



## Original Article

# Psychophysiological effects of gum chewing on cognitive performance: A gender-based comparative study

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## Abstract

**Background:** Chewing before performing a cognitive task increases oxygen levels in the Central Nervous System (CNS) areas important for processes of learning and memory. This study was done to evaluate and compare the effects of chewing gum on reaction time, visual short term memory, selective attention, verbal and non-verbal reasoning, and problem-solving ability in healthy male and female subjects.

**Methodology:** The comparative, gender-based, interventional study was conducted involving 300 individuals placed in the control (n=150) and interventional group (n=150). Participants in the interventional group were required to chew gum till they completed the task. A questionnaire was designed to record the reaction time, memory, attention, executive and intellectual functioning and time took to solve each parameter. Each subject in both control and interventional group completed the questionnaire with and without chewing gum, respectively. Results for the two groups were compared using SPSS version 20.0.

**Results:** It was found that the gum chewing group performs significantly better than the control group, thus chewing gum significantly improves cognitive performance. These cognitive effects of chewing were comparable among the two genders but relatively more pronounced among male participants as compared to females.

**Conclusion:** Chewing gum is positively associated with higher level of cognitive performance than controls.

## Keywords

Chewing Gum, Mental Health Performance, Cognitive Skills, Intellectual Functioning, Reaction Time, Memory, Reasoning.



## Introduction

Regardless of its fame and commerciality, gum chewing is an unusual action, it's like eating without the act of associated digestion. The continual use of gum chewing has been promoted due to its breath enhancing properties for decades<sup>1</sup>. In 1939, the first study was conducted to determine whether chewing gum can reap any other benefits than breath enhancement and it was found that gum can reduce stress<sup>2</sup>. Subsequently, many other studies were conducted to investigate other positive effects of chewing gum, and it was concluded that chewing gum has many useful impacts on brain activity<sup>3,4</sup>.

Chewing gum has found to help manage nicotine withdrawal, stress and acid reflux<sup>5,6</sup>. Many researchers figured out that chewing gum is involved in hyposalivation that removes debris from the teeth and also prevents caries<sup>1,7</sup>. For the dieter or health-conscious individuals, the gum is a low-calorie snack and a simple way to burn a few extra calories<sup>8</sup>. One of the most astounding findings is that researchers have recently established that chewing gum can improve the cognitive functioning of the brain areas controlling memory and attention<sup>9</sup>. The behavioral effects of chewing gum have been studied for over 80 years and much of the research has been concerned with increases in alertness and attention<sup>10</sup>.

There are various conceivable components through which chewing gum may influence stress, alertness, and attention, for example, changes in the activity of the brain or elevated heart rate<sup>11</sup>. Moreover, the length over which the gum is chewed might generate impacts. Several studies have demonstrated that chewing helps to maintain cognitive functions in brain regions including the hippocampus, a CNS region vital for memory and learning<sup>11</sup>.

Currently, there was a debate about the effects of gum chewing on cognition. Several well-controlled studies examined the effects of chewing gum on aspects of memory and

attention in healthy young adults and found that gum chewing enhances cognitive functioning with regards to learning and memory. Because of these positive findings, there was quite some enthusiasm among researchers concerning this beneficial impact of gum chewing on cognition<sup>12</sup>.

Thus, if the process of chewing gum really enhances memory then it could be used as a booster to increase learning and memory and also to positively impact the mental health performance of the healthy individuals. This study aimed to evaluate and compare the effects of chewing gum on the mental health performance among healthy male and female subjects by observing the comparative alterations in the reaction time, visual short term memory, selective attention, verbal and non-verbal reasoning, and problem-solving ability in the two genders.

## Methodology

This comparative, gender-based, interventional study was conducted including 300 healthy individuals, including both males and females within 19-35 years of age. Subjects were randomly selected from University of Karachi and placed into two groups namely: a control (non-gum chewing) group and gum chewing group with 150 subjects in each group. All the enrolled participants were required to fill out the study questionnaire. The control group had to answer the questionnaire without chewing gum, while the participants in the interventional group had to solve the questionnaire right after chewing gum until they completed the whole questionnaire. The questionnaire consisted of five cognitive parameters, including:

**Visual short-term memory** that was an object learning task. The subjects were given a set of 8 colored images and were told to remember as many of them as possible for 2 minutes. After two minutes, they were asked to point out the objects that were not present in the given list and the time duration was recorded for their task completion.



**Selective attention** was tested by using the digit symbol substitution test taken from the Wechsler Adult Intelligence Scale (WAIS). The subjects were asked to complete this test within 90 seconds. For each corrected item, the subject scored 1 and for the wrong ones zero was given.

**Verbal and non-verbal reasoning** was determined by taking questions from the standard psychometric analysis of Alice Heim Group Ability Test (AH4) and WAIS. The subjects were asked to solve logical reasoning questions: 5 for verbal and 5 for non-verbal reasoning. All questions had one correct answer. The time taken by the subjects to solve the questions was noted.

**Problem-Solving ability** was evaluated by doing calculations and solving word problems. The subjects were asked to solve given math problems, which were tested by two methods: calculations (Numerical) and word problems (Analytical mathematics/Charts). The time taken by the subjects to solve the questions was noted.

**Reaction time** was analyzed through the Ruler and Drop Method (Visual analysis). Once the measurements were taken, reaction time was calculated using the formula  $t = \sqrt{2y/g_0}$ , where,  $Y$  = the distance you measured in centimeters,  $g_0$  = the acceleration due to gravity constant ( $980 \text{ cm/sec}^2$ ), and  $t$  = time in seconds.

All the statistical calculations were done through IBM SPSS version 16.0. Descriptive statistics were used for categorical variables and independent "t" tests were performed for inferential statistics. Thereby, a p-value of less than 0.05 was determined as statistically significant.

## Result

The study included 300 random healthy individuals, including both males and females between the ages 19-35 years. Our results showed improved cognitive performance following chewing gum in both genders (Table 1).

**Table 1: Mean-time taken by the individuals to complete the mental health performance tasks with and without chewing gum**

Study Parameters	Male		Female	
	Control	Intervention	Control	Intervention
<b>Visual Short Term Memory</b>	12.7±5.0	10.3±5.2*	10.8±5.1	8.5±5.6*
<b>Selective Attention</b>	42.4±10.4	40.7±8.7*	45.6±8.2	49.6±8.4
<b>Verbal Reasoning</b>	53±31.9	63.5±26.5	59±24.1	56.6±18.0*
<b>Non-Verbal Reasoning</b>	43±30.4	56.7±31.4	67±37.4	64.1±28.6*
<b>Problem-Solving Ability</b>	71.7±43.2	63±22.8*	67±30.3	79.4±39.3
<b>Reaction Time</b>	0.1±0.0	0.1±0.0*	0.2±0.0	0.2±0.0

\*Values are given as mean ± SD

\*Statistically Significant

Visual short term memory was evaluated through the object learning task and it was found that less time was taken by subjects in the intervention group as compared to control group i.e. 10.3±5.2 vs 12.7±5.0 among males and 8.5±5.6 vs 10.8±5.1 among females, thereby it could be determined that chewing gum increases visual short term memory, hence the mental health performance of both males and females. In case of selective attention, it was found that the mean time taken by the subjects in the intervention group was 40.7±8.7 among males while 49.6±8.4 among females which was comparatively high as compared to those in the control group. Thus, the comparison between the genders determines that males have better selective attention, problem-solving ability and reaction time than females. Whereas, the results for verbal and non-verbal reasoning were comparatively better among females.



## Discussion

Currently, there is an ongoing debate about the effects of gum chewing on cognition and mental health performance. To investigate the hypothesis that chewing gum increases cognitive performance, this study was designed to evaluate and compare the effects of chewing gum on cognitive performance among healthy male and female subjects. It was found that visual short term memory was increased among both the genders as a result of chewing gum which is consistent with the previous research, as it determined that chewing sugar-free gum improved aspects of verbal and visual memory<sup>13</sup>.

The results clearly indicate that less time has been taken by both male and female subjects in performing short term memory tests while chewing gum. Here the robust effects of gum chewing may be due to increased delivery of glucose to the brain in association with increased metabolic activity<sup>14</sup> and may also be associated with increased cerebellar blood flow during mastication<sup>15</sup>. This is also in agreement with the previous researches which showed that chewing immediately before a cognitive task increases oxygen levels in the Prefrontal Cortex (PFC) and hippocampus, both CNS areas important for processes of learning and memory<sup>16,17</sup>. Additionally, imaging studies have likewise uncovered sex-related hemispheric lateralization of amygdala function in connection to memory for emotional material. In particular, the reviews reliably displayed a special contribution of the left amygdala in memory for emotional material (for the most part visual pictures) in ladies, yet a special inclusion of the right amygdala in memory for similar material in males<sup>18-20</sup>.

It was found that selective attention was increased among males but it was relatively decreased in females following chewing gum. This is because it has been assumed that the cognition-enhancing effect of gum chewing is caused by an increased release of insulin and a changed pattern of regional cerebral blood flow, in particular in fronto-

temporal regions of the brain<sup>13,21,22</sup>. Furthermore, it has been determined through the researches that the Inferior Parietal Lobule is larger in males than females<sup>23</sup> and is related to the mathematical capacity and permits the brain to process data from senses and help in selective attention and perception<sup>24</sup>.

Verbal and non-verbal reasoning was found to be decreased in males but it was increased in females. This may be due to the difference in brain morphology between the two genders, females have larger volumes, relative to cerebrum size, particularly in frontal and medial paralimbic cortices. Therefore, females have better verbal and nonverbal reasoning than males<sup>25</sup>. Furthermore, the left hemisphere, which is important to communication, is thicker in female-oriented brains<sup>25</sup>. Additionally, the brain of female processes verbal language simultaneously in the two sides (hemispheres) of the frontal brain, while men tend to process it on the left side only<sup>26</sup>.

Furthermore, it was also found that problem-solving ability was increased in males but it was decreased in females following chewing gum. This is in agreement with the research that men had larger volumes, relative to cerebrum size, in the fronto-medial cortex, the amygdala and the hypothalamus<sup>25</sup>. Therefore, men have better selective attention and problem-solving ability than females. Besides, males possess larger cerebra than women of the same age and health status, even if the body size differences are controlled statistically. Male brains are larger than female brains in all locations, though male enlargement was most prominent in the frontal and occipital poles, bilaterally<sup>27</sup>. The male differentiated brain has a thicker right hemisphere. This may be the reason males tend to be more spatial, and mathematical.

Chewing gum had a positive effect on reaction time tests among males, enabling them to take less time to respond to the given visual stimulus as compared to females. This may be because males and females differ in the way they estimate time, judge speed of





things<sup>27</sup>, carry out mental mathematical calculations, orient in space and visualize objects in three dimensions and the way their brains process language information, emotion and cognition<sup>24</sup>. Males as compared to females can remain occupied with visual or hands-on learning tasks<sup>28</sup>. Moreover, chewing gum increases cerebral blood flow and also the supply of oxygen to the prefrontal cortex.

Both genders are equivalent in insight, however, gender differences in mental health performance have been associated with their tendency to work differently. Males and females seem to utilize distinctive parts of the brain to encode memories, sense feelings, perceive faces, take care of specific issues and decisions. Without a doubt, when males and females of comparable knowledge and talent perform similarly well, their brains seem to go about it differently, as though nature had isolated outlines. Gender contrasts in the brain may assume a part in learning forms, speech development and progression of neurologically-based ailments. Gender contrasts should be considered in studying brain structure and capacity<sup>24</sup>.

Males showed more positive effects while chewing gum than females. This is because the proportions of dark to white matter likewise contrast fundamentally between the genders in differing areas of the human cortex<sup>29</sup>. Men have roughly 6.5 times more grey matter in the mind than ladies, and ladies have around 10 times more white matter than men do<sup>30</sup>. And this grey matter is related to better cognitive performance and better reaction time in males.

## Conclusion

It is concluded from the study results that chewing gum improves certain cognitive skills including; memory and intellectual functioning. Males showed relatively more positive effects while chewing gum than females. Thus it is positively associated with mental health performance, however the precise mechanism for improved cognitive functions due to gum chewing remains

unclear. For a more complete picture of the relationship between physiological and cognitive aspects of chewing gum further investigations are required in beta and delta wave patterns. All these transformations in the after-test condition proposed that the pleasant sounds might develop a calm mind and body connection that significantly overcome stress to a certain degree.

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