

CONFECTIONARY GUM'S ABILITY TO IMPROVE  
ATTENTIONAL PERFORMANCE WITHIN  
A POPULATION WITH SYMPTOMS OF ADHD.

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## CHAPTER I

### INTRODUCTION

For years confectionary gum consumers have chewed gum with the belief that they reap some benefits from its use. These beliefs have not been empirically tested and therefore warrant scientific investigation. The continual use of confectionary gum across the decades has been promoted by the novelty of its use, its breath enhancing properties, and the individual beliefs about the benefits that it provides (Hendrickson, 1996). It was not until 1939 when the first study was conducted to determine whether chewing confectionary gum had any effects above breath enhancement. Hollingworth (1939) found that confectionary gum did have stress reducing potential. Since this trailblazing research was conducted others have followed Hollingworth's pursuit and have demonstrated that chewing confectionary gum may have multiple benefits.

Researchers have found that confectionary gum can provide its users with many benefits. Thus far, confectionary gum has been determined to be helpful in managing nicotine withdrawal, stress, and acid reflux (Cohen, 2005, Odulsola, 1991). Chewing confectionary gum has been found to help promote hyposalivation which aids in the removal of debris from the teeth. It also contributes to the prevention of tooth caries (Hendrickson, 1976; Polland, Higgins, & Orchardson, 2003; Weakley, Petti, & Karwisch, G., 1997).

For the dieter or health conscious individual, confectionary gum is a low calorie snack and a simple way to burn a few extra calories (Levine, Baukol, & Pallidis, 1999). With a growing research base supporting confectionary gum's benefits, it is not surprising that so many people chew confectionary gum.

One of the most surprising findings is that researchers have recently demonstrated that chewing gum can improve cognitive functioning in the areas of memory and attention. In 2002, Wilkerson demonstrated that chewing gum can improve working memory and immediate and delayed word recall. Since then, others have investigated chewing gum's performance enhancing potential and have found some encouraging findings. While there are inconsistencies amongst the findings, they generally indicate that chewing gum may have the ability to increase memory and attentional functioning. Research (Masumoto, Morinushi, Kawasaki & Takigawa, 1998; Morinushi, Masumoto, Kawasaki, & Takigawa, 2000; Onozuka, Fujita, Watanabe, Hirano, Niwa, Nishiyama, & Saito, 2002; Onozuka, Fujita, Watanabe, Hirano, Niwa, Nishiyama, & Saito, 2003; Scott, Song, & McCarthy, 2004; Sesay, Tanaka, Ueno, Lecaroz, & Gense De Beaufort, 2000; Takada & Miyamoto, 2004) examining the physiological effects of confectionary gum on the central nervous system and body provide some support for these findings. However, as will be discussed in further detail, the literature in this area is in need of replication and further examination above what has been done to date.

The research in this area is in its infancy and has inherent methodological concerns which need to be addressed in future research. As mentioned previously, the findings thus far have been inconsistent and need further replication. Additionally, the assessment measures used (i.e., Drug Research Screener and self develop measures) are

not consistent across studies and most measures have little or no psychometric data to warrant their use. Previous research has provided the field with a good starting point, but thus far has only tapped portions of the memory and attentional functions. As well, the focus of their population has been limited to a normal functioning college sample and needs further expansion to determine confectionary gum's impact on a more diverse population (i.e., sample with reported attentional problems).

Therefore, the primary goal of this project was to address these limitations in the area of attentional functioning. This project attempted to determine chewing gum's effect on the attentional functioning in a normal population using valid and reliable measures that assess a broad spectrum of the attentional functions: focused or selective attention (concentration), sustained attention (vigilance), divided attention, and alternating attention: shifting focus of attention. In addition to observing the effect of confectionary gum on a normal population, we assessed confectionary gum's effect on a population with Attention Deficit Hyperactive Disorder (ADHD) symptoms. We proposed that chewing confectionary gum will improve performance on attentional measures in both populations.

In the next section, the literature will be reviewed in the following areas: first, a detailed review of the benefits of chewing gum will be presented followed by an examination of chewing gum's effects on the body and brain. The effects of chewing confectionary gum on cognition and confectionary gum as it relates to ADHD will be discussed. Afterwards, a presentation of the goals and specific hypotheses of the study will be presented. A detailed description of the current studies' protocol and procedures

will be discussed. This will be followed by an examination of the statistical strategy that was employed.



## CHAPTER II

### REVIEW OF LITERATURE

The present study investigated whether chewing gum improves attentional functioning in both a normal population and a population with symptoms of ADHD. The differential affects of confectionary gum across the two populations was also examined. The literature review focuses on chewing gum's broad health benefits. In addition, research on confectionary gum's physiological effects on the body and brain will be reviewed. Last, the current state of the literature will be discussed as it relates to confectionary gum's effects on cognition.

#### *Chewing gum*

Confectionary chewing gum has a long history that can be dated back to 7000 B.C. (Aveling & Heron, 1999). The research that has investigated chewing gum does not enjoy as long of a history. However, this has not stopped people from speculating about the benefits that chewing gum can provide to its users. The William Wrigley Company reports that retail sales of chewing gum in the U.S. total more than \$2 billion dollars. That averages out to more than 190 sticks of gum per person every year (Wrigley Marketing & Advertising, 2007). Considering these statistics, it is clear that users of confectionary gum must experience some type of reinforcement (benefit) from its use. Hendrickson (1996) reported several reasons for its use. First, Chewing gum may relieve feelings of loneliness and boredom. Second, chewing gum appears to relieve tension.

The release of tension is thought to come about by the discharging of nervous energy through chewing. Third, rage, anger, and irritation may be attenuated in a quick and socially acceptable way by chewing gum (Hendrickson, 1996). These propositions are only a hand full of speculated benefits of confectionary gum. Over the years of mastication on non-edible substances, other propositions (i.e., improves cognitive functioning) have been put forth as to man's motives to engage in what seems to be a useless behavior.

Research on chewing gum is fairly recent. In 1939, the first scientific study on chewing gum was published. Hollingworth, studied confectionary gum in relation to strain and relaxation, writing pressure, speed and accuracy of typing, and output of routine work. He concluded that chewing confectionary gum can reduce tension, and to some degree induce the relaxation of mealtime (Hollingworth, 1939). More recent research indicates that chewing gum appears to help people manage symptoms of nicotine withdrawal, stress, acid reflux, promote hyposalivation, prevent tooth caries, remove debris from the teeth, and promote fresher smelling breath (Polland, Higgins, & Orchardson, 2003; Odulsola, 1991; Weakley, Petti, & Karwisch, G., 1997; Hendrickson, 1976, Cohen, 2005). Chewing gum can also be utilized as a low calorie snack when trying to manage weight. In addition, research shows chewing confectionary gum to be an easy way to burn calories with little effort (Levine, Baukol, & Pallidis, 1999).

In 2005, the William Wrigley Company put out a monograph reviewing the current beneficial effects of chewing gum (Wm. Wrigley, 2005). The monograph summarized the findings in several areas: chewing and blood flow, chewing and reflux, chewing and learning, chewing and salivary flow, and chewing and stress relief.

Many people experience dry mouth due to a lack of salivation. Chewing confectionary gum increases salivary flow (Dawes, 2005). Salivation is helpful in promoting oral health by removing food debris that are retained around the teeth and on the oral mucosa. Not removing these debris can aid in the process of bacterial growth which is harmful to oral health. Salivary flow helps in the shedding of epithelial cells within the mouth which assists in bacteria removal. Additionally, an increase in bicarbonate and pH levels can be observed. According to Dawes (2005), studies have demonstrated that chewing gum promotes increases in salivary flow. Therefore, these benefits can be increased by chewing confectionary gum.

The increase in salivary flow has also been shown to be helpful with other oral esophageal problems. Specifically, chewing gum can provide benefit to an individual with gastroesophageal reflux disease (GERD) (Robinson, 2005). Approximately 20% of adults suffer from heartburn or acid regurgitation at least once weekly which is a typical complaint of patients with GERD. These symptoms are often brought about by certain foods or by overindulgence in food and drink. Research data has demonstrated that these symptoms can be temporarily alleviated using options ranging from over-the-counter remedies to pharmacotherapy to surgery. While treatment options are efficacious in most cases, Robinson reports that non-antacid chewing gum markedly shortens esophageal acid clearance time by way of increasing salivary flow. Such findings have led to a new antacid formulation which combines chewable antacid efficacy with recognized confectionary gum benefits (Robinson, 2005).

Chewing gum also appears to be an effective means for people to manage stress (Cohen, 2005). With respect to stress, chewing gum has been shown to help with nicotine

withdrawal and generalized stress. As noted earlier, the first published research on the benefits of confectionary gum evaluated its ability to reduce stress or tension as measure by self report and behavior observation (Hollingsworth, 1939). The Wrigley's company is reported to be the first to research chewing gum, but Hollingworth's work is the ground breaking research in the area (Hendrickson, 1976). He reported a series of experiments which indicated that chewing gum results in the lowering of tension (Hollingworth, 1939).

In 1999, Gomez and colleagues investigated the relationship between chewing gum and stress. They reported that chewing confectionary gum reduced physiological markers of stress in Sprague-Dawley rats. Specifically, the expression of non-functional mastication attenuated the release of dopamine in rats during a brief period of stress. This study provided preliminary evidence that chewing gum may ease the effects of stress on the brain (Gomez, Giralt, Sainz, Arrur, Prieto, & Garcia-Vallejo, 1999).

When dependent smokers cannot smoke they typically experience nicotine withdrawal. Fortunately, research demonstrates that chewing confectionary gum helps dependent smokers manage nicotine withdrawal and change smoking topology (Cohen, 2005). Cohen, Collins, and Britt (1997) examined the effects of chewing gum on nicotine withdrawal in a laboratory setting. Data demonstrated that when dependent smokers endured a nicotine deprivation period of approximately 3 hours, chewing confectionary gum reduced subject's cravings and lessened their nicotine withdrawal symptomology. The findings do not imply that chewing gum extinguishes withdrawal and cravings, but rather helped minimize their presence. In a follow-up study researchers demonstrated that chewing gum continued to attenuate withdrawal symptomology when the nicotine

deprivation period was increased (Cohen, Britt, Collins, al' Absi, & McChargue, 2001). However, this study did not find that chewing gum was helpful in reducing cravings as found in the previous study.

Research examining the relationship between cigarette smoking and chewing gum use in college students showed a significant association between smoking status and chewing gum status. A larger percentage of non-smokers compared to smokers reported being gum chewers. This may indicate that the more a person smokes the more likely they are to not chew confectionary gum (Britt, Collins, & Cohen, 1999). Examining smoking topology researchers found that when subjects chewed gum, were not restricted from smoking and given small rewards for not smoking they took fewer puffs compared to a control. Subjects that chewed gum also waited significantly longer before smoking a cigarette and smoked fewer cigarettes (Cohen, Britt, Collins, Stott, & Carter, 1999). These findings considered with previous studies points to chewing gum's potential applications in the area of nicotine cessation and harm reduction.

The anxiolytic effect of confectionary gum was examined again in another series of studies. Britt, Cohen, Collins, and Cohen (2001) examined the effects of cigarette smoking and chewing gum on urge to smoke, nicotine withdrawal, and anxiety while experiencing a laboratory-induced stressor (public speaking task). This is the first contemporary research to examine confectionary gum's ability to reduce anxiety. Substantiating earlier findings data showed that chewing gum was not an effective way to reduce urge to smoke (Britt, et al., 2001). Data established that confectionary gum reduced nicotine withdrawal when a dependent smoker experienced stress, but was unable to show that chewing confectionary gum helped manage incurred stress. However,

data demonstrated that chewing gum helped in the recovery from a stressful event (Britt, et al., 2001). Chewing gum's post-stressor effects have yet to be replicated. On the other hand, chewing gum's effects on nicotine withdrawal continue to withstand the vigor of scientific research. This cannot be said for its effects on anxiety and stress.

In a recent study, Miller (2006) focused research efforts on a non-nicotine dependent population using the same public-speaking paradigm. Using a college-based sample he examined how chewing confectionary gum influences subjective levels of stress and anxiety in non-smokers in response to a laboratory stressor. This research is the first to examine confectionary gum's effect on non-smoker's reported stress levels. Results demonstrated that nonsmokers did not experience significant anxiety reduction when stressed compared to those without access to chewing gum. This indicates that confectionary gum may not be helpful in reducing stress in a non-smoking population (Miller, 2006).

### *Effect on the Body and Central Nervous System*

Research evaluating confectionary gum's abilities and attributes has demonstrated that its effects go beyond the management of nicotine withdrawal. Researchers have found that chewing confectionary gum has observable physiological effects on its user. In the following section we will focus on research which investigates those physiological effects. We will discuss how chewing gum affects heart rate and blood pressure. As well, confectionary gum's effects on blood flow in the brain and brain activity will be reviewed. The research in this area can be divided into two parts: confectionary gum's effects on the body and confectionary gum's effects on the brain.

Farella, Bakke, Michelotti, Marotta and Martina (1999) examined the hardness of gum and its effect on the body and demonstrated that chewing confectionary gum increases blood pressure and heart rate. Data demonstrated that the hardness of the gum was positively correlated with heart rate. Sham chewing, also called “empty chewing” produced a small effect of an increase of  $1 \pm 1$  beat/min. However, chewing a soft, moderately hard or very hard gum had a greater impact on heart rate. Heart rate increase  $5 \pm 1$  beat/min for soft gum,  $9 \pm 1$  beat/min for moderately hard gum, and  $10 \pm 1$  beat/min for very hard gum. These increases in heart rate is said to be similar to prolonged light physical work (Farella, et al., 1999). In this same study Farella and colleagues demonstrated that chewing confectionary gum significantly increased blood pressure. Blood pressure increased  $0 \pm 1$  mmHg (millimeters of mercury) for empty chewing,  $3 \pm 1$  mmHg for soft gum,  $8 \pm 2$  mmHg for moderately hard gum, and  $13 \pm 2$  mmHg for very hard gum, respectively. The effects of chewing gum gradually began to fall after ten minutes of recovery (Farella, et al., 1999). This data indicates that the effects of chewing confectionary gum is linearly correlated with its hardness and that chewing gum facilitates increases in heart rate and blood pressure above and beyond just the opening and closing of the mouth. Therefore, confectionary gum users should receive all the same benefits that an increase in heart rate and blood pressure would provide if they were obtained from an alternative physical activity (Farella, et al., 1999).

In the next section the effects of chewing confectionary gum on the central nervous system (CNS) will be reviewed. To date several different technologies have been used to evaluate confectionary gum’s effects. Research confirms that confectionary

gum's effects on the body and brain are wide spread, but not understood at this time. The implications of this research will also be addressed.

Electroencephalography (EEG), Functional magnetic resonance imaging (fMRI), Computed tomography (CT), and Positron emission tomography (PET) technologies have all been used to understand the effects chewing confectionary gum has on the CNS. Research reveals that chewing confectionary gum does affect brain activity in numerous brain regions. However, the state of the science is short of providing a definitive explanation of the practical implications of these findings. In the following, we will review the effects of chewing confectionary gum on brain activity and blood flow in the brain.

EEG technology has been used to examine confectionary gum's effects on the brain (Masumoto, Morinushi, Kawasaki, Takigawa, 1998; Morinushi, Masumoto, Kawasaki, Takigawa, 2000). An EEG is a test that measures and records the electrical activity of the brain by using sensors (electrodes) attached to the head which are connected by wires to a computer (Ebersole, 2002). Using this technology Masumoto, Morinushi, Kawasaki, Takigawa (1998) and Morinushi, Masumoto, Kawasaki, Takigawa (2000) demonstrated that chewing gum increases alpha and beta waves throughout the brain. Chewing confectionary gum also changed the ratio of theta waves in the frontal area of the brain. Morinushi et al. (2000) proposed that the differences in the theta, alpha, and beta bands suggest that chewing gum could induce "concentration with a harmonious high arousal state in brain function". They also propose that these findings could indicate a heightened arousal status as well as a high cognitive and emotional status. Currently,



these researchers concede that they do not completely understand the cause and implications of these findings.

Confectionary gum chewing has been examined using Functional Magnetic Resonance Imaging (fMRI). fMRI is the use of MRI to measure the changes in blood flow and blood oxygenation in the brain (haemodynamic response) related to neural activity (Scott, Song, & McCarthy, 2004). Utilizing fMRI, Onozuka and colleagues (2002) demonstrated that chewing confectionary gum significantly increases the blood oxygenation level-dependent signal in various regions of the brain. Increases were observed bilaterally in the primary sensorimotor cortex extending down into the upper bank of the operculum and insula. Increases were also observed in the supplementary motor area, extending down into the cingulated gyrus, thalamus, and cerebellum. Changes in the striatum and pre-frontal cortex were seen but were not consistent across subjects. Increases in signal were greater in the cerebellum when chewing harder gum indicating that the effects of chewing gum may be affected by the hardness of gum. Research conducted by Penfield and Boldrey (1938) mapping the primary motor cortex demonstrated that the masticatory organs are represented on the inferior aspects of the primary motor cortex. Regions activated in the primary sensorimotor cortex facilitated by chewing gum are consistent with Penfield and Boldrey findings. This indicates that part of the activation seen in this area may be the result of general mastication and not only related to chewing confectionary gum (Onozuka, Fujita, Watanabe, Hirano, Niwa, Nishiyama, & Saito, 2002). Onozuka and colleagues (2003) replicated these results and found that chewing confectionary gum also resulted in an increase in blood flow in the right prefrontal area of the brain. Additionally, researchers suggest that age may moderate

the intensity of brain activity that is produced by chewing gum (Onozuka, Fujita, Watanabe, Hirano, Niwa, Nishiyama, & Saito, 2003).

The most recent study using fMRI revealed that chewing confectionary gum increased brain activity above that believed to be related to the mastication center of the brain. Takada and Miyamoto (2004) observed significant increases in the dorsolateral prefrontal cortex, ventral prefrontal cortex, parietal cortex, frontal gyrus, and the interior frontal gyrus. These findings are not completely understood however, Takada and Miyamoto do indicate that previous research has made a connection between activation in these regions and other higher order functions like memory. In a review, Fletcher and Henson (2001) state that the ventrolateral prefrontal area was involved in processes like maintenance of information. Therefore, as we will discuss later these findings may have significant implications as to confectionary gum's facilitation of cognitive benefit.

Two other types of technologies have been used to look at confectionary gum's affect on the brain. Research using Xeon-Enhanced Computer Tomography (XE-CT) and Positron Emission Tomography (PET) support previous findings indicating that chewing gum affects blood flow in the brain. Computed Tomography (CT) employs Tomography, which is imaging by sections. Tomography is coupled with digital geometry processing which is used to generate three-dimensional images of the internals of objects from a large series of two-dimensional X-ray images (Haacke, Brown, Thompson & Venkatesan, 1999). Sesay, Tanaka, Ueno, Lecaroz, and Gense De Beaufort (2000) utilizing CT found that chewing confectionary gum resulted in a wide spread increase in cerebral blood flow in the frontotemporal cortex, the caudate nucleus, and the thalamus. Non-significant increases were also observed in the parietal cortex, insula,

cingulated, and cerebellum. Sesay et al. (2000) reported that the mechanisms of cerebral blood flow modulation are not clearly understood. However, they speculate that their effects may result in cerebral vasodilation with neurogenic, myogenic, or metabolic influences.

Momose et al. (1997) explored cortical areas of the brain during mastication of confectionary gum with Positron Emission Tomography (PET). He found an increase in cerebral blood flow in several areas: Rolandic area (precentral gyri), Insula, Supplementary motor areas, Striatum, and Cerebellum. A 25-28% increase in cerebral blood flow (CBF) was reported in the Rolandic area, a 9-17% increase in the insula and supplementary motor areas, and an 8-11% increase in the cerebellum and striatum areas. Momose et al. noted that CBF began to return to baseline levels after about 15 to 30 minutes of rest. The nature of these blood flow increases is not exactly understood. They propose that the changes may be the result of local vasodilator factors created by increased neuronal metabolism.

This review indicates that the effects of chewing confectionary gum on the central nervous system are generally reliable and pervasive. It also demonstrates that some of effects chewing confectionary gum have on the brain result from the initiation and maintenance of the chewing behavior. However, a portion of the effects go beyond that of general chewing behavior and result from chewing confectionary gum. Our understanding of the brain is not at the point where we can clearly make the distinction of where the effects of the initiation and maintenance of the chewing behavior start and where the additional effects begin. However, Takada and Miyamoto (2004) have demonstrated that the effects of chewing confectionary gum go well beyond that of just

chewing. The question then becomes what benefit or purpose does the added activation and increase blood flow brought about by chewing confectionary gum provide. The answer to this question has yet to be completely delineated although researchers have demonstrated some promising and intriguing possibilities. For years lay people have believed and proposed that chewing gum must have some cognitive benefits. It wasn't until 2002 when chewing gum's cognitive benefits were finally tapped with promising results. Recent research demonstrates that confectionary gum's effects on the brain may contribute to increases in cognitive performance. The research in the area is in its infancy but, the findings are promising and indicate a need for further research. Following we will review the nature of the findings.

#### *Effect on Cognition*

Several studies suggest that chewing confectionary gum enhances memory performance. Wilkinson, Scholey, and Wesnes (2002) were first to examine this phenomenon. They asked participants to chew sugar-free gum, mimic gum chewing without gum, or sit quietly. Using the Cognitive Drug Research (CDR) computerized battery they found that chewing sugar-free gum significantly improved performance on standardized tests. Specifically, working memory and immediate and delayed word recall were improved. Working memory can be assessed in many different ways. This particular study used a task that measures the subject's ability to retain and retrieve spatial information using working memory. On this task it is reported that the Spatial Working Memory sensitivity index was improved. Additionally, they used a task that measured how well a short series of numbers could be held in memory and how quickly the numbers could be recognized. Chewing confectionary gum appears to increase numeric

working memory reaction time on this measure. However, in this study chewing gum did not have a performance impact on attention as measured by simple reaction time, choice reaction time, and digit vigilance. Their assessment of attention was narrow and cannot be perceived as assessing all facets of the attentional function. Nonetheless, chewing gum did not significantly impact attention on these measures.

Since the Wilkinson et al. (2002) study, two other studies (Stephens & Tunney, 2004; Baker, Bezance, Zellaby, & Aggleton, 2004) have been published supporting their original findings. These new studies also propose mechanisms that may contribute to confectionary gum's effect. Stephens and Tunney put forth hypotheses that go beyond that of increased brain activity and cerebral blood flow increases. Stephens and Tunney (2004) examined the possibility that chewing gum improved memory by improving the delivery of glucose to the brain. Using several cognitive assessment measures they examined the effects of confectionary gum and glucose administered separately and together on cognitive performance. Data from Auditory Verbal Learning Test (AVLT) supported previous findings that chewing gum improves immediate recall. They also found that Digit Span, Spatial Span, and Grammatical Transformation were similarly improved. Digit Span and Spatial Span are both measure of working memory.

Improvements on these tasks closely parallel previous findings reported by Wilkinson, Scholey, and Wesnes (2002). While previous findings do not find chewing gum helpful in improving attention. Stephens and Tunney did show that chewing confectionary gum improved Grammatical Transformation which is a measure of attention and processing speed. As well, performance on Digit Span relies heavily on attentional functioning. This is the first study to indicate that chewing confectionary gum may help modulate attention.

However, Stephens and Tunney did not substantiate previous findings that chewing improved delayed recall. Data showed an increase for chewing gum but the findings were not statistically significant (Stephens & Tunney, 2004). Their glucose delivery proposal did find some support with respect to working memory, immediate episodic long-term memory and language-based attention and processing. However, their findings were not consistent across all measures. Stephens and Tunney's findings do suggest that the improved delivery of glucose to the brain may account for some of confectionary gum's cognitive benefits.

Baker, Bezance, Zellaby, and Aggleton, (2004) examined whether confectionary gum's effects on memory are context dependent effects and not the result of chewing confectionary gum. In two different studies they were able to show that chewing gum led to better delayed recall of a word list. However, the increase in immediate recall did not reach statistical significance, but increases were observed. A different assessment measure was used in these studies bolstering the generalizability of chewing gum's effects on memory. However, Baker et al. (2004) were only partially able to demonstrate that confectionary gums effects may be attributable to context effects. Specifically, their data showed that switching from chewing gum to not chewing gum between learning and recall 24 hours later decreased the chewing enhancement effect to some degree. Context dependent memory effects, also known as Proustian memory, has been well established (Simon & Down, 2000). However, chewing gums effects appear to go beyond that of context dependent effects (Baker, Bezance, Zellaby, & Aggleton, 2004).

While all the studies to this point have demonstrated some improvement in memory, the most recent report did not show the same trend. The opposite can be said for

their examination of confectionary gum's effect on attention. Tucha, Mechlinger, Maier, Hammerl and Lange (2004) found that chewing spearmint gum did not improve immediate or delayed recall of a word list of 15 nouns compared to a sham chewing and quiet control. In regard to attention, Tucha et al. reported no effect on measures of divided attention, selective attention, and visual scanning or vigilance. However, chewing gum did positively impact sustained attention. The differential effects of confectionary gum on memory and attention is not understood. The changes in effect could be due to numerous factors: different types of gum leading to difference in chewing resistance, differences in assessment procedures and inventories used, or preexisting difference in samples. Nonetheless, Tucha and colleagues do provide some encouraging findings which warrant further investigation in this area.

Scholey (2005) reports that researchers, using mice as their subjects, have investigated the relationship between chewing and cognitive abilities. He reports that they used mice that had their molars extracted. In this line of research they measured mice's ability to find a submerged platform (Morris water maze). Researchers found data indicating that the ability to engage in effective chewing is associated with a mouse's ability to use spatial memory. Therefore, mice that had the ability to chew were able to locate the submerged platform more quickly. However, Scholey reports that other research has found that the inability to effectively chew only affects older mice. This area of research provides more data indicating the possible importance of chewing on cognitive performance. (Scholey, 2005)

To date no new studies had pursued the impact of chewing gum on cognition. Yet, more research is needed to determine whether chewing gum can affect memory or

attention performance. Given the overview of the research in this area several things are apparent and attest to the need for the current project. First, the data presents conflicting findings. The majority of research supports the notion that chewing gum can aid in memory performance on some tasks. However, the research findings are not consistent. Further, none of the studies to this point are true replication studies and therefore need to be more closely replicated to support confectionary gum's benefits. Specifically, researchers do not utilize the same methods which include using identical assessment measures. Another point of contention is the assessment measures utilized to assess cognitive functioning. The majority of the measures have no standardization or psychometric data warranting their use. In the same vain, the assessment of memory and attention can be assessed in numerous ways and across different sensory modalities. As well, the presentation of data can also vary innumerably. It is possible that the findings to date are not contradictory, but rather an indication that confectionary gum's effects are specific to particular types of memory or attention function. Further research is needed to determine the validity of this statement.

Research thus far has only focused on a narrow band of the population. It is possible that confectionary gum's effects are specific to a particular population. It is reasonable to consider that confectionary gum's effects on the population examined thus far are not substantial, and that investigating other populations may show greater and more consistent effects. While this postulation is only a hypothesis research is needed to determine its significance. Additionally, more research in this area may lead to a better understand of how confectionary gum's effects vary across different variables.

*Chewing gum and Attention Deficit Hyperactive Disorder*



Lay people believe that chewing confectionary gum may enhance their concentration (Hendrickson, 1996). The Wrigley Company (2007) reports that for decades consumers used chewing gum to improve alertness, focus and concentration. They indicate that athletes are constantly seen chewing gum on the playing field and that the U.S. Armed Forces supplied chewing gum to their soldiers in the field and even put it in combat rations since World War I. In the education environment we find that some teachers have reversed traditional chewing gum policies and encourage students to chew during tests to increase alertness.

Prior to the current study no research had addressed the effect that chewing confectionary gum may have on a population that has attentional problems. Even though some initial studies have begun to look at chewing gum's effects on attention they do not address the population that could possibly benefit most from its effects: Attention Deficit Hyperactive Disorder (ADHD) population. Currently, we do not know confectionary gum's true applicability and whether chewing gum could have a great impact on an ADHD population. Therefore, this project investigated whether chewing gum can increase attentional performance in a population with attention problems. Specifically, we assessed confectionary gum's impact on the different domains of attentional functioning in both a normal population and a population with ADHD symptoms. The four domains of attention that were investigated are focused or selective attention (concentration), sustained attention (vigilance), divided attention, and alternating attention (shifting focus of attention) (Lezak, 2004).

Previous research findings warrant the direction this study has taken. A review of the research looking at chewing gum's effects on a normal and college population

indicate that its scope and consistency of findings are limited. Therefore, our study continues to examine the normal college population. To add to the current research base we assessed a population that endorsed experiencing five or more ADHD symptoms. The classic hallmark behaviors or symptoms seen in this population are as follows: Often does not give close attention to details or makes careless mistakes in schoolwork, work, or other activities; Often has trouble keeping attention on tasks or play activities; Often does not seem to listen when spoken to directly; Often does not follow instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behavior or failure to understand instructions); Often has trouble organizing activities; Often avoids, dislikes, or doesn't want to do things that take a lot of mental effort for a long period of time (such as schoolwork or homework); Often loses things needed for tasks and activities (e.g. toys, school assignments, pencils, books, or tools); Is often easily distracted; and Is often forgetful in daily activities (American Psychiatric Association, 2004). Only six of these symptoms are necessary to meet the symptom count for the disorder. As a result, individual's presentation can vary due to the polythetic nature of the diagnostic system. Additionally, the endorsement of one additional symptom may change the diagnostic classification of a presentation. However, this does not mean that a significant change in behavioral severity is present. While six symptoms is the technical threshold at which an ADHD diagnosis can be made, it is acceptable to make a diagnosis with only five symptoms endorsed. Therefore, this study will use a population that endorses five or more ADHD symptoms.

A tremendous amount of research has devoted its efforts to determine the etiology of ADHD. To date research indicates that the etiology of the disorder is multifaceted.

Genetic factors (heredity), toxin exposure, and psychosocial are factors that have been identified (Barkley, 2006). However, the following discussion will focus on the neurological factors that are correlated with an ADHD diagnosis. This approach is taken because our bases for exploring a population with ADHD symptoms hinges on the neurological data that explains the etiology of ADHD.

Examining the neuropsychological research in the areas of confectionary gum and ADHD indicates that areas of the brain shown to be dysfunctional in an ADHD population are the same areas of the brain that are substantially affected by chewing confectionary gum. Neuropsychological research with an ADHD population has steadily grown over the past two decades. Research findings in this area are not consistent, but are beginning to show that ADHD is associated with neurological difference in the frontal lobes, basal ganglia, cerebellum, and anterior cingulated regions (Barkley, 2006). Research using EEG technology often in conjunction with vigilance tests has found increased theta activity and decreased beta activity in an ADHD population (Barkley, 2006). As discussed previously participants that used confectionary gum demonstrated increased alpha and beta waves throughout the brain. Chewing confectionary gum also changed the ratio of theta waves in the frontal area of the brain which is consistent with the ADHD findings (Masumoto, Morinushi, Kawasaki, Takigawa, 1998; Morinushi, Masumoto, Kawasaki, Takigawa, 2000). The most notable finding from this comparison is the compatibility of these findings. Specifically, ADHD research shows a decrease in beta activity while chewing gum has the ability to increase beta activity (Masumoto, Morinushi, Kawasaki, & Takigawa (1998); Morinushi, Masumoto, Kawasaki & Takigawa (2000). The theta activity data in the chewing gum research is not described in

enough detail to make a straightforward comparison to the ADHD findings. While not completely conclusive, research shows that EEG brain activity patterns related to sustained attention suggest that ADHD subjects have an under responsiveness to stimulation (Barkley, 2006). This lack of responsiveness is characterized in part by decreased beta activity. We proposed that if a population with ADHD symptoms utilized chewing gum during a task with a high attentional load that chewing confectionary gum could improve their performance. Sometimes stimulant medication is used to correct the under responsiveness in this population. It is possible that using stimulant medication in conjunction with confectionary gum may lead to an additive or even synergistic effect on performance.

In an ADHD population, Hendren, Wenning, Mueller, Qunaibi, Sass and Herpetz-Dahlamann (2000), have found decreased cerebral blood flow in areas of the brain. Sieg, Gaffneym, Preston and Hellings (1995) report that ADHD subjects have a decreased blood flow to the prefrontal regions (primarily the right side) of the brain. Decreases are also seen in the pathways (Striatum) connecting these regions to the limbic system. Specifically, decrease blood is observed in the anterior regions; the caudate and the cerebellum. Gustafsson and colleagues (2000) have reported that the degree of blood flow to these areas is correlated with behavioral severity and motor impairment. Research demonstrates that the use of methylphenidate, a stimulant, can affect blood flow in these regions of the brain. Methylphenidate is one treatment option for ADHD. Pairing imaging research conducted on subjects chewing confectionary gum with these findings hint to the possible applied benefits of confectionary gum within the ADHD population.

Examining the chewing gum literature demonstrates that chewing confectionary

gum increases blood flow in the same areas of the brain that in an ADHD population have been found to have a decrease in blood flow. Specifically, the research shows an increase in blood flow in the prefrontal regions, striatum, caudate nucleus and the cerebellum. Favorably, these findings have been replicated. As previously reviewed, chewing gum also led to an increase in blood flow in other areas of the brain, but the areas highlighted above are correlated with regions of the brain showing abnormalities in the ADHD population. In addition, the direction of effect among the ADHD and confectionary gum findings are compatible and in the appropriate directions. These findings further support our contention that chewing gum has the potential to have a performance enhancing effect in the area of attention within a population with ADHD symptoms. To this point we have discussed two areas of neurological research that provide support for examining the effects confectionary gum may have on a population with ADHD symptoms. A third position relates ADHD symptomology to a diminished glucose metabolism in the brain (Sesay, Tanaka, Ueno, Lecaroz, & Gense De Beaufort, 2000). This position fits with the proposal that the increase in blood flow resulting from chewing confectionary gum may result in cerebral vasodilation with metabolic influences (Sesay, Tanaka, Ueno, Lecaroz, & Gense De Beaufort, 2000). Therefore, it is reasonable to consider that chewing confectionary gum could increase glucose metabolism in a population with ADHD symptoms to the point where they could benefit behaviorally and cognitively. Considering all the research just reviewed, the current research study was conducted.

## CHAPTER III

### METHODOLOGY

The present study was designed to determine if chewing confectionary gum improves attentional functioning in both a normal population and a population with five ADHD symptoms. As well, the study has determined if chewing confectionary gum has differential affects on attentional functioning across the two groups. Standard neuropsychological measures designed to assess different areas of attentional functioning were used to measure attentional performance.

This study is an extension of previous work which focuses on the effects that confectionary gum has on different cognitive functions. Findings reported by Wilkinson, Scholey, Wesnes (2002), Stephens and Tunney (2004), Baker, Bezance, Zellaby, and Aggleton, (2004), and Tucha, Mechlinger, Maier, Hammerl and Lange, (2004) indicate that chewing confectionary gum increases long-term and short-term memory as well as attention. These researchers have made postulations about the mechanisms driving these findings. They propose that the effects are the result of increased blood flow, increased brain activity, improved delivery of glucose to the brain, or are context dependent effects.

However, the research to support confectionary gum's cognitive effects is inconsistent and in need of further assessment. This research is reviewed in more detail in previous sections. In short, these studies indicate that chewing confectionary gum may improve cognitive functioning in the areas of memory and attention. The limitations of

previous research are its lack of consistency in findings as well as its narrow focus on a college population without any cognitive limitation. Additionally, research focused on attentional functioning did not use a broad and psychometrically sound neurological assessment battery. Aside from these limitations, we believe that neurological findings support evaluating the effects of chewing confectionary gum on a population with ADHD symptoms. As well, confectionary gum's impact on attention in a normal population should continue to be investigated to give support to previous findings. Therefore, the present study employed a psychometrically sound battery to assess confectionary gum's effects on attentional performance. The effect of confectionary gum on each group was observed as well its differential effects.

Participant's attention was assessed using several neuropsychological measures designed to assess different aspects of attentional functioning (described in detail in following sections). This study used a 2 X 2 between subjects multivariate design. The independent variables are attentional problems vs. no-attention problems and gum vs. no-gum. Subjects were in one of four conditions: gum /attention problems, gum / no-attention problems, no-gum / attention problems, and no-gum / no attention problems; based on the order they presented to the clinic and the number of ADHD symptoms they endorsed. The dependent variables examined were the participant's performance on measures of attention. Participant's attention was assessed using the CPT-II, Trials A and B, and the Digits Forward and Backward subtest from the WAIS-III. To determine if attentional difficulties were present, subjects completed the Disruptive Behavior Rating Scale which aided in the assessment of ADHD symptomology. Only the inattention

symptoms were scored to determine group assignment. Demographic data were also collected but, was not of primary interest.

The present study was designed to address two primary predictions. First, it was expected that participants' performance on measures of attention would improve when chewing confectionary gum. Second, a larger increase in attentional performance was expected to be observed in the group with ADHD symptoms compared to control.

### *Hypotheses*

Hypothesis 1: It was predicted that participants without attentional problem that chewed confectionary gum would perform better on a neuropsychological battery focused on attentional functioning compared to a non-gum chewing control group. If substantiated, findings would indicate that chewing confectionary gum would modulate attentional functioning in a normal population. To determine if a significant group difference was present, a comparison was made between the gum no-attention problem condition and the no-gum no-attention problem condition.

### Hypothesis 2:

It was predicted that participants with attentional problems that chewed gum would perform better on a neuropsychological battery focused on attentional functioning compared to a non-gum chewing control group. If substantiated, findings would suggest that chewing confectionary gum may modulate attentional functioning in an ADHD population. To determine if a significant group difference was present, the performance of the gum attention problem condition was compared to that of the no-gum attention problem condition.

### Hypothesis 3:



It was predicted that chewing confectionary gum would result in a larger increase in attentional performance in the population with ADHD symptoms more so than compared to the normal conditions. Specifically, we expected to find a greater performance difference between the gum attention problem group and the gum no-attention problem group. This would indicate that the effects of confectionary gum on attentional performance vary across different population variables.

### Participants

Participants were 108 undergraduate students attending Oklahoma State University (see Table 2). Participants consisted of 62 females and 46 males with a mean age of 20.11 (SD =2.72). Participants were excluded from the study if they indicated that they disliked chewing gum, had any oral complications which restricted their ability to chew, were currently taking medication for attention problems, or currently used nicotine products. Participants were recruited through the Oklahoma State University Psychology Department's research subject pool. The research subject pool was operated using Sona's internet based software (more detail on Sona's software can be found at [www.sona-systems.com](http://www.sona-systems.com)). Each participant participated in the present study to fulfill either a class requirement or for extra credit. Subject's condition was predetermined by randomly drawing the order of conditions that each participant would participate based on the order they presented to the lab. A separate order was drawn for each gender to help insure that gender representation was fairly equal across conditions. When drawing conditions, each condition was exhausted before a condition could be redrawn. All participants were treated in accordance with APA standards.

### Materials

The current study was conducted in an 11 foot by 8 foot room in the Oklahoma State University Psychology Building. The room contained one 6 foot by 5 foot observation window (one way mirror). The temperature in the room was controlled by a central air conditioning unit. Contained in the room were two metal chairs, a 1950's military style metal desk and a Micro personal computer system. Attentional functioning was assessed using the Conners' CPT-II Continuous Performance Test II, Wechsler Adult Intelligence Scale-III: Digits forward and Digits backwards, and the Trail Making Test. The level of attention problems experienced by the subject was assessed by the Disruptive Behavior Rating Scale. Participants chewed "Wrigley" spearmint chewing gum.

Conners' CPT-II Continuous Performance Test II, (CPT-II); (Connors, 2000).

The CPT-II is a computer based measure designed to assess attention disorders in individuals 6 years of age and older. The CPT-II takes approximately 14 minutes to complete and provides several types of measures: Omissions, Commission, Hit Reaction Time, Hit Reaction Time Standard Error, Variability of Standard Error, Attentiveness (d'), Perseverations, Hit Reaction Time Block Change, Hit Standard Error Block Change, Hit Reaction Time ISI (Inter-Stimulus Interval) Change, Hit Standard Error ISI Change. During an administration, respondents press the space bar whenever any letter except the letter "X" appears on the screen. The speed (ISI) at which the letters are presented varies during the administration. Specifically, the ISI's are 1, 2, and 4 seconds with a display time of 250 milliseconds. Additionally, there are 6 blocks, with 3 sub-blocks, each containing 20 trials (letter presentations).

Conners reports the CPT-II to be a psychometrically sound instrument based on research conducted using several diverse populations. Most of the basic psychometric data were gathered from two large studies one of which was a “multi-site research study” and the other was an NIMH funded “epidemiological study”. All together there were 1920 cases included in the sample. The composition was respectably diverse across age, gender, ethnicity, and impairment level (Conners, 2000).

The CPT-II is a valid and reliable measure. Research examining its reliability demonstrates that its split-half reliability ranges from .73 to .95 between the different measures. Its test-retest correlation coefficients were found to be highly satisfactory for most measures with test retest correlation ranging from .60 to .89. In terms of its validity research found that on the CPT-II ADHD individuals performed more poorly on the task than individuals with other diagnostic conditions. A significant performance difference was also found between an ADHD sample and a non-clinical sample on all but one measure on the CPT-II (Conners, 2000).

Wechsler Adult Intelligence Scale-III: Digits forward and Digits backwards (WAIS-III);  
(Carlson et. al., 1989).

Digit Span is a subsection of the WAIS-III which has two parts: Digit forward is primarily a measure of short-term sequential auditory memory and attention. Digit backwards is a measure that relies on mental tracking, divided, and shifting attention. Digit forward contains a series of numbers ranging in length from two to nine digits. Digit backwards contains a series of numbers ranging from two to eight digits. On these tests, the subject listens to a series of digits given orally by the examiner. The subject

then recites as many digits as he or she can. On Digits backward the digits are recited in reverse order of presentation. For both sub-tests there are two sets of digits of each length.

Digit Span has been demonstrated to have good psychometric properties with a test-retest reliability coefficient ranging from .66 to .89 and high construct validity (Kaplan, Fein, Morris, & Delis, 1991). As well research shows Digit Span forward to be closely related to the efficiency of attention or freedom from distractibility (Kaufman, McLean, & Reynolds, 1991). Additionally, Hale, Hoepfner, and Fiorello, (2002) found that scores on Digit Forward and Digit Backward predicted performance on attentional measures.

Trail Making Test (TMT); (Army Individual Test Battery, 1944).

The TMT, originally known as Partington's Pathways or the Divided Attention Test is a two part assessment tool designed to measure scanning, visuospatial tracking, divided attention, and cognitive flexibility. Part A, also referred to as "Trial A" is a page with 25 numbered circles randomly arranged. Individuals are instructed to draw lines between the circles in increasing sequential order until they reach the circle labeled "End". Part B, also referred to as "Trial B" is a page with circles containing the letters A through L and 13 numbered circles intermixed and randomly arranged. Individuals are instructed to connect the circles by drawing lines alternating between numbers and letters in sequential order, until they reach the circle labeled "End." The task is to connect as many circles as the subject can without lifting their pencil from the paper. If the individual makes a mistake the mistake is quickly brought to their attention, and they continue from the last correct circle. The most common method of scoring was developed by Reitan (1958) which requires examiners to point out errors to the subject so that the

subject can correct the error resulting in completed tests every time. This method allows the examiner to base scoring solely on time. The test takes approximately five to 10 minutes to complete. The TMT has been demonstrated to be sensitive to brain injury due to its complex visual scanning with a strong motor component. Reliabilities for this measure are typically within the .80-.90 range although there have been a few reports of reliabilities in the .60 range (Spreeen & Esther, 1998; Broshek & Jeffrey 2000).

Adult Behavior Rating Scale – Self-Report of Current Behavior (Barkley, Edwards, & Robins (1999).

The Adult Behavior Rating Scale is a self-report measure that permits the researcher to obtain information concerning the presence of symptoms of ODD, CD, and ADHD in adults. As well, severity is also determined. The questions on this scale load directly on to the corresponding DSM-IV-TR psychodiagnostic criteria.

#### Procedure

Participants were a convenient sample obtained from a research subject pool. Subject's condition was predetermined by randomly drawing the order of condition that each participant would participate based on the order they presented to the lab. A separate order was drawn for each gender to help insure that gender representation was fairly equal across conditions. When drawing conditions each condition was exhausted before a condition could be redrawn. This procedure was used to help maintain equal cell size. The four conditions are as follows: 1) gum with attention problems; 2) gum without attention problems; 3) no gum with attention problems; and 4) no gum without attention problems.

Once the participant arrived at a designated time and place for the study they signed an informed consent form. Then, the instructions of the study were read. Next, they were given and asked to chew one stick of Wrigley's chewing gum during the course of the study. Participants were asked to chew gum prior to the administration of the attentional assessment measures to control for the possible influence of flavor and give ample time to induce increased blood flow and brain activity. During this time participants filled out the demographic measure and the Adult Behavior Rating Scale. Participants were given 5 minutes to complete these tasks. If demographic measures were completed before the 5 minutes expired they were asked to sit quietly until the researcher returned. The primary investigator then entered the room and began the administration of the assessment measures. Each participant was administered the Continuous Performance Task – II (CPT-II), followed by Trails A and B, Digit Span Forward, and Digit Span Backwards. The participants were then be debriefed and released from the study (See Appendix - Table 1 for an outline of the procedure).

## CHAPTER IV

### FINDINGS

#### *Overall Analytic Strategy*

The present study used a 2 X 2 between subjects multivariate factorial design. The primary independent variables that were evaluated are gum status (gum present and gum not present), and attention status (attention problems and no attention problems.) The dependent variables under evaluation were participant's performance on four measures of attentional functioning. Participant's attentional functioning was assessed using the Continues Performance Task – II (CPT-II), Trails A and B, Digit Span Forward, and Digit Span Backwards. To evaluate the current studies three hypotheses a 2 (gum status) X 2 (attentional status) Multivariate Analysis of Variance (MANOVA) was conducted to specifically assess performance on the Continues Performance Task – II (CPT-II), Trails A and B, Digit Span Forward, and Digit Span Backwards. Main effects and interactions were observed to determine group differences. Planned comparisons to identify specific group difference were determined a priori and tested by simple effects test. Tukey post-hoc test were employed when appropriate.

#### *Preliminary Analyses*

Descriptive statistics. Descriptive statistics were calculated for the full sample ( $N = 108$ ) and are provided in the Appendix - Table 2. No significant difference for age across gender or group condition was found.

## *Repeated Measures Analysis of Variance*

### Hypothesis 1, 2 and 3– Trials A and B, Digit Span, and CPT-II

It was predicted that chewing confectionary gum would result in a larger increase in performance in both a normal population and a population with ADHD symptoms compared to their controls. We expected to see an increase in performance on a neuropsychological battery focused on attentional functioning. Specifically, the gum/no attention problem condition were expected to have significant better performance than the no-gum/no attention problem condition. Similarly, the gum/attention problem condition was expected to have significant better performance than the no-gum/attention problem condition.

It was also predicted that chewing confectionary gum would have a larger impact on performance in the population with ADHD symptoms compared to a normal control. We proposed that the gum/attention problem condition would significantly out perform the gum/no attention problem condition. To test these hypotheses one 2 (gum status) X 2 (attentional status) Multivariate Analysis of Variance (MANOVA) was conducted to assess performance on the Continues Performance Task – II (CPT-II), Trails A and B, and Digit Span Forward and Backwards. We expected to find a main affect for gum across all dependent measures as well as an interaction with attentional status. To assess the hypotheses simple effects were explored. The results for the overall model where not found to be significant,  $F(1,102) = .885, p > .05, \eta^2 = .140, power = .910$ .

Trails A and B. A 2 X2 multivariate analysis of variance was employed. No significant findings were found. Specifically, no gum status X attention status interaction was found for Trails A,  $F(1,102) = .173, p > .05, \eta^2 = .018, power = .275$  or Trails B,  $F$



(1,102) = .347,  $p > .05$ ,  $\eta^2 = .003$ ,  $power = .090$ . Additionally, no significant main affect for gum status or Attention status was observed for Trial A,  $F(1,102) = .1519$ ,  $p > .05$ ,  $\eta^2 = .015$ ,  $power = .231$ ;  $F(1,102) = 2.04$ ,  $p > .05$ ,  $\eta^2 = .020$ ,  $power = .293$  or Trial B,  $F(1,102) = .012$ ,  $p > .05$ ,  $\eta^2 = .000$ ,  $power = .051$ ;  $F(1,102) = 2.787$ ,  $p > .05$ ,  $\eta^2 = .027$ ,  $power = .380$ . These findings demonstrate that chewing confectionary gum was not helpful in significantly increasing scanning ability, visoumotor tracking, divided attention, and cognitive flexibility in both populations. As well, regardless of attentional status chewing confectionary gum did not have an impact on these areas of functioning.

Digit Span. A 2 X2 multivariate analysis of variance was employed and no significant findings were found. Specifically, no gum status X attention status interactions were found for Digit Forward Total  $F(1,102) = .561$ ,  $p > .05$ ,  $\eta^2 = .005$ ,  $power = .115$ ; Digit Backward Total  $F(1,102) = .207$ ,  $p > .05$ ,  $\eta^2 = .002$ ,  $power = .074$ ; Digit Total  $F(1,102) = .519$ ,  $p > .05$ ,  $\eta^2 = .005$ ,  $power = .110$ ; Longest Digit Forward  $F(1,102) = .272$ ,  $p > .05$ ,  $\eta^2 = .003$ ,  $power = .081$ ; or Longest Digit Backward  $F(1,102) = .075$ ,  $p > .05$ ,  $\eta^2 = .001$ ,  $power = .058$ . Additionally, no significant main affects for gum status was observed for Digit Forward Total  $F(1,102) = 1.527$ ,  $p > .05$ ,  $\eta^2 = .015$ ,  $power = .232$ ; Digit Backward Total  $F(1,102) = .764$ ,  $p > .05$ ,  $\eta^2 = .007$ ,  $power = .139$ ; Digit Total  $F(1,102) = 1.586$ ,  $p > .05$ ,  $\eta^2 = .015$ ,  $power = .239$ ; Longest Digit Forward  $F(1,102) = 1.620$ ,  $p > .05$ ,  $\eta^2 = .016$ ,  $power = .243$ ; or Longest Digit Backward  $F(1,102) = .071$ ,  $p > .05$ ,  $\eta^2 = .001$ ,  $power = .058$ . There was also no main affects found for attention status on these measures. These findings demonstrate that chewing confectionary gum was not helpful in significantly increasing short-term sequential auditory memory, mental tracking and divided and/or shifting attention as measured by

digit span test. As well, regardless of attentional status chewing confectionary gum did not have an impact on these areas of functioning.

Conners' CPT-II Continuous Performance Test II, (CPT-II). A 2 X2 multivariate analysis of variance was employed and yielded no significant interactions. Specifically, gum status X attention status interactions were not significant for Omissions  $F(1,102) = .083, p > .05, \eta^2 = .001, power = .059$ ; Commissions  $F(1,102) = 1.055, p > .05, \eta^2 = .010, power = .174$ ; Hit rate  $F(1,102) = 1.601, p > .05, \eta^2 = .015, power = .241$ ; Hit rate Standard Error  $F(1,102) = .927, p > .05, \eta^2 = .009, power = .159$ ; Attentiveness  $F(1,102) = 1.060, p > .05, \eta^2 = .010, power = .175$ ; Hit reaction time block change  $F(1,102) = .410, p > .05, \eta^2 = .004, power = .097$ ; Hit Standard Error Block Change  $F(1,102) = .2.211, p > .05, \eta^2 = .021, power = .313$ ; Hit reaction time ISI change  $F(1,102) = .067, p > .05, \eta^2 = .001, power = .058$ ; or Hit Standard Error ISI change  $F(1,102) = .416, p > .05, \eta^2 = .004, power = .098$ . These findings indicate that the effects of confectionary gum do not vary in relation to the subject's attentional status. However, effects were observed for gum status independently. Main effects for gum status yielded mixed results. Specifically, no significant main effects for gum status was observed for Omissions  $F(1,102) = .383, p > .05, \eta^2 = .004, power = .094$ ; Commissions  $F(1,102) = 3.270, p > .05, \eta^2 = .031, power = .433$ ; Attentiveness  $F(1,102) = 2.079, p > .05, \eta^2 = .020, power = .298$ ; Hit reaction time block change  $F(1,102) = 1.198, p > .05, \eta^2 = .012, power = .192$ ; and Hit Standard Error Block Change  $F(1,102) = .391, p > .05, \eta^2 = .004, power = .095$ . However, significant main effects for gum status was observed for Hit rate  $F(1,102) = 3.741, p < .05, \eta^2 = .035, power = .482$ ; Hit rate Standard Error  $F(1,102) = 4.579, p < .05, \eta^2 = .043, power = .563$ ; Hit reaction time ISI change  $F(1,102) = 5.337, p$

$< .05$ ,  $\eta^2 = .050$ ,  $power = .629$ ; and Hit Standard Error ISI change  $F(1,102) = 5.260$ ,  $p < .05$ ,  $\eta^2 = .049$ ,  $power = .622$ . There were no main effects found for attention status on all dependent measures.

#### *Secondary Analysis: Regression*

We conducted a regression analysis to see the amount of variance that gum status and Attention status accounted for in the outcome measure of Hit rate. The model was not statistically significant  $F(1, 105) = 1.388$ ,  $p > .05$ . However, the analysis indicated that gum status accounts for 15% of the variance in Hit rate. Adding Attention status to the model only accounts for an additional 1% of the variance. These findings indicate that other variables not measured in this study account for the other 84% of variance.

Nonetheless, chewing confectionary gum may be able to increase a person's reaction time.

Overall, these findings indicate that confectionary chewing gum does not have a significant impact on most CPT measures of attention. However, some significance was observed. Specifically, chewing confectionary gum appears to improve reaction time which may indicate a decrease of inattentiveness. Further, results indicate that confectionary gum may increase consistency in reaction time which may indicate an increase in vigilance. Last, results indicate that when subjects chewed confectionary gum they were better able to adjust to the change in presentation speed of the target stimuli as measure by Hit reaction time ISI change and Hit Standard Error ISI change.

## CHAPTER V

### CONCLUSION

#### *General Findings and Limitations*

The main goal of this study was to determine if chewing confectionary gum could increase attentional performance, within a normal population and a population with five or more ADHD symptoms, on well established neuropsychological measures of attention. As well, it was important to determine the differential impact that chewing confectionary gum may have across these two populations.

Support for the hypotheses of the current study is mixed. Findings indicate that confectionary gum did not improve performance on the majority of the dependent measures of attentional functioning. Specifically, performance on the Trial Making Test, Digit Span, and most CPT-II subscales were not improved when chewing confectionary gum. However, findings show that confectionary gum had a positive impact on Hit rate, Hit rate Standard Error, Hit reaction time ISI change, and Hit Standard Error ISI change. These findings support the theory that confectionary gum may only affect specific types of attentional functioning. While main effects for gum were found, data did not demonstrate that confectionary gum's affects changed in relation to the subjects attentional status (i.e., no significant interaction were found). This indicates that there were no significant differences between cell means. These findings also indicate that confectionary gum does not have a differential impact on attention across a normal population and a population with ADHD symptoms.

The current study was not able to completely reject the null hypotheses for each dependent variable. However, the findings are consistent with some of the literature that examines the attentional effects of confectionary gum.

Previous research has only minimally begun to examine the effects of confectionary gum on attention. Wilkinson, Scholey, and Wesnes (2002) using the Cognitive Drug Research screener found that confectionary gum did not have a performance impact on attention as measure by simple reaction time, choice reaction time, and digit vigilance. However, they did find a positive effect for gum on numeric working memory reaction time. Unfortunately, their examination of attention was narrow and did not tap all the aspects of attention. However, this research was the first to examine this aspect of confectionary gum. Tucha, Mechlinger, Maier, Hammerl and Lange (2004) also found that chewing spearmint gum had no effect on measures of divided attention, selective attention, visual scanning or vigilance. They did find that chewing confectionary gum did result in longer reaction times in tonic and phasic alertness task and increased commission errors. This may indicate that chewing confectionary gum inhibited performance. However, findings did show that chewing gum had a positive impact on a sustained attention task as measured by reaction time.

It important to note that no assessment measure or subtest is a clean discrete measure of any one aspect of attention. As well, performance on most measures relies on more than one aspect of attention. Further, the current state of the science does not allow us to determine what portion of performance on a measure of attention can be attributed to a particular aspect of attention. At best, we can infer from the current understanding of

psychological processes and research how an aspect of attention may affect performance. This discussion is important to understand prior to reviewing the following sections.

Previous research does not give a definitive answer to the impact chewing confectionary gum has on attentional functioning. However, coupling the previous research with the current study does provide a little clarification and support for some of the previous findings. Earlier research indicates that chewing confectionary gum does not have an impact on focused or selective attention. Focused or selective attention is the capacity to highlight the one or two important stimuli or ideas being dealt with while suppressing awareness of competing distraction. Our data is consistent with previous findings as evidenced by data on Trials A, Trail B, CPT subtest, and digit span. While each of these measures load on other aspects of attention they also rely on a subject's ability to stay focused on stimuli.

In the area of sustained attention or vigilance previous research showed confectionary gum had no affect. Sustained attention or vigilance refers to the capacity to maintain an attentional activity over a period of time. Our data is also consistent with this finding. For example, similar to our findings a previous research study showed that confectionary gum did not impact omission and commission error rates. Further, our study demonstrated that performance on the CPT was not impacted when subjects chewed confectionary gum. The CPT is a measure that relies greatly on a subject's ability to remain vigilant. Therefore, these findings support the contention that chewing confectionary gum may not have a large enough effect to impact this aspect of attentional functioning. However, it must be mentioned that chewing confectionary did not negatively impact performance in this area as indicated by previous research.

Divided attention involves the ability to respond to more than one task at a time or to multiple elements or operation within a task. One previous study found that chewing gum did not affect divided attention. Similarly, we found that chewing confectionary gum did not affect performance on Trails B or Digit Span Backwards. Performance on these tasks greatly relies on a subject's ability to divide their attentional capacity. These results taken with previous finding continue to strengthen the theory that chewing confectionary gum may not bolster a person's ability to divide attention.

Previous research makes no reference to confectionary gum's impact on shifting attention, which is the shifting in the focus of attention. Performance on Trails B and Digit Span Backwards rely heavily on this ability. However, our data did not support confectionary gum's impact on this type of attentional functioning. While this is the first research to examine the shifting of attention it appears that confectionary gum's effects are not strong enough to increase performance in this area. However, more data is needed to determine this conclusively.

The data discussed thus far has only supported previous finds indicating that chewing confectionary gum is not helpful in improving attentional performance. However, our research data also shows that confectionary gum does improve reaction time as well as reaction time consistency. Further, it also indicates that confectionary gum helped subjects maintain their reaction time increases even when the presentation speed of stimuli changes. Consistency in reaction time was also better when the presentation speed of stimuli changed. Previous research indicated that chewing confectionary gum resulted in slower simple and choice reaction time, as well as longer reaction times in tonic and phasic alertness task. The CPT is very similar to measures

used in previous research, yet the current research supports that chewing confection gum increases reaction time. Our findings were supported by some previous finds that indicated that confectionary gum increased numeric working memory reaction time and reaction time in a sustained attention task. These finds combined with the current study provide encouraging data that chewing confectionary gum may have a positive impact on reaction time as well as its consistency.

Our current study indicates that confectionary gum was not more helpful to subjects with ADHD symptom than to a normal population. We had proposed that confectionary gum would result in increases in performance in this population. However, we were not able to find support for this proposal. Post hoc review of the data and methodology reveal some limitation to the method which may have prevented us from finding significance. Taking another look at our method for group assignment we find a possible explanation for these results. Subjects were identified as having ADHD symptoms or being normal based on their self report of ADHD symptomology. Specifically, subjects that endorsed 5 to 9 symptoms were considered to have a significant amount of symptoms. While those that endorsed 4 to 0 were considered normal. Our dichotomous method of subject assignment is closely related to an ongoing issue in psychology's diagnostic system. Our goal in assignment was to develop two distinct groups as it relates to attentional ability. However, given that it only takes one additional symptom to move in or out of a group we cannot confidently say that our groups are truly distinct. Specifically, we cannot confidently say that a subject that endorses 4 symptoms is less severe than one that endorses 5. Further, given the polythetic nature of the diagnostic system subjects that endorse the same level of symptomology



may not experience the same symptoms or at the same level of severity. Further, our data support this line of thought. Specifically, we would expect to see significant performance difference between the no-gum/at-risk condition and the no-gum/normal condition on most dependent measure. However, we found equivalence on all which indicates two similar populations. As a result, we cannot conclude from the current study that chewing gum does not have an impact on attentional performance within population with ADHD symptoms.

There are other inherent limitations and explanations for the current results. Each of them must be given careful consideration when evaluating the findings. In the following section we will present several limitations and alternative explanations of the current study's methodology and results. The current study has attempted to determine if the effects of confectionary gum change across different populations. However, while we have branched into new direction there are still many other components of chewing that must be considered. Specifically, no published research has examined chewing rates, chewing intensity, gum hardness, and perceived benefit of chewing. It is plausible to consider that each of these variables could be a mediating factor for confectionary gum's cognitive benefits. For example, research has demonstrated that gum hardness has a significant impact on blood pressure and heart rate. Therefore, it is important to understand how gum hardness may affect cognitive performance. Further, it is likely that individual differences in chewing rate and intensity affect performance. Additionally, the way a person chews on gum may affect other variables like cerebral blood flow and brain activity. We are equally concerned about what benefits participants think they get from chewing gum. For example, we may find that only people that believe chewing gum is

helpful in some way will reap its benefits. While these analogues postulations have no empirical support at this time they still must be empirically reviewed prior to concluding on confectionary gum's abilities.

Support for taking our research in the current direction relies greatly on previous research indicating that chewing confectionary gum has a significant affect on cerebral blood flow and brain activity. We propose that part of confectionary gum's impact on attention is a result of changes in these two areas. Unfortunately, the current project was not able to assure that changes in blood flow and brain activity actually occurred. Therefore, it is worth considering that due to individual differences we were not able to induce changes in these areas equally across condition. As a result, the effects of confectionary gum may not be visible and appear as if confectionary gum has no impact on cognitive performance. It is important that future researchers consider strategies for controlling for cerebral blood flow and brain activity.

It was important for the current study to control for whether a person was a gum chewer or not a gum chewer. While we were able to insure that each participant chewed gum we were not able to determine how forced chewing impacts confectionary gum's benefits. Specifically, each participant was requested to chew, but did not engage in the behavior on their own freewill. It is possible that the benefit of chewing confectionary gum is isolated to internal seeking out of chewing rather than being prompted or requested to chew. Hypothetically, typical chewing behavior may arise from a homeostatic signal or diathesis that promotes the seeking out of an outlet for chewing. As a result, the physiological changes that result from chewing may not be realized when one is artificially required to engage in chewing. Therefore, it is important for us to

consider how this may interactive with our findings. As well, it should be monitored in future studies that examine chewing behavior.

Attentional functioning is a complex construct. Being complex and multidimensional this construct can be measured in many different ways. It was important to this study to apply a broad assessment of attentional functioning across the accepted domains of attention. However, while our assessment method was good it is not exhaustive. Specifically, due to practical limitations we were not able to assess every dimension of attention from all sensory modalities. For example, the digit span test is presented verbally, but can also be administered visually. All of our measures could be presented in different formats and therefore allows attention to be assessed in more ways than is possible in one study. This limitation opens up the possibility that our measures are not sensitive to confectionary gums effects or that confectionary gum may not impact the types of attention that were assessed. However, our findings do provide some initial data about the impact confectionary gum has on these particular measures of attention. Future research must continue to broaden their assessment of chewing gum utilizing different assessment measures.

As discussed there are numerous variables to consider when examining these findings. It is reasonable to consider that chewing gums full potential has yet to be completely assessed. However, in light of the findings that did not allow us to reject the null hypotheses, significant finding were found. Specifically, our data indicates that chewing confectionary gum may help with reaction time and its consistency over time. As well, findings indicate that confectionary gum can help a person maintain increased reaction time in the presence of changes in stimulus speed. These findings may shed

some light on the high rate of chewing gum use. As well, there are real world application where and increase of reaction time would be helpful. These findings may help explain why chewing gum use is high by athletes. For example, athletes playing baseball are often seen chewing gum. Baseball is sport where milliseconds in delayed response “reaction time” could mean the difference in a positive or negative outcome.

Hypothetically, chewing confectionary gum may give its users an advantage over non-users. There are other real world examples where chewing gum may be helpful. For instance, chewing gum may have a significant impact when operating a motor vehicle. When operating a vehicle on the public streets the difference in a few milliseconds may mean the difference between running into another car, running over a dog, or running a red light. Whatever, the situation the use of chewing gum while driving could produce a more alert state resulting in increasing reaction time. These postulations are only inferences, yet future research must determine the true applicable nature of chewing confectionary gum.

In summary, the current research attempts to shed light on gum’s ability to increase cognitive performance in a normal population and a population with ADHD symptoms. Results taken with previous research indicates that confectionary gums impact on attentional performance may be limited or specific to particular types of attention or within particular populations. Research does support confectionary gum’s positive impact on reaction time. However, given the inherent limitations of the current study future research must continue to determine how chewing confectionary gum may help in increasing cognitive performance. Given the state of the literature there is enough data to support the continued use of confectionary gum. No research has indicated that its use is

harmful to the integrity of the self or the ability to perform numerous tasks. At its best, its users may gain a cognitive advantage by its use. At the least, chewing confectionary gum will continue to freshen our breath in times of need.

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## APPENDICES

Table 1  
Timeline of Procedure and Activities

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<u>Time of procedure</u>	<u>Activity</u>
<u>Introduction</u>	Participants introduced to lab, project described, consent forms signed.
<u>Gum administration</u>	Gum condition: given gum and left to chew for 5 minutes. Control condition left to sit for 5 minutes. All participants will complete the demographic and Adult Behavior Rating scale during this five minute period.
<u>Administration of assessment Battery</u>	Participants will be administered the Continues Performance Task – II (CPT-II), followed by Trial A and B, Digit Span, and Digit Span Backwards.
<u>Debriefing</u>	

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Table 2

Participant Characteristics and Demographics

<u>Participant Characteristics</u>		<u>Condition</u>			
	Sample	G/A	G/NA	NG/A	NG/NA
<u>Gender</u>					
Male	46	7	15	8	16
Female	62	7	26	5	24
Total	108	14	41	13	40
<u>Age</u>					
Mean	20.11	19.86	20.61	19.31	19.95
SD	2.71	3.08	3.04	1.37	2.53
Range	(18-30)	(18-30)	(18-30)	(18-22)	(18-30)

Note. G/A = Gum/Attention Problems. G/NA = Gum/No-Attention Problems. NG/A = No-Gum/Attention Problems. NG/NA = No-Gum/No-Attention Problems.

Table 3

Mean and standard deviations of MANOVA

Group	<u>Trials A</u>		<u>Trials B</u>		<u>DG Forward</u>		<u>DG Backwards</u>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
No-Gum/NA	19.74	(4.88)	52.87	(15.2)	10.44	(2.34)	6.69	(1.96)
No-Gum/A	23.42	(7.30)	57.17	(21.4)	11.00	(2.48)	6.92	(2.84)
Total	20.61	(5.68)	53.88	(16.7)	10.57	(2.36)	6.75	(2.17)
Gum/NA	19.93	(5.71)	50.10	(16.1)	10.19	(2.00)	6.50	(1.87)
Gum/A	20.00	(6.50)	59.08	(22.6)	10.00	(2.08)	6.31	(1.54)
Total	19.95	(5.85)	52.22	(18.0)	10.15	(2.00)	6.45	(7.19)

Note. Gum/A = gum with attention problems. Gum/NA = gum with no attention problems. No-Gum/A = no gum with attention problems. No-Gum/NA = no gum with no attention problem. DG Forward = Digit Span Forward (WAIS-III subscale). DG Backwards = Digit Span Backwards (WAIS – III subscale). Trial A and B reported in seconds to complete task.

Table 4

Mean and standard deviations of MANOVA

Group	<u>DG Total</u>		<u>Omission</u>		<u>Commission</u>		<u>Hit Rate</u>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
No-Gum/NA	17.13	(3.60)	2.28	(3.79)	12.51	(6.75)	47.84	( 8.65)
No-Gum/A	17.92	(4.90)	3.25	(3.38)	11.33	(8.55)	53.30	( 12.5)
Total	17.31	(3.90)	2.50	(3.68)	12.24	(7.14)	49.13	( 9.85)
Gum/NA	16.69	(3.25)	1.59	(2.88)	13.90	(8.47)	46.35	( 9.26)
Gum/A	16.31	(2.78)	3.00	(2.91)	16.38	(7.61)	46.16	(11.53)
Total	16.60	(3.13)	1.92	(2.93)	14.49	(8.27)	46.30	( 9.73)

Note. Gum/A = gum with attention problems. Gum/NA = gum with no attention problems. No-Gum/A = no gum with attention problems. No-Gum/NA = no gum with no attention problem. DG Total = Digit Span Total (WAIS-III subscale). Omission = CPT-II measure. Commission = CPT-II measure. Hit Rate = reaction time measure from CPT-II.

Table 5

Mean and standard deviations of MANOVA

Group	<u>HR STD</u>		<u>Attentiveness</u>		<u>Perseverations</u>		<u>HRBC</u>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
No-Gum/NA	51.02	(12.55)	50.43	(9.51)	49.06	(7.04)	49.20	(9.77)
No-Gum/A	57.27	(13.71)	47.46	(13.1)	51.05	(8.13)	53.67	(9.17)
Total	52.49	(12.97)	49.73	(10.4)	49.53	(7.28)	50.25	(9.74)
Gum/NA	47.99	(9.219)	51.45	(10.8)	49.41	(9.44)	48.16	(11.0)
Gum/A	49.29	(10.56)	53.55	(11.7)	50.15	(7.60)	49.72	(6.75)
Total	48.30	(9.467)	51.94	(10.9)	49.59	(8.98)	48.53	(10.1)

Note. Gum/A = gum with attention problems. Gum/NA = gum with no attention problems. No-Gum/A = no gum with attention problems. No-Gum/NA = no gum with no attention problem. HR STD = Hit rate Standard Error. Attentiveness = measure from CPT-II. Perseverations = measure from CPT-II. HRBC = Hit Rate Block Change.



Table 6

Mean and standard deviations of MANOVA

Group	HR-SEBC		HR-ISIC		HR- SEISI	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
No-Gum/NA	52.05	(11.75)	55.60	(12.92)	53.60	(13.06)
No-Gum/A	60.28	(11.33)	57.25	(18.22)	58.05	(11.70)
Total	53.99	(12.07)	55.99	(14.16)	54.65	(12.78)
Gum/NA	54.15	(10.25)	50.00	(8.91)	49.59	(8.43)
Gum/A	55.13	(7.083)	50.25	(10.0)	50.89	(7.18)
Total	54.38	(9.546)	50.06	(9.09)	49.90	(8.11)

Note. Gum/A = gum with attention problems. Gum/NA = gum with no attention problems. No-Gum/A = no gum with attention problems. No-Gum/NA = no gum with no attention problem. HR-SEBC = Hit Rate Standard Error Block Change. HR-ISIC = Hit Rate Inter Stimulus Interval Change. HR- SEISI = Hit Rate Standard Error Inter Stimulus Interval Change

**Oklahoma State University Institutional Review Board**

Date: Monday, October 15, 2007  
IRB Application No AS0765  
Proposal Title: Confectionary Gum's Ability to Improve Attentional Performance within an ADHD and Normal Population  
Reviewed and Processed as: Expedited

**Approval Status: Provisionally Approved**

Principal Investigator(s)

Victor H Wong  
215 North Murray  
Stillwater, OK 74078

Thad Leffingwell  
215 N. Murray  
Stillwater, OK 74078

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The research procedures of the IRB application referenced above include the use of the OSU Subject Pool. The application and procedures have been reviewed by the IRB and are provisionally approved to allow registration of the research project with the Subject Pool coordinator. **This provisional approval will be effective for two weeks** to allow proof of registration to be provided to the IRB. Once proof of registration is received, full approval will be granted and a letter sent to the PI(s).

Sincerely,



Sue C. Jacobs, Chair, Institutional Review Board

VITA

Victor H Wong Jr

Candidate for the Degree of

Doctor of Philosophy

Thesis: CONFECTIONARY GUM'S ABILITY TO IMPROVE ATTENTIONAL PERFORMANCE WITHIN A POPULATION WITH SYMPTOMS OF ADHD.

Major Field: Clinical Psychology

Biographical: Biographical: Born in Coffeerville, Kansas, December 15, 1977

Education:

Completed the requirements for the Doctor of Philosophy in Clinical Psychology at Oklahoma State University, Stillwater, Oklahoma in December, 2009.

Professional Memberships: American psychological Association.

Name: Victor H Wong Jr

Date of Degree: December, 2009

Institution: Oklahoma State University

Location: Stillwater, Oklahoma

Title of Study: CONFECTIONARY GUM'S ABILITY TO IMPROVE ATTENTIONAL PERFORMANCE WITHIN A POPULATION WITH SYMPTOMS OF ADHD.

Pages in Study: 62

Candidate for the Degree of Doctor of Philosophy

Major Field: Clinical Psychology

Scope and Method of Study: The present study was designed to determine if chewing confectionary gum improves attentional functioning in both a normal population and population with ADHD symptoms. As well, the study has determined if chewing confectionary gum has differential affects on attentional functioning across the two groups. Standard neuropsychological measures designed to assess different areas of attentional functioning were used to measure attentional performance.

Findings and Conclusions:

Support for the hypotheses of the current study is mixed. Findings indicate that confectionary gum did not improve performance on the majority of the dependent measures of attentional functioning. Specifically, performance on the Trial Making Test, Digit Span, and most CPT-II subscales were not improved when chewing confectionary gum. However, findings show that confectionary gum had a positive impact on Hit rate, Hit rate Standard Error, Hit reaction time ISI change, and Hit Standard Error ISI change.

ADVISER'S APPROVAL: Thad Leffingwell

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