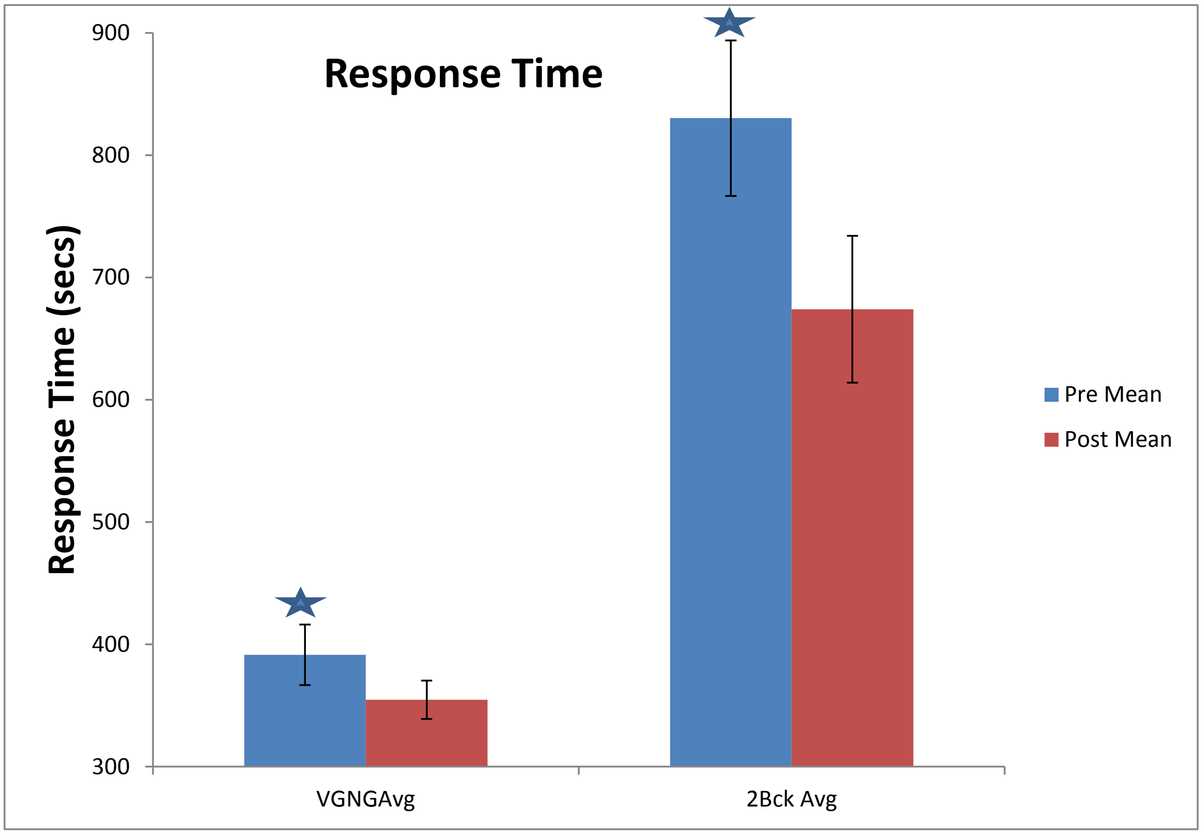

Figure 5 demonstrates the differences in reaction time during the visual Go/No-go task and the 2-back working memory task. Stars indicate a significant difference.

A significant difference of average response time during the visual go/no-go task was revealed [$T_{(9)}$= .049, P< .05]. This indicate that there response time during the post-drug visual Go/No-go task was significantly faster than during the pre-drug test. A significant difference of average response time during the 2-back working memory task was also revealed [$T_{(9)}$= .019, P< .05]. This demonstrates that response time during the post-drug 2-back working memory task was significantly faster than during the pre-drug test.

Discussion:

Overall Sudafed® had significant effects on reaction time during the visual go/no-go and the 2-back working memory task. During post-drug testing, results demonstrate quicker response than during the pre-drug tests. There was also a significant effect of accuracy during the 4-back working memory task, which indicates that the presence of PSE increased accuracy when comparing the pre- and post-drug 4-back memory task. Results also revealed that, although not a significant difference, there was more activity in the right hemisphere during the 4-back than in the left hemisphere and overall there more activity in the right hemisphere under the effect of the drug. Although PSE has been found to increase performance during physical exercise, as cited by Gill et al. (2000), an overall increase in cognitive tasks was not found from the present study.

As a sympathomimetic drug, Sudafed® increases systolic and diastolic blood pressure, heart rate, peripheral vascular tone, respiratory stimulation, bronchial tube dilation, and pupillary dilation. The significant difference in response time during the visual go/no-go task therefore can be attributed to having an increased heart rate and also having pupillary dilation. With increased heart rate, participants could have been more ready to respond to visual stimuli. The difference in the visual go/no-go and the auditory go/no-go may have been due to the reported side effect of pupillary dilation. Pupillary dilation is also an indicator of increased alertness. Although there was no significant effect of PSE on focused attention, there was still a slight increase. This increase in attention may account for the significant difference of the pre- and post-drug test response time during the visual go/no-go test.

To improve this study for future investigations, it may be important to increase the duration between the pre- and post-drug measurements during cognitive testing. By increasing the wait time between the pre- and post-drug tests, there is greater chance that the drug can actually have an effect on cognitive functioning. Although sources state that Sudafed® should be effective within 30-45 minutes, increasing the wait time will account for individual differences. Multiple participants reported that they felt an effect, such as increased heart rate, as little as an hour after being administered Sudafed®. Although the current study did not support increased cognitive functioning, a few participants claimed that Sudafed® still helped them focus better on their homework. However, the perceived effect may be explained by the placebo effect.

References

Gill, N.D., Shield, A., Blazevich, A.J., Zhou, S., & Weatherby, R.P. (2000). Muscular and cardiorespiratory effects of pseudoephedrine in human athletes. *Clinical Pharmacology*, 50, 205-213.

Pseudoephedrine. (2011). Retrieved from http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0000731/