Evaluation of Effects of Black Tea and Coffee on Learning Process and Memory in Healthy Human Volunteers

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ABSTRACT

The study was conducted in healthy human volunteers adhering to good clinical practices and institutional human ethical norms. All the volunteers have completed the study. There were no dropouts and no signs and symptoms of any adverse effect after consumption of the beverages. This indicates the positive compliance in the study.

The overall effect observed in the study that the consumption of beverages Black Tea and Coffee increases alertness in the volunteers and it helps to facilitate the performance and thus enhance the memory. This is confirmed by the level of confidence development in the volunteers to perform the psychopharmacological parameters. The parameters selected in the study are the functional characteristics of thought process, learning and memory. The reduction in reaction time after the consumption of Black tea and Coffee signifies the effect on learning process. The improvisation of this facilitates the memory in the form of retention and its implementation in developing skills. Clinically these results are very promising and can be extrapolated for the treatment of neurodegenerative disorders like Alzheimer's disease, dementia where at least partial effect on the process of learning and recent memory.

Black Tea and Coffee are consumed many times by the individuals in the situations like appearing for examinations where the level of performance is of significance to have optimum outcome. These may be recommended for short time use. However, the additional effects may be confirmed in larger studies in controlled manner.

Keywords: Black Tea, Coffee, Memory, Learning, Physiological Performance.

INTRODUCTION

Learning is the cognitive process of acquiring skill or knowledge or it refers to the acquisition, and transfer to long-term memory of experience, Information, and Knowledge may subsequently be used for solving problems, making decisions, and creating new knowledge for further application in daily routines. Learning in general, is the change of thought, behavior and perception of the person due to his interaction with environment. The theories that analyze the nature of learning and its effects are categorized into four groups:

➢ Behaviorist Orientation
➢ Cognitive Orientation
➢ Humanistic Orientation
➢ Social and circumstantial Orientation

Behaviorist theory considers that learning is formed by change in behavior of a human being with the time as a result of stimuli in external environment. It produces behavioral change in desired direction to elicit desired response.

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The cognitive orientation indicates learning is a non-observable process.

It is an internal mental process including insight, information processing, memory, perception due to internal cognitive structuring. It develops capacity and skills to learn better. During Cognitive development, intelligence, learning and memory are functions of age, and learning is manifestations in adult learning.

Memory refers to the processes that are used to acquire, store, retain and later retrieve information. There are three major processes involved in memory: encoding, storage and retrieval**.** Short-term memory is closely related to "working" memory. It is very short time that one keeps something in mind before rejecting or transferring it to long-term memory. Short-term memory is shorter than we think, lasting less than a minute. It allows us to remember the first half of a sentence we hear or read long enough to make sense of the end of the sentence but in order to store that sentence (or thought, fact, idea, word, impression, sight etc) for longer than a minute or so, it has to be transferred to long-term memory. As we grow older our short-term memory span often becomes even shorter. This makes us more likely to have trouble keeping up with certain tasks. It also gives our brains less time to

successfully move new information to long-term memory, which makes us more likely to forget details of recent events. A long-term memory is anything we remember that happened more than a few minutes ago. Long-term memories are not all of equal strength. Stronger memories enable us to recall an event, procedure and fact on demand. Long-term memory is not static. We do not imprint a memory and leave it as if untouched. Instead, we often revise the memory over time perhaps by merging it with another memory or incorporating what others tell us about the memory. The process of learning and memory develop simultaneously in individuals. The learning process begins in infantile stage and is geared up during the process of maturity and adolescence age. Subsequently the process of learning itself is utilized for storage of memory which is recalled as past memory. However, the process of recent memory is influenced by many factors which may include repetitive learning

MATERIALS AND METHODS

The present study was carried out with the objective of comparison of effect of commonly consumed beverages on functional parameters of learning and memory. These characteristics are evaluated using psychopharmacological tests commonly indicating the process of learning and improvising memory. Study was conducted to indicate any effects of consumption of normally consumable beverages (Black tea and Coffee) on functional parameters especially the learning and memory process in healthy human volunteers.

The beverages used were purchased from ready market
1) Black Tea
2) Black Coffee

Preparation of Black Tea
1. Decoction of raw material was prepared in freshly boiled water.
2. Decoction was filtered through the sieve.
3. Sugar was added to the decoction and served to the volunteers.

Preparation of Black Coffee
1. Coffee powder was added to the freshly boiled water.
2. Decoction was filtered through the sieve.
3. Sugar was added to the decoction and served to the volunteers.

STUDY PROTOCOL

This was a human study and hence approval was obtained from institutional ethics committee for the conduct of the study. The study was conducted adhering to norms of good clinical practices and good laboratory practices. No blood samples or any other body fluids were withdrawn during the study.

The study was planned to be carried on healthy young volunteers. They were divided in two groups each consisting of six volunteers. The volunteers of 22-28 years age groups were selected for the study. On detailed discussions with them regarding the nature and objective of the study, written informed consent was obtained and enrolled in the study after physical evaluation parameters. Subsequently they were evaluated for the evaluative tests.

EVALUATION PARAMETERS

The volunteers were evaluated using following parameters.

Mathematical Calculation test

In this test, the volunteers were asked to solve a mathematical summation problem (Chart - 1).

The volunteers were evaluated for:
i. Total time taken to complete the exercise,
ii. Total correct answers and
iii. Total incorrect answers

Chart 1: Mathematical Calculation Test									
35	40	40	60	40	55	35	30	35	12
25	50	50	90	30	60	60	20	95	45
50	30	30	25	25	40	45	64	15	55
40	20	50	60	55	30	30	35	34	35
60	50	40	75	15	50	20	95	56	53
55	40	30	30	50	40	55	35	43	17
25	55	20	55	80	45	25	65	17	37
20	60	80	35	40	45	15	30	50	13
30	15	50	60	45	35	65	20	38	27
25	75	80	20	25	20	30	25	12	20
Total									

Number Cancellation Test

In this test, the volunteers were given a table consisting of 10X10 (100 small squares) and were asked to cancel a particular number in a random fashion (Chart – 2).

The volunteers were evaluated for:
i. Total time taken to complete the exercise,
ii. Total number of cancelled number and
iii. Incorrect number(s) cancelled.

Chart 2: Number Cancellation									
6	1	5	7	9	4	3	7	1	2
5	2	4	8	5	1	3	5	9	7
7	6	9	1	2	6	9	4	6	1
9	5	3	8	9	4	2	9	3	5
2	9	2	1	3	9	1	7	2	4
3	4	4	7	4	8	3	8	1	9
5	4	3	5	6	2	8	1	3	7
8	5	9	4	1	3	6	7	6	3
6	1	7	3	4	1	7	5	4	9
4	5	5	2	5	9	4	6	2	4

Alphabet Cancellation Test

In this test, the volunteers were given a table containing alphabets in 100 small squares, each alphabet repeated 7 to 8 times randomly and were asked to cancel a particular alphabet (Chart – 3).

The volunteers were evaluated for:
i. Total time taken to complete the exercise,
ii. Total alphabets cancelled and
iii. Incorrect alphabets(s) cancelled.

Chart 3: Alphabet cancellation Test									
A	D	C	B	F	G	H	M	B	V
Q	G	S	X	S	B	Z	X	A	D
E	T	F	C	F	G	H	B	X	Z
S	L	A	G	J	K	A	S	N	Z
K	J	H	D	A	G	S	X	V	K
J	E	H	J	D	D	A	D	C	S
K	J	H	D	A	G	S	X	V	K
F	S	B	L	K	A	G	D	X	A
H	E	S	A	G	J	C	R	Y	U
P	O	Y	E	A	P	O	A	W	R

Upward Digit Scale Test

In this test, the volunteers were verbally informed eight numbers (10-99) in upward order and were asked to memorize the numbers in the same manner and reproduce in the same order (Chart – 4).

The volunteers were evaluated for:
i. Synchrony of numbers
ii. Missing number(s)

iii.   Incorrect Number(s)

Chart 4: Upward digit scale
12
21
29
47
53
62
77
83

Fixed Digit Test

In this test the volunteers were given a fixed double digit and were asked to apply mathematical calculation as directed in the test chart. Each time the evaluator would give exercise the sum as add or cancel. The answer within 10 seconds would be given the score of 2, later than 10 second 1 and incorrect and missing answer as 0. The total score is measured at evaluation each time (Chart- 5).

The volunteers were evaluated for the following:

i.   Total Score
ii.   Correct answers
iii.   Incorrect answers.

Chart 5: Fixed Digit Test			
Sr. No.	Number	Result	Score
1	25 – 15		
2	25 + 45		
3	25 ÷ 5		
4	25 + 40		
5	25 + 7		
6	25 – 11		
7	25 + 50		
8	25 – 13		
	Total Score		

Total score was calculated as follows

Answer	Score
Before 10 sec.	2
After 10 sec	1
Incorrect answer	0

Four Words Test

In this test the volunteers were given four words with no interlink among them and were asked to memorize them in a particular sequence they want and to recall the word when asked. The words were to be memorized throughout the study time. (Chart - 6)

The volunteers were evaluated for the following
i.   Synchrony of words
ii.   Missing Word(s)
iii.   Incorrect Word(s)

Chart 6: Four Words Test	
Aircraft	Desert
Needle	Lunch

The study was performed in three steps
A. **Basal Reading:** Before administering the beverages.
B. **30 Minutes:** Volunteers were evaluated for above mentioned tests after 30 minutes of ingestion of beverage
C. **90 Minutes:** Volunteers were evaluated for above mentioned tests after 90 minutes of ingestion of beverage.

Statistical Evaluation

The comparative analysis was made using Prism software. The values are compared with basal and 30 and 90 minutes. The level of significance was defined as $p < 0.05$ and 0.02.

RESULTS AND DISCUSSION

Mathematical Calculation Test

All the volunteers have completed the study. There was no dropout from the study volunteers. The basal time taken for solving mathematical calculation test was 393.2 and 339.4 seconds respectively in the groups of Black tea and Black Coffee. This time reduced in the same test after 30 minutes in both groups to 267.8 & 271 seconds. The reduction in time taken to solve the mathematical calculation test indicates the influence of beverage on volunteers. This is reflected in the form of increasing alertness and to perform better. This effect is maintained at 90 minutes evaluation. The number of sum correct in this test has been 9.167 and 8.4 at 30 minutes and 8.33 & 8.8 at 90 minutes in both groups as compared to basal which was 8.00 & 8.00. Similar is the result of incorrect answers which decreased from 2 to 0.8333 & 1.6 at 30 minutes (Table 1).

Table 1: Mathematical Calculation Test

Beverage	Total Time Taken (Sec.)			Correct Answer			Incorrect Answer		
	Basal	30 min.	90 min.	Basal	30 min.	90 min.	Basal	30 min.	90 min
Black Coffee	393.2	*267.8	*261.7	8	*9.167	8.333	2	0.8333	0.00
Black Tea	339.4	*271	365.4	8	8.4	8.8	2	1.6	0.00

*The level of significance was defined as $p < 0.05$

Number Cancellation Test

The time taken to cancel the given number is decreased after Black tea consumption and there is no significant change in case of Black Coffee consumption. (Table 2)

Table 2: Number Cancellation Test

Beverage	Total Time Taken (Sec.)			Total Number Cancelled			Incorrect Number Cancelled		
	Basal	30 min.	90 min.	Basal	30 min.	90 min.	Basal	30 min.	90 min.
Black Coffee	19.5	*16.83	*16.83	100	97.92	100	0.00	0.00	0.00
Black Tea	22.8	19.4	20.2	98.33	100	100	0.00	0.00	0.00

*The level of significance was defined as $p < 0.05$

Alphabet Cancellation Test

The time taken to cancel the given alphabet in random manner is decreased after Black tea consumption and there is no significant change after Black Coffee consumption. The results were uniform at 30 minutes and 90 minutes. (Table 3)

Table 3: Alphabet Cancellation Test

Beverage	Total Time Taken (Sec.)			Total Alphabet Cancelled			Incorrect Alphabet Cancelled		
	Basal	30 min.	90 min.	Basal	30 min.	90 min.	Basal	30 min.	90 min.
Black Coffee	16.33	16	*15.83	97.92	94.44	100	0.00	0.1667	0.00
Black Tea	19.4	19.2	16.8	100	100	97.78	0.00	0.00	0.00

*The level of significance was defined as $p < 0.05$

Upward Digit Scale Test

The analysis of upward digit scale test did not indicate any significant difference in memorizing synchronically the upward digits, missing numbers and incorrect numbers. (Table 4)

Table 4: Upward Digit Scale Test

Beverage	Synchrony			Missing Number			Incorrect Number		
	Basal	30 min.	90 min.	Basal	30 min.	90 min.	Basal	30 min.	90 min.
Black Coffee	1.833	2	2.833	0.8333	1.333	1.5	1	0.6667	0.00
Black Tea	2.4	1.8	1.6	1	0.8	0.4	1.4	1	0.00

Fixed Digit Test

The total score obtained in evaluation of fixed digit test showed trend towards improvisation of memory. The effects were uniform after 30 minutes and 90 minutes evaluation. The correct answers were maintained in most volunteers. (Table 5)

Table 5: Fixed Digit Test

Beverage	Total Score			Correct Answer			Incorrect Answer		
	Basal	30 min.	90 min.	Basal	30 min.	90 min.	Basal	30 min.	90 min.
Black coffee	96.88	100	97.92	7.833	8	7.833	0.2	0.00	0.00
Black Tea	88.75	*92.5	*93.75	7.2	7.4	7.6	0.8	0.6	0.00

*The level of significance was defined as p< 0.05

Four Words Test

There was ease of memorizing four words each time at 30 minutes and 90 minutes after the consumption of beverages. It was observed that memorizing word, were easier than mathematical numbers. (Table 6)

Table 6: Four Words Test

Beverage	Synchrony of Words			Missing Words			Incorrect Words		
	Basal	30 min.	90 min.	Basal	30 min.	90 min.	Basal	30 min.	90 min.
Black Coffee	100	100	100	0.00	0.00	0.00	0.00	0.00	0.00
Black Tea	100	100	100	0.00	0.00	0.00	0.00	0.00	0.00

The trend towards making mechanical errors in incorrect answers was reduced following consumption of these beverages. Although, there was no distinctive difference with the individual type of beverages, of them produce alertness, concentration and indirectly improved the physiological and psychopharmacological performance.

The level of significance is determined by using students' paired 't-test. The statistical analysis shows very marginal significant difference before and after the consumption, however, clinically the difference was highly significant. (Table 7, 8, 9, 10, 11 & 12)

Table 7: t-values of Mathematical Calculation Test

Beverage	Total Time Taken (Sec.)		Correct Answer		Incorrect Answer	
	Basal vs. 30 min	Basal vs. 90 min	Basal vs. 30 min	Basal vs. 90 min	Basal vs. 30 min	Basal vs. 90 min
Black Coffee	1.788	2.144	2.445	0.4385	2.445	0.4385
Black Tea	2.126	0.1928	0.5898	0.7493	0.5898	0.7493

Table 8: t-values of Number Cancellation Test

Beverage	Total Time Taken (Sec.)		Total Number Cancelled		Incorrect Number Cancelled	
	Basal vs. 30 min	Basal vs. 90 min	Basal vs. 30 min	Basal vs. 90 min	Basal vs. 30 min	Basal vs. 90 min
Black Coffee	1.164	0.9818	1.685	1.122	0.00	0.00
Black Tea	0.9481	1.812	1.000	1.000	0.00	0.00

The study protocol and volunteer screening format was examined and approved by institutional ethics committee. The formal approval was obtained on both protocol and volunteer screening form. The study was conducted in healthy human volunteers adhering to good clinical practices and institutional human ethical norms. All the volunteers have completed the study. There were no dropouts and no signs and symptoms of any adverse effect after consumption of the beverages. This indicates the positive compliance in the study.

Table 9: t-values of Alphabet Cancellation Test

Beverage	Total Time Taken (Sec.)		Total Alphabet Cancelled		Incorrect Alphabet Cancelled	
	Basal vs. 30 min	Basal vs. 90 min	Basal vs. 30 min	Basal vs. 90 min	Basal vs. 30 min	Basal vs. 90 min
Black Coffee	0.1671	0.6956	0.5502	1.000	0.00	0.00
Black Tea	0.09829	1.857	0.00	1.000	0.00	0.00

Table 10: t- values of Upward Digit Scale Test

Beverage	Synchrony		Missing Number		Incorrect Number	
	Basal vs. 30 min	Basal vs. 90 min	Basal vs. 30 min	Basal vs. 90 min	Basal vs. 30 min	Basal vs. 90 min
Black Coffee	0.2774	1.225	0.8885	1.581	1.000	0.7906
Black Tea	0.4966	1.000	0.1728	0.7385	0.5898	0.2500

Table 11: t- values of Fixed Digit Test

Beverage	Total Score		Correct Answer		Incorrect Answer	
	Basal vs. 30 min	Basal vs. 90 min	Basal vs. 30 min	Basal vs. 90 min	Basal vs. 30 min	Basal vs. 90 min
Black Coffee	1.464	1.000	0.00	0.00	1.000	0.00
Black Tea	0.8018	0.5898	0.00	0.00	0.5345	1.1770

Table 12: t-values of Four Words Test

Beverage	Total Score		Correct Answer		Incorrect Answer	
	Basal vs. 30 min	Basal vs. 90 min	Basal vs. 30 min	Basal vs. 90 min	Basal vs. 30 min	Basal vs. 90 min
Black Coffee	0.00	0.00	0.00	0.00	0.00	0.00
Black Tea	0.00	0.00	0.00	0.00	0.00	0.00

It was observed in this study that compliance with both Black Tea and Black Coffee tested was excellent. There was no drop out from the study indicates the positive compliance. All volunteers were co-operative and there were no incidences of adverse effects reported during the trial.

The time taken to complete the mathematical summation and other tests like cancellation of random number and random alphabet from the chart is reduced, indicating that Black tea and Coffee helps to improve alertness and concentration while performing the task. During the phase of alertness the physiological performance increases which reflects in facilitating solving mathematical summation, ability to perform faster and better in arithmetic and number cancellation and random alphabet cancellation test. The influence on performance ability suggests improvement or facilitation of learning process with Black tea and Coffee.

The analysis of results show that the level of statistical significance is only marginal, however, this can be improved

by increasing the number of volunteers and using strict adherence to selection criteria of volunteers and evaluation conditions.. The large and broad variation in performance criteria between volunteers could be one of the factors for marginal statistical significance. Black tea ingestion produced an increase in alertness and self-reported improvements in mood. When taken in regular amounts throughout the day, black tea appeared to prevent the diurnal pattern of performance reduction. [1]

An amino acid found in tea called thiamine which could act as a neurotransmitter. A study in rats found that thiamine modulated serotonin and dopamine levels and appeared to improve memory and learning ability. [2]

Chronic administration of tea polyphenols has shown reversal of scopolamine induced retention deficits in passive avoidance and spontaneous alertness behavior tasks. [3]

In a study of two different age groups: 20-25 years and 50-65 years, it has been observed that the younger participants generally performed better than the older on psychomotor and cognitive tests. After caffeine, both groups showed an improvement in psychomotor and cognitive performance, particularly in offsetting the declining performance over time in the older participants. [4]

In another set of experimental studies, the improvement of long term memory has been seen in rats. The rats were able to find and perform faster after treatment with caffeine particularly increase in memory retention. [5]

In human study it was shown that caffeine possesses cognition enhancing property. The result seen in our study on volunteers with black coffee consumption shows improvement on functional cognitive performance as reported by other researchers. [6]

The study examined the association of caffeinated and decaffeinated coffee intake with cognitive function in a community-based sample of older adults in 1988–1992. Participants were 890 women with a mean age of 72.6 years and 638 men with a mean age of 73.3 years from the Rancho Bernardo Study. Cognitive function was assessed by 12 standardized tests, and lifetime consumption and current coffee consumption were obtained by questionnaire. After adjustment for confounders, higher lifetime coffee consumption in women was associated with better performance on six of 12 tests, with a trend on two other cognitive function tests. [7]

The overall effect observed in the study that the consumption of Black Tea and Coffee increases alertness in the volunteers and it helps to facilitate the performance and thus enhance the memory. This is confirmed by the level of confidence development in the volunteers to perform the psychopharmacological parameters in subsequent time intervals. The parameters selected in the study are the functional characteristics of thought process, concentration, ability to express and learning and memory. The reduction in reaction time in all the tests performed which includes mathematical summations, cancellation of numbers and alphabets after the consumption of Black tea and Coffee signifies the effect on learning process and resultant effects on memory. The improvisation of this facilitates the memory in the form of retention and its implementation in developing skills. Clinically these results are very promising and can be extrapolated for the treatment of neurodegenerative disorders like Alzheimer's disease, dementia where at least partial effect on the process of learning and recent memory.

Black Tea and Coffee are consumed many times by the individuals in the situations like appearing for examinations where the level of performance is of significance to have optimum outcome. These may be recommended for short time use. However, the additional effects may be confirmed in larger studies in controlled manner.

CONCLUSION

The overall effect observed in the study that the consumption of Black Tea and Coffee increases alertness in the volunteers and it helps to facilitate the performance and thus enhance the memory. This is confirmed by the level of confidence development in the volunteers to perform the psychopharmacological parameters in subsequent time intervals. The parameters selected in the study are the functional characteristics of thought process, concentration, ability to express and learning and memory. The reduction in reaction time in all the tests performed which includes mathematical summations, cancellation of numbers and alphabets after the consumption of Black tea and Coffee signifies the effect on learning process and resultant effects on memory. The improvisation of this facilitates the memory in the form of retention and its implementation in developing skills. Clinically these results are very promising and can be extrapolated for the treatment of neurodegenerative disorders like Alzheimer's disease, dementia where at least partial effect on the process of learning and recent memory.

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