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The Effects of Mastication On Memory and Recall in Elementary Students

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THE EFFECTS OF MASTICATION ON MEMORY AND RECALL IN ELEMENTARY STUDENTS

by

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ABSTRACT

The Effects of Mastication on Memory and Recall in Elementary Students

The purpose of this study was to research the effect of mastication through gum chewing on memory and recall in elementary students. It is imperative to research ways in which to increase brain stimulation in order to enhance memory and recall to provide students with academic success. This research was conducted to assist educators in aiding students in review and recall.

Fifty students were randomly selected from first, second, and third grade classrooms in a public school. The students were from varied socioeconomic and intellectual backgrounds with varied family structures. The controlled group of twenty-five students were administered four tests targeting memory and recall. The experimental group of twenty-five participants were administered identical examinations of those in the controlled group. However, the experimental group was given a piece of sugar-free gum to chew during the four sessions.

The results of this research indicated that the act of mastication through gum chewing increased students' scores on tests of memory and recall. Mastication improved students' short-term memory when recalling letters and improved auditory memory when memorizing a list of words. The greatest impact of mastication during memory and recall in this project occurred in the trial that tested the memorization of spatial locations. Students who chewed gum during these sessions completed the activity with a quicker speed and memorization.

Chapter 1

INTRODUCTION

A majority of Americans spend a great deal of their days chewing gum. Fifty-one percent of individuals in the United States chew gum during the course of a week (Shapiro, 2004). Gum chewing has been traditionally promoted to the public as a treat. Brands have defined themselves around enjoyment of their taste, flavor, and refreshment.

While many Americans may be astonished to find that the act of chewing gum can improve their memory, they may not be surprised to learn that gum is a healthful product. More than one in two Americans believe that chewing gum is beneficial to the health of their gums and teeth. There is an additional belief that gum chewing yields psychological benefits; twenty-eight percent state that it relieves stress (Shapiro, 2004).

Over the last four years, it has been found that the act of mastication through gum chewing can: (a) be effective in helping individuals reduce stress and anxiety, (b) increase working short-term and long-term memory and recall, and (c) improve the brain's ability to perform tasks.

In a study at the University of Northumbria, psychologists asked three groups of volunteers to memorize a list of words, pictures, and telephone numbers. While studying the lists, individuals in one group chewed gum, participants in the second group did not, and individuals in the third group pretended to chew gum. The seventy-five test subjects were then tested to see how well they were able to recall the information presented. The

researchers found that the gum chewers recalled thirty-five percent more than the individuals in the other two groups (Scholey, 2003).

Another recent study confirmed the idea that the act of chewing gum increases memory on recall examinations. Jess Baker and associates examined the hypothesis that chewing gum affects memory using a study of eighty-three undergraduates from Cardiff University. Randomly assigned to one of four conditions, participants were asked to chew gum, or not chew gum at specific moments in the review and recall sessions. Data collected from these scores indicated that the group who chewed gum at both review and recall scored higher than those not chewing gum (Baker, Bezance, Zellaby, et. Al., 2004).

The researchers involved in these studies have shown that the act of mastication improves short-term and long-term memory, yet the researchers are unclear as to how gum chewing improved the cognitive abilities of their test subjects. Some believed that the simple act of chewing increases heart rate and blood flow, sending an increased amount of oxygen to the brain. Increased oxygen is known to improve brain function (Chevat, 2004).

Another theory involving the hormone insulin, which is secreted by the pancreas and helps the body's cells absorb glucose, was responsible for the improvement in memory. Andrew Scholey, (2003) the psychologist who conducted the University of Northumbria study, stated,

> When you chew, the body releases insulin. We know that the brain contains receptors for insulin. Although the function isn't well known, we know the receptor are fairly densely packed in a part of the brain that is crucial for memory (p. 2)

Statement of the Problem

Cognitive and brain activity based research has become a growing trend in the field of education. One of the most intriguing studies involving gum chewing and its ability to increase short-term and long-term memory as much as thirty-five percent (Scholey, 2003) emphasizes that the simple act of chewing stimulates brain activity and may increase memory. Research has been limited to adult participants in sterile, research based environments. Studies have been absent in public school settings. The idea of mastication as a means to improve memory may prove to be a successful tool in the elementary classroom. Culturally, gum chewing in the classroom has been deemed inappropriate and distracting to student learning. Yet, if research determines that students achieve higher recall scores when allowed to chew gum during reviewing and testing, educators may be more inclined to allow gum into the classroom.

Research Question

The following question will be addressed to accomplish the purpose of the study: Will the act of mastication through gum chewing during review and recall improve memory in elementary students?

Definition of Terms

Brain-based research: scientific studies of how the brain functions.

Brain stem: the stalk of the brain below the cerebral hemispheres. It is the major route for communication between the forebrain, the spinal cord, and peripheral nerves. It controls various autonomic functions such as respiration and the regulation of heart rhythms as well as perceptual functions such as the primary aspects of sound localization.

Cerebellum: a region of the brain that plays an important role in the integration of sensory perception and motor output.

Cerebrum: name for the large region within the brain that is attributed to speech and language and motor function.

Declarative memory: memories that can be explicitly verbalized.

Glucose: a simple sugar used as a source of energy.

Hippocampus: an area of the brain that plays a part in memory and navigation.

Insulin: a hormone in the human body that regulates carbohydrate metabolism.

Long-term memory: memory stored as meaning that can last as little as thirty seconds or as long as a decade.

Mastication: the process in which food is crushed or torn with teeth.

Memory: a process in which the human brain acquires and stores new information.

MRI: Magnetic resonance imaging is a method used to visualize the inside of living organisms.

Short-term memory: memory which stores a limited amount of information, often referred to as "primary" or "active" memory.

Purpose of the Research Project

The purpose of this study is to determine if the mastication of chewing gum can induce memory and recall effects tested by comparing the scores of students who chewed gum during review and recall to those students who did not chew gum during an identical examination. It is imperative to research ways to increase brain stimulation in order to enhance memory and recall in students. It has been noted that individuals who chewed

throughout tests of both long-term and short-term memory produced significantly better scores than the individuals who did not.

Chapter Summary

Basic examinations of short-term and long-term memory and recall show that the act of mastication, particularly gum chewing greatly improves cognitive ability. In this chapter, gum chewing and its effect on memory and recall was briefly introduced, and the purpose of this projected was detailed. In Chapter 2, the relevant literature is reviewed. In Chapter 3, the methods to be utilized in this research is presented.

Chapter 2

REVIEW OF THE LITERATURE

The focus in this review of literature is on the relevant issues related to the act of mastication through gum chewing and how it affects cognitive abilities in short-term and long-term memory and recall.

Mastication and memory are two physiological functions of the human body addressed within this review of literature. The following explores these two entities separately and then illustrates how they relate to each other in learning functionality. Addressed in this literature review are the anatomy and physiology of the brain, the effects of motor controlled activities on the brain, and research involving the function of the brain on short-term and long-term memory and recall. Included also are the effects of mastication on brain activity and body functions. Finally, this review of literature explores the research linking gum chewing and improved memory.

Anatomy and Function of the Human Brain

The brain is the source of all human behavior: it is responsible for controlling major functions in the human body (Wolfe, 2001). In order to comprehend how memory and the act of mastication are related, the complex structures of the brain must be understood.

The human brain is divided into three main areas: the cerebrum, the cerebellum, and the brain stem. The cerebrum, which is Latin for "brain," is the largest part of the brain. It is responsible for functions like perception, imagination, thought, judgment, and decision making. The cerebrum is divided into four lobes, or parts, that have

separate functions. The temporal lobes, located on both sides of the brain just able the ears are divided into several subsections that are responsible for language, hearing, and some aspects of memory. Located at the lower central back of the brain is the occipital lobe which is responsible for processing visual stimuli. This area of the brain is the visual cortex: it is split into multiple subdivisions, each playing a role in processing visual information. At the top of the brain is a flat, plate-like area on both the left and right side of the brain. These areas are called the parietal lobes, which are divided into two parts. The frontal lobe, or anterior, is responsible for touch and temperature, pain and pressure, and body position. The anterior lobe of the brain occupies the largest portion of the brain and is liable for the most complex functions including behavior, creative thought, abstract thought processes, problem solving, and judgment (Boeree, 2003).

The cerebellum, or "little brain," is similar to the cerebrum in that it has two hemispheres and has a highly folded cortex. The cerebellum processes input from various areas of the brain, spinal cord, and sensory receptors to provide precise timing for coordinated movements of the skeletal muscular system (Wikipedia, n.d.). It is within this large area of the brain that balance and body posture are monitored. Researchers, who have investigated the functions of the brain, suggested that the cerebellum is responsible for cognition as well as gross motor functions (Wolfe, 2001).

The brain stem is the area at the base of the brain that comprises of the mesencephaladon, the pons, and the medulla oblongata. The brain stem regulates heart rhythms, blood pressure, respiration, and perceptive functions in the human body (Wikipieda, n.d.). It is also the main source for the production of the brain's chemical

messengers (Boeree, 2004). The brain stem plays a vital role in basic attention, arousal, and consciousness. All information to and from the body passes through the brain stem on the way to or from the brain.

In addition to the three major areas of the brain which relate to cognitive functioning is the area of the brain called the hippocampus. The hippocampus is a part of the brain located inside the temporal lobe. It plays a part in navigation and memory, in particular in the formation of new memories of experienced events. The hippocampus is considered to be part of a larger medial temporal lobe memory system responsible for general declarative memory (Wikipedia, n.d.).

Brain-Based Research on Memory

In order to improve cognitive functions of the human brain, researchers focused on specific motor activities and the area of the brain that they affected. With the use of such technology as the MRI and the PET, researchers had the ability to study the human brain, its structure and function, as well as its blood flow and reactions to outside stimuli. This technology became an effective tool in brain-based research on memory (Wolfe, 2004).

The hippocampus of the brain is responsible for acting as a “gateway” in which all information must pass before it can be memorized and then recorded into long-term memory. Cerebral blood flow, caused by motor controlled activities or physical movement, is required in ensuring an effective delivery to this part of the brain (National Institute of Health, 2003).

In addition to blood flow, neurotransmitters have a significant impact on learning and memory. These chemical messengers within the brain are responsible for the transmission of nerve impulses and are stimulated by movement (Sprenger, 1999).

Cognitive Testing, Memory, and Recall

Tests of cognition detect changes in brain functions. Areas consistently examined during cognitive tests include: memory, concentration, attention, abstract thinking, problem solving, and judgment. Although cognitive skills are often determined by a battery of tests, examination of memory skills involve memorization and recall of simple words, drawing, and object location (Preson, 2004). The two main types of memory are short-term memory and long-term memory.

Short-term memory, sometimes referred to as “primary” or “active” memory, stores a limited amount of information for a limited amount of time. Short-term memory is stored for approximately fifteen to thirty seconds. The information held in short-term memory includes: recently processed sensory input; items recently retrieved from long-term memory; or the result of recent mental processing (Wikipedia, n.d.).

Long-term memory is stored as meaning that can last as little as thirty seconds or as long as a lifetime. It differs structurally and functionally from short-term memory in that long-term memory derives from short-term memory that is rehearsed or associated with meaningful experiences. Long-term memory is dependent of the depth of processing and on the number of recalls or retrievals and the perceived importance of the material (Wikipedia, n.d.).

Effects of Mastication on Brain Activity and Cardiovascular Response

Age-Related Changes in Brain Regional Activity During Chewing

In a study on mastication-induced brain neuronal activity, Onozuka (2002) and associates used an MRI to evaluate the interaction between gum-chewing and blood circulation in the human brain. The study comprised of three groups of neurologically healthy subjects; a young adult group, ages nineteen to twenty six; a middle-aged group, ages forty-two to fifty-five; and an aged group, ages sixty-five to seventy-three years. In all the volunteers, mastication was functionally normal.

The task paradigm involved periods of rhythmic chewing of odorless and tasteless gum followed by periods of no chewing. Each participant performed eight cycles of thirty-two second rhythmic chewing and thirty-two second without rhythmic chewing. During each of these cycles, functional and anatomical images were acquired by means of the MRI scanner. One hundred twenty-eight total images were obtained for each individual involved in the study.

In all subjects, mastication was always associated with significant bilateral increased in the BOLD signal in the primary sensorimotor cortex, extending down into the upper bank of the operculum and insula. In addition, increases were seen in the supplementary motor area, the cerebellum, and the right prefrontal area. Mastication-induced increase in the signal in the primary sensorimotor cortex of the middle-aged and aged subjects was sixty-three point three percent. The increase in the young adult subjects was thirty-two point seven percent. An increase in the signal in the cerebellum was sixty-five point nine percent for the aged subjects and forty point five percent for those in the young adult volunteers. In the prefrontal areas, the signal increase for the

middle-aged and aged subjects was one hundred seventy-four point three percent and four hundred twelve point seven percent in the young adult subjects.

In Onozuka's findings, mastication significantly activated the oral region of the primary sensorimotor cortex, supplementary motor area, insula, and cerebellum. Former studies on aging and mastication have shown that the loss of teeth and muscle power deficits seen with advanced age impair masticatory function, caused a reduction in sensory input activity to the sensorimotor system. This study involved the relationship between mastication and in increase in the right prefrontal cortex associated with better memory performance. If the interpretation of this study was accurate, it is possible that mastication stimulated neuronal activity within a network between the right prefrontal cortex and the hippocampus, which might be useful in stimulating and maintaining cognitive function (Onozuka, Fujita, Watanabe, et. al., 2002).

Effect of Mastication on Regional Cerebral Blood Flow in Humans Examined by a Positron-Emission Tomography with O-Labeled Water and Magnetic Resonance Imaging

Mastication is a coordinated function of the masticatory system, which comprises of three units: the peripheral effector organs, the sensory input and the central nervous control (Kubota, 1989, as cited in Momose, Nishikawa, & Watanabe, 1997). The human masticatory apparatus involves such body activities as chewing, swallowing, digestion, respiration, speech, and non-verbal communication, and is interrelated with blood circulation and excretion. In the following study, Momose (1997) and colleagues suggested that mastication may stimulate the brain and accelerate its energy-consuming

metabolism. The purpose of the study was to investigate the changes in regional cerebral blood flow during mastication.

The study consisted of five males and seven females within the age range of eighteen and forty. The test subjects were instructed to chew gum with their eyes closed and their ears plugged throughout the study. During the experiment, the twelve volunteers underwent four brain scans every fifteen minutes during four tasks: (a) at rest, (b) while chewing, (c) at rest fifteen minutes after stopping chewing, and (d) at rest thirty minutes after stopping chewing.

Using PET imaging during data analysis, researchers determined that several different brain areas were activated while the participants chewed gum. Significant increases of twenty-five to twenty-eight percent in regional cerebral blood flow in the lower parts of the perceptual areas and nine to seventeen percent in the supplementary motor areas occurred in all of the volunteers. Within the cerebellum, an increase of eight to eleven percent was observed. On the basis of this study, Momose (1997) and associates determined that mastication increased the regional blood flow in the oral region and the cerebellum, the regions of the brain responsible for stimulating brain function (Momose, Nishikawa, Watanabe, et. al., 1997).

Cardiovascular Responses in Humans to Experimental Chewing of Gums of Different Consistencies

In 1999, researchers from the University of Naples and the University of Copenhagen addressed cardiovascular responses to jaw muscle activity. Ten volunteers, five men and five women, were involved in this study. Their ages ranged from twenty-five to thirty-eight. Each test subject undertook four sessions at intervals of one week

between each analysis. The study participants were requested to participate in the following sessions: (a) empty chewing, (b) chewing a soft gum, (c) chewing a moderately hard gum, and (d) chewing a very hard gum.

Before each assessment, participants were allowed to relax for ten minutes as baseline measurements were recorded. When instructed to chew, volunteers chewed for twenty minutes while electromyographic jaw-elevator activity, heart rate, arterial blood pressure, and perceived masticatory fatigue were assessed. Heart rate and blood pressure were recorded two minutes before the chewing task, during chewing at the two, then, and twenty minute intervals, and then finally after cessation of chewing, at the two, five, and ten minute intervals.

At the summation of the study, heart rate and blood pressures were slightly increased throughout the chewing session and at the cessation of the chewing exercise. After the ten minute recovery interval, the heart rate and blood pressures decreased gradually (Farella, Bakke, Michelotti, et. al., 1999).

Chewing Gum Selectively Improves Aspects of Memory in Healthy Volunteers

In one of the most highlighted studies on the effects of mastication, Andrew Scholey (2002) and his colleagues from the University of Northumbra examined the act of chewing on the human brain and body. The study comprised of seventy-five participants divided into three groups. One third of the participants chewed gum, the second group mimicked the movement of mastication, and the third group of twenty-five volunteers did not chew. Each participant was assessed for twenty minutes. A baseline heart rate measure was acquired before the assessment session and then throughout the twenty minute procedure. During the examination, the participants were requested to

perform a battery of tasks involving both long-term and short-term memory functions. Included in these tasks were reaction time, test of immediate word recall and recognition, and picture recognition. Upon cessation of the cognitive tasks followed by a five minute period of relaxation, the heart rate measure was acquired for sixty seconds. Using this data, Scholey and his colleagues concluded that the act of mastication during these specific tasks showed a significant increase in heart rate in those who chewed gum compared to the other fifty individuals who either simulated mastication or did not chew (Wilkinson, Scholey, Wesnes, 2002).

Effects of Gum Chewing on Memory and Recall

Chewing and Learning: The Benefits of Chewing

Andrew Scholey's (2003) research into the effects of mastication on the human body and brain determined that a rise in heart rate in conjunction with an increase in cerebral blood flow during chewing had the potential to increase cognitive function in individuals. Scholey stated, "Anything that can improve delivery of things like oxygen in the brain such as an increased heart rate is a potential cognitive enhancer to some degree.

Early research in 1997 concluded that brain activity in the hippocampus increased during acts of mastication. Since insulin receptors in the hippocampus are involved in memory, any surge in activity in which an increase in insulin occurs, may aid in an increase of cognitive ability (Momose, Nishikawa, Watanabe, et. al., 1997).

Scholey (2003) issued a statement concluding that his finding involved a thirty-five percent increase of overall memory improvement in the group of participants who chewed gum during the tasks of memory and recall. Scholey supported his finding using

the 1997 report of insulin induced brain activity by Momose and associates. Scholey stated:

> Insulin mops up glucose in the bloodstream and chewing causes the release of insulin because the body is expecting food. If insulin receptors in the brain are involved in memory, we may have an insulin-mediated mechanism explaining our findings (p. 4).

Role of Glucose in Chewing Gum-Related Facilitation of Cognitive Function

Prompted by Scholey's statements regarding the role of insulin production and brain activity, Richard Stephens and Richard J. Tunney (2004) studied the effects that chewing gum had on the release of glucose to the brain to stimulate memory and attention. Their study tested the hypothesis that chewing gum led to cognitive benefits through improved delivery of glucose to the brain. Stephens and Tunney compared the cognitive performance effects of gum and glucose administered both separately and together.

PET imaging showed a twenty-five percent increase in blood flow to brain regions including the frontal-temporal cortices and the cerebellum associated with the act of mastication. Researchers stated that this increased blood flow to the areas of the brain associated with cognition was a possible explanation of why past studies have concluded that chewing gum increased cognition and memory. Stephens and Tunney proposed this study to expose the effects of improved glucose delivery to the brain in respect to cognitive domains, working memory, immediate episodic long-term memory, language-based attention, and processing speed.

Participants in this study comprised of thirty undergraduates. Of these individuals fifteen were females and fifteen were males. The age range of the participants was

eighteen to twenty-two years. All non-smoking volunteers in the experiment declared no previous concussion, diabetes, or neurological conditions.

In the glucose condition, twenty-five grams of glucose powder was dissolved in two hundred fifty milliliters of water. In the non-glucose condition, participants were given two hundred fifty milliliters of water. The drinks were administered twenty minutes prior to the forty-five minute testing session. Participants were allowed five minutes to consume the liquid. Immediately after consuming the water or glucose drink, the volunteers were asked to either chew on sugarless gum or suck on a sweet flavored mint.

The study was conducted on four separate days in order to complete the four conditions (glucose-sweet, glucose-gum, no glucose-sweet, and no glucose-gum). The university students participated in the administration of eight neuropsychological tests: Baddeley's Grammatical Transformation test, WAIS-R Digit Symbol, WAIS-R Digit Span, WMS III Spatial Span, the Rey Auditory Verbal Learning test, Trail Making, the Controlled Oral Word Association test, and a paper and pencil Digit Cancellation task. The study required three forms of each test. Participants were blind to the conditioned groups and were not told the aim of the study.

At the conclusion of the study, it appeared that chewing gum appeared to benefit working memory, episodic long-term memory, language-based attention and processing speed. However, these results were not to exclusive function. The results indicated that the effect of mastication is mediated via chewing which enhanced the glucose delivery to the brain improving cognitive performance (Stephens & Tunney, 2004).

Chewing Gum Differentially Affects Aspects of Attention in Healthy Subjects

The effect of chewing gum on cognitive abilities to increase memory skills has been examined. The results showed that that act of mastication improved working memory and immediate and delayed recall of words. However, an increase in memory ability was not examined. Tucha, Mecklinger, Maier, Hammeri, and Lange (2004) explored the concept that chewing gum could improve memory and a variety of attentional functions.

Tucha and associates questioned the hypothesis that the act of chewing gum could affect aspects of attention and memory. Researchers further examined if mastication differentially affected specific aspects of attention to include sustained attention, alertness, and flexibility. The researchers in this study proposed this examination on the affects of chewing gum to review the initial idea that chewing gum increases recall and working memory as well as to look at the affects of mastication on attention.

The study consisted of two specific experiments. In the first study, participants comprised of fifty-eight adults, half of which were male. Individuals were assessed for memory and attentional functions under four conditions. Conditions were: quiet condition (no chewing), mimicking condition (mimicking chewing movements), neutral condition (chewing a tasteless piece of gum), and spearmint condition (chewing a piece of flavored gum. Volunteer participants were read a list of fifteen words and then asked to recall the words immediately and then again at a forty minute interval.

In the second experiment, fifty-eight additional participants performed the same memory and alertness examinations used in the first experiment. Additionally, they

performed a visual vigilance tasks for a period of forty minutes, carried out between the immediate recall and the forty minute interval.

In the chewing conditions, individuals were instructed to chew naturally and constantly during the whole testing session. Reaction time and the number of omission errors or commission errors were recorded. In both experimental studies, the pulse rates of participants were measured three times in a period of one minute.

Insignificant difference in immediate and delayed word recall was apparent in either experiment. In addition, no differences were observed in measures of selective attention, divided attention, vigilance, or visual scanning. Pulse rates were not significantly difference across the conditions. Significant differences were discovered in sustained attention, flexibility, and both tonic and phasic alertness. During the conditions of mastication or imitation of chewing, participants displayed longer reaction times in a tonic alertness task. In the second experiment, reaction time in the phasic alertness task improved in the conditions of chewing and mimicking. Compared to the neutral condition, there was a marked improvement of sustained attention in the spearmint condition.

This study was unable to replicate the findings of previous experiments as to the effects of chewing gum on memory and recall. Researchers found through this study that the act of chewing gum did not improve cognitive functioning or memory. Participants in this study did not improve their memory functions using the act of mastication. Furthermore, the study indicated that chewing may differentially affect specific aspects of attention. Sustained attention was improved by chewing. Alertness and flexibility was negatively affected by gum chewing (Tucha, Mecklinger, Maier, et. al., 2004).

Chewing Gum Can Produce Context-Dependent Effects Upon Memory

Initial tests on the effects of mastication of gum and performance on recall exams proved that the act of chewing improved spatial and numeric working memory. However, researchers have yet to pinpoint how chewing gum improves these tasks. Hypotheses have included the ideas that chewing gum may increase insulin in the body or change blood flow to the brain released by the act of mastication.

Jess R. Baker, Jessica B. Bezance, Ella Zellaby and John P. Aggleton (2004) examined the hypothesis that chewing gum affects memory if it is sufficient to induce context-dependent effects. If their hypothesis was true, then the act of gum chewing in both the learning environment and the recall exam should increase performance greatly. Furthermore, their experiment tested the reliability of past reports on the influences of chewing gum and memory.

Participants in this study comprised of eighty-three undergraduates from Cardiff University. Of these individuals, fifty-seven were females and twenty-six were males. The age range of the participants was eighteen to forty-six years. Randomly assigned to one of four conditions, individuals in this study were asked to chew gum (or not) at the time of learning or at the time of recall. The first group comprised of twenty-three individuals who chewed gum at both the learning session and the recall session. The second group included twenty participants who chewed gum at the learning session and not at the recall session. The third group of twenty volunteers had no gum at the learning session but did chew gum at the recall session. The final group comprised of twenty participants who had no gum at either session.

All participants at the university were tested individually on their ability to recall a list of words. The volunteers were given two minutes to review a list of fifteen words on a sheet of paper. Recall of the words was tested immediately and again at a twenty-four hour interval. All participants were allowed two minutes to write down their recall of the words on the list. The individuals included in this study were directed as to when they could chew the gum, according to their selective group (gum-gum, no gum-gum, gum-no gum, and no gum-no gum).

The first question the researchers hypothesized was whether the mastication of gum can induce context-dependent effects was tested by comparing the scores of the two context-change groups (gum- no gum, no gum- gum) with the scores of the two consistent groups (gum-gum, no gum-no gum). Data collected from these scores indicated that the consistent groups had significantly higher recall scores. The second hypothesis considered by this study asked the question if chewing gum enhances initial learning. This was answered by comparing the two groups that chewed gum in the learning session with the two groups that did not. It was found that both recall sessions scored higher for those chewing gum at encoding.

To further compare the four distinct groups, researchers looked at the comparisons of scores at the immediate and twenty-four hour recall sessions. For the constant context groups, the gum-gum group had higher overall scores than the no gum-no gum group of individuals. When comparing these two groups, the gum-gum group scored significantly higher at the twenty-four hour interval. A less marked difference was noted at the immediate recall. There was no overall difference in the scores of the gum – no gum and no gum – gum condition groups.

The results of this study indicated that chewing gum can aid in the act of learning. Evidence for this context-dependent effect was derived from the significant difference between the consistent groups (gum-gum, no gum-no gum) and the inconsistent groups (gum-no gum, no gum-gum). These results supported the finding of the original studies on the effects of gum chewing and recall. This study also concluded that chewing gum can lead to context-dependent effects so that recall is hindered by a change in context (Baker, Bezance, Zellabe, et. al., 2004).

Chapter Summary

The findings from the experiments presented in this review of literature indicated that the act of mastication through gum chewing can affect the human body and mind to enhance memory and recall skills. A majority of the studies (Baker, Bezance, Zellabe, et .al., 2004; Momose, Nishikawa, Watanabe, et. al., 1997; Scholey, 2003; Stephens & Tunney, 2004; and Wilkinson, Scholey, & Wesnes, 2002) indicated a positive effect of the use of gum chewing to improve cognitive functions. In one study (Tucha, Mecklinger, Maier, et. al., 2004) results of the chewing test subjects were not significantly different when compared to the condition of non-chewing participants. In this researcher's opinion, further research in the area of the effects of mastication on memory and recall is indicated. The method used in the design of this experiment is presented in Chapter 3.

Chapter 3

METHOD

Mastication, or the act of chewing, has been proven to induce brain activity, increase the heart rate, and blood flow, and stimulate insulin production. Researchers have indicated that chewing gum stimulates activity within the human brain and body that increases memory and recall. The purpose of this research project was to determine if gum chewing in the classroom aids elementary students in memory during tasks of review and recall.

Procedure

This research project was conducted with first, second, and third grade students from an elementary school in Colorado Springs, Colorado. The students were from socioeconomically and intellectually varied backgrounds and varied family structures. A group of fifty students, twenty-three females and twenty-seven males were administered four distinct tests targeting memory and recall. Randomly assigned to one of the two conditions, individuals in this study were asked to chew gum (or not) at the time of memory and at recall. The first group comprised of twenty-five elementary students (nine first graders, seven second graders, and nine third graders) who chewed gum during the experimental sessions. The second group included twenty-five students (eight first graders, eight second graders, and nine third graders) who did not chew during the targeted sessions. All participants were tested individually on their ability to recall a list of words, commit to memory a visual list of letters, memorize the spatial location of objects, and recall a visual stimuli of pictures.

Research Design

The method implemented for this study involved four memory recall tests administered in identical setting to both the control group and the experimental group participants. The experimental group received the independent variable, a piece of sugarless chewing gum during the testing session. All other variables were indistinguishable in the experimental and control group sessions.

Instrument Used

Four individually administered memory recall tests were used for this research study. The first test examined the students' abilities to remember a list of capital letters within six trials. The letters were presented visually using large flash cards. Each card was held up for the student to see for ten seconds. Each of the six trials increased in difficulty as the number of letters to recall expanded. The second test studied the participant's ability to memorize and recall pictures presented in an array of fifteen colored photographs. All fifteen photos were displayed for twenty-five seconds. Students were asked to orally recall the pictures. The third test assessed the students' abilities to recall a list of words that were presented orally. Students were asked to recall the words after hearing the complete list and waiting one minute upon completion of the list. In the final test, the researcher asked students to remember the spatial location of objects by presenting a three by four block of cards. Each block contained one single digit number. Each number block was covered by a blank card. Students were to pick up two cards at a time, revealing the digit underneath, and removing the cards when they found a match until all cards were cleared.

Method of Data Collection

Permission to conduct this research study was granted by the principal of the elementary school. A permission letter to the parents of students participating in the study was developed. Students participating in this research study were randomly selected from first, second, and third grade classrooms. Participants were not informed of the conditioned and experimental groups; they were not told the aim of the study.

Analysis of Data

Data collected from the testing sessions was compiled and the results shown in descriptive statistical figures. The results for each student and the comparison of score averages under each of the two groups are displayed as figures.

Chapter Summary

This experimental study obtained results from elementary students in a public school setting. Participants were randomly assigned to one of two conditions and then individually administered for tests targeting memory and recall. The researcher analyzed the results of these examinations. The results of this evaluation process and the summary of the results of this study are provided in Chapter 4.

Chapter 4

RESULTS

The purpose of this study was to determine the effect of mastication through gum chewing on memory and recall in elementary students. Research presented in this study suggests that the act of mastication through gum chewing selectively progresses memory by increasing heart rate, increasing glucose and oxygen to the brain, and activating insulin receptors in the brain. Thus, students who chewed gum during memory and recall should score higher on individualized exam sessions than those students who did not chew gum when presented with identical sessions. Presented in this chapter are the results of this experiment.

Selection of the Sample

The participants in this study comprised of students in first, second, and third grade from a public elementary school in Colorado Springs, Colorado. The school enrollment is approximately five hundred forty students. The students included within this study were mixed in regard to ability and socioeconomic level. Fifty students were involved in this study, twenty-seven males and twenty-three females with age ranges from six to ten years of age. This was a good representative sample of the school population for the district and the community.

Data Analysis

In May of 2006, fifty randomly selected students in first, second, and third grade were individually administered four distinct tests targeting memory and recall.

Individuals who participated in this study were assigned to one of two conditioned groups. The first group of twenty-five students chewed gum during the four sessions. The second group was administered identical tests in an identical environment. The only difference during these sessions was that the control group did not chew gum during memory or recall (See Table 1 and Table 2).

Table 1

Control Group					
Student ID	**Trial 1: Recall of Letters**	**Trial 2: Visual Memory**	**Trial 3: Auditory Memory**	**Trial 4A: Spatial Location of Objects**	**Trial 4B: Spatial Location of Objects**
AB1	.619	.466	.466	9	1:19
EM1	.5	.333	.2	15	1:13
JS1	.404	.333	.266	21	2:58
CH1	.476	.533	.333	9	:57
MT1	.476	.4	.4	13	1:13
NM1	.523	.533	.466	14	1:01
KB1	.452	.4	.133	13	1:14
DH1	.523	.466	.266	13	2:16
GE2	.690	.533	.133	17	1:29
DM2	.523	.533	.466	17	1:48
LF2	.690	.466	.266	15	1:06
MC2	.619	.333	.333	14	1:20
CC2	.642	.4	.533	11	:46
MR2	.523	.466	.4	11	:57
MC2	.476	.466	.333	15	1:03
SC2	.5	.666	.4	15	1:18
JS3	.547	.4	.2	10	:56
NP3	.809	.466	.266	12	:36
JR3	.547	.666	.4	16	1:23
AH3	.547	.466	.666	14	1:07
MP3	.428	.533	.333	17	1:42
AH3	.595	.733	.333	14	:54
AR3	.642	.466	.266	13	:55
HQ3	.642	.666	.333	14	:57
SL3	.619	.533	.4	13	:58

Table 2

Experimental Group					
Student ID	**Trial 1: Recall of Letters**	**Trial 2: Visual Memory**	**Trial 3: Auditory Memory**	**Trial 4A: Spatial Location of Objects**	**Trial 4B: Spatial Location of Objects**
ER1	.642	.533	.466	11	1:01
TM1	.809	.466	.466	13	1:24
SR1	.452	.266	.133	11	1:08
SD1	.404	.466	.266	13	1:06
AA1	.738	.6	.6	8	1:19
DR1	.642	.466	.466	8	:43
AH1	.595	.533	.333	14	:59
JJ1	.476	.466	.4	16	1:05
AK1	.642	.533	.533	7	:52
SG2	.619	.333	.4	14	:51
RM2	.428	.4	.333	14	:56
DW2	.571	.533	.333	9	:53
TA2	.425	.533	.333	14	:52
AS2	.642	.533	.4	15	:52
CM2	.666	.4	.2	10	:45
RG2	.547	.466	.466	10	:52
NI3	.595	.466	.333	13	1:19
KD3	.666	.333	.333	10	:45
MC3	.547	.466	.4	10	:27
HL3	.738	.6	.4	11	:49
BG3	.666	.6	.2	10	:51
HN3	.880	.733	.533	8	:44
AC3	.690	.533	.4	10	:47
SC3	.761	.6	.466	12	1:00
JH3	.880	.733	.466	7	:57

The first trial targeted recall of letters. Students were asked to recall a list of capital letters presented in flash card form. Letters were presented visually for fifteen seconds per flash card. Six assessments were given per student, each one adding two letters to the previous trial. Students were allowed one minute to recall the letters. In the first trial, in the control group where students did not chew gum, students scored a mean of 56%. Students in the experimental group who chewed gum during memory and recall scored a mean of 63%. First grade students in the control group scored a mean of 49% and a mean of 59% in the experimental group. Second grade students in the control group scored a mean of 58% and a mean of 56% in the experimental group. Third grade students in the control group scored a mean of 59% and a mean of 71% in the experimental group (See Figure 1).

The second session targeting memory and recall emphasized skills in visual memory. Students were directed to memorize and recall pictures in an array of fifteen large colored photographs. Each photograph was presented for ten seconds, in a continuous display. Students had three minutes to recall the pictures. In this second trial, students in the control group scored a mean of 49%. Students in the experimental group who chewed gum during memory and recall scored a mean of 50%. First grade students in the control group scored a mean of 43% and a mean of 48% in the experimental group. Second grade students in the control group scored a mean of 49% and a mean of 46% in the experimental group. Third grade students in the control group scored a mean of 55% and a mean of 56% in the experimental group (See Figure 2).

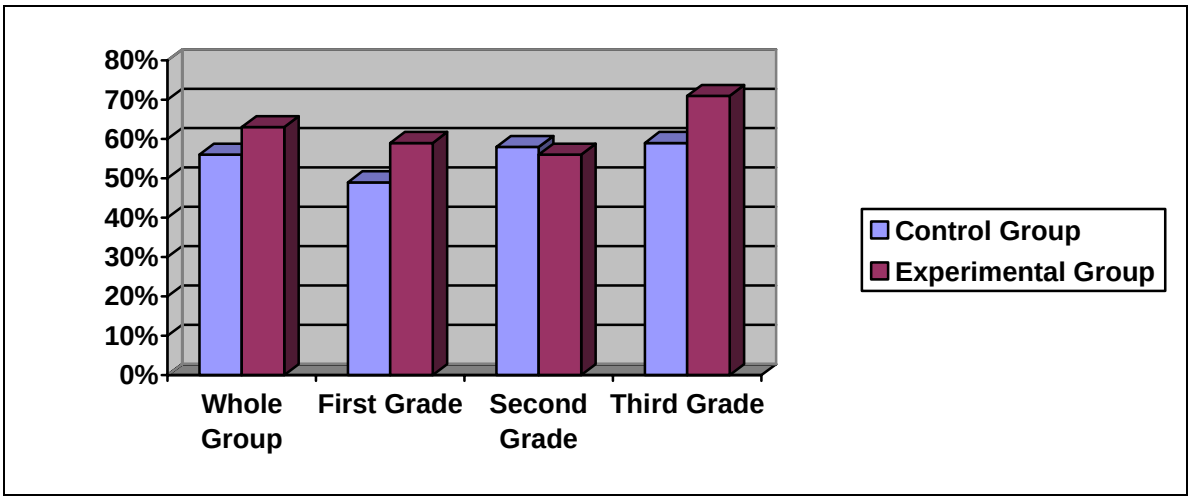
The third trial conducted in this study targeted auditory memory. Students were asked to listen to a list of fifteen common words, wait thirty seconds at the completion of

the list, and then recall as many words as they could remember. Students were allotted three minutes for recall. The third trial presented the following data. Students in the control group scored a mean of 34%. Students in the experimental group scored a mean of 39%. First grade students in the control group scored a mean of 31% and a mean of 41% in the experimental group. Second grade students in the control group scored a mean of 35% and a mean of 35% in the experimental group. Third grade students in the control group scored a mean of 35% and a mean of 39% in the experimental group (See Figure 3).

The fourth trial asked students to find the spatial location of objects. Students were given a large card with twelve single digit numbers in a display of a three by four grid. Each number was covered by a card. Students were directed to pick up two cards in a turn. If the two numbers matched, they removed the pair. The examiner recorded the number of turns it took to completely clear the game board. The total time to complete this activity was also recorded. In this trial, students in the control group who did not chew gum scored a mean of 13.8 turns with a mean of one minute sixteen seconds to clear the board. Students in the experimental group who chewed gum during memory and recall scored a mean of 11.1 turns with a mean of fifty-six seconds to complete the activity. First grade students in the control group scored a mean of 13.3 turns with a mean of one minute thirty-one seconds. First grade students in the experimental group scored a mean of 11.2 turns with a mean of one minute four seconds. Second grade students in the control group scored a mean of 14.4 turns with a mean of one minute thirteen seconds. Second grade students in the experimental group scored a mean of 12.2 turns with a mean of fifty-one seconds. Third grade students in the control group scored

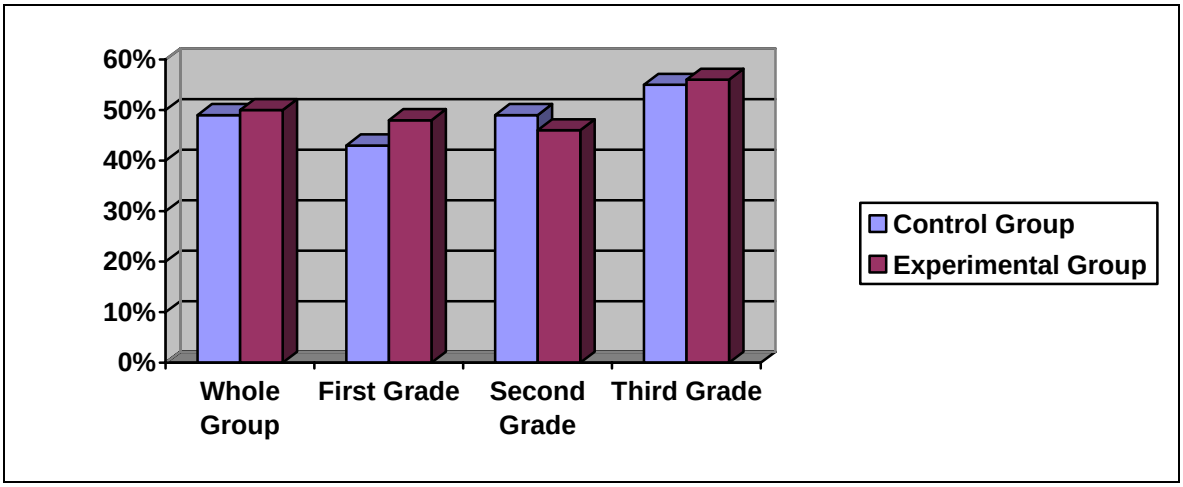
a mean of 13.7 turns with a mean of one minute three seconds. Third grade students in the experimental group scored a mean of 10.1 turns with a mean of fifty-one seconds (See Figure 4 and Figure 5).

Figure 1



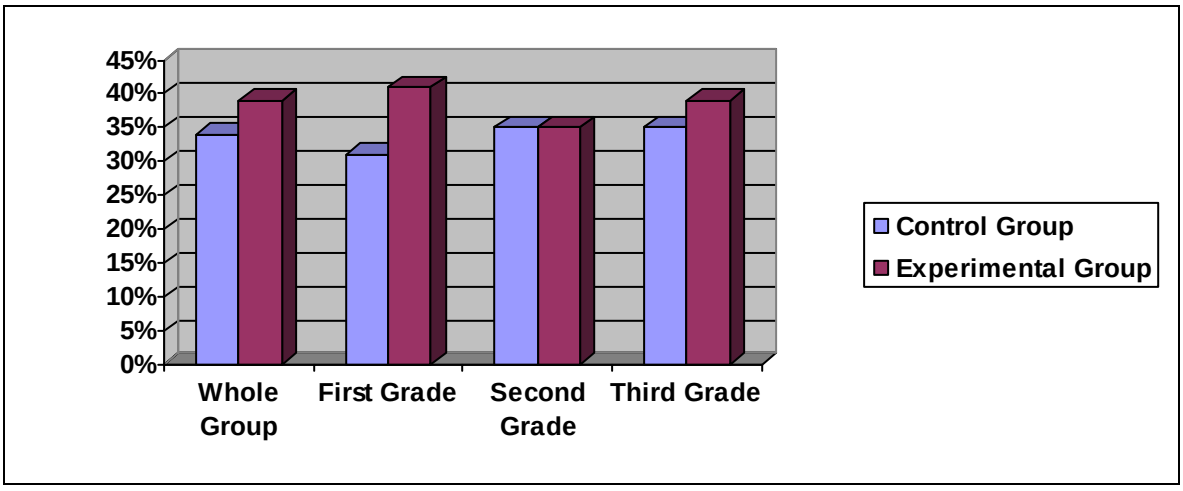
Trial 1: Recall of Letters

Figure 2



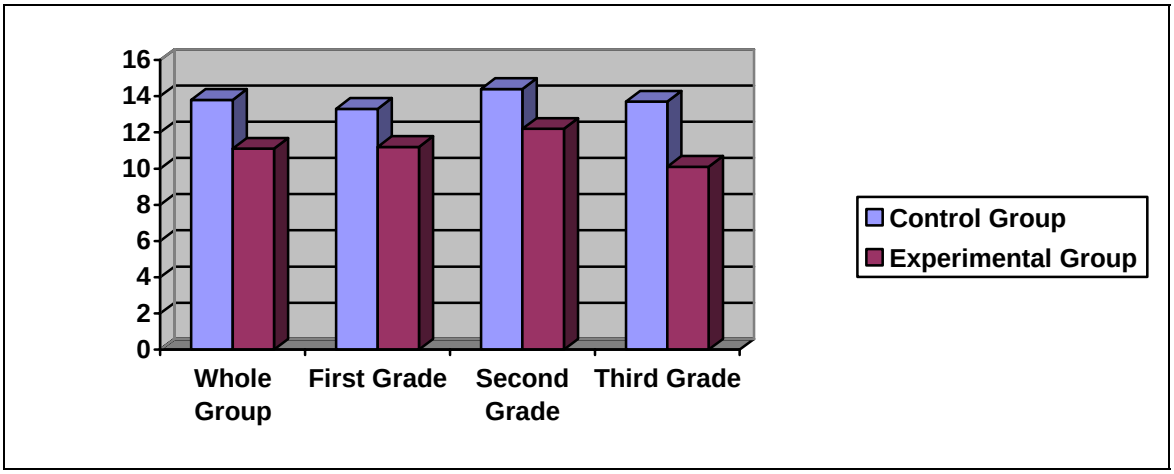
Trial 2: Visual Memory

Figure 3



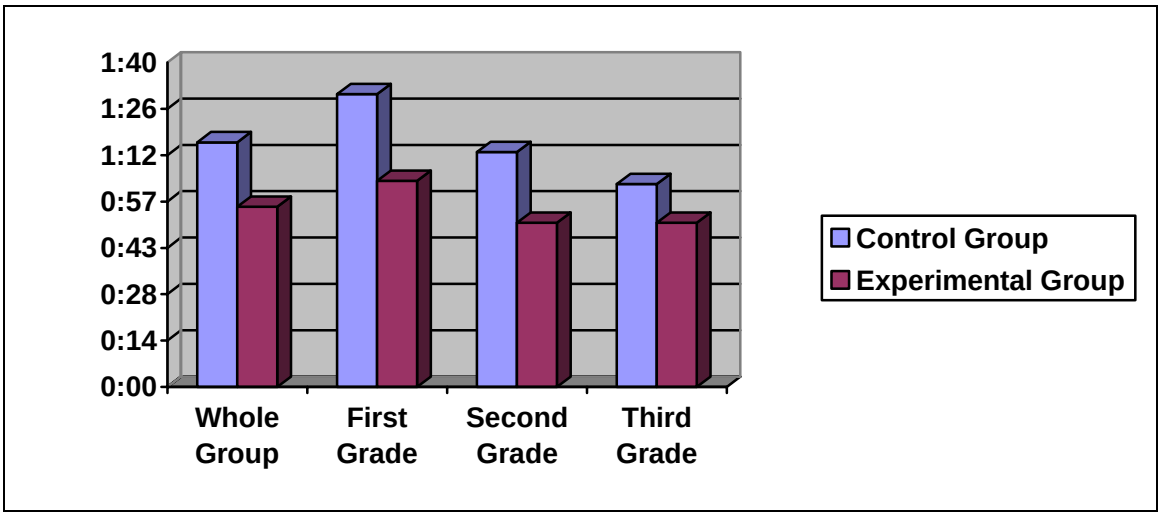
Trial 3: Auditory Memory

Figure 4



Trial 4: Spatial Location of Objects (Number of Turns)

Figure 5



Trial 4: Spatial Location of Objects (Amount of Time)

Table 3 represents the statistical analysis of the control group's scores for the first trial targeting memory through the recall of letters. The highest assessment score for the control group, or the non-gum chewers was 80% and the lowest assessment score for the group was 40%. The control group resulted in a median of 54% with an absolute deviation of 7.4. First grade students in the control group presented a high score of 61% with a low score of 40%. First grade students in this group presented with an absolute deviation of 4.4 from the median of 48%. Second grade students in the group gained a high score of 69% with a low score of 47%. Students in the second grade control group received an absolute deviation of 7.7 from the median of 57%. Third grade students in the control group presented with a high score of 80% and a low score of 42% in the first trial. These third grade students received a median of 59% with an absolute deviation of 7.1.

Table 3

Control Group: Whole Group Scores	High:	0.809
	Low:	0.404
	Median:	0.547
	Absolute Deviation:	7.428
Control Group: First Grade Scores	High:	0.619
	Low:	0.404
	Median:	0.488
	Absolute Deviation:	4.463
Control Group: Second Grade Scores	High:	0.690
	Low:	0.476
	Median:	0.571
	Absolute Deviation:	7.737
Control Group: Third Grade Scores	High:	0.809
	Low:	0.428
	Median:	0.595
	Absolute Deviation:	7.144

Trial 1: Recall of Letters

Table 4 represents the statistical analysis of the experimental group's scores for the first trial targeting memory through the recall of letters. The highest assessment score for the experimental group, or the gum chewers was 88% and the lowest assessment score for the group was 40%. The experimental group resulted in a median of 64% with an absolute deviation of 9.9. First grade students in the experimental group presented a high score of 81% with a low score of 40%. First grade students in this group presented with an absolute deviation of 0.1 from the median of 64%. Second grade students in the experimental group gained a high score of 66% with a low score of 43%. Students in the second grade experimental group received an absolute deviation of 7.5 from the median of 57%. Third grade students in the experimental group presented with a high score of 88% and a low score of 55% in the first trial. Third grade students within this group received a median of 69% with an absolute deviation of 8.7.

Table 4

Experimental Group: Whole Group Scores	High:	0.880
	Low:	0.404
	Median:	0.642
	Absolute Deviation:	9.908
Experimental Group: First Grade Scores	High:	0.809
	Low:	0.404
	Median:	0.642
	Absolute Deviation:	0.100
Experimental Group: Second Grade Scores	High:	0.666
	Low:	0.425
	Median:	0.571
	Absolute Deviation:	7.529
Experimental Group: Third Grade Scores	High:	0.880
	Low:	0.547
	Median:	0.690
	Absolute Deviation:	8.722

Trial 1: Recall of Letters

The statistical analysis of the control group's scores for the second trial targeting visual memory is represented in Table 5. The highest assessment score for the control group was 73% and the lowest assessment score for the group was 33%. The control group resulted in a median of 46% with an absolute deviation of 7.7. First grade students in the control group presented a high score of 53% with a low score of 33%. First grade students in this group presented with an absolute deviation of 6.6 from the median of 43%. Second grade students in the control group gained a high score of 66% with a low score of 33%. Students in the second grade control group received an absolute deviation of 6.6 from the median of 46%. Third grade students in the control group presented with a high score of 73% and a low score of 40% in the second trial. Third grade students within this group received a median of 53% with an absolute deviation of 8.8.

Table 5

Control Group: Whole Group Scores	High: Low: Median: Absolute Deviation:	0.733 0.333 0.466 7.728
Control Group: First Grade Scores	High: Low: Median: Absolute Deviation:	0.533 0.333 0.433 6.650
Control Group: Second Grade Scores	High: Low: Median: Absolute Deviation:	0.666 0.333 0.466 6.663
Control Group: Third Grade Scores	High: Low: Median: Absolute Deviation:	0.733 0.400 0.533 8.889

Trial 2: Visual Memory

Table 6 represents the statistical analysis of the experimental group's scores for the second trial targeting visual memory. The highest assessment score for the experimental group was 73% and the lowest assessment score for the group was 26%. The experimental group resulted in a median of 53% with an absolute deviation of 8.2. First grade students in the experimental group presented a high score of 60% with a low score of 26%. First grade students in this group presented with an absolute deviation of 5.9 from the median of 46%. Second grade students in the experimental group gained a high score of 53% with a low score of 33%. Students in the second grade experimental group received an absolute deviation of 6.6 from the median of 46%. Third grade students in the experimental group presented with a high score of 73% and a low score of 33% in the second trial. Third grade students within this group received a median of 60% with an absolute deviation of 9.6.

Table 6

Experimental Group: Whole Group Scores	High:	0.733
	Low:	0.266
	Median:	0.533
	Absolute Deviation:	8.280
Experimental Group: First Grade Scores	High:	0.600
	Low:	0.266
	Median:	0.466
	Absolute Deviation:	5.944
Experimental Group: Second Grade Scores	High:	0.533
	Low:	0.333
	Median:	0.466
	Absolute Deviation:	6.657
Experimental Group: Third Grade Scores	High:	0.733
	Low:	0.333
	Median:	0.600
	Absolute Deviation:	9.644

Trial 2: Visual Memory

The statistical analysis of the control group's scores for the third trial targeting auditory memory is represented in Table 7. The highest assessment score for the control group was 66% and the lowest assessment score for the group was 13%. The control group resulted in a median of 33% with an absolute deviation of 9.1. First grade students in the control group presented a high score of 46% with a low score of 13%. First grade students in this group presented with an absolute deviation of 0.1 from the median of 29%. Second grade students in the control group gained a high score of 53% with a low score of 13%. Students in the second grade control group received an absolute deviation of 9.1 from the median of 36%. Third grade students in the control group presented with a high score of 66% and a low score of 20% in the third trial. Third grade students within this group received a median of 33% with an absolute deviation of 8.1.

Table 7

Control Group: Whole Group Scores	High:	0.666
	Low:	0.133
	Median:	0.333
	Absolute Deviation:	9.072
Control Group: First Grade Scores	High:	0.466
	Low:	0.133
	Median:	0.299
	Absolute Deviation:	0.100
Control Group: Second Grade Scores	High:	0.533
	Low:	0.133
	Median:	0.367
	Absolute Deviation:	9.175
Control Group: Third Grade Scores	High:	0.666
	Low:	0.200
	Median:	0.333
	Absolute Deviation:	8.156

Trial 3: Auditory Memory

Table 8 represents the statistical analysis of the experimental group's scores for the third trial targeting auditory memory. The highest assessment score for the experimental group was 60% and the lowest assessment score for the group was 13%. The experimental group resulted in a median of 40% with an absolute deviation of 8.2. First grade students in the experimental group presented a high score of 60% with a low score of 13%. First grade students in this group presented with an absolute deviation of 0.1 from the median of 46%. Second grade students in the experimental group gained a high score of 46% with a low score of 20%. Students in the second grade experimental group received an absolute deviation of 5.7 from the median of 33%. Third grade students in the experimental group presented with a high score of 53% and a low score of 20% in the second trial. Third grade students within this group received a median of 40% with an absolute deviation of 6.6.

Table 8

Experimental Group: Whole Group Scores	High:	0.600
	Low:	0.133
	Median:	0.400
	Absolute Deviation:	8.260
Experimental Group: First Grade Scores	High:	0.600
	Low:	0.133
	Median:	0.466
	Absolute Deviation:	0.104
Experimental Group: Second Grade Scores	High:	0.466
	Low:	0.200
	Median:	0.333
	Absolute Deviation:	5.714
Experimental Group: Third Grade Scores	High:	0.533
	Low:	0.200
	Median:	0.400
	Absolute Deviation:	6.656

Trial 3: Auditory Memory

Table 9 represents the statistical analysis of the control group's scores for the fourth trial targeting memory through the location of spatial objects. The first part of this trial analyzed the number of turns taken to clear a board of twelve numbers, matching pairs one at a time. The highest assessment score for the control group, or the non-gum chewers was 9 turns and the lowest assessment score for the group was 21 turns. The control group resulted in a median of 14 turns with an absolute deviation of 1.9. First grade students in the control group presented a high score of 9 turns with a low score of 21 turns. First grade students in this group presented with an absolute deviation of 2.3 from the median of 13 turns. Second grade students in the group gained a high score of 11 turns with a low score of 17 turns. Students in the second grade control group received an absolute deviation of 1.6 from the median of 15 turns. Third grade students in the control group presented with a high score of 10 turns and a low score of 17 turns in the fourth trial. These third grade students received a median of 14 turns with an absolute deviation of 1.4.

Table 9

Control Group: Whole Group Scores	High:	9 turns
	Low:	21 turns
	Median:	14 turns
	Absolute Deviation:	1.96
Control Group: First Grade Scores	High:	9 turns
	Low:	21 turns
	Median:	13 turns
	Absolute Deviation:	2.38
Control Group: Second Grade Scores	High:	11 turns
	Low:	17 turns
	Median:	15 turns
	Absolute Deviation:	1.62
Control Group: Third Grade Scores	High:	10 turns
	Low:	17 turns
	Median:	14 turns
	Absolute Deviation:	1.44

Trial 4A: Spatial Location of Objects

Table 10 represents the statistical analysis of the experimental group's scores for the fourth trial targeting memory through the location of spatial objects. The highest assessment score for the experimental group, or the gum chewers was 7 turns and the lowest assessment score for the group was 16 turns. The experimental group resulted in a median of 11 turns with an absolute deviation of 2.1. First grade students in the experimental group presented a high score of 7 turns with a low score of 16 turns. First grade students in this group presented with an absolute deviation of 2.4 from the median of 11 turns. Second grade students in the group gained a high score of 9 turns with a low score of 15 turns. Students in the second grade control group received an absolute deviation of 2.0 from the median of 14 turns. Third grade students in the control group presented with a high score of 7 turns and a low score of 13 turns in the fourth trial.

Students in the third grade experimental group received a median of 10 turns with an absolute deviation of 1.2.

Table 10

Experimental Group: Whole Group Scores	High:	7 turns
	Low:	16 turns
	Median:	11 turns
	Absolute Deviation:	2.12
Experimental Group: First Grade Scores	High:	7 turns
	Low:	16 turns
	Median:	11 turns
	Absolute Deviation:	2.44
Experimental Group: Second Grade Scores	High:	9 turns
	Low:	15 turns
	Median:	14 turns
	Absolute Deviation:	2.00
Experimental Group: Third Grade Scores	High:	7 turns
	Low:	13 turns
	Median:	10 turns
	Absolute Deviation:	1.22

Trial 4A: Spatial Location of Objects

The statistical analysis of the control group's scores for the fourth trial targeting memory through the spatial location of objects is represented in Table 11. This trial analyzed the amount of time needed per student to completely clear the board when asked to match pairs of numbers in a grid of twelve numbers. The highest assessment score for the control group was 36 seconds and the lowest assessment score for the group was one minute eighteen seconds. The control group resulted in a median of 1:07 with an absolute deviation of 19.5. First grade students in the control group presented a high score of fifty-seven seconds with a low score of one minute eighteen seconds. First grade students in this group presented with an absolute deviation of 25.4 from the median

of 1:13. Second grade students in the control group gained a high score of 46 seconds with a low score of one minute forty-eight seconds. Students in the second grade control group received an absolute deviation of 15.4 from the median of 1:12. Third grade students in the control group presented with a high score of 36 seconds and a low score of one minute forty-two seconds in the fourth trial. Third grade students in this group received a median of 57 seconds with an absolute deviation of 12.1.

Table 11

Control Group: Whole Group Scores	High: Low: Median: Absolute Deviation:	0:36 2:58 1:07 19.5
Control Group: First Grade Scores	High: Low: Median: Absolute Deviation:	0:57 2:58 1:13 25.4
Control Group: Second Grade Scores	High: Low: Median: Absolute Deviation:	0:46 1:48 1:12 15.4
Control Group: Third Grade Scores	High: Low: Median: Absolute Deviation:	0:36 1:42 0:57 12.1

Trial 4B: Spatial Location of Objects

Table 12 represents the statistical analysis of the experimental group's scores for the fourth trial targeting memory through the spatial location of objects. The highest assessment score for the experimental group was 27 seconds and the lowest assessment score for the group was one minute twenty-four seconds. The experimental group resulted in a median of 52 seconds with an absolute deviation of 9.1. First grade students

in the experimental group presented a high score of 43 seconds with a low score of one minute five seconds. First grade students in this group presented with an absolute deviation of 9.1 from the median of 1:05. Second grade students in the experimental group gained a high score of 45 seconds with a low score of 56 seconds. Students in the second grade experimental group received an absolute deviation of 1.8 from the median of 52 seconds. Third grade students in the experimental group presented with a high score of 27 seconds and a low score of one minute nineteen seconds in the fourth trial. Third grade students in this group received a median of 49 seconds with an absolute deviation of 9.3.

Table 12

Experimental Group: Whole Group Scores	High: Low: Median: Absolute Deviation:	0:27 1:24 0:52 9.16
Experimental Group: First Grade Scores	High: Low: Median: Absolute Deviation:	0:43 1:24 1:05 9.11
Experimental Group: Second Grade Scores	High: Low: Median: Absolute Deviation:	0:45 0:56 0:52 1.86
Experimental Group: Third Grade Scores	High: Low: Median: Absolute Deviation:	0:27 1:19 0:49 9.33

Trial 4B: Spatial Location of Objects

Students' high and low scores were compared as a whole group and for the first grade, second grade and third grade groups. The statistics for these groups are represented in Figures 5 through 9.

Figure 5: Trial 1

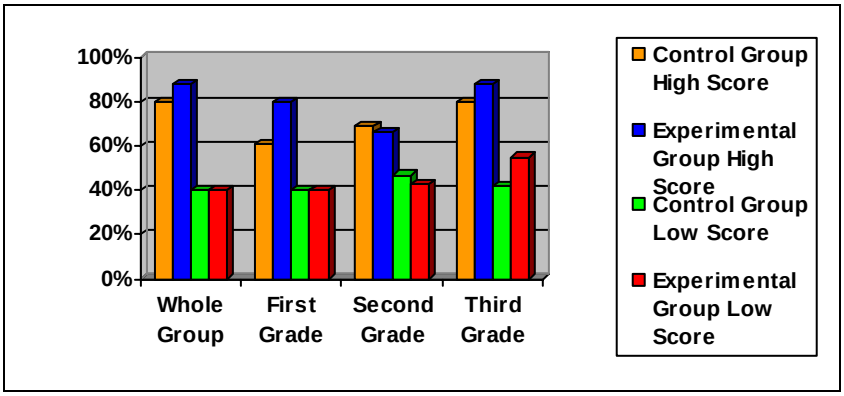


Figure 6: Trial 2

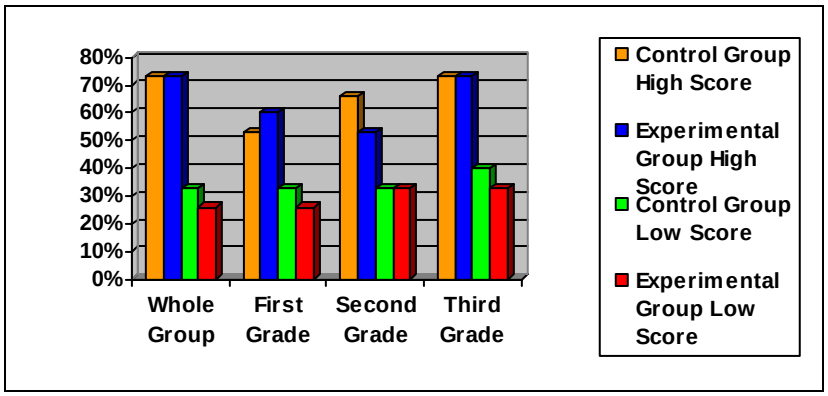


Figure 7: Trial 3

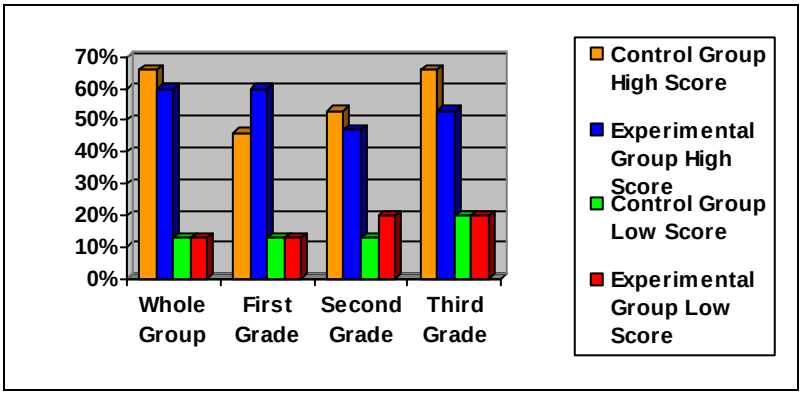


Figure 8: Trial 4

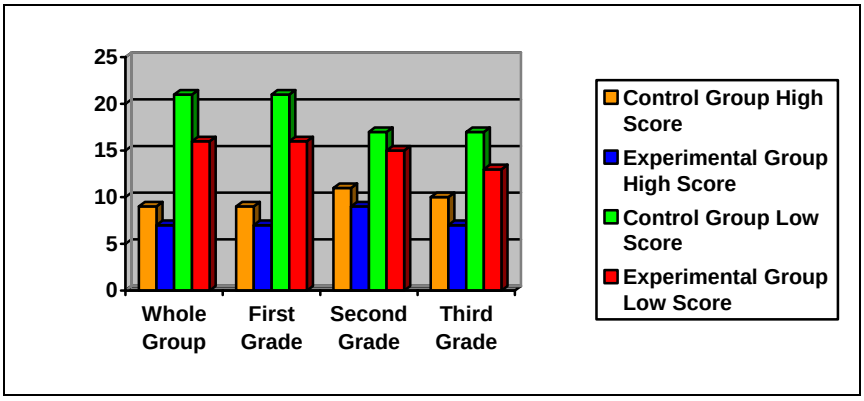
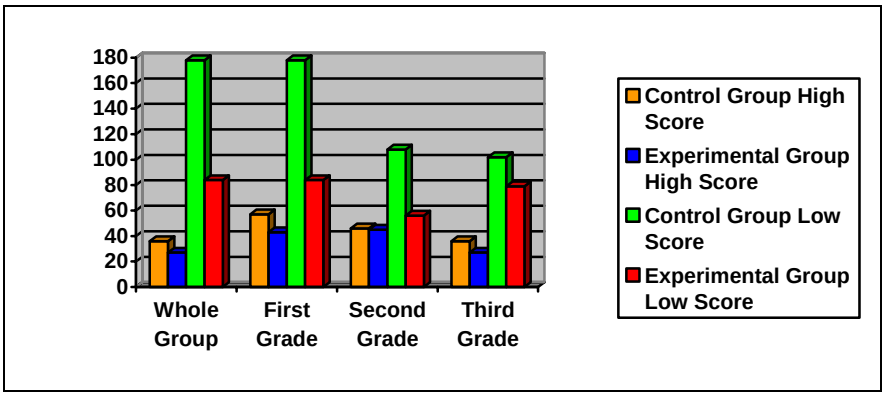


Figure 9: Trial 4



Chapter Summary

Data collected for the four trials was compiled and the results are shown in descriptive statistics and graphic displays. Percentages were displayed as visuals. The results from this study are discussed in Chapter 5.

Chapter 5

DISCUSSION

The purpose of this study was to determine if the effects of mastication through gum chewing would increase memory and recall on the outcomes of individualized sessions with elementary students. Presented in this chapter is the discussion of the finding of this project.

Overview of Findings

In 2003, researchers indicated that the act of mastication through gum chewing enabled individuals to increase short-term and long-term memory as much as thirty-five percent over those individuals who did not chew gum during identical examinations (Scholey, 2003). Recently, educators have come to consider that this information on mastication may enable students to increase test scores by allowing students to chew gum during memory and recall.

The trials conducted in this research project were administrated in an individualized setting. Each student was administered four short memory and recall examinations. All student examinations were highly identical. The experimental group chewed gum during memory and recall. The control group did not chew gum during the sessions.

The first trial administered targeted memory and recall through letter recall. Using the statistical mean, students in the experimental group scored seven percent higher than students in the control group. First grade and third grade students scored ten

to twelve percent higher in the experimental group than in the control group. Second grade students scored two percent higher in the control group than in the experimental group. The experimental group's high score was 88%, eight percent higher that the high score in the control group. The low scores in each group were identical at 40%.

The second session administered targeted visual memory. Using the statistical mean, students in the experimental group scored one percent higher than students in the control group. First grade students scored five percent higher in the experimental group than in the control group. Second grade students scored three percent higher in the control group than in the experimental group. Third grade students scored one percent higher in the experimental group than in the control group. The experimental group and the control group's high scores were identical at 73%. The low score in the experimental group was 26% compared to 33% in the control group.

The third trial administered targeted auditory memory. Using the statistical mean, students in the experimental group scored four percent higher than students in the control group. First grade and third grade students scored four to ten percent higher in the experimental group than in the control group. Second grade students identical in both the experimental and control groups. The experimental group's high score was 60%, six percent lower that the high score in the control group. The low scores in each group were identical at 13%.

The fourth trial targeted memory and recall through the location of spatial objects. Using the mean for each group, this research identified the experimental group to use 2 less turns to clear the board of the twelve numbers. Students in first, second, and third grade within the experimental group performed this skill using two to three turns less

than the students in the control group. The high score in the experimental group was seven turns, two less than in the control group. The low score in the experimental group was sixteen turns, five less than the control group.

The second element to trial four was to analyze the amount of time needed for students to clear the board of the twelve numbers. Using a statistical mean, the control group used twenty seconds more on average than the experimental group. First grade students in the experimental group were faster than students in the control group by twenty-seven seconds. Second grade students used, on average, twenty-two seconds less in the experimental group than in the control group. Third grade students in the experimental group were quicker than students in the control group by fourteen seconds. The highest score in the control group was thirty-six seconds, nine seconds slower than the high score in the experimental group. The low score in the control group was two minutes fifty-eight seconds, one minute thirty-four seconds slower than the low score in the experimental group.

Overall, students in the experimental group who used mastication during memory and recall performed better on the individualized sessions. However, the impact of the gum-chewing was not significant in all trials. Mastication appeared to improve the ability to recall letters in student's short-term memory bank when compared to the scores of students who did not chew gum during identical sessions. During this project, visual memory was not influenced greatly by mastication as both the control group and experimental group scored comparatively similar on the examination. Auditory memory appeared by be impacted by the act of mastication as students in the experimental group, particularly first grade students, scored higher than students in the control group. The

greatest difference between the experimental group and the control group was displayed during trial four. Memory and recall was targeted through the spatial location of objects. Students in the experimental group scored significantly better and faster when compared to students in the control group. The act of mastication appeared to greatly improve their ability to memorize the location of numbers, enabling them to complete the activity with fewer turns, and a quicker time.

Scope and Limitations

The research study was limited by the small sample size. Only fifty of the approximate five hundred students in the school population were invited to participate in this study, and only half of those students were allowed chewing gum during the memory and recall sessions. Due to this small sample size, generalization of the results was reduced.

It is assumed that all students put forth their best effort during the four sessions they were asked to complete. However, due to the fact that the examiner sent home permission slips explaining the research project, some students may chosen responses based on their assumptions of the study.

Recommendations for Further Study

Further study in the area of mastication and its effects on memory and recall with differing populations of students is warranted. Studies in which the act of mastication is examined over longer periods of time, larger numbers of individuals are included in the sample, and standardized testing is included in the examinations are needed for more accurate results.

Furthermore, this study needs to be expanded by examining the skills of a sample of students without the aid of mastication. Those same students should then be re-examined using similar tests while chewing gum. This may provide results that allow educators to see which students the act of mastication aids in memory and recall. Utilizing a resource to allow students better abilities and skills in recall and memorization is important to a student's school success. Any available resource or aid than can assist in this development should be employed.

Project Summary

The results of this research indicated that students performed better during trials of memory and recall when allowed to chew gum during the examination sessions. The mean results of the examinations produced a slightly higher percentage for students in the experimental group when compared to students in the control group. The act of mastication during memory and recall significantly impacted the ability to locate spatial objects with advanced and more rapid memorization.

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Appendix A

Collection of Trial Data

Effects of Mastication on Memory and Recall in Elementary Students
Trial # 1: Recall of Letters

Procedure: Students were asked to recall a list of capital letters presented in flash card form. Letters were visually presented for fifteen seconds per flash card. Students were allowed one minute to recall letters. Data was collected on the following chart.

Trial #	**Total Number of Letters in the Set**	**Correct Letters**	**Total Number of Letters Recalled in Trial**	**Percentage of Letters Recalled in Trial**
1	2	CT		
2	4	NYLD		
3	6	KRCHFO		
4	8	EHWSNYOL		
5	10	RQJMPXNBOZ		
6	12	ZUREMBTQVONJA		

Student Name:	
Grade:	
Homeroom Teacher:	
Experimental / Control Group:	EG CG

Effects of Mastication on Memory and Recall in Elementary Students
Trial # 2: Visual Memory

Procedure: Students were asked to memorize and recall pictures presented in an array of fifteen colored photographs. Each photograph was presented for ten seconds, in a continuous display. Students had three minutes to recall the pictures. Data was collected on the following chart.

Visual Stimuli	**Recalled (Yes/No)**	**Identified As (if different from examiner's label)**
horse	Y N	
teacup	Y N	
airplane	Y N	
apple	Y N	
butterfly	Y N	
ice cream cone	Y N	
scissors	Y N	
telephone	Y N	
light bulb	Y N	
soccer ball	Y N	
pencil	Y N	
kite	Y N	
guitar	Y N	
train	Y N	
hammer	Y N	

Total Recalled:		Time: minutes (standard of 3)

Student Name:	
Grade:	
Homeroom Teacher:	
Experimental / Control Group:	EG CG

Effects of Mastication on Memory and Recall in Elementary Students
Trial # 3: Auditory Memory

Procedure: Students were asked to listen to a list of fifteen words, wait thirty seconds, and then recall as many words as they could remember. Students were allotted three minutes for recall. Data was collected on the following chart.

Auditory Stimuli	**Recalled (Yes/No)**	**Identified As (if different from examiner's label)**
purple	Y N	
oven	Y N	
elephant	Y N	
pencil	Y N	
wait	Y N	
feather	Y N	
apple	Y N	
pinecone	Y N	
computer	Y N	
green	Y N	
chalkboard	Y N	
more	Y N	
hotdog	Y N	
giraffe	Y N	
red	Y N	

Total Recalled:		Time: minutes (standard of 3)

Student Name:	
Grade:	
Homeroom Teacher:	
Experimental / Control Group:	EG CG

Effects of Mastication on Memory and Recall in Elementary Students
Trial # 4: Spatial Location of Objects

Procedure: Students were given a large card with 12 single digit numbers in a display of a three by four grid. Each number was covered with a card and students were asked to pick up two cards in a turn. If the two numbers matched, they removed the pair. The examiner recorded the number of turns it took to completely clear the game board. The total time to complete this activity was also recorded. Data was collected on the following chart.

8	7	9	3
1	5	8	7
3	9	1	5

Total of Turns to Clear the Board																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54

Total Time Used to Clear the Board	minutes

Student Name:	
Grade:	
Homeroom Teacher:	
Experimental / Control Group:	EG CG

Appendix B

Permission Letter to the Parent/Guardian of the Student

D.J. Laskaris, Elementary Teacher
Otero Elementary School
Harrison School District Two
(719) 579-3504

Dear Parents/Guardians:

I am currently completing my master's degree through Regis University. As part of the requirement for graduating, I must complete a research project. I would like to ask your permission for your son/daughter to participate in this research project.

The purpose of this project will be to determine if chewing gum can increase memory and recall skills in students by comparing the scores of students who chewed gum during review and recall to those students who did not chew gum during identical examinations. Students will be administered four FUN tests in a one-on-one setting outside of their classrooms. Student's tests will be scored only for the purposes of this research project and the scores will have no outcome on their academic success.

I would like to conduct this study over the course of this week. If you would like your child to participate, please sign the following permission slip. Feel free to contact me if you have any questions or concerns. Please complete and return the attached permission slip.

Thank you for your assistance.

Sincerely,

DJ Laskaris

PERMISSION TO PARTICIPATE IN RESEARCH PROJECT

I give _____ permission to participate in the research
(Name of Child)

project being conducted by D.J. Laskaris as outline on the previous page.

_____ _____
Parent Signature Date