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Original Article

# A Study to Compare "change" in Auditory and Visual Reaction Time After Administration of Caffeine in Medical Students

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## Abstract

**Introduction:** The present study is a comparative study of the changes seen in auditory reaction time (ART) and visual reaction time (VRT) in 1st-year medical students after the administration of caffeine present in coffee.

**Purpose:** This study is aimed at comparing how the ART and VRT are affected after caffeine present in coffee is administered to them.

**Materials and Methods:** The study was conducted on 42 male and 35 female 1st-year medical students. The 77 students were not regular coffee drinkers and were tested for changes in auditory and VRTs after the administration of caffeine present in coffee.

**Results:** It was found that the change in either ART or VRT did not differ significantly ($P > 0.05$) in either gender after the administration of caffeine.

**Conclusion:** No significant differences in change were observed between ART and VRT post caffeine intake in either gender. In both gender changes in ART and VRT were comparable after the intake of caffeine.

**Key words:** Auditory reaction time, Caffeine, Coffee, Visual reaction time

## INTRODUCTION

Reaction time (RT) is the time that elapses between a person being presented with a stimulus and the person initiating a motor response to the stimulus. It involves the reception of stimuli by sense organ, conduction of information through the nerve to brain, and from brain to muscle contraction and movement. It is thus a simple and effective method of studying central neuronal processing and is a simple method of determining sensory-motor association, performance, and cortical arousal. Apart from the time required for sensory-motor association, this is the time required by the brain for perceptual decision making and motor planning.[1] RT depends on age, sex, fatigue, fasting state, sleep, and stress.

In daily life, one has to respond to various situations immediately and as the RT indicates the time taken by an individual to react to an external stimulus, it can be important in the case of various activities that are carried out on a day to day basis. These activities can be both of "Auditory" as well as "Visual" in nature. Auditory ones could be like a response to a phone call, a door bell, whistle of pressure cooker or even may be a "cry of help." Visual ones could be like responding to traffic signals, "Driving and changing lanes," maneuvering a fighter plane, responding to enemy fire, or even preventing an accident from occurring. Thus, they could just be normal routine activities or could also extend to crucial ones pertaining to life and death.

Caffeine is one of the most commonly used substances found in everyday beverages such as tea and coffee. It is an alkaloid compound and is actually a bitter substance

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found in coffee beans, cocoa beans, and many other plant products. The scientific name for caffeine is 1,3,7-trimethylxanthine.[2] Caffeine is known to stimulate the central nervous system. Mild cortical stimulation appears to be beneficial, resulting in more clear thinking and less fatigue. Caffeine in low doses is capable of causing desirable improvement of physical and cognitive functions. The usage of caffeine is also considered to be addictive in nature. Daily use of caffeine is known to cause some sort of dependence for this substance in the form of nervousness, headache, and irritation.[3] But used judiciously within limits, it is known to have many beneficial effects. The USFDA considers a moderate intake of caffeine to be "SAFE." Safe doses of caffeine are considered to be around 300 mg/day in an adult.[4,5] Beneficial doses of caffeine which increased motor and mental performances range to about 65–130 mg of caffeine in a single take.[6]

Studies done on caffeine by Bullock and Gilliland[7] on the auditory modality have shown speeding up of the sensory component of brainstem auditory evoked potentials. This finding suggests that caffeine keeps the auditory sensory pathways alert, probably at the brainstem level.

Similarly, studies done by Tharion *et al.*[8] on both auditory and visual stimuli showed caffeine to significantly ignore distracting or irrelevant stimuli, thus helping the subjects focus more on the task, thereby giving rise to improved RTs. Furthermore, studies done by Lorist *et al.*[9] showed the effect of caffeine in reducing visual RT (VRT) by stimulating the input and output stage of the information processing system.

After considering the studies done on the effects of caffeine, there remains no uncertainty that caffeine improves the RTs in both the visual as well as the auditory scales. However, we as researchers were curious to know if caffeine affects auditory and visual modalities differently. Hence, we decided to check how the administration of caffeine fared comparatively on the improvement in VRT and ART on the male and female subjects and thus have tag on information about the effects of caffeine present in a standard cup of coffee.

## MATERIALS AND METHODS

The study was conducted in Grant Government Medical College on 42 male and 35 female 1st-year medical students. Entire batch was requested to enroll for the study. However, those who turned up for the study, on their own, were considered for the study. Informed consent of the subjects and approval from the institutional ethics committee was taken to conduct the study. The study was conducted in the Department of Physiology when the authors were posted there.

The subjects being 1st-year medical students were mostly of the same age range. Habitual coffee drinkers were excluded from the study to discard the effects of caffeine dependence. Too obese or too lean subjects were excluded from the present study. Studies done on the female subjects were done after excluding their menstrual and premenstrual period.

The coffee sachets from a well-known coffee brand were taken. We considered the fact that beneficial dose of caffeine for increased mental and motor performance is about 65–130 mg of caffeine.[6] Hence, 2 g of coffee powder was used to make one cup of coffee, which contained around 63 mg of caffeine, thereby bringing the caffeine content to near ideal doses.

Both the male and the female medical students were tested for RT "before" and 30 min "after" the intake of coffee, considering that the effects of caffeine are known to be more pronounced within the 1st h of coffee intake.[10] RT measurements were done in the form of auditory RT (ART) and VRT.

RT apparatus (Anand Agencies, Pune) was used for the study. It has a built-in 4 digit chronoscope and displays accuracy of 1 ms. Recordings were taken in the morning time. Subjects were instructed to come with routine normal breakfast. Recordings were taken "before" and 30 min "after" the intake of a standard cup of coffee as mentioned before. ART was recorded for auditory beep sound stimulus and VRT for red light stimulus. To avoid the effect of lateralized stimulus, the subjects were given visual and auditory stimuli from the front. They were instructed to respond with their dominant hand as soon as they perceived the visual or auditory stimulus. Subjects were given adequate exposure to get acquainted with the working of the apparatus before starting with the actual test.[11,12]

### Calculation and Result

The present study had data generated from 42 male and 35 female students. Data obtained for ART and VRT was presented as mean ± SD. These data comprised ART and VRT done in the male and female subjects "before" and 30 min "after" consumption of caffeine. The motive was to find out what "changed" more, ART or VRT after caffeine usage. Hence, the data obtained "before" and 30 min "after" consumption of caffeine for ART was compared with similar data obtained for VRT in both genders. Statistical analysis for the study was done using

the popular software GraphPad prism 5 software. Paired and unpaired *t*-test used for comparing the data between the ART and VRT change. $P > 0.05$ was considered non-significant.

Results are summarized in Tables 1-3:

Data were analyzed separately for both male and female subjects. In both cases, there was a significant decrease found in ART as well as VRT after caffeine intake ($P < 0.05$), but on comparing the changes obtained between ART and VRT after caffeine intake, the result was not found to significant ($P > 0.05$) in either of the gender.

## DISCUSSION

Caffeine in one of the world's most widely used psychoactive substance. However, the use of caffeine is legal and widely accepted, unlike other psychoactive substances. Caffeine is most commonly consumed by humans as coffee brewed from the extract of beans of coffee plants. The USFDA lists caffeine as a "Multiple purpose generally recognized as safe food substance."[13] The widespread consumption of coffee in the absence of a clear definition of physiological and behavioral spectrum of action has continued to stimulate research. Mental performance where speed, endurance, or vigilance was required showed reported benefits from caffeine intake.[14] Evidence for the behavioral effects of caffeine is well documented in the literature. It is associated with increased subjective alertness. Ingestion of caffeine within physiological limits caused the subjects to experience a decrease in fatigue, lesser drowsiness, enhanced wakefulness, more concentration or reduced distraction, and increased energy.[9,15]

The effects of caffeine were seen to improve the RTs in both the visual as well as the auditory scales. Studies done by Bullock and Gilliland[7] on the auditory modality have shown speeding up of the sensory component of brainstem auditory evoked potentials. This finding suggests that caffeine keeps the auditory sensory pathways alert, probably at the brainstem level.

Similarly, studies done by Tharion *et al*.[8] on both auditory and visual stimuli showed caffeine to significantly ignore distracting or irrelevant stimuli, thus helping the subjects focus more on the task, thereby giving rise to improved RTs. Furthermore, studies done by Lorist *et al*.[9] showed the effect of caffeine in reducing VRT by stimulating the input and output stage of the information processing system.

While comparing two types of stimuli, plenty of studies maintain the fact that VRT was more than ART.[16-19] This can be attributed to the number of synapses in the visual pathway as compared to the auditory pathway. Vision takes 20–40 ms to travel in the visual pathway,[20] while sound takes just 8–10 ms to travel in the auditory pathway.[21,22] Thompson *et al*.[23] has documented that the mean RT to detect visual stimuli is approximately 180–200 ms, whereas for the sound, it is around 140–160 ms. Consequently, since the auditory stimulus reaches the cortex faster than the visual stimulus, the ART is faster than the VRT. Shelton and Kumar[24] also concluded that simple RT is faster for auditory stimuli compared with visual stimuli and auditory stimuli have the fastest conduction time to the motor cortex along with fast processing time in the auditory cortex. Such studies support the evidence that ART is faster than the VRT.[25]

However, the above findings are contradictory to the studies done by Shenvi and Balasubramanian,[26] who therein state that the auditory pathway is more polysynaptic than the visual pathway. At each synaptic junction, there is a modest (0.1–0.5 ms) and somewhat variable synaptic delay and therefore the conduction time is greater from the cochlea to the auditory cortex.[26,27] Again another research done by Yagi *et al*.[28] shows that RT to visual stimuli is faster than to auditory stimuli.

From the previous studies, it is clear that ART as well as VRT both decrease after administration of caffeine. It was also seen in most of the studies that ART is less than VRT. With this prior knowledge, we, therefore, conducted this study to check whether it was ART or was it VRT which was affected more by the administration of caffeine. This thought led us to the present study and led us to understand that caffeine influenced both ART as well as VRT equally.

**Table 1: Comparison of changes in ART and VRT after caffeine intake in males and females. Data obtained was presented as mean±SD**

| Reaction time | Males (*n*=42) | | | Females (*n*=35) | | |
|---|---|---|---|---|---|---|
| | Before caffeine | After caffeine | Difference in mean | Before caffeine | After caffeine | Difference in mean |
| ART (ms) | 243.45±10.43 | 231.52±12.38 | 11.93±7.84 | 243.03±10.35 | 228.80±11.32 | 14.23±9.12 |
| VRT (ms) | 200.21±7.77 | 186.57±12.01 | 13.64±9.03 | 199.84±10.22 | 183.01±11.60 | 16.83±7.53 |
| | Unpaired *t*=0.91 | | | Unpaired *t*=1.28 | | |
| | *P*>0.05 | | | *P*>0.05 | | |

**Table 2: Comparison of ART on 42 male and 35 female medical students "before" and "after" intake of caffeine. Data obtained was presented as mean±SD**

| Subjects | ART before caffeine | ART after caffeine | *P*-value |
|---|---|---|---|
| Males (*n*=42) | 243.45±10.43 | 231.52±12.38 | <0.01 |
| Females (*n*=35) | 243.03±10.35 | 228.80±11.32 | <0.01 |

ART: Auditory reaction time

**Table 3: Comparison of VRT on 42 male and 35 female medical students "before" and "after" intake of caffeine. Data obtained was presented as mean±SD**

| Subjects | VRT before caffeine | VRT after caffeine | *P*-value |
|---|---|---|---|
| Males (*n*=42) | 200.21±7.77 | 186.57±12.01 | <0.01 |
| Females (*n*=35) | 199.84±10.22 | 183.01±11.60 | <0.01 |

VRT: Visual reaction time

No differences were observed in our study for the decrease in RT post caffeine consumption in either gender for ART and VRT. Similar studies seem to not have been done till date, so corroboration of our data with other studies was difficult at this juncture. Future studies as and when undertaken could obviously compare with our data and thus validation obtained.

RT depends on several factors, that is, arrival of the stimulus at the sensory organ, conversion of stimulus to a neural signal by sensory organ, transmission and processing of neural signal, muscular activation, soft tissue compliance, and the selection of an external measurement parameter. The study done by Lorist *et al.*[9] supported the view that caffeine increases cortical arousal and perceptual sensitivity and that stimulating effect of caffeine was mainly located at input and output stages of the information processing. Caffeine did not seem to affect central processing. The main differences in ART and VRT, as pointed before, involved various polysynaptic pathways from the receptor organ to the brain. That, coupled by the fact that caffeine hardly has a role to play in affecting central processing, it had not affected either VRT or ART differentially. This seems to be the most probable rationalization for not deriving any significant differences between changes in ART and VRT post caffeine intake in our study.

## CONCLUSION

In this study, ART as well as VRT decreased in both gender after intake of caffeine, but no significant differences in change were observed between ART or VRT post caffeine intake in either gender. The present study thus sheds light upon the fact that the administration of caffeine improves ART and VRT to an equal extent in either gender. In a lighter note, it also shows that both males and females can gain equally on RT for many auditory and visual tasks after the judicious intake of caffeine in the form of tasty beverages like coffee.

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