

Original Article

A comparative study of caffeinated beverages; tea and energy drink consumption on attention span of healthy male and female subjects

Kiran Zafar¹, Arfa Naeem¹ and Faizan Mirza^{1,2}

¹Psycho-physiology research lab, Department of Physiology, University of Karachi.

²Psycho-physiology Research Division, AEIRC

Email of corresponding author: kiran.zafar@hotmail.com

Abstract

Tea is the most widely consumed beverage after water around the globe with consumer-base of both young and old, while energy drinks are popular primarily among young adults. Among the different varieties available black tea is the most commonly used and contains L-Theanine, theobromine, theophylline and the highest amount of caffeine. Energy drinks on the other hand contain taurine, herbs, B vitamins and stimulant drugs chiefly caffeine. The purpose of the study conducted was to evaluate the effect of regular tea and energy drinks on attention. A survey was conducted and subjects were given a task that was designed to test the above mentioned parameter and time taken to solve each part of the task was accurately noted. Results of the energy drink group and the tea group were compared to the control group. Gender based differences were also analyzed. Our results lead us to conclude that the most widely taken beverages enhance attention in both genders, with women outperforming men.

Keywords

Attention span, energy drink consumption, tea users

Introduction

Energy drinks are energy boosting carbonated drinks popular among young adults with caffeine and taurine as main ingredients and contain amino acids, minerals, vitamins, preservatives, flavorings and colorings (Kammerer et al., 2014). On the other hand, tea is consumed worldwide and consists of consumers of all age groups. The stimulants present in black tea are caffeine, flavonoids, theophylline, theobromine and L-Theanine (Zameer et al., 2013). The use of these beverages by general population for their mind reviving effects indicates their role in neurophysiology. Caffeine is common ingredient to both and maybe the only psychoactive drug legally available over the counter. Caffeine can pass biological membranes including blood-brain barrier and exerts its effects on various brain areas, enhancing human vigilance and mental alertness and influencing selective visual task and Stroop color-word task (Brunye et al., 2010; Smith, 2002; Snell et al., 2011; M. Lorist et al., 1996). There are two brain regions involved in the processing of Stroop task anterior cingulate cortex and dorsolateral prefrontal cortex (Milham et al., 2003). Some cerebellar regions also activate on attention task (Allen et al., 1997). Hemispheric difference has also been proved by a study that right cerebral hemisphere reads the color and the left cerebral hemisphere insists to read the word (Adleman et al., 2002). Brains of men and women though have anatomic, biochemical and functional differences; they have equal intelligence

(haier et al., 2005). Both male and female subjects received the same neuro-stimulants, but they processed them differently.

Methodology

This prospective design study was conducted on 300 random people of age group 18-32 in Karachi. The subjects were all either undergraduates/ post-graduate belonging to fields of biological sciences, commerce, engineering, social sciences and arts. Subjects were divided into three groups with 100 subjects each (50 males and 50 female subjects). Subjects included were of the defined age group, healthy and control group subjects were non-users of caffeinated beverages and color-blind people were excluded from the study.

Control group took the test without any beverage consumption. Tea group were given tea made using: 4 grams' milk powder, 2 grams' table sugar, Lipton black tea bag (55mg caffeine) and 250 ml boiled water and solved the test after 20 minutes. The subjects of third group were given 250ml of energy drink took the test after 45 minutes. Time taken to solve each part was accurately noted in minutes. Result was analyzed using t-test; p value 0.05.

Attention span was tested by the standard 'Stroop effect'. Stroop task consists of three parts; first reading out a list of words printed in black, second reading the same list printed in congruent colors and

finally a list of names of colors printed in incongruent shades. In the third part the individual need to read

the color of ink from which the word is written and not what the word says (Stroop, 1935).

Result

Table 1

	Attention		
	Control	Tea	Energy drink
Male Subjects	58.56+-10.192	50.68+-14.433	52.56+-9.706
Female subjects	54.30+-18.455	40.68+-10.611	50.54+-12.951

Table 1- Table showing values of mean and standard deviation of both male and female subjects of control, tea and energy drink groups for attention.

The mean of male subjects for control group was found to be 58.56 with standard deviation of 10.192 whereas the mean value of female subjects was 54.30 with standard deviation of 18.455. The difference between male and female control group was insignificant ($p > 0.05$). The mean value of male subjects for tea group was 50.68 with standard deviation of 14.4333 and that of female subjects 40.68 mean with standard deviation of 10.611. The result of male and female subjects of tea group was significantly different ($p < 0.05$). The mean of male subjects of the energy drink group was found to be 52.56 with standard deviation of 9.706 while the

female subjects had the mean of 50.54 with standard deviation of 12.951 whereas the difference was insignificant ($p > 0.05$). Inter-comparison of male subjects of control group with tea group and energy drink group both turned out to be significant ($p < 0.05$). Inter-comparison of female subjects of control group with tea group was significant ($p < 0.05$) whereas control group and energy drink group was insignificant ($p > 0.05$). Comparing the results of tea group and energy drink group for both genders, the difference of male subjects was insignificant ($p > 0.05$) while that of female subjects was significant ($p < 0.05$).

Figure-1

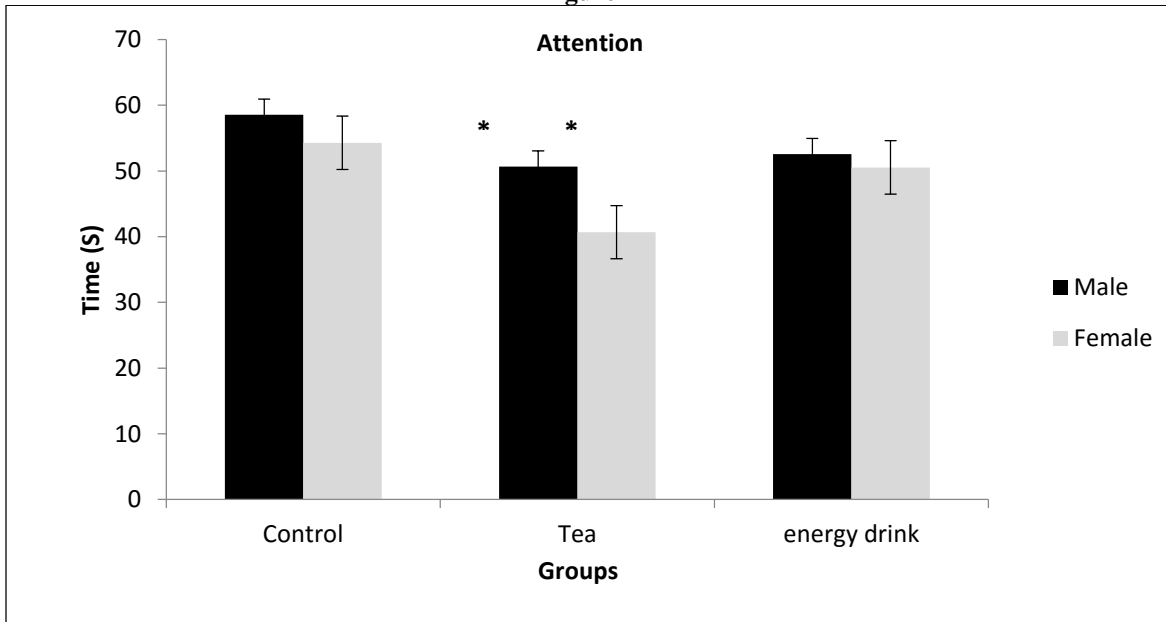


Fig-1 shows time taken by male and female subjects to solve attention test without consuming anything i.e. control, with the consumption of regular tea and energy drink.

Discussion

Attention was tested by Stroop and the Stroop task tests the reaction time and color recognition of the human brain. Energy drink and tea seem to have similar effect on attention on both genders as compared to the control group. The decreased time taken to solve the task is due to the synergistic effect of caffeine and taurine in energy drinks and caffeine and L-Theanine in tea that enhances attention (Dombovy, 2010; Parnell et al., 2006). Beneficial synergistic effect of glucose and caffeine of energy drinks on attention has also been seen (Adan et al., 2010). Caffeine is a common ingredient in both, the tea and the energy drink. The main effect of caffeine is through blocking adenosine receptors on dopamine rich areas of brain that are involved in alertness and executive control of visual attention (Tad et al., 2010). Adenosine is a sleep inducer and caffeine antagonistically binds its receptor, by doing so caffeine is acting opposite of activation of adenosine receptors, hence improves performance (Ribeiro et al., 2010).

Several studies directly support that in individuals at rest, L-theanine increases alpha-brain waves, which are associated with a relaxed but alert mental state (Song et al., 2003; Nobre, 2008). Activity in the alpha-band has been linked with general attention processes and recent research has shown that oscillations in the alpha band are a key component in selective attention (Klimesch, 1999). A recent study has shown that a high amount of L-theanine improves attention related alpha activity, thus having a specific effect on the brain's attention circuitry. With L-theanine, the brain shows greater differentiation between visual and auditory sensory information which may enable individuals to focus attention more effectively (Ramirez et al., 2007). While research is still emerging, it does suggest that L-theanine may increase the ability to concentrate and focus on tasks.

Combination of ginkgo biloba and ginseng has shown to have some effect on attention one way or the other and has been included in many studies but the results remain highly controversial due to insufficient human trials (Amandeep, 1998; Kennedy et al., 2003; Henrik et al., 1996).

In the prefrontal cortex of female brains, neurons are more closely packed together than male brains and the prefrontal cortex is involved in Stroop task and problem solving (Witelson et al., 1995; Milham et al., 2003; Sietske et al., 2013). Corpus callosum, a large tract of neural fibers that allows the free flow of

communication between both hemispheres of the brain, is larger in women as compared to men and by acting as a partial barrier mediates the inter-hemispheric Stroop effects (Leonard et al., 2008; David, 1992). It was observed that it takes longer to name ink colors of incongruent words as people are practiced at reading words than naming colors. Color-word interference is produced which is described as what happens when a subject's educated mind reads the word instead of recognizing what color the ink really is (Davidson, 2003; Alansari, 2004).

Female subjects outperformed male subjects in all three groups because female hormones estradiol and progesterone help while on Stroop task (Takeshi, et al., 2009). Estradiol also improves attention, verbal ability and memory (Hogervorst: Hormones, Cognition and Dementia) But female subjects of the tea group took the least time in all because of stronger effect of caffeine on them and already being able to recognize and name colors better than male subjects (Arab et al., 2013; Smith, 2012). Energy drink and tea both increased attention of male subjects with tea group having a more prominent effect because of the effect of caffeine and L-theanine on attention as mentioned earlier. Male subjects of energy drink group performed better than the control group because taurine stimulates testosterone secretion and testosterone enhances attention (Hogervorst: Hormones, cognition and dementia; Yang et al., 2010).

Tea group shows dominant effect than both the other groups, hence, the effect of tea on male and female subjects reassures the strong effect of caffeine and L-theanine on attention (Kelly et al., 2008). Female subjects also had better accuracies on the test, as they tend to pay more attention to detail while being timed (Hibbard et al., 2010). While the energy drink group did better than the control group due to beneficial synergistic effect of glucose and caffeine on attention (Adan et al., 2010) and the combination of caffeine, taurine and glucuronolactone that increases concentration (Alford, 2000).

Conclusion

Both beverages enhance attention but tea has stronger effect and lead the results with significant difference. Females are more attentive, albeit, consumption of beverages decreased time of attention test for male subjects, females surpassed them in all three groups.

Competing Interests

No competing interests were found in the preparation of this paper.

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References

- Adan A, Serra-Grabulosa JM. Effects of caffeine and glucose, alone and combined, on cognitive performance. *Hum Psychopharmacol*. 2010 Jun-Jul; 25(4):310-7.
- Alansari B. M. (2004). *Gender and cultural performance differences on the Stroop color and word test: A comparative study*. Kuwait.
- Allen G, Buxton RB, Wong EC, Courchesne E. (1997). Attentional activation of the cerebellum independent of motor involvement. *Science*, 275(5308):1940-3.
- Anna C Nobre, Anling Rao and Gail N Owen (2008). L-theanine, a natural constituent in tea, and its effect on mental state. *Asia Pac J Clin Nutr* 2008; 17 (S1):167-168
- C. Alford, H. Cox, and R. Wescott (2001). The effects of Red Bull Energy Drink on human performance and mood. *Amino Acids* 21: 139–150.
- David AS (1992) Stroop effects within and between the cerebral hemispheres: studies in normals and aphasics. *Neuropsychologia*. Feb;30(2):161-75.
- Davidson, D. J. (2003). Stroop interference, practice, and aging. *Neuropsychol Dev Cogn B Aging Neuropsychol Cogn*. 2003 Jun; 10(2): 85–98.
- Eef Hogervorst: *Hormones, Cognition and Dementia: State of the Art and Emergent Therapeutic*. Publisher: Cambridge University Press
- Haier RJ, Jung RE, Yeo RA, Head K, Alkire MT (2005). The neuroanatomy of general intelligence: sex matters. *Neuroimage* 2005; 25(1): 320-7.
- Henrik S0rensen and Jesper Sonne (1996). Effects of ginseng on cognitive functions: a double masked study, *current therapeutic research* VOL. 57, NO. 12.
- Hibbard, D. R., & Buhrmester, D. (2010). Competitiveness, gender, and adjustment among adolescents. *Sex Roles*, 63(5), 412-424.
- Hira Zameer., Mehrunisa Iqbal., Lubna Anwer., Sadaf Ahmed & Samia Mushtaq (2013) Comparative effects of caffeine & L-theanine consumption on subjective cardiovascular signs and neurophysiological responses. *International journal of endorsing health science research Volume 1 Issue 1 July 2013*.
- J. Ridley Stroop (1935), studies of interference in serial verbal reactions, *Journal of Experimental Psychology*, 18, 643-662.
- Jan Snel and Monique M. Lorist (2011). Effects of caffeine on sleep and cognition, H. P. A. Van Dongen and G. A. Kerkhof (Eds.) *Progress in Brain Research*, Vol. 190 ISSN: 0079-6123.
- Kennedy DO, Scholey AB, Drewery L, Marsh VR, Moore B, Ashton H (2003). Electroencephalograph effects of single doses of Ginkgo biloba and Panax ginseng in healthy young volunteers, *Pharmacol Biochem Behav*. 2003 Jun; 75(3):701-9.
- Klimesch, W. (1999). EEG alpha and theta oscillations reflect cognitive and memory performance: review and analysis. *Brain Research Reviews*, 29, 169-195.
- Lenore Arab, Faraz Khan, and Helen Lam, (2013). Epidemiologic Evidence of a Relationship between Tea, Coffee, or Caffeine Consumption and Cognitive Decline. *Adv Adv Nutr vol. 4: 115-122, 2013*.
- Leonard CM, Towler S, Welton S (2008). Size matters cerebral volume influences sex differences in neuroanatomy, *Cereb Cortex*. 2008; 18(12): 2920-31
- Lorist MM, Snel J, Kok A, Mulder G, (1996) Acute effects of caffeine on selective attention and visual search processes., *Psychophysiology*. 1996 Jul; 33(4):354-61.
- Manuel Gomez-Ramirez, Beth A. Higgins, Jane A. Rycroft, Gail N. Owen, Jeannette Mahoney, Marina Shpaner, and John J. Foxe (2007). The Deployment of Intersensory Selective Attention: A High-density Electrical Mapping Study of the Effects of Theanine. *Clinical neuropharmacology Volume 30, Number 1 January / February 2007*.
- Marissa Dombovy-Johnson (2010). The Effects of Taurine and Caffeine Alone and in Combination on Locomotor Activity in the Rat. *Colgate Academic Review. Volume 7 (Spring 2010) Article 10*.
- Mark Smith (2012). Stroop Task and Sex Differences. *Upward Bound Regional Math Science. University of Maine*.
- Maximiliano Kammerer, Jaime A Jaramillo, Adriana García, Juan C Calderón and Luis H Valbuena (2014). Effects of

- energy drink major bioactive compounds on the performance of young adults in fitness and cognitive tests: a randomized controlled trial · *Journal of the International Society of Sports Nutrition* 2014, 11:44
- Milham, M (2003). "Practice-related Effects Demonstrate Complementary Roles Of Anterior Cingulate And Prefrontal Cortices InAttentional Control". *NeuroImage* 18 (2): 483–493.
 - Nancy E. Adleman, VinodMenon, Christine M. Blasey, Christopher D. White, Ilana S. Warsofsky, Gary H. Glover, and Allan L. Reiss(2002). A Developmental fMRI Study of the Stroop Color-Word Task.*NeuroImage* 16, 61–75
 - Parnell H, Owen GN, Rycroft JA (2006). Combined effects of L-theanine and caffeine on cognition and mood. *Appetite*, 2006;47:273
 - Ribeiro JA, Sebastiao AM (2010). Caffeine and adenosine. *J Alzheimers Dis.* 2010; 20 Suppl1:S3-15.
 - ShergillAmandeep, Ginseng and memory, *Nutrition Bytes*, 4(2). Publication date: 1998.
 - Sietske W. Kleibeuker, P. Cédric M.P. Koolschijna, Dietsje D. Jolles, Margot A. Schel, Carsten K.W. De Dreud, Eveline A. Cronea (2013). Prefrontal cortex involvement in creative problem solving in middle adolescence and adulthood. *Developmental Cognitive Neuroscience* 5; 197–206.
 - Simon P. Kelly, Manuel Gomez-Ramirez, Jennifer L. Montesi, andJohn J. Foxe (2008). L-Theanine and Caffeine in Combination Affect Human Cognition as Evidenced by Oscillatory alpha-Band Activity and Attention Task Performance. *American society. Journal of nutrition.* vol. 138no. 8 1572S-1577S
 - Smith, A (2002). Effects of caffeine on human behavior. *Food and Chemical Toxicol*, 40(9): 1243–55
 - Song CH, Jung JH, Oh JS, Kim KS (2003). Effects of thiamine on the release of brain alpha waves in adult males. *Korean J Nutrition.* 2003;36:918-923.
 - Tad T Brunye, Caroline R. Mahoney, Harris R. Lieberman, Holly A. Taylor (2010). Caffeine Modulates Attention Network Function, *Brain and Cognition* 72 (2010) 181–188
 - Tad T. Brunyé, Caroline R. Mahoney, Harris R. Lieberman, Grace E. Giles, Holly A. Taylor (2010). Acute caffeine consumption enhances the executive control of visual attention in habitual consumers, *Brain and Cognition* 74 (2010) 186–192.
 - Takeshi, H., & Nagaya, K. (2009). Menstrual cycle phase effects on memory and Stroop task performance. *Archives of Sexual Behavior*, 38(5), 821-827.
 - Witelson SF, Glezer II, Kigar DL (1995). Women have greater density of neurons in posterior temporal cortex, *J Neurosci.* 1995; 15: 3418-28.
 - Yang, J., Wu, G (2010). CSD mRNA Expression in Rat Testis and the Effect of Taurine on Testosterone Secretion. *Amino Acids* June 2010. 39(1), 155-160.