REVIEW OF LITERATURE

The study of reaction time spans more than a century and provided an indicator index of the processing capability of the central nervous system (CNS) and also a simple means determining sensor motor performance. (Geraldine, 1981)

Persian scientist, Abu Rayhan al-Biruni was the first person to describe the concept of reaction time (RT). The first scientist to measure reaction time (RT) in the laboratory was Donders (1868). (Chandra et al 2010)

Reaction time is defined as a time interval between the application of a stimulus and initiation of appropriate voluntary response under the condition that the subject has been instructed to respond as early as possible. (Teichner 1954)

Reaction time is the elapsed time between presentation of a sensory stimulus and the subsequent behavioural response. (Chandra et al 2010)

Reaction time involves stimulus processing decision making and response programming. (Malathi et al 1990)

One measure of information processing is reaction time and is used to judge the ability of a person to concentrate and co-ordinate. It provides an indirect index of integrity and processing ability of the central nervous system (Lofthus 1981) and simple non-invasive means of determining sensor motor co-ordination and performance of an individual. (Das et al 1997)
Reaction time measurement includes the latency in sensory neural code traversing peripheral and central pathways, perceptive and cognitive processing, and a motor signal traversing both central and peripheral neuronal structures and finally the latency in the end effectors activation (i.e. muscle activation). So any change in reaction time indicates presence of peripheral and central disturbance. (Botwinick and Thompson 1966)

Simple reaction time evaluates the processing speed of CNS and the co-ordination between the sensory and motor systems. (Shenvi and Balasubramanian 1994)

As reaction time involves a speed and accuracy it has provided a way to evaluate commonly used psychological tests (mental chronometry) for alternation concentration in and cognitive skill with well proven diagnostic and predictive validity. (Welford 1980)

Reaction time is an index of cortical arousal and has been recognized as a potentially powerful means to assess the integrity of sensory motor co-ordination system of the body in response to an external stimulus. (Nikam and Gadkari 2012)

Auditory reaction time (ART) and visual reaction time (VRT) are non invasive technique used to assess relationships between sensory and motor activities of the CNS. It also provides information about integrative capability of CNS for sensory and motor signals. (Badwe et al 2012)
Reaction time is very powerful means of relating mental events to physical measure.

Because the reaction time involves sensory as well as motor alertness, factor affecting the sensory as well as motor system can affect the reaction time so it is found to be affected by many factors which affect sensory as well as motor system like mood, memory, psychological state, stress and first time performance etc.

Reaction time is a measure of function of sensory motor association and performance of an individual. It has physiological significance and is a simple and non-invasive test for peripheral as well as central neural structure. (Myrsten et al 2010)

All the components of reaction time, the mental processing time to perceive a signal and to decide upon a response, movement time and device response time are likely to get delayed in elderly people. Senile changes in peripheral processes, like decreased muscular response and impulse transduction through sensory nerve can account for increase in reaction time. (Cerella 1985)

1 ART-VRT: General:

Many researchers Woodworth and Scholoberg (1954) Von Fieandt et al (1956) Brebner (1980) Welford (1980) have confirmed that reaction to sound is faster than reaction to light with mean auditory RT being 140 – 160 ms and visual RTs being 180 – 200 ms Perhaps this is because an auditory stimulus only takes 8-10 ms to reach the brain (Kemp, 1973), where as a visual one takes 20-40 ms (Marshal et al, 1943). RT to touch
is intermediate, at 155 ms, (Robinson and Tamir 2005). Differences in RT between these types of stimuli persist whether the subject is asked to make a simple or a complex response. (Sanders, 1998)

Human visual and auditory systems have been evolving for long time and have attained very high performance as sensory organs, and they have been frequently studied. However, interactive characteristics between the visual and the auditory system were not very investigated.

Jing-Long Wu et al (1997) studied human interactive characteristics between the visual and the auditory system measured by psychological experiment and functional Magnetic Resonance Imaging (fMRI) with using task of the mental arithmetic problems. The results of psychological experiments suggested that the visual reaction time is remarkably affected by the auditory stimuli; however, the auditory reaction time cannot be affected by the visual stimulus when ART and VRT are concurrently presented.

In the experiments of fMRI the activation of cortex is succeeded in the measuring as the visual processing and the auditory processing for the mental arithmetic problem, respectively. The experimental result of fMRI suggested that the strongest response (activation) is to visual stimulus in the Brodmann’s area 39, and the activation of the partial lobe is to calculation.

In the auditory fMRI experiment, activation of the left partial lobe is observed in all subjects.
(2) ART-VRT: pranayam and exercise:

Borkar and Pednekar (2003) studied the changes on Visual reaction time (VRT) and auditory reaction time (ART) before and after 4 weeks of pranayamic breathing exercises. In this study, there was reduction in VRT from 0.196 sec. to 0.141 sec. after 4 weeks of pranayamic breathing exercise and ART reduced from 0.188 to 0.139 sec. Both values were statistically significant. A decrease in reaction time indicated an improved sensorimotor performance and could be due to an enhanced processing ability of the central nervous system. This effect on central nervous system could be due to greater improved concentration power and inhibit extraneous stimuli indicting better attention and less distractibility.

Malathi and Parulkar (1989) studied visual and auditory reaction time in 83 healthy male subject of 30-40 years The subject were divided in to two groups viz. group A whose ART and VRT was determined after 1 hr of yogasan and group B whose ART and VRT was determined after 6 weeks yogasan. ART and VRT showed a significant reduction in group A (P<0.05) and group B (P<0.001)

Chandra et al (2010) studied visual and auditory simple reaction time for both right and left hand of 15 young male students before and after exercise schedule and reported that there is decrease in both visual and auditory reaction time after the exercise but marked increase in them was noticed when exercise was performed at elevated temperature in a climatic chamber.
Appelle and Oswald (1974) studied effect of meditation on reaction time on 30 volunteers who were assigned to either the rest or task group mediators (15 in each group). The mean reaction time was significantly different following the rest condition and sorting task. Mediators showed no change in reaction time after meditation. However their score were significantly different following the rest condition.

RT and alertness have been positively correlated. Electrophysiological correlates of alertness have also been related to RT. For example, electroencephalographic indices of arousal correlate with simple RT to light (Morris, 1971) when α blocking precedes stimulus presentation, the visual RT may be markedly reduced (Lansing et al, 1959).

Wallace and Benson (1972) have found dramatic changes during Transcendental Meditation in oxygen consumption, blood lactate, skin resistance, blood pressure and respiration.

Badwe et al (2012) studied the hand reaction time to visual stimuli in 117 students in the age group of 17-20 year studying in first MBBS. They noticed significant difference in VRT of left hand and right hand in both sexes. Right hand VRT recorded a shorter duration than left hand as right hand being the dominant hand exhibited enhanced motor activity and hence VRT recorded in right hand was of shorter duration. Thus the time taken by central nervous system to process sensory and motor signals is dependent on human behaviour.
(3) **Effect of age on reaction time:**

Nikam and Gadkari (2012) studied the effect of age, gender and body mass index on visual and auditory reaction time in Indian population and reported that audio reaction time and visual reaction time were significantly higher in older individual as compared to younger. The process of ageing is characterized by progressive and generalized impairment of homeostasis resulting in declining ability to respond to external or internal stresses and increased risk of diseases. (Sircar, 2001)

VRT were significantly higher in older individual than young individual in either sex (P=0.000).

ART were also significantly higher in old individual than young individual in either sex (P=0.000).

All the components of reaction time; the mental processing time to perceive a signal and to decide upon a response, movement time and device response time are likely to get delayed in elderly. Senile changes in peripheral processes, like decelerated muscular response and impulse transduction through sensory nerves can account for 20% of reaction time lengthening. (Cerella, 1985)

But since sensory receipt and motor outflow times are believed to remain similar across the lifespan, the cause could be the slowed processing rate of central nervous system in old individuals (Marsh and Geel, 2000).
Bunce et al (2004) reported that RT is quickest for young adults and gradually slows down with age.

The study by Jadhao et al (2013) showed that delayed reaction time was more significant in higher age groups. That is, as age advances smoking related changes in the auditory and visual reaction time also go on increasing.

The probable explanation for this finding is that, as the age increases various changes occur in nerves e.g. increased fibrosis, segmental demyelization and degeneration leading to slowing of conduction velocity in motor nerves. These changes are more prominent beyond 50 years of age. With advancing age there is also an age related decline in psychomotor speed leading to delayed response in elderly individuals. (Houx and Jolles, 1993)

Chandak and Makwana (2012) evaluated the effect of advancing age and gender on visual and auditory reaction time in 320 normal male and female volunteers in the age group of 21-60 years. These volunteers were divided into two groups. Group A: 200 volunteers in age group of 21-45 years and Group B comprised of volunteers in age group of 46-60 years. The auditory and visual reaction time was recorded. They observed a significant increase in visual reaction time and auditory reaction time with advancing in age. The result for change in auditory reaction time due to advancing age as well as the result for effect of aging on visual reaction time was significant.
The effect of age on the reaction time is thoroughly studied by Crossman and Szafran (1956). Proportionate increase in reaction time with age is shown by various workers. (Griew, 1959 and Suci et al, 1960)

As the person ages, reaction to auditory as well as visual stimuli slow down.

Result of this study is in conformity with the study by Obrist (1953) which shows that there is shorting of the reaction time till 19th year of life which remains constant till the 26th year and then there is steady increase in the reaction time as person ages. Miles (1931) and Bells (1933) showed that reaction time of adult increase with age but the rate of this increase is apparently much greater during senescence than in middle age of life.

According to Welford (1980), the reason of slowing of reaction time with advancing age is not simple mechanical factor like the speed of nerve conduction but also because older people tends to be more careful and monitor their responses more thoroughly.

Botwinick and Thompson (1966) hypothesised that this could be due to the effect that older people are less aroused than those who are younger and that older people tend to look more at what they are doing and are more cautious in reacting to stimuli.

Distracted driving results in increased in number of car-accidents there for Androsen et al (2012) studied the reaction time in response to distraction to drivers like texting, listening to music, actively engaging in
conversations and in a control setting where no distractions were present.

Passive listening result in the stimulation of the primary auditory cortex, a region of the brain in the temporal lobe that is responsible for processing auditory inputs (Purves et al 2001). Thus the stimulation of the primary auditory cortex may add to the cognitive load and cause a subsequent decrease in neural activity in the areas of the brain responsible for the completion of driving tasks.

All three distraction condition invoked an average increase in reaction time as compared to the control condition. The music condition had the lowest percent increase 1.58% and the texting condition had the highest percent increase 94.94%. The conversation condition had a percent increase of 13.84%. A paired two sample ‘t’ test for means comparison was used. Control and music conditions, control and conversation conditions and control and taxing conditions differed significantly. The increase in reaction time can lead to safety risks on the road. In situation such as breaking response, the reaction time of the driver is not simply a one step process, but rather a sequence of complex reaction. The braking response involved mental processing time, movement time and device response time. Mental processing time consists of four subsequent components: sensation, perception/recognition, situational awareness and response selection (Green 2009). The results showed that cell phone use and actively participating in conversation increase reaction time.
(4) Smoking and reaction time:

Cigarette smoke is a toxic mixture of more than 7000 different chemicals which includes hundreds of poisonous and carcinogenic compounds. (Hecht et al 2012)

When inhaled, these chemicals affect the human body in multiple ways, none of which are beneficial. The immune system is compromised and the functioning of internal organs is also affected by these toxic chemicals. (Sopori 2002)

Tobacco smoking has also been associated with negative effects on several types of cognitive functions. (Gibbons et al 1996)

Cognition involves brain’s processing capability which can be assessed with various neurophysiological and or neuropsychological tests. Reaction time is an index of cortical arousal and has been recognized as a potentially powerful means to assess the integration of sensory, motor and coordination system of the body in response to an external stimulus. It is an interval between application of the stimulus and the initiation of the appropriate voluntary response by the subject as early as possible. (Jadhao et al 2013)

The delayed or fast reaction time indicates deteriorated or improved processing capability of central nervous system and or sensory motor performance. Therefore, with the hypothesis that the reaction time of chronic smokers might be delayed than that of normal individuals.

Ischaporia et al (1991) studied reaction time in smokers and healthy control and reported that a significant decrease in the visual and
auditory reaction times (VRT and ART) was found in 50 smokers as compared to healthy controls of the same age group.

Ichaporia et al (1991) studied audio reaction time and visual reaction time in the healthy adult male age group of 35-45 year (control) and compare with the basal audio reaction time and visual reaction time of 50 male chronic smokers.

Smokers often claim that their cigarettes are an aid to mental concentration Ichaporia et al (1991) reported that the subject of their study claimed that they smoked in order to increase their concentration and to relieve anxiety and hence visual reaction time and auditory reaction time (VRT and ART) in smokers was determined as a means of arousal. Control VRT of healthy adults was 220.34 ± 14.62 millisecond as compared to basal VRT of 207.06 ± 26.99 millisecond in smokers. This difference was also statistically significant. (P < 0.001)

Control ART of healthy adults was 190.76 ± 20.81 millisecond as compared to basal ART of 174.66 ±24.90 millisecond in smokers. This difference was also statistically significant.

Basal VRT of smokers declined from 207.06 ± 26.99 millisecond to 172.44 ± 22.71 millisecond and basal ART of smokers declined 174.66 ± 24.90 millisecond to 144.96 ±19.53 millisecond after smoking one cigarette. Both the reductions in reaction times were statistically significant. Thus there is a statistically significant decrease in basal VRT and ART of smokers as compared to healthy control.
Myrsten et al (1968) have claimed cigarette smoking tends to shorten reaction time.

After smoking one cigarette a significant decrease in VRT and ART has been noticed. Literature suggests that nicotine in the quantities taken by human smoker can be a central nervous system stimulant drug.

The stimulating action of nicotine on the human nervous system has also been accepted by Bell (1968).

The decrease in VRT and ART after one cigarette could be due to the stimulant action of nicotine on the nervous system.

Glad and Sundaramurthy (2012) studied dipping tobacco a form of smokeless tobacco. With the advent of price raise on the smoking tobacco products and the ban on public smoking there is reduction in the number of smokers and a marked rise in the number of users of this smokeless tobacco. The reason is so simple that, in comparison with the smoking tobacco, smokeless tobacco has all these following advantages for an addict of nicotine.

A packet is enough for more than 5 dips in a day, The lasting and strong effects of nicotine they get in a matter of seconds, The extent to which the effect remains after a single dip, Social status / behaviour is not altered, Easy to get a share / to be shared among the peers. Needs no private area to engage in dipping like that of smoking.

These advantages could have led a shift in the people to get into this mode of nicotine addiction. Although there are plenty of studies done with the effects of nicotine in smokers, there is a lacuna for studying the
impact of nicotine in the health of these smokeless tobacco users as there is only a recent raise in this kind of tobacco users in India.

Nicotine’s effect on dipping tobacco users will differ from that of smokers because of the route of its entry into the body. Direct dissipation of nicotine into the nervous system through the cardiovascular system will definitely have a serious impact.

Glad and Sundaramurthy (2012) tried to understand the impact of nicotine on the reaction times especially visual reaction time (VRT) and auditory reaction time (ART). Following table present Visual Reaction Time (VRT) and Auditory Reaction Time (ART) of different groups under their study.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group 1 Control Group (N=30)</th>
<th>Group 2 Dipping Tobacco Users (N=30)</th>
<th>Statistical Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjects Visual Reaction Time (m. Sec)</td>
<td>0.237±0.04</td>
<td>0.177 ± 0.01</td>
<td>0.001*</td>
</tr>
<tr>
<td>Subjects Auditory Reaction Time (m. Sec)</td>
<td>0.191± 0.03</td>
<td>0.153 ± 0.02</td>
<td>0.02*</td>
</tr>
</tbody>
</table>

Above table shows the reaction time values of the two groups. There is a decrease in the Visual reaction time of the group 2 than that of group 1,
(0.177 ± 0.01 and 0.237 ± 0.04, p<0.001). Also there is a significant decrease in the auditory reaction time of the group 2 subjects (0.153 ± 0.02 and 0.191 ± 0.03, p<0.02).

Decrease in the reaction time shows that there is an alteration in the sensory-motor performance.

For dipping tobacco users it was found that both of these ART and VRT values decreased which shows that there is an acceleration of the response to the stimulus. There is a faster reaction to the stimulus given. People consume tobacco products for an increasing alertness and a state of relaxation. But what makes this observation important is that these dipping tobacco users who were in the initial stage of addiction were having a greater arousal in terms of the reaction times obtained.

Myrsten et al (2010) has already established that cigarette smoking tends to shorten reaction time.

This raise in the systems response is due to the excessive adrenaline/noradrenalin release and greater amount of dopamine decrease in the central nervous system (Pomerleau and Pomerleau 1984).

Myrsten et al (2010) believed that this temporary surge in these neurotransmitters may cause these users to have delay in the responses when they become chronic users. Also it could happen early if the addiction level increases.

Hauser et al (1988) reported that greater sympathetic activity, a state of greater alertness was already reported in smokers which are due to the nicotine.
It is revealed that there is an acute speed up in the response to the basic audio and visual stimulus in these dipping tobacco users.

In dipping tobacco, introduction of nicotine is directly into the blood, the effect could be so high if the quantity and frequency of the dipping habit increases.

Jadhao et al (2013) studied the audiovisual reaction time of 120 male subjects with age ranging from 25 to 55 years forming various groups as control and smoker. The observations revealed that both auditory and visual reaction times were significantly delayed in chronic smokers as compared to that in controls. The results indicated that alteration of the processing capability of central nervous system as reflected by the changes in auditory and visual reaction times might be due to impaired perceptual-motor coordination in chronic smokers.

The findings of the study suggested that both auditory and visual reaction time was longer in smokers as compared to non-smokers. This delayed response to auditory as well as visual stimuli by chronic smokers might be due to several pathophysiological changes in their body systems. One of the most important pathophysiological changes is probably the atherogenesis of arteries and arterioles supplying blood to cerebral hemispheres. This may be the result of long term tobacco smoking which leads to:-

i) Abnormal increase in blood total triglycerides, very low density lipoprotein (VLDL) and low density lipoprotein (LDL) cholesterol and decrease in HDL cholesterol. (Mahajan et al 1995).
ii) Enhanced blood co-agulability due to increased fibrinogen and other clotting factors. (Benowitz, 1988 and Holbrook, 1998)

iii) Decreased synthesis of prostacyclin by vascular endothelium which has anti-aggregation effect on platelets. (Rogers et al 1985)

Chronic smokers develop elevated carboxyhaemoglobin levels which might impair function of central nervous system by affecting oxygen transport and its utilization. (Rang et al 1999)

Thus reduced cerebral blood flow and hypoxic impairment of central nervous system might have lead to cognitive dysfunction and perceptual-motor delay in habitual smokers.

The study by Jadhao et al (2013) showed that delayed reaction time was more significant in higher age groups. That is, as age advances smoking related changes in the auditory and visual reaction time also go on increasing. They also reported that addiction of smoking causes damage to health over time. As the auditory and visual reaction time is delayed, these addicts may have trouble in handling complex tasks. With long term exposure, even simpler tasks can be difficult for them because of impaired perception and reaction time. Thus, it is advisable to discourage the community from chronic cigarette smoking and health education to that effect is a need.

Pomerleau (1992) reported that the effects of nicotine are centrally mediated. The impact of nicotine on the central nervous system is neuroregulatory in nature, affecting biochemical and physiological functions. Dose dependent neurotransmitter and neuroendocrine
effects occur as plasma nicotine levels raise when a cigarette is smoked. Circulating levels of nor epinephrine and epinephrine increase, and the bioavailability of dopamine is altered as well. Among the neuroendocrine effects are release of arginine, vasopressin, β endorphin, adrenocorticotropic hormone and cortisol. Notably, several of these neurochemicals are psychoactive and/or known to modulate behaviour. Thus, affective states or cognitive demands may be favourably modified (at least temporarily) by nicotine intake. When nicotine is inhaled, the neuroregulatory effects just described are immediately available and the reinforcing effects of the drug are maximized. On the other hand, nicotine gum and most other nicotine replacement vehicles in current use have a slower onset of action, resulting in less reinforcement value.

After a cigarette is smoked, circulating levels of catecholamine increase as plasma nicotine levels rise. (Pomerleau and Pomerleau 1984) Even when there is only a modest increase in plasma nicotine level (as seen in individuals who have already smoked several cigarettes during the day), a profound increase in circulating norepinephrine levels is observed. These increased levels of both nicotine and nor epinephrine subsequently decay rapidly. Epinephrine levels rise in a dose-dependent fashion when a cigarette is smoked, and nicotine also alters the bioavailability of dopamine. All these effects are most pronounced following the first cigarette of the day.

The administration of nicotine via cigarette smoking is particularly well suited to maximizing the neuroregulatory impact of the drug. Inhaled
nicotine undergoes rapid absorption; with approximately 25% of the inhaled drug reaching the brain within 7 seconds (USDHHS 1988).

Much remains to be learned about the neuroregulatory mechanisms by which nicotine exerts its effects.

In the future, newer research approaches—e.g., blood flow and metabolic studies using techniques such as positron emission tomography—may shed light on the particular neuroregulatory pathways involved in human smoking. These technologies should facilitate the specification of the neural locus of action of nicotine in relation to its behavioural and physiological effects (Pomerleau 1992).

Examination of the psychological consequences of smoking suggests that affective states or cognitive demands can be modified in a favorable or adaptive manner, at least temporarily, by nicotine stimulation (Pomerleau et al 1992). By increasing central dopaminergic turnover, for example, nicotine can elicit or enhance “pleasure”. Increase in nor epinephrine and β-endorphin may be implicated in these effects as well.

Bates et al (1994) studied effect of smoking on simple and choice reaction time on 29 subjects 13 women aged 17-28 years and 16 men aged 18-32 years with four levels of choice task complexity under non smoking, sham smoking, and low, medium and high nicotine cigarette condition.

Nicotine is a mimetic of the neurotransmitter acetylcholine at nicotinic-cholinergic receptor sites. As such it is a psychoactive drug able to act at many sites in both the central and the peripheral nervous system. One
of the clearest effects of acetylcholine within the brain is on information processing (Callaway et al 1992), and much of the literature has focused on the enhancing effect of nicotine on either information processing or more particularly, on focused attention and vigilance.

Nicotine has been shown to improve reaction time Revell (1988) for instance, reported that smoking as few as two puffs of a cigarette improved both correct detections and reaction time on a rapid serial visual information processing (RSVIP) task, both during and immediately after smoking.

One of the most commonly given reasons for smoking is that it aids concentration (Russell et al 1974). Smoking has been found to prevent the decrement found in visual vigilance and auditory vigilance (Wesnes and Warburton 1983)

Over 95% of nicotine inhaled in cigarette smoke is absorbed (Armitage et al, 1974) and this nicotine passes into the brain in about 10 second. Thus it is conceivable that performance may be affected by single puffs from a cigarette.

(5) Blood pressure, pulse rate:

Tobacco in cigarettes and cigars contains nicotine which constricts the walls of the blood vessels. Constriction means the vessel is narrower, requiring the heart to pump harder to push the blood through the narrower vessel, throughout the body, and back to the heart. Because blood volume, viscosity, nutrient demand of tissues, and many more parameters are variable, our body needs a way to regulate blood
pressure. One of the ways to regulate it is to make blood vessels larger or smaller in diameter, which is achieved by constricting or relaxing muscles around blood vessels. The brain has a centre for regulation of blood pressure, which is affected by nicotine. Also, the decreased amount of oxygen in the blood of smokers is a trigger for release of epinephrine (adrenaline) and constriction of blood vessels. The nicotine from smoking gets into blood stream thus causing blood pressure to rise. More the nicotine in blood stream more is the rise in blood pressure.

Because the chemicals in the smoke constrict blood vessels, making it harder for the heart to pump blood to all of the body. It beats harder, which makes blood pressure to rise. Like a hose turned all the way up, but the nozzle is closed, eventually the hose will burst.

To study the effect of nicotine gum on blood pressure and pulse rate Shahrokhi et al (2006) divided 24 healthy smokers smoking an average of 20 cigarettes a day for 15 years into three groups (first group only cigarettes smoking second group with smokers given piece of nicotine gum every two hours and third group was given a pieces of non nicotine gum (placebo) every two hours. The subject’s blood pressure was checked 12 times during four daily intervals.

Drugs or substances that can influence the pattern of blood pressure and pulse rate variations and stimulate the sympathetic nervous system can increase the risk of cardiovascular diseases and be considered as a risk factor. To gain better insight into nicotine pharmacology and to evaluate the safety of various forms of nicotine including nicotine gums,
were compared the pattern of changes in blood pressure and pulse rate of cigarette smokers following smoking, use of nicotine gums and placebo were compared.

No significant difference was found between mean 24-hour systolic blood pressure and mean blood pressure in the three groups (Cigarette smokers, nicotine gum users and placebo gum users). However, mean diurnal blood pressure in cigarette smokers was markedly higher than in nicotine and placebo users. Mean 24-hour diastolic blood pressure in smokers was notably higher than in nicotine gum and placebo users, with no significant difference between nicotine gum and placebo users. Mean 24-hour pulse rate in smokers was notably and significantly higher than in nicotine gum and placebo users.

Diastolic blood pressure rise slightly in smokers compared to nicotine gum and placebo users but was not statistically significant. No difference in systolic pressure and/or the circadian pattern of blood pressure variations was seen between smokers and the other two groups.

The increase in blood pressure and pulse rate due to nicotine is mediated by activation of the sympathetic nervous system and the subsequent release of epinephrine and nor epinephrine. (Muller et al, 1985)

Nonetheless, the increase in pulse rate following smoking in daytime, and activation of the sympathetic nervous system with the start of daily activities are all in agreement with studies which suggest a higher incidence of cardiovascular accidents in the early hours of the day.
Studies have suggested that 30% of cardiovascular accidents are related to cigarette smoking.

Circadian variations of blood pressure and increased diurnal blood pressure can be attributed to the more active state of the sympathetic nervous system in daytime.

More precise assessment of daily blood pressure variations using accurate invasive methods, such as catheters or Holter monitoring is recommended.

The effect of longer-term exposures to ETS on HRV has not been analysed. Short-term effects have been described by Pope et al (2001), who found a reduction in HRV in 16 never smoking subjects equipped with Holter monitors, who were moved from the non-smoking section of an airport to the smoking lounge. Pope et al (2001) studied effect of ETS on blood pressure among the 16 never smokes and former smokers regularly exposed to environmental tobacco smokes (ETS) blood pressure was measured twice on the left upper arm with the subject sitting and at rest, by an automatic device (705CP,OMRON, Tokyo, Japan) according to WHO recommendations. Blood pressure values used in the regression model were the arithmetic mean of the two measurements. High blood pressure was defined as either a systolic blood pressure (SBP) >140 mmHg, or a diastolic blood pressure (DBP)>90 mmHg. Pulse rate was 2.7% (CI 0.1to 5.5%; P¼0.049) higher in subjects exposed>2 h/day to ETS than in unexposed subjects. Systolic blood pressure (SBP) was similar in the two groups and Diastolic blood
pressure (DBP) was 1.9% (3.0 to 2.9%; P<0.174) higher in subjects exposed to ETS>2 h/day. (Dietrich et al 2007)


ETS exposure is associated with cardiac autonomic deregulation, which may be an intermediate step in the pathway to cardiac instability. (Tsuji et al, 1996 and Lombardi et al, 2000) These observations are in agreement with the findings of Pope et al, (2001) who described a short-term decrease in all HRV domains after acute exposure to ETS. It was observed that ETS-associated increases in pulse rate and, more weakly, in DBP, consistent with increases in sympathetic stimulation.

These results contribute to the evidence that exposure to second-hand smoke increases cardiac risk through cardiac autonomic dysfunction.

ETS has been shown to be a risk factor for cardio-vascular disease, but so far little is known about possible mechanism. This study show that subject exposed to environmental tobacco smoke (ETS) for 2h/day at home and or at work had reduced pulse rate variability compared with unexposed subject. Exposed subject also had a higher pulse rate and a tendency for higher diastolic blood pressure, suggesting a possible pathway of increased cardiac risk through disturbances in the autonomic nervous system.

Gilbert et al (1989) studied effect of smoking cigarettes with different nicotine deliveries on anxiety, EEG activity in 40 smokers and 40 non
smokers group. The effects of nicotine on pulse rate were evaluated using a 3x8 repeated measures analysis of variance, in which the three nicotine groups and the eight time periods (pre-smoking, and 4, 13, 15, 17, 20, 21, and 23 min post-smoking). Analysis showed a significant time x nicotine effect. This main effect and interaction reflected the substantial increase in pulse rate associated with the smoking of the high-nicotine cigarette. A larger pulse rate increase (P<0.05) in high nicotine group than in low was recorded.

If nicotine has activation-reducing effects on EEG during stress, these effects may be related to the frequently reported findings that nicotine and smoking help smokers to relax and cope with stress and negative affect (Spielberger, 1986).

Although the literature generally supports the view that nicotine in smoking-size doses has relaxing and mood-improving effects, the mechanisms that underlie these effects are not clear (Gilbert, 1979; Pomerleau and Pomerleau 1984).

The question of whether nicotine has mood-improving effects in individuals who do not habitually use tobacco has not received sufficient attention.

The acute effects of smoking and nicotine on performance measures are consistent with the view that smoking reduces performance on predominantly right-hemisphere-based tasks during moderately stressful situations. (Gilbert and Welser 1989)
Mean pulse rates and change scores of the low-nicotine and non-smoking control conditions differed significantly during the first two periods subsequent to smoking. (minutes 4 and 13)

The result of Gilbert et al (1989) can be interpreted as: The nicotine reduces anxiety and with our hypothesis that nicotine has anxiolytic properties are mediated by the right hemisphere. Normal/high nicotine delivery cigarettes, relative to low-nicotine control cigarettes, produced cortical activation (decreased α power) in both hemispheres the no-stress control condition prior to the onset of the movie, but produces the opposite effect, decreased activation. (increased α power)

The finding that smoking a high-nicotine delivery cigarette was associated with tonic elevations in pulse rate, but decreased phasic pulse rate responses to stress replicates. (Schachter, 1973 and Gilbert, 1979)

The elevated pulse rate in normal/ high nicotine group is consistent with a view that this group did not, in fact received significantly more nicotine than did the low nicotine group.

Relatively high positive correlations between plasma nicotine concentrations and pulse rate increases have been reported. (Benowitz et al 1982)

Pulse rate, EEG, and anxiety responses of non-smokers tended to be more similar to those of the low than those of the high-nicotine smokers. The mean pulse rate of the non-smoker group was essentially identical to that of the low-nicotine group.