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Effect of caffeine on information processing using Stroop Task

KEYWORDS: Caffeine, Facilitation, Interference, Stroop

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ABSTRACT

Background: Caffeine is a pyschostimulant present in various beverages and known to alter alertness and performance by acting on the central nervous system. The Stroop task is a widely used tool in psychophysiology to understand the attention processes and is based on the principle that processing of two different kinds of information (like the word or colour) is parallel and at different speeds with a common response channel. Objectives: To determine effect of caffeine on information processing by virtue of observations obtained from classical colour-word Stroop task. **Material and Methods**: This study was conducted at the Department of Physiology, Pt JNM Medical College, Raipur CG. 42 healthy 1st year medical student volunteers in the age group of 18-25 years were recruited after explaining the procedure and taking written consent. **Results:** There was a statistically significant reduction in pre caffeine and post caffeine reaction times across all three conditions in the stroop color-word test indicating faster information processing and choice selection post administration of caffeine in well rested volunteers. Our study clearly demonstrated a reduction in the reaction time post caffeine and it was statistically significant (p value <0.0001) for all three conditions. **Conclusion:** We therefore hypothesize that caffeine by altering the levels of neurotransmitters leads to processing of relevant information in the classical color word Stoop task which manifests as faster reaction times.

Introduction:

In today 's fast-paced lives people need vigor to keep up with their demanding schedules and lifestyles. Often, they need some assistance in doing so. Caffeine is a naturally occurring chemical and is referred to as an "ancient wonder drug" 1 for its potential to revive weary workaholics. It was discovered in the coffee bean (Coffea arabica) in Arabia, the tea leaf (Thea sinensis) in China, the kola nut (Cola nitida) in West Africa, and the cocoa bean (Theobroma cacao) in Mexico[2].

Caffeine (1,3,7 trimethylxanthine) is one of the most widely used psychoactive drug in the world and consumed in various forms like tea, coffee, and colas. The half life of caffeine is 3-7 hours and its significant levels can be detected in the brain after 5 minutes of oral intake, with the peak levels reaching in about 30-40 minutes 3,4 . Caffeine has a chemical structure of is 1,3,7-trimethyl xanthine. Methylxanthine has similar structure to purines, adenosine, xanthine, and uric acid 2. 99% of the orally ingested chemical is taken up within 45 min[2].

Caffeine's main mechanism of action is by blocking the adenosine receptors and altering the levels of various neurotransmitters like dopamine, adrenaline, serotonin, and acetylcholine.5 Other mechanisms like mobilization of calcium, inhibition of phosphodiesterases, and binding to benzodiazepine receptors have also been postulated.[6-8]

The Stroop task [9] constitutes one of the most widely used paradigms in cognitive control studies; in this task, an automatic or predominant response tendency (i.e., word reading) must be withheld in favor of a more controlled one [10]

In the classical Stroop task, participants are presented with color words (i.e., names of colors) in different colored print. Word meaning and ink color are either congruent (e.g. the word "blue" printed in blue letters) or incongruent (e.g. the word "blue" printed in red letters). Participants are instructed to name the print color while ignoring the meaning of the word. The Stroop effect refers to the finding that participants are slower to name the correct color in incongruent trials, compared to congruent trials[11].

The Stroop task is believed to be the "Gold Standard of attentional measures" aimed at studying the interference of a stimulus of one dimension with recognition of stimulus of another dimension.12 The conventional color word version task consists of words like "Blue", "Red", "Green" and "Yellow" written in another color or are incongruent (e.g., Red is written with blue ink) or symbols like "XXX" in different colors or are neutral. 13 The subject has to respond to the color. The time taken to perform the task in the two conditions (incongruent and neutral) is recorded and the difference between the two represents "interference". Similarly the time difference between congruent ("Red" written in Red ink) and neutral is an indication of "facilitation".

Aim and Objectives:

To determine effect of caffeine on information processing by virtue of observations obtained from classical colour-word Stroop task.

Material and Methods:

This study was conducted at the Department of Physiology, Pt JNM Medical College, Raipur CG. Forty two (42) healthy 1st year medical student volunteers in the age group of 18-25 years were recruited after explaining the procedure and taking written consent. A list of volunteers was drawn, out of which 42 candidates were drawn by lottery method.

The subjects were asked to refrain from caffeine or caffeine containing food items for at least 12 hours prior to the study. They were asked to report to the lab by approx. 9 a.m on the day of testing after having proper night sleep. The subjects were given a practice session a day before the day of testing. Persons aged 18-25 years of age and willing to participate were included in the study. Names of all such candidates were drawn in a list and 42 test participants were chosen by simple random sampling.

Those having history of medical illness especially neurological diseases, history of smoking, alcohol or any other drug consumption, subjects on any medications during last two weeks and not willing to participate were excluded from the study.

An analysis program reads the data file and computes means and standard deviations of the reaction times for correct responses in each of the three conditions. The means of reaction time obtained in each condition is compared with that obtained after caffeine consumption which was further analysed using paired t-test .

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Interference and facilitation was computed for each condition in pre and post caffeine sessions.

Paired t-test was also used to analyse the number of correct responses pre n post caffeine session. One way anova test was used to predict the effect of caffeine on cumulative mean reaction times of all 42 subjects undergoing the stroop task. The level of significance was kept as 0.05.

Results:

This study was conducted at the Department of Physiology, Pt JNM Medical College, Raipur CG. 42 healthy 1st year medical student volunteers in the age group of 18-25 years were recruited in the study. Males (62%) outnumbered females (38%) in the study.

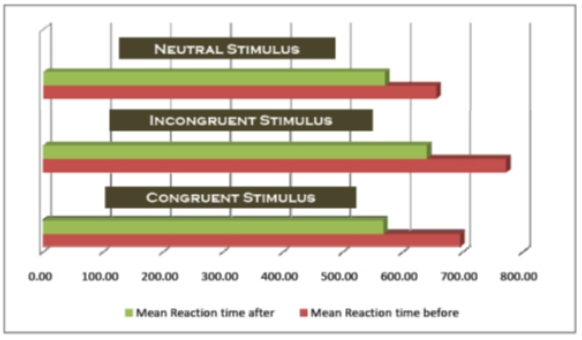
The study clearly demonstrated a reduction in the reaction time post caffeine and it was statistically significant (p value <0.0001) for all three conditions (Neutral /Incongruent/ Congruent).

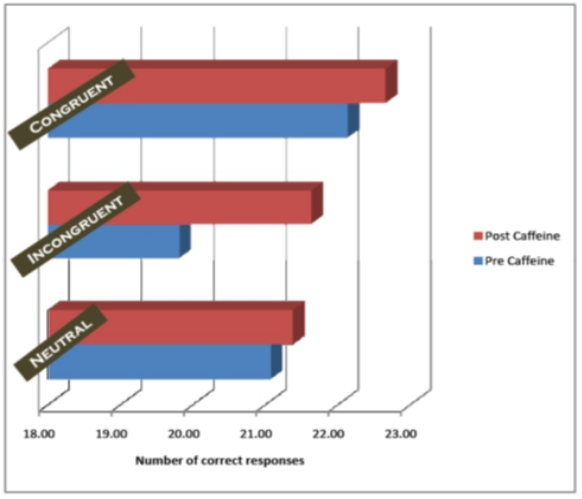
Table 1: Comparison of cummulative Mean Reaction time (in ms) before and after caffeine ingestion for all three stimuli (p value <.01)

Stimuli	Mean reaction time before	Mean reaction time after
Neutral	696.18	567.49
Incongruent	773.03	640.23
Congruent	656.69	570.94

Table 2: Comparison of number of correct responses (accuracy) before and after caffeine

No. of correct responses		
	Pre caffeine	Post caffeine
Neutral	21.07	21.38
Incongruent	19.81	21.64
Congruent	22.14	22.67





Discussion:

The Stroop color/word task is a prototypic paradigm in cognitive neuroscience to probe attentional phenomena, such as the selection of processing and the inhibition of habitual responses 14. This task is, in fact, an archetype of human intentional behavior for many cognitive neuropsychologists 15. Numerous chronometric studies have sought the mental locus of the powerful Stroop effect. Perceptual conflict 16, conceptual encoding17, response interference18, or combinations of these have been posited as the source of the effect.

Our study clearly demonstrated a reduction in the reaction time post caffeine and it was statistically significant (p value <0.0001) for all three conditions. Among the three conditions, processing was found to be enhanced more for incongruent and neutral stimuli (mean decrease in reaction time of 130+/-2 msec) relative to congruent stimulus (mean decrease in reaction time of 85.75 msec) . However, studies done by Lyvers et al19. and Deslandes et al.20 did not find any significant effect of caffeine on Stroop task.

The findings in our study was similar to that reported by Hasenfratz and Batting21and Kenemans et al22. Hasenfratz and Battig21 had twenty female regular cigarette smokers and coffee drinkers performed a numerical Stroop task in a 2 x 2 (caffeine x smoking) prepost crossover design. In the easier of the two different versions, caffeine and smoking reduced the reaction times (RT's) when given alone, but there was no additive effect. The Stroop effect itself (difference between RT's to numbers and RT's to symbols) was reduced by the two treatments only in the more difficult version, but the combination did not differ from the placebo condition. The physiological reactions to both treatments were additive, although the two reaction profiles were different. They found an improvement in performance after administration of caffeine. But the difference between their study and ours was that they had smokers as their subjects who were in a state of nicotine deprivation when the testing was done and also they had used numerical stroop task and not the color word task. Nicotine deprivation by itself is known to effect cognitive processes. Hence, their results cannot be attributed to pure caffeine effect.

Conclusion:

The present study evaluated the effect of caffeine, a known CNS stimulant on the color-word Stroop task. There was a statistically significant reduction in pre caffeine and post caffeine reaction times across all three conditions in the stroop color-word test indicating faster information processing and choice selection post administration of caffeine in well rested volunteers. Our study clearly demonstrated a reduction in the reaction time post caffeine and it was statistically significant (p value <0.0001) for all three conditions.
We therefore hypothesize that caffeine by altering the levels of neurotransmitters leads to processing of relevant information in the classical color word Stoop task which manifests as faster reaction times across all three conditions.

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References:

1. McCarthy D. M., Mycyk M. B., DesLauriers C. A. (2008). Hospitalization for caffeine abuse is associated with abuse of other pharmaceutical substances. Am. J. Emerg. Med. 26, 799– 80210.1016/j.ajem.2007.10.018
2. Chou T. (1992). Wake up and smell the coffee. Caffeine, coffee and the medical consequences. West. J. Med. 157, 544–553
3. Undem BJ, Lichtenstein LM. Drugs used in treatment of asthma. In: Hardman JG, Limbird LE, Gilman AG, editors. Goodman and Gilman's The Pharmacological basis of Therapeutics. 10th ed. New York: McGrawHill; 2001. pp. 743–7.
4. Latini R, Bonati M, Catelli D, Garrattini S. Dose dependent kinetics of caffeine in rats. ToxicolLett. 1978;2:267–70.
5. Daly JW. Mechanism of action of caffeine. In: Garattini S, editor. Caffeine, coffee and health. New York: Raven Press; 1993. pp. 97–150.

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6. Bianchi CP. The effects of caffeine on radiocalcium movement in frog Sartorius. J Gen Physiol. 1961;44:845–58.
7. Vernikos-Danellis J, Harris CG., III The effect of in-vitro and in vivo caffeine, theophylline and hydrocortisone on the phosphodiesterases activity of the pituitary, median eminence, heart and cerebral cortex of rat. ProcSocExpBiol Med. 1968;128:1016–21
8. Boulenger JP, Patel J, Marangos PJ. Effects of caffeine and theophylline on adenosine and benzodiazepine receptors in human brain. NeurosciLett. 1982;30:161–6.
9. Stroop JR (1935) Studies of interference in serial verbal reactions. Journal of Experimental Psychology 18: 643–662.
10. MacLeod CM (1991) Half a century of research on the Stroop effect: An integrative review. Psychological Bulletin 109: 163–203.
11. MacLeod CM, Dunbar K (1988): Training and Stroop-like interference:Evidence for a continuum of automaticity. J ExpPsychol[Learn MemCogn] 10:304–315.
12. MacLeod CM. The Stroop Task: The "Gold Standard" of attentional measures. J Exp Psychol. 1992;121:12–4.
13. MacLeod CM, MacDonald PA (2000) Interdimensional interference in the Stroop effect: Uncovering the cognitive and neural anatomy of attention. Trendsin Cognitive Sciences 4: 383–391. pmid:11025281 doi: 10.1016/s13646613(00)015308.
14. Mesulam, M. M. (1985) Principles of Behavioral Neurology(Davis, Philadelphia), pp. 124-163
15. Posner, M. 1. (1986) Chronometric Explorations of the Mind(Oxford Univ. Press, New York), pp. 91-97.
16. Hock HS, Egeth H. Verbal interference with encoding in a perceptual classification task. J Exp Psychol. 1970 Feb;83(2):299–303.
17. Seymour PH. Conceptual encoding and locus of the Stroop effect. Q J Exp Psychol. 1977 May;29(2):245–265..
18. Proctor RW. Sources of color-word interference in the Stroop color-naming task. Percept Psychophys. 1978 May;23(5):413–419
19. Lyvers M, Brooks J, Matica D. Effects of caffeine on cognitive and autonomic measures in heavy and light caffeine consumers. Aus J Psychol. 2004;56:33–41
20. Desandes AC, Veiga H, Cagy M, Piedade R, Pompeu F, Ribiero P. Effects of caffeine on the electrophysiological, cognitive and motor responses of the central nervous system. Braz J Med Biol Res. 2005;38:1077–86.
21. Hasenfratz M, Bättig K. Action profiles of smoking and caffeine: Stroop effect, EEG, and peripheral physiology. PharmacolBiochemBehav.1992;42:155–61.
22. Kenemans JL, Wieleman JS, Zeegers M, Verbaten MN. Caffeine and stroop interference. PharmacolBiochemBehav. 1999;63:589–98.