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Does Aerobic Exercise or Cardiovascular Exercise Facilitate Explicit Memory?

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Abstract

This study examined whether cardiovascular or aerobic exercise aids in explicit memory. Five male and twenty-four females on the Bard College campus either engaged in cardiovascular or aerobic exercise (experimental condition) or watched a video (control condition). Before beginning these tasks, participants read a list of 15 words. After the task, participants recalled as many words as they could from the previous list. The participants' test scores did not indicate that a specific condition aided in their received score, meaning memory did not differ across conditions, $F(2,29)= .420$, $p>.05$. Future directions would implement a longer period of time for the participant to exercise, and include a larger population of subjects to determine if this helps improve the participants' test score.

Does Aerobic Exercise or Cardiovascular Exercise Facilitate Explicit Memory?

Exercise is part of a person's everyday life; playing outside at recess, going for a walk with friends, or even walking around a grocery store can be considered exercise. Anything that gets a person's body up and moving, and one of the most important things about our bodies is our brain; remembering to do small tasks like going to meet someone or getting groceries is a large part of our everyday lives. Many studies have shown that exercise helps successful brain function (Cotman, Berchtold, & Christie, 2007) and that fitness may be related to better cognitive function in teenagers and increased cognitive health in both children and adults (Hillman, Castelli, & Buck, 2005). These results are seen throughout two different types of exercise: aerobic and cardiovascular. Cardiovascular exercise is when a person's heartbeat rises significantly from its resting level and beats faster than normal, rising above 90 bpm; this could include but is not limited to running, elliptical running, and brisk walking. Aerobic exercise is the intake and flow of air throughout the body while exercising; this could include but is not limited to swimming, biking, and yoga. Both of these exercises use the same function, when a person goes on a run their heart is working and their body is also taking in more oxygen. But there are some exercises from these two categories that are different from each other and those will be used in this study: Yoga and running, walking, or jogging. The question worth asking is, does cardiovascular exercise or aerobic exercise facilitate scores on a free recall test?

Overview

The literature states that fitness may be related to academic achievement, that there is a positive relationship between physical activity and academic achievement, cognition, academic achievement, and fitness may be related to cognitive function (Hillman et al., 2005). With all of

this research why has nothing changed? Older adults and children are being researched on this topic, but young adults are being omitted. As a person moves throughout the school system their physical activity time is cut down and their workload is increased. When a person gets to college they must spend the majority of their day on work with little time for other activities. If research indicates that it is beneficial to start physical activity as a child because it helps with academic achievements then why, when school gets harder, should young adults stop getting the opportunity to have time in school for physical activity. This is why young adults need to be studied more on this subject so they can have the support that research provides. Research would explain why this age group should make time to exercise during their busy day.

Physical activity provides an abundance of benefits to those who participate regularly (Castelli, Hillman, Buck, & Erwin, 2007). That is why for my experiment I want to focus my age group on young adults aged 18-22. This group has had little if any research done on them to support or deny that physical activity is related to academic achievement and cognitive functioning. Using cardiovascular and aerobic exercises, a free recall test will provide scores of explicit memory to determine if exercise affects mental ability.

Brain Function

To further understand the benefits of exercise it is also important to understand the brain functioning surrounding this concept. To better understand the neurological component will provide more background to what is happening in the brain when a person exercises. This experiment will be investigating memory, more specifically explicit memory. In the brain memory is stationed in the hippocampus. The hippocampus is towards the middle lower part of

the brain and is close to the amygdala, the fear center in the brain. The hippocampus is responsible for memories that a person experiences.

Like any part of the body, things start to slow down and stop working as they age. Just like the body the brain also goes through this aging process. In the hippocampus specifically there is a process called hippocampal hyperactivity (Setti, Hunsberger, & Reed, 2017), this occurs when there is over activation in the hippocampus. The over stimulation of the hippocampus may result in excitotoxicity, which is a "pathological process that kills neurons due to overactivation" (Setti et al., 2017). Studies have been shown that exercise can help rebuild the neurons that deteriorated in the brain, specifically endurance exercise.

Endurance exercise has been found to increase expression in the brain through a process called brain-derived neurotrophic factor or BDNF (Misuraca, Miceli, & Teuscher, 2017). BDNF is a protein that can help the neurons regenerate themselves. This process helps the hippocampal neurons become stronger and more durable, being able to withstand things like hippocampal hyperactivity and excitotoxicity. Endurance exercise helps to produce more of the BDNF protein which can make the brain more efficient, plastic, and adaptive (Misuraca et al., 2017). This is important because if the neurons are more flexible and strong they can protect themselves from natural aging. It is important to learn how to create this protein more effectively because the earlier the prevention of natural aging, the longer the brain will stay healthy throughout one's life.

Erickson et al., completed a study that analyzed whether exercise training helped increase the size of the hippocampus. They found that exercise training did in fact help increase the size of the hippocampus (Erickson et al., 2011). Their participants were older adults who participated for a year to determine if their hippocampus size increased. The aerobic exercise they took part

in was on a motor driven treadmill and they took a spatial memory test to determine memory function (Erickson et al., 2011). They found that aerobic exercise does help increase hippocampal size. This is promising for the hypothesis of my study, which states that the aerobic exercise group will do better on their free recall test than the cardiovascular exercise group. Erickson et al. found that aerobic exercise helps with hippocampal growth and this provides support for my hypothesis because more hippocampal volume allows for more neurons and plasticity. Since I am targeting explicit memory. Which resides in the hippocampus, as seen in the literature exercise helps increase hippocampal size. If these claims are true, then hopefully either aerobic or cardiovascular exercise will help with the growth of the hippocampus and therefore aid in the free recall test scores.

BDNF is an important chemical that helps with the restoration of neurons in the brain. Soya et al. worked with rats to find when the BDNF chemical is most prominent during high, low, or mild intensity exercise. They had the rats workout over a period of ten days and when they had completed the exercise they humanely dissected their brains to see how much of the BDNF chemical was produced during the high, low, or mild intensity exercise (Soya et al., 2007), doing this allowed for the researchers to see all of the produced BDNF chemical right after exercise was completed. If they did not look at the brains right after exercise they would not have gotten an accurate measurement of the BDNF chemical being produced. The experimenters found through rats, that a mild exercise intervention, like jogging, would be the most helpful in producing this BDNF chemical in humans (Soya et al., 2007).

In another one of Erikson's articles he talks about ways that the human brain can benefit from BDNF. One way is that age-related memory impairments could be fixed by the production of BDNF, meaning if the brain produced more BDNF protein then memory impairment could

improve (Erickson, Miller, & Roecklein, 2012). It is known that BDNF starts to decrease with age, but it has been found that it can regenerate itself with exercise. If exercise helps generate the BDNF protein, people should be exercising and regenerating this protein their whole lifetime, not just in old age. If they exercise and regenerate this BDNF protein their whole lives they will not have to work from a deficit in old age. Like the example in the Soya et al. study, it is found in humans as well as rats that exercise helps produce the BDNF chemical. Aerobic exercise is shown to elevate BDNF levels in the hippocampus and other brain regions, aerobic exercise has also been associated with larger hippocampal volumes (Erickson et al., 2012). These findings also help support my study because if the aerobic exercise group performs better on their free recall test than the cardiovascular exercise or control group. Putting it all together, exercise helps improve hippocampus function which decreases hippocampal atrophy, which is the breakdown of tissue, and could mean that it is fixed by the increased BDNF levels in the brain (Erickson et al., 2012), meaning that exercise helps with hippocampal health.

Exercise is not only important for a healthy body but is also important for a healthy mind. Exercise helps create the BDNF chemical and makes hippocampal volume larger as well, these two things can help keep the mind strong and sound. Adding exercise to the equation can help maintain the brain's plasticity for many years, longer than it would if the brain was not producing more of the BDNF chemical. Therefore, exercise is important for the growth and development of brain functions and can help keep memory intact for much longer than it would without these beneficial additives. The part of the brain that is important in memory is the hippocampus, if there is any deteriorating in this section of the brain then the memory function starts to fade away, literature states that exercise facilitates hippocampal neurogenesis which is associated with learning and memory (Szabo et al., 2011). Hippocampal neurogenesis is when more neurons are

formed in the hippocampal region, neurogenesis is a good thing because it keeps that part of the brain working and helps prevent deterioration. Cardiovascular exercise helps create neurogenesis' bonds by keeping the brain healthy. A healthy heart and a healthy brain work in tandem for the body.

Explicit Memory

Explicit memory is used when performance on a task requires conscious recollection of a previous experience (Greenwald & Banaji, 2017), explicit memory is a direct remembrance of specific information. Explicit memory is conscious recollection, remembering information that was just given to you. It requires conscious thought ("Explicit Memory," 2015) and an example would be if someone asked their friend to remind them to email their advisor after the activity they are participating in. I have chosen to use explicit memory because I wanted the memory that is being targeted to be as life-like as possible. People use explicit memory every day; remembering what appointments they have that day, what they need to get at the store, what they need to get done at the house, etc. Explicit memory in this experiment will be tested by a free recall test. This is when a participant is given a list of words and they have to learn them in a set amount of time and then later they need to then recall the words from memory. This test does a good job of targeting the specific memory that is being tested for my experiment. It also portrays the example above and creates a realistic feel for the participant.

Light & Singh did an experiment looking at implicit and explicit memory in young and older adults and ran three different experiments; the first experiment compared young and older adults with their implicit and explicit memory, they used a recall test to evaluate their explicit memory. They found that the older adults did worse on their recall test than the younger adults

did (Light & Singh, 1987). Their second experiment looked at only explicit memory through recall tests, they again found that the older adults did worse on these recall tests than the younger adults did (Light & Singh, 1987). Their third experiment looked at only implicit memory between young and older adults, they found that the older adults compared about equally with the younger adults (Light & Singh, 1987). These results are significant because they compare with other research stating that exercise helps to strengthen the hippocampus, providing support that older adults should be exercising daily to help with their explicit memory. As seen in this study, their implicit memory is not a problem, they are able to remember things they already know. But their explicit memory is a problem, which is important to all ages because people need to remember information just given to them, like doctors' appointments, etc. This experiment shows that explicit memory does decline with age so things should be done to try and prevent it. Like exercise, which literature indicates that it influences explicit memory.

Human and animal studies show that exercise intervention is a powerful behavioral tool to improve cognitive function and brain health (Berchtold, Castello, & Cotman, 2010). Berchtold, Castello, and Cotman studied mice and their learning progression with an exercise intervention of running. One of their main questions asked if this exercise intervention is long term, or if the benefits only occur after the exercise is performed. This is an intriguing question because most studies do longitudinal studies that assess the participants exercise and memory over a long period of time. But during this experiment, the mice exercised and then stopped for a period of time, but then were tested again. In their results they found that mice in the exercise intervention group remembered the cognitive task better than those that were not. The other group, waited a week to do the cognitive task again after exercising, and they remembered the cognitive task faster than those who did not participate in the exercise group (Berchtold,

Castello, & Cotman, 2010). They conclude their results with the argument that the data suggest the exercise stimulus impacts the strength of retention/recall (Berchtold, Castello, & Cotman, 2010). These results are important because they found that the mice did better after waiting a week to do the memory task and this could happen for humans as well. If it does then it adds to the fact that people should be exercising their whole lives so that they can have better memory as they grow old. It is now important to figure out if exercise is more beneficial over a long period of time in humans, because it shows that mice over time do better on their memory test than those that did not exercise, so now it needs to be applied to humans.

Prospective memory like explicit memory, is the ability to remember to execute tasks in the future (Cuttler, Connolly, LaFrance, & Lowry, 2018), it is a different way of looking at explicit memory. In this experiment they compared aerobic exercise and resistance training (weight training) with both prospective and retrospective memory, memory for previously learned information, facts, and events (Cuttler et al., 2018), like implicit memory. The study found that the resistance training group did a better job on the prospective memory tests than the aerobic group (Cuttler et al., 2018). This is different than the research that has been looked at previously stating that the aerobic and cardiovascular groups do better on the memory tests than resistance training does. It is important to look at prospective memory as well as explicit memory because of the similarities between them, which is why this study is beneficial. If prospective memory does better with resistance training exercise then explicit memory may have the same effect. The important thing to note is that exercise did have an effect on the prospective memory of the participants. Which is significant because it adds to the mounting evidence that exercise helps with memory.

Cardiovascular

Cardiovascular exercise is what most people associate with fitness as a whole. Cardiovascular exercise like running, jogging, and walking can be done anywhere. Studies have found that people who do more cardiovascular exercise have higher levels of hippocampal volume which helps improve the memory function (Åberg et al., 2009). In Åberg et al's study, they found that cardiovascular fitness was associated with cognitive performance. They researched twins in Sweden who were entering the military, at 18 years old. This was a longitudinal study, they followed up with the participants about 40 years later. They evaluated weightlifting and cardiovascular exercise but found that cardiovascular fitness was significantly paired with cognitive function (Åberg et al., 2009). They also included their grades from high school before the study to see if their scores changed over time. They found that cardiovascular fitness and cognitive performance at age 18 are positively associated and cardiovascular fitness during early adulthood predicted socioeconomic status and educational success later in life (Åberg et al., 2009).

Cross-sectional studies and randomized clinical trials suggest that cardiorespiratory fitness is associated with brain structure and function, when there are improvements in fitness it also improves processing speed and executive function (Szabo et al., 2011). Furthering this, "the cardiovascular fitness hypothesis suggests that cardiovascular fitness is the physiological mediator that explains the relationship between physical exercise and improved cognitive performance" (Åberg et al., 2009). Even though cardiovascular and aerobic exercise are sometimes classified as the same type of exercise, so this hypothesis could apply to both exercises. My study is looking at two different parts of these exercises, yoga will provide air flow throughout the body to get an aerobic base and light walking, jogging, or running on a treadmill will provide the cardiovascular base.

Throughout the literature it has been reviewed that while explicit memory tends to deteriorate with old age, implicit memory seems to stay intact longer. In Padilla, Maya, Ballesteros, & Andres' experiment on physical exercise and implicit and explicit memory, they looked at sedentary (non-active) and active exercise. They found that exercise does help with free recall tests, explicit memory. The active group did slightly better on their free recall test than the non-active group did (Padilla, Mayas, Ballesteros, & Andrés, 2017). This information shows how exercise helps specifically with explicit memory. The exercise group excels at the memory tests and this has been found at all age ranges, this shows that exercise is not only healthy for the body but also for the brain. Though implicit memory was also targeted the exercises did nothing to aid with those tests, only the explicit memory improved. It also shows that while implicit memory may stay intact longer through old age, explicit memory does not, so it is important to help with explicit memory before it is irreversible.

Koutsandreas, Wegner, Niemann, and Budde (2016), researched younger aged kids and had two groups: A motor exercise group and a cardiovascular group. The cardiovascular group completed a fitness test that was a shuttle run or also commonly known as the pacer test and the motor exercise was tasks like balance, rhythm, spatiotemporal orientation, and motor adaptation to moving objects; they used a letter digit span to test memory (Koutsandréou, Wegner, Niemann, & Budde, 2016). This study is particularly important to my experiment because they have the same type of controls that are seen in my study. This study has a cardiovascular group and a motor group, while my present study has a cardiovascular group and an aerobic group that participates in yoga. The motor group in the Koutsandreas, Wegner, Niemann, and Budde (2016), study took part in some exercises that are similar to yoga, so the results of this study are influential. They found that before they were separated into groups the cardiovascular group did

better on the letter digit span than the motor exercise group but then after the exercises took place the motor exercise group did better than the cardiovascular group (Koutsandréou, Wegner, Niemann, & Budde, 2016), not only did they do better but they surpassed the cardiovascular scores on their posttests as well. This is relevant to my study because my hypothesis states that the aerobic group will do better on their free recall test than the cardiovascular group will. This study shows similar results, to support my hypothesis.

Colcombe et al. (2004) did a longitudinal study on older adults who participate in a cardiovascular stress test known as the Rockport 1-mile walk test and then, for their memory test, they performed a flanker task which shows the participants arrow patterns (< < < or > > < > >). They found that older adults who had higher cardiovascular fitness demonstrated more activations in the brain where attentional control resides (Colcombe et al., 2004). In this study they also did a 6-month intervention period and when they looked at their brains again they found that the exercise group had a greater level of activity in these attentional control areas (Colcombe et al., 2004). These results are significant because they found that exercise has a lasting effect in the brain region that it targets. This is relevant because if it has a lasting effect, then people should be exercising every day to help brain function stay strong for a long time. The effects of cardiovascular fitness takes place in less than 6 months (Colcombe et al., 2004) so people should be exercising every day to provide the brain function with this change and then continue to exercise so the effects can last throughout a whole lifetime.

In Hötting et al., they researched middle-aged adults and had them cycle or stretch, while using a free recall test to evaluate memory, the participants took part in the experiment for 6 months. Both of these groups provided about the same results but the cycling group improved with their long-term recognition over either the stretching or control group (Hötting et al., 2012).

These results, like Colcombe et al., also indicate that cardiovascular exercise has a long lasting effect on the brain and helps to develop consistent memory over time for a long time. This experiment also has specific relations to my experiment. This study has a cardiovascular based exercise and an aerobic exercise, theirs is stretching, while mine is yoga. The results state that both exercising groups showed a larger improvement in memory compared with a control group (Hötting et al., 2012). This also shows that the exercise group does better with the memory test over a longer period of time. Again, showing that participating in exercise can help with memory function over a lifetime. The cardiovascular group did better on the recognition score than the other two groups (Hötting et al., 2012) and although this result does not support my hypothesis, it still indicates that some type of exercise helps with explicit memory and that is significant to the project as a whole.

Cardiovascular fitness will always be an exercise with a lot of movement and that is why participants will be running, jogging, or walking on a treadmill. But for the aerobic exercise I want to look fully into the air intake that the participant will be taking part in. That is why I chose yoga as the aerobic exercise because while I could have also chosen running or a biking exercise I want to see if it is really the air flow that is facilitating the memory or if it is the heart beating fast that is facilitating the memory.

Aerobic

Research has indicated that aerobic fitness is positively associated with achievement (Castelli et al., 2007), improved mood, reduced psychophysiological response to behavioral stressors, improved self-esteem, and is associated with improved cognitive functioning and psychomotor speed (Blumenthal & Madden, 1988). Wu et al., (2011) found that higher aerobic

fitness was related to more accurate cognitive performance, compared to those with a lower aerobic fitness base. This study compared preadolescents who were put into two different groups: The aerobic group and the anaerobic group. They found that those in the aerobic group did better on the memory test than those who were in the anaerobic group (Wu et al., 2011). Although my experiment will be done with young adults, ages 18-22, it is important to see how other age groups tested on this type of topic. Knowing that younger children showed signs of improved memory could help indicate that young adults will also show improved memory after doing an aerobic exercise.

Stroth, Hille, Spitzer, and Reinhardt (2009) had young adults participate in an aerobic run test. This test has a cardiovascular component as well, but the experimenters only tested for the participants O2 (oxygen) level. They then took part in a Visual and Verbal Memory Test and the d2 Test of Attention. They found that the exercise group did better on the posttest of both memory tests (Stroth, Hille, Spitzer, & Reinhardt, 2009). Runners in the aerobic run test improved on their memory tests, while the control group had no significant results (Stroth, Hille, Spitzer, & Reinhardt, 2009). These results are meaningful because it indicates that the aerobic group had better memory scores than the control group. This provides support that the results could be similar in my study.

In Pontifex, Hillman, Fernhall, Thompson, and Valentini (2009), they used a Sternberg task, tests working (short-term) memory in participants, and they use a treadmill for walking or running. They increased the speed of the treadmill every two minutes until the participant could not walk or run anymore, this adds in the aerobic air flow component so the task is not just cardiovascular based. This is unlike my study because they went as long as they could, which means it could be five minutes or 20, however long the participant could last. They also

completed the study over a period of time, about a week. The study's results showed that the task was better performed immediately and 30 minutes after the aerobic exercise (Pontifex, Hillman, Fernhall, Thompson, & Valentini, 2009). These results are different than other results have previously shown. Most articles have articulated that participants were able to perform significantly better on their memory test months after the exercise was completed and one study indicated that the participant did better when there was an intervention (Colcombe et al., 2004). But this study says that the participants did better when the exercise occurred closer to when the memory test was administered. This could prove helpful to the theme that has been frequent in this review, that people should be exercising every day to help their brain improve its memory for a longer period of time. This study shows that exercise should be done every day so that working memory can work to its fullest effect. If done frequently, as studies indicate, then participants' memory can improve.

Unlike Pontifex, Hillman, Fernhall, Thompson, and Valentini's (2009) study Chapman et al. (2013) conducted a longitudinal study. Chapman et al. (2013) had two groups participate for two weeks: Physical training and a wait-list control. The physical activity group went on the exercise bike or the treadmill for 60 minutes, at a pace that provided increased air flow throughout the body, not just increased heart rate. The memory test analyzed executive function, memory function, and complex attention function. They found that aerobic exercise can improve cognitive function and brain health (Chapman et al., 2013). They used brain scans to evaluate the hippocampus and saw the growth during the weeks that the subjects participated in the exercise and memory tests. They also make a claim that "the sooner a person starts exercising the better since the slope of declines in brain and cognitive health become steeper from age 50 and on"

(Chapman et al., 2013). This quote solidifies the theme of the introduction that exercising daily can help access the benefits that exercise provides in humans later years.

Like Chapman et al. (2013), Erickson et al. (2011) also looked at hippocampal size in relation to the effects of aerobic exercise. In their study they compared aerobic exercise, walking exercise, and a stretching group. They used a spatial memory test for the memory assessment and were assessed over a period of two years. They found that the aerobic exercise group was effective in increasing the size of the hippocampus and interestingly, while the aerobic group's hippocampus size grew over the course of the study, they also found that the stretching group showed a decline in their hippocampal volume (Erickson et al., 2011). As remembered from the brain function section, the more hippocampal volume and healthy neurons within the hippocampus the better memory function. In this study they found that aerobic exercise does help with the volume of the hippocampus but they found that stretching actually decreases the hippocampal volume. This indicates that people should get out and move to get the benefits of aerobic exercise. In under two years it is seen that the hippocampus can create more neurons and become larger in volume. Therefore, all humans should consider exercising more often so they can too benefit from this hippocampal growth.

"Neuroelectric is the electrical phenomena (as potentials or signals) generated by the nervous system" ("Medical Definition of NEUROELECTRIC," n.d.) and research has indicated that aerobic fitness is linked with improvements in neuroelectric and behavioral performance, which is very beneficial to a person's cognitive health (Castelli et al., 2007). This means that exercise helps the neurons in the brain fire better, allowing for improved memory function. Hillman et al. (2005), also found that aerobic exercise influences this neuroelectric phenomena aiding in attention and working memory. Neuroelectric bonds are important to a human's

cognitive health. They repair signals to help the brain work better. This is relevant for any age and if aerobic exercise does help strengthen these bonds everyone should know about it, something of this caliber should be researched further to help society. Aerobic exercise can help improve cognitive function (Blumenthal & Madden, 1988), but it needs to be researched even more than it currently is. That is why aerobic exercise will be one of the groups for my experiment. All of this research stating how beneficial aerobic exercise is for the brain was helpful in choosing this exercise as one of my groups. The group will be doing yoga, so that they can focus on their breathing and their oxygen (O2) intake. Some of the exercises mentioned in this section are similar to the exercises in the cardiovascular section. But that is why I am using yoga in my experiment, so the air flow component can be assessed by itself without the cardiovascular component connected to it. Running provides both aerobic and cardiovascular bases, and each can be tested within, but using walking and yoga can separate these bases into their own entities, to be easily tested separately.

Yoga

Yoga is about breathing and the controlled breaths that are taken to help concentrate both on the body and the mind (Miles, 1964). Breathing is done during activities in a controlled setting, and even sports that require a great output of muscular effort or speed requires breathing; much attention during life is given to breathe control (Miles, 1964). When people participate in yoga, they perform different types of breathing that keep their body relaxed and keeps a control over their respiratory muscles (Miles, 1964). The participants in the yoga condition, focused on their breathing and made sure that they were calm and in control of their body and mind while

doing the exercises. The purpose of including yoga is so the participant can focus on their O2 intake without having to add a strenuous component to the exercise.

Most of the studies that have been reviewed do not specifically have yoga as one of their exercises, but have more of running base aerobic exercise. This means that the exercise the participant is taking part in has a cardiovascular component and not just an aerobic air base. Erickson et al. (2011) uses stretching as their aerobic exercise which is more related to yoga. Even though their stretching group did worse on the test, it still compares because the stretches are similar to yoga yet not completely the same, meaning they are two different exercises. I believe that it is important to zone in on the specific type of exercise function and try to target only what function is being asked for. That is why yoga is being used for the aerobic group and walking, jogging, or running is being used for the cardiovascular group in my study. Manjunath and Telles (2004) use yoga in their study directly, they use a verbal and spatial memory test compared with three groups: Yoga, fine arts, and a control group. They found that the yoga group showed a significant increase in their spatial memory test scores compared to the fine arts group (Manjunath & Telles, 2004). They also performed a longitudinal study that took place at a camp for over ten days. This study is relevant to note because they, like my study, used yoga as one of their controls and although the age group was slightly younger than young adults or college aged students, it still allows for a good relation to my study. The study suggests that yoga breathing, meditation, and guided relaxation improves the recall of spatial information (Manjunath & Telles, 2004). This relates to my hypothesis because I also believe that the relaxed breathing and concentration of the body and mind through yoga will help the participant perform better on the free recall test.

Hypothesis

My stated hypothesis is: Participants in the aerobic exercise group will have better free recall test scores than those in the cardiovascular exercise group or the control group, and those in the cardiovascular group will have better scores than those in the control group.

Due to the literature stating that aerobic exercise will aid in better memory from the participants, my hypothesis also follows this pattern, to analyze if the aerobic exercise group will provide better free recall test scores. Mostly, all studies include that their aerobic group is some type of running exercise, but this includes heartbeat as well as air flow. In these studies, the aerobic exercise still scores higher during recall tests than the other groups. This leads me to believe that air flow throughout the body has something to do with the participant doing well on the recall tests, meaning that air flow throughout the body plays a bigger role than heartbeat throughout the body.

Another reason for choosing yoga and treadmill exercise, is because I want to target both of these different mechanisms that go on in the body during exercise, air flow and heartbeat. When someone exercises, they have increased heart rate and increased air flow during the strenuous exercise. A lot of exercises have both of these mechanisms within it like running does, so I tried to target these two mechanisms separately. If a person is walking at a decent pace they do not exert enough energy to be breathing very heavily but they can still get their heart rate above 90 bpm. The participant will take part in yoga so that they can focus and target controlled breathing during their exercise. Having these two exercises can keep the mechanisms separate so that information can be given on each individual mechanism.

It is meaningful to conclude which mechanism works more efficiently, air flow or heartbeat. If the yoga group has better recall test scores then that means in order to keep the hippocampus healthy a person can focus more on aerobic based exercises. They can go on walks

or runs if they want because those have an aerobic component as well. If the cardiovascular group does better on their recall test, to keep the hippocampus healthy a person needs to participate in cardiovascular based exercise. I think that the air flow in the body will help produce better scores and a healthier hippocampus. This will be figured out through the results of the study itself.

Methods

Participants/subjects

There were 29 participants in this study (24 females, five males). The participants were 18-22 years of age (M=20.21, SD=1.37). Participants were recruited from the Stevenson Athletic Center on the campus of Bard College. The table was set up next to the check-in desk at the entrance of the gym. On the table there was candy for potential participants. Potential subjects were asked if they would be interested in participating in a psychology experiment. If a person was prepared to participate immediately, they were brought to a reserved conference room where the experiment would begin. If they were unable to participate that day, they were provided with a schedule of time and dates to look over and sign up accordingly. More than half of the participants elected to sign up at a later date (about 20). If the participant chose to participate in the study, they were randomized into one of three different groups: Cardiovascular exercise, aerobic exercise, and the control group. The randomizing was done through excel using the RAND function. The participants' assigned group was predetermined before they chose to participate in the study. All data are included in this study, no participant was exempt.

Materials

Liability waiver.

Prior to beginning the experiment, the participant was handed a liability waiver (appendix G). This waiver made sure to inform the subject that they were participating in the experiment voluntarily and that they understood the risks of the experiment. By signing the waiver, they indicated that they understood the risks of the study and that the occurrence of any warned risk could not enable the participant to take any legal action against the individual administering the experiment, their advisor, or the Stevenson Athletic Center. Only after signing this waiver was the participant eligible to participate in the experiment.

Consent form.

After completing the liability waiver, the participant was handed a consent form (appendix A). This form included a short background of the study; including what would take place during the study, the risks and benefits of participating in the study, the anonymity of the participant, the participant's rights, and a confirming statement that the participant was over 18 years of age. Only after signing this form was the participant eligible to participate in the experiment.

Exercise questionnaire.

After the liability waiver and consent form was signed, the participant was given an exercise questionnaire (appendix B) aimed to determine the participants' level of exercise. The questionnaire consisted of eight questions. The first five questions asked the participant if (1) they do not exercise and do not want to start, (2) they do not exercise but do want to start, (3) they do exercise but not a lot, (4) they exercised vigorously in the past six months, and (5) they exercised vigorously in the past year (Jackson, Morrow, Bowles, FitzGerald, & Blair, 2007). These questions were asked on a Likert scale out of five, with one being strongly disagree and five being strongly agree. The last three questions on the questionnaire asked how often the

participants exercise and if they do, how long and for how many days a week do they exercise. The purpose of this questionnaire is to indicate to the experimenter if the participant has exercised in the past. It is helpful to the experimenter to know if it was the participants' first time exercising, because it would indicate that it was also their first time doing yoga or going on a treadmill. It would be important for the results if someone who has never exercised before is in one of the exercise groups and excels at the free recall test. This could potentially indicate that the exercise helped aid in their free recall test score. The other purpose of the exercise questionnaire is to indicate to the experimenter if the participant has ever taken part in exercise activities, being able to see if they have ever exercised before allows the experimenter to be aware that this may be their first time taking part in yoga or being on a treadmill.

Explicit memory test.

The free recall test consisted of 15 words (Cartoon, Monkey, Negative, Pie, Pork, Creature, Dry, Bonnet, Groom, Rein, Wander, Sorry, Cabin, Collapse, Classroom; Appendix D) that participants each read over these words for 90 seconds. They only have 90 seconds because if the participant knows the words then they will write them quickly, but if they do not know the words then I do not want to give them a long time to try and remember them. They were told that the list consisted of random words and were not meant to mean anything. This was done so that they would not easily remember the list of words. It can also simulate a situation in which they might be asked to remember a random task before an activity. This part of the experiment tested the proficiency of the participants' explicit memory. The more correct words the participant remembered, the better their explicit memory.

Demographic questionnaire.

This questionnaire asked the participants their age, gender, and race (Appendix C). It is used to further understand more about the participants' demographics that may be important for the results of the experiment. Certain responses could be related to the score a participant receives. For example, scores between the male and female participants can be compared.

Exercise

Cardiovascular.

The group completing the cardiovascular exercise did a combination of constant running, jogging, or walking for 10 minutes. This was done in order to get their heart rate into the desired zone for 10 minutes, which was 90 bpm. They began on the treadmill at a slow rate that they felt comfortable with, while gradually increasing their speed to get their heart rate to 90 bpm. They were only allowed to increase their speed if they felt comfortable and it indicated they could increase on their exercise questionnaire (Appendix B). They tested their own heart rate every 30 seconds for a 10 minute period, on the metal heart monitors placed at the front of the treadmill. Their heart rate had to rise above 90 bpm, before they began the 10 minute period. Most participants were able to reach 90 bpm at a slightly fast walk on the treadmill. The number of times they touched the heart rate monitor was noted in the comments for each participant. Before they started, they were informed that they were able to leave the experiment at any time with no questions asked.

Yoga.

The group participating in aerobic exercise group watched a ten minute yoga video, designed for beginners (https://www.youtube.com/watch?v=VaoV1PrYft4). In the video a female instructor leads the exercise. A mat is provided for each participant by Stevenson Athletic

Center, which were cleaned thoroughly after each use. The video incorporates yoga exercises alongside concentrated breathing. Participants begin with controlled breathing and stretches while in a sitting position. Gradually, they move to a kneeling position and do different stretches. Next, they move to a standing position, until they end in the child's pose. The video instructor tells the participant to breathe throughout each stretch, focusing on what they are doing. The participant is informed, prior to beginning this section that they can leave at any time with no questions asked.

Control.

The control group watched a video meant to capture their interest and keep them preoccupied so they did not get bored. It was a ten minute video of a person making specialty cakes (https://www.youtube.com/watch?v=1jFbyGvyAAE). This video was a compilation of a baker making large exotic cakes that are big and beautiful with detailed pictures on the top. The cakes do not even look like real food sometimes. The video shows the cakes being made from start to finish, at an accelerated time to ensure that the viewer does not get bored while watching. Before starting, the participant was informed that they can leave at any time with no questions asked.

Procedure

In this experiment, two different exercises are being tested: Cardiovascular and aerobic exercise. There was also a control group being tested. The cardiovascular exercise consists of walking, jogging, or running on a treadmill. The aerobic exercise consists of yoga stretches and controlled breathing instructed by a prerecorded video. As soon as the participant entered the reserved conference room, the set of events went as follows: (1) participants are given a liability

waiver (Appendix G) and consent form (Appendix A) to sign before they start any part of the experiment. Then (2) participants are given a demographics questionnaire to fill out (Appendix C). Once they are done with the demographics questionnaire, (3) they are given an exercise questionnaire (Appendix B) to fill out. After the questionnaires are completed, (4) the participants take part in the free recall test (Appendix D), which is done before the exercise portion. They are told that they have 90 seconds to read over the words that are about to be given to them and their time starts when they turn the piece of paper over. They are asked if they have any questions, if they do not, the paper is then placed in front of them. After the 90 seconds pass, the paper is taken from them immediately and they are given directions for the exercise portion of the experiment. They are (5) put into predetermined groups to participate in either cardiovascular exercise, aerobic exercise, or the control group. After they are done with their respective exercise group, (6) they go back to the conference room (7) and are told to write the words they saw before they exercised, on a piece of paper. They are given a piece of paper and a writing utensil and if the participant does not have any questions the piece of paper is placed before them. They have 90 seconds to write the words and their time starts when their pen hits the paper. After the 90 seconds, (8) they are given the debriefing statement (Appendix F) and asked if they have any questions.

Results

There are four questions that are being analyzed in this results section in accordance to the hypothesis: Participants in the aerobic group will have better free recall test scores than those in the cardiovascular exercise group or the control group.

Does The Condition Affect The Score?

The main question of this study is if the task that the participant completed affected their free recall test score. Whether the condition (M=.93, SD=.842) affected the score (M=7.41, SD=2.95) was analyzed using a one-way ANOVA. These results show that the specific condition a participant was placed in did not affect the result of the free recall test score they received, F(2,29)= .420, p=.66. All of the groups had equal free recall test scores. But as seen in the figure, the cardiovascular group has slightly worse scores than the aerobic and control groups, but this did not generate a main effect between conditions (Figure 1). Although not significant, this does relate to my hypothesis because it states that the aerobic group will do better than the cardiovascular group on the free recall test.

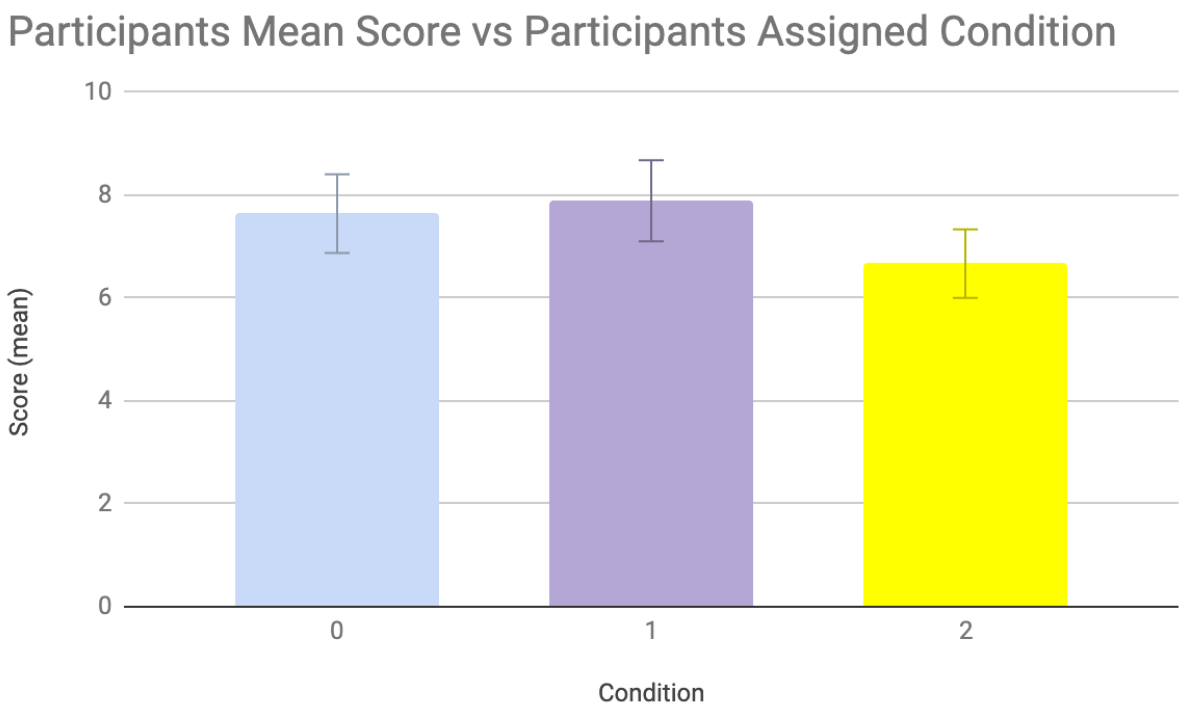

Figure 1. Bar graph. The scores received are compared to the condition. The y axis holds the mean scores participants received on their free recall tests. The x axis holds the condition that the

participant was in. 0= control group, 1= yoga (aerobic group), and 2= treadmill (cardiovascular) group.

Do male and female scores differ?

A t-test for independent means was conducted and produced non-significant results. The gender (male (M=7.20, SD=2.78) or female (M=7.46, SD=3.04) of the participants does not differ when compared with their free recall test scores, t(27)= -.175, p=.862. These results most likely do not compare because there were five males who participated and 24 females. These groups were not evenly distributed and therefore cannot be reliable within the results.

But even though the groups were not evenly distributed the mean scores were still about the same as seen in the figure (Figure 2). Both genders received the same scores, even though there were more females who participated than males. This is interesting to note because with the uneven groups one may think that the scores would not be as evenly distributed. But both genders still receive the same average of scores. This could indicate that exercise and explicit memory does not differ across different genders.

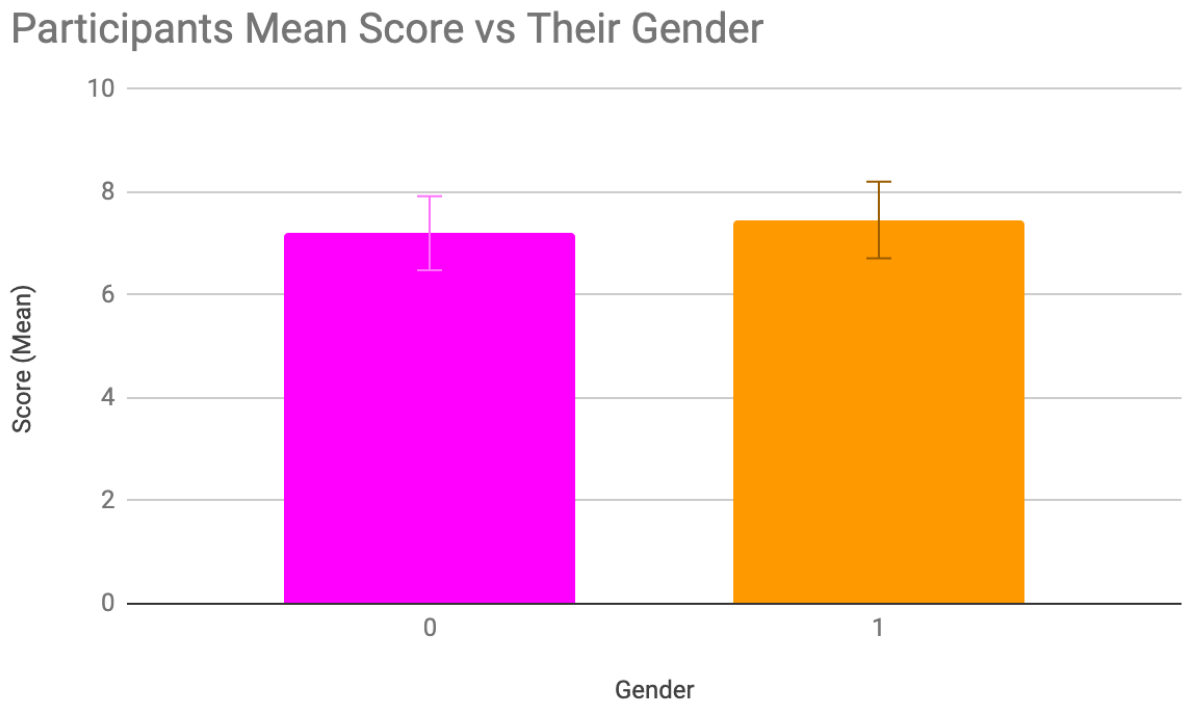

Figure 2. Bar graph. The score received is compared to gender. The y axis holds the mean scores participants received on their free recall tests. The x axis holds the genders of the participants, 0= male and 1= female.

Does The Amount Exercised in Everyday Life Affect Score?

The amount of exercise that the participant took part in was also analyzed; how many minutes (M=96.60, SD=34.66) the participant exercises for per day, the number of days per week (M=5.69, SD=1.17) the participant exercises for, and the total minutes exercised in a week (M=577.80, SD=245.76) the participant takes part in. Total minutes exercised in a week was calculated by multiplying minutes exercised in a day and days exercised per week (eg. 60 minutes5 days per week). A correlation was used to test for associations between time exercised and memory score. The correlation between minutes exercised per day and score was negatively correlated and non-significant, r(23)= -.193, p=.355. Meaning the amount of time exercised per

day is not correlated with the score the participant received on their free recall test. The correlation between days they exercised per week and score was negatively correlated but significant, $r(27)= -.387$, $p<.05$. Meaning the more days they exercise per week, the worse they did on their free recall test scores. The correlation between total minutes exercised per week and score was negatively correlated and non-significant, $r(23)= -.224$, $p=.281$. Meaning the amount of time they exercise per week is not correlated with the score the participant received on their free recall test. The only significant result was the number of days the participant exercises per week, this indicates that if the participant exercises more during the week then they will receive a worse score on their free recall test.

It is worth noting that even though the amount of days exercised per week is negatively correlated with score this may not indicate that exercise does not help with explicit memory. The figure shows that the people who scored higher worked out fewer times during the week than other participants (Figure 3). This means that constant exercise can be bad for explicit memory but does show that exercise is good in smaller doses, two to four times a week being most beneficial as seen in the figure.

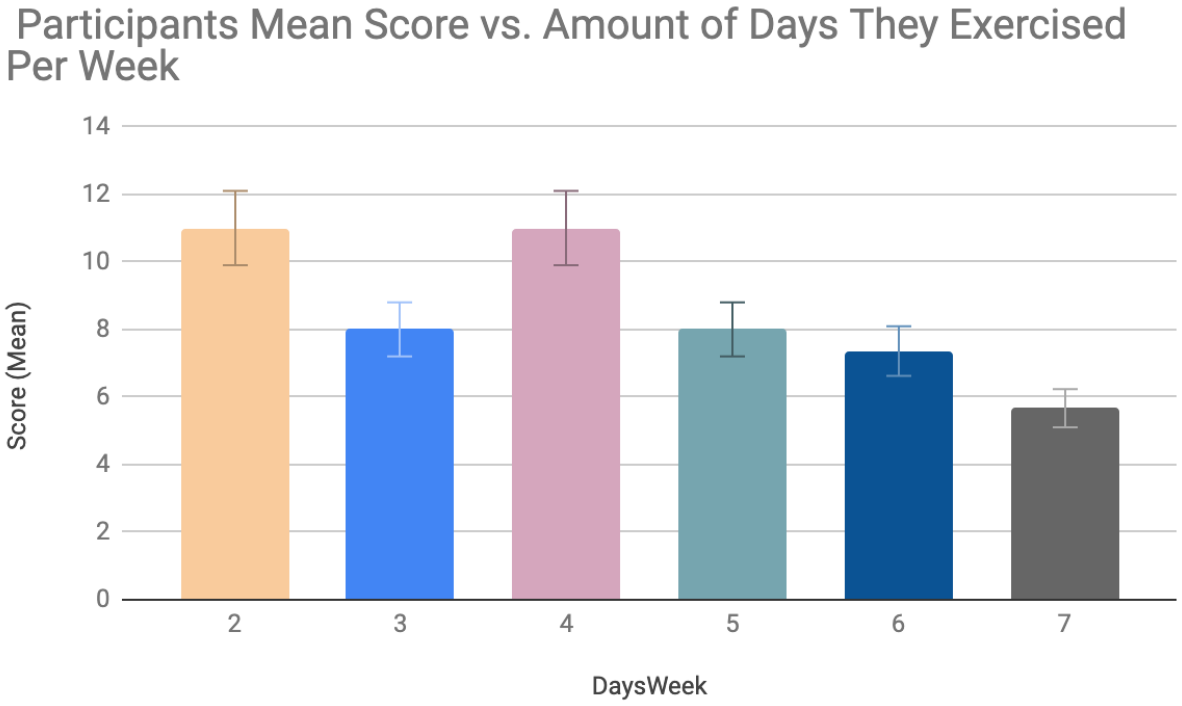

Figure 3. Bar Graph. The score received is compared to how many days the participants exercise per week. The y axis is the mean scores achieved on the free recall test. The x axis is the amount of days per week the participants said they exercised for.

The amount of time that the participant exercised each day was also not significant to the score the participant received on their free recall test. The figure shows that the majority of the scores were the same except for those who exercise for more than two hours, those participants generally got around a six out of fifteen on their free recall test (Figure 4). The amount of time exercised does not aid in the score the participant receives. Interestingly, the participants who did not provide an amount of time that they exercise each day (N/A group on graph) had the best scores on their free recall test scores than the other participants, who did indicate how long they exercised for.

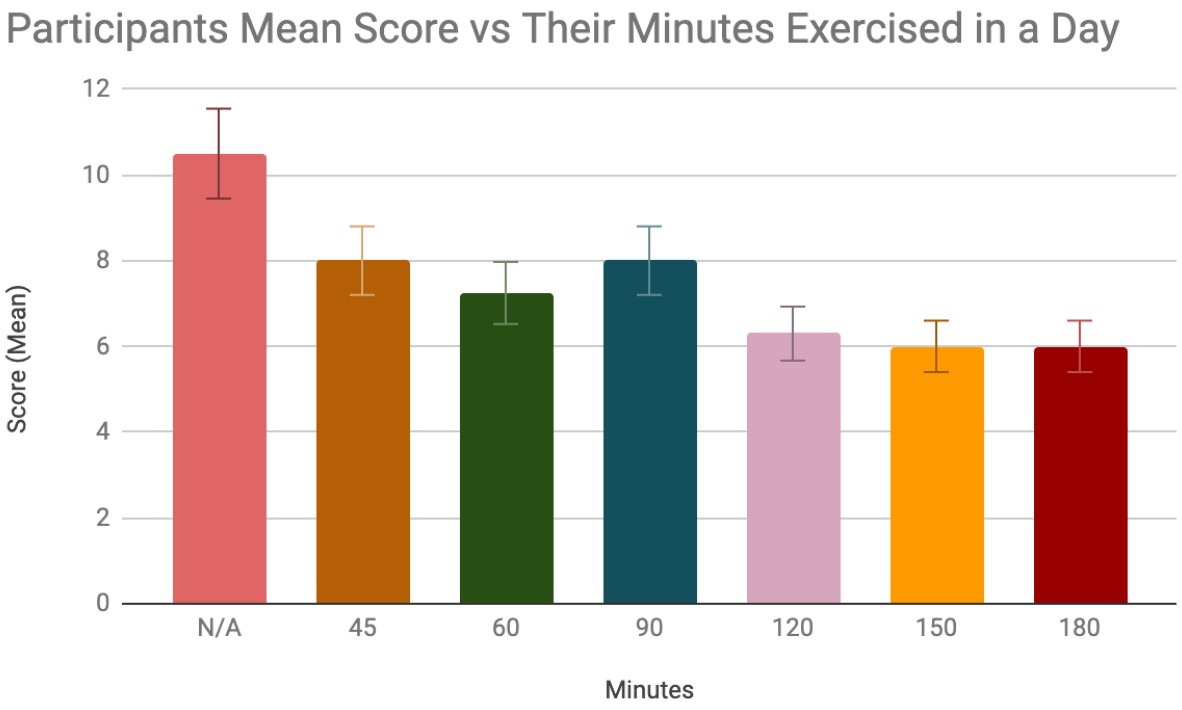

Figure 4. Bar Graph. The score received is compared to how many minutes the participants exercise per day. The y axis is the mean score the participant received. The x axis is the amount of minutes participants exercise per day. N/A refers to participants who did not answer this specific question but still received a free recall test score and indicated they exercise each week.

Total amount of exercise per week was also non-significant. The scores were all equal throughout the different amount of time exercised, but like amount of time exercise per day, the amount of time exercise per week also generally got a score of six when they exercised about 900 minutes per week (Figure 5). Like amount exercise per day, the amount a participant exercises per week also does not aid in the participants test score.

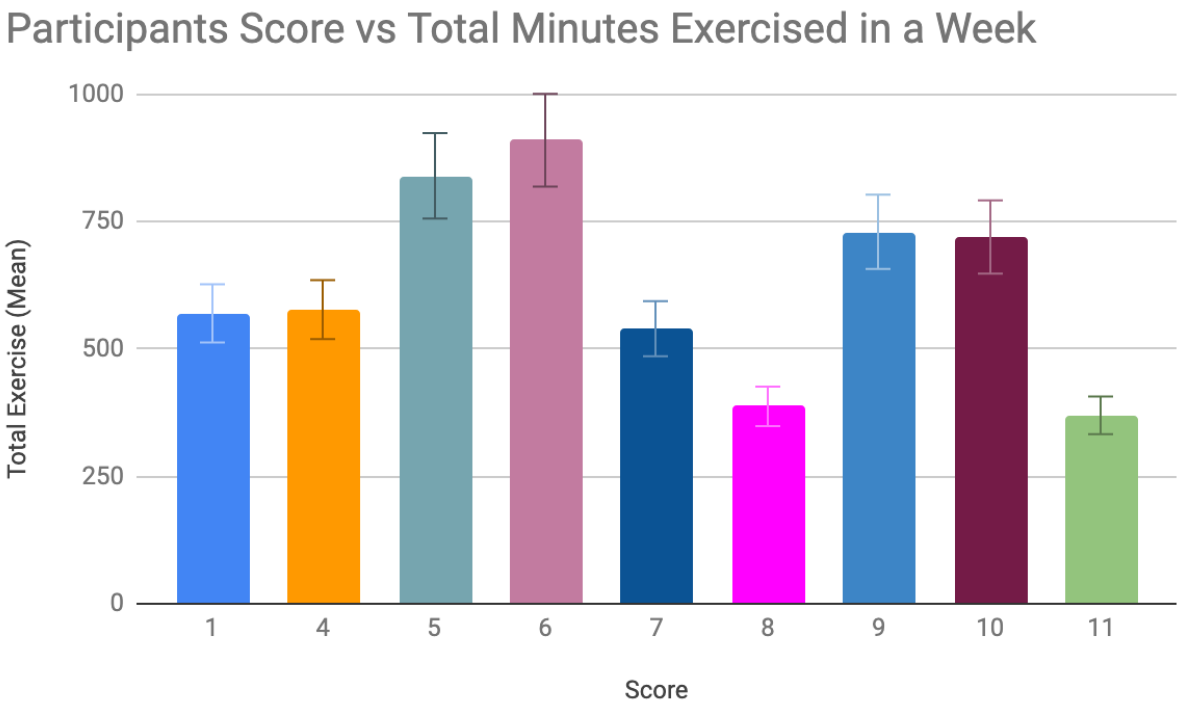

Figure 5. Bar graph. The score a participant received compared to how many minutes they exercise during the week. The y axis holds the mean minutes exercised in a week. The x axis holds the score a participant received.

Does Age Affect Score?

The age (M=20.21, SD=1.37) that a participant is, is analyzed to inspect if the participants age affected the score (M=7.41, SD=2.95) they received. A correlation was used to determine if age affected the score they got on their free recall test. The correlation between age and score was non-significant, r(29)= -.190, p=.32. Showing that age was not correlated with the score that the participant received on their free recall test. All of the age groups received around the same score on their free recall test as seen in the figure, 21 year olds did score less than the other ages participating (Figure 6).

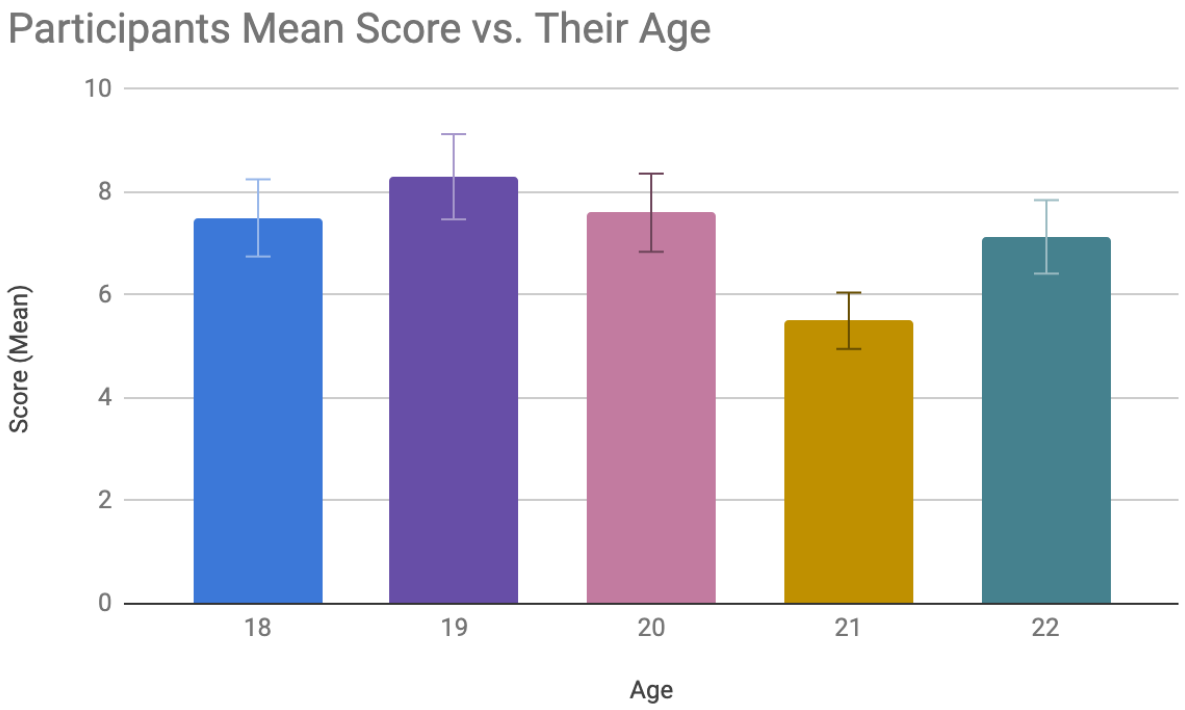

Figure 6. Bar graph. The score received compared to the age of the participant. The y axis holds the mean score the participant revived. The x axis holds the age of the participant.

Discussion

Review

This study tested to see if either cardiovascular exercise (running, jogging, or walking) or aerobic exercise (yoga) helped to facilitate a free recall test that consisted of 15 words. The participants were expected to study the list of words for 90 seconds, then participate in either an exercise or the control group, and then recall the words that they had seen 10 to 15 minutes before. The participants were 18-22 years old and were all recruited from the Stevenson Athletics Center at Bard College.

The experiment yielded non-significant results, stating that the condition did not affect the score, $F(2,29)= .420$, $p=.66$. Other tests also came back non-significant like; male scores vs female scores, minutes exercised per day vs score, total minutes exercised per week vs score, and age vs score. One test did come back significant, days per week exercised vs score, $r(27)= -.387$, $p<.05$. It is negatively correlated which shows that the more a participant exercised per week, the worse their free recall test score was. This could mean that the more a participant exercises it can over work them and be worse for brain functioning, so participants should workout sporadically for the best results. No study has researched people being overworked, so this could be an avenue for further analysis.

This being said, my hypothesis was not supported. I hypothesized that the aerobic exercise group would have better free recall test scores than the cardiovascular exercise and control group. Though the mean score for the aerobic group was higher than the cardiovascular group, the results were not statically significant, concluding that my hypothesis was not supported in this study. In another way, it is not supported because those who exercised more throughout the week ended up performing worse on the free recall test, so it seems that there is a limit to how much exercise should be done during the week.

Implications

Doing this project has taught me a lot about the brain and the way that it operates under different types of stressors. I have learned that the brain is very malleable and is essentially connected to everything that the body does and responds to everything put into it. I was inspired to conduct this study when I learned that people with Alzheimer's disease should walk every day to help reduce the symptoms they were experiencing. I wanted to research this further and

explore how exercise could help those of all ages avoid Alzheimer's and not just those in old age or already with the disease. Through research I have found that individuals of both young and old ages are affected by exercise. This then led me to conduct a study on young adults in order to see if the effects that individuals were experiencing were the same between young adults and those of old age. Memory and learning affects all ages; children, young adults, and older adults.

When one is exercising, the BDNF protein is produced and is able to regenerate healthy neurons in the brain. This is necessary for keeping the brain healthy at all stages of life. Therefore, one can aid in producing it throughout their life and not only at an older age. Unfortunately, my results were not significant in finding this, but this is a topic that should be further studied. More time and a greater number of participants would help to get proper results, and help determine if this is a topic worth spreading.

Alzheimer's disease.

As mentioned in the literature review, exercise produces a protein called BDNF, which helps with the regeneration of neurons in the hippocampus, the memory headquarters of the brain. Studies have shown that older adults who are more fit not only have better memory, but better visuospatial function as well (Shay & Roth, 1992). Visuospatial function is an understanding of the things and objects surrounding oneself. Having good visuospatial function is associated with memory. This memory is important because if someone has a better understanding of what is going on around them, then they are able to be more independent and are more likely to remember things in greater depth. This will allow older adults to be able to live and function on their own. Exercise aiding visuospatial function also indicates that exercise continues to help regenerate brain function even into old age.

Additional data has also found that exercise helps produce greater hippocampal volume which is the associated with better memory (Szabo et al., 2011). A higher fitness level indicates a greater hippocampal volume which is then linked to better memory overall. This all relates back to the BDNF protein helping with hippocampal growth. The bigger the hippocampal volume the more neurons it can hold, which suggests better memory due to the extra support the neurons provide the hippocampus. Alzheimer's disease affects the memory function in the brain, being able to repair this function can lessen the symptoms of Alzheimer's disease.

All of this literature supports the claim that older adults should be exercising into and during older age. This can help with diseases like Alzheimer's because it causes hippocampal loss. To counteract this, patients should be walking and exercising every day in order to regenerate the neurons that they are losing in their hippocampus. By doing this, they can help to lessen the symptoms of Alzheimer's disease, through the regeneration of neurons. More research should be done on this claim, to show that older adults can get ahead of this disease.

School children.

Recently, schools have been cutting physical activities like recess, and physical education class so that students can spend more time in the classroom (Wu et al., 2011). Studies done on younger children have found that extra participation in aerobic activity actually helps cognition during pre-adolescent childhood (Wu et al., 2011). Wu and his colleagues also looked at studies that argued, physically inactive school-age children might be more likely than their physically active peers to develop chronic disease risk factors and that childhood exercise behaviors usually continue throughout one's life (Wu et al., 2011). This could affect children later in their lives; what they do in their early life translates into the rest of their lives.

Even though there are differences seen in age, children are actually similar to adults in that exercise helps strengthen the bonds within the hippocampus (Tomporowski, Davis, Miller, & Naglieri, 2008). If exercise helps improve a child's mental function, then they should not be solely sitting in a classroom all day to facilitate learning. They should be active in physical education or at recess in order to help start and strengthen the learning process.

A study was done on third and fifth graders to evaluate their standardized test scores in relation to exercise. The study found that physical fitness was related to higher test scores on their standardized tests (Castelli, Hillman, Buck, & Erwin, 2007). This evidence indicates that schools should not be cutting physical education classes from their curriculum. They instead should be working to find ways to support physical education classes because of the effects that exercise can have on the children. More sound research is necessary for this topic so that schools can stop cutting physical education classes that can help facilitate learning in a way that a child can enjoy and helps the children on a neurological level.

Ethics

This experiment was ethical for a couple different reasons. One being, the only exercise group that was of concerned with risks was the cardiovascular group because they went on the treadmill, but the participant never went above a slightly fast walk. Therefore, they were not nervous about being on the treadmill and if they were to fall it would not be going fast. Secondly, there was no invasion of the participants' privacy. Their names are not used anywhere in the experiment. The only time their name was used was to sign the consent and waiver form. Additionally there was a liability waiver to warn the participants of the risks before they started the experiment. Thirdly, nobody was asked to participate in vigorous activity.

Limitations

In the preliminary stages of this experiment, the first problem that arose was trying to recruit participants for the study. Several students tried to pass the table without looking and when asked to participate, they responded that they did not have enough time in their day (30 minutes) or they asked if they would be paid. I indicated that they could have a chance to win one of two $25 amazon gift cards. They however did not like that response and they politely declined to participate. If I could re-do this experiment, I would have researched older adults because those were the people who came up to me the most and were eager to help and participate, but were saddened to hear they did not fit the experiments requirements. I would want to use the older population from the gym because they were the most supportive in helping me run my experiment.

Some participants were able to figure out what I was trying to control with the free recall test. I had one participant on the treadmill tell me how she knew that I was talking to her because I was trying to distract her from remembering the words that were given to her. Another person during the treadmill exercise told me they thought they could only remember two of the words. For both of these people, I tried to distract them from the comments they said but it did make me change the way I ran the treadmill group from then on. I made sure I talked to them for the majority of the time they were on the treadmill. I asked them to touch the heart monitors every 30 seconds, but this did not seem to distract them enough. If I were to do this again, I would make them watch something while they were on the treadmill so that they could focus on something other than the words they just saw and the touching of the heart monitor, especially because the other groups had to pay attention to their videos much more. I would not suggest doing a more difficult exercise because I wanted to target only their heartbeat and if something

harder was to be done that would also bring in an aerobic component to the exercise. That is why a more distracting component would just be necessary.

While I was debriefing the participants, some indicated that they had taken a psychology course at one point in their academic careers and that they knew there would probably be some type of deception. This is a problem with using students as participants because they are in a college setting and thus have possibly taken courses in psychology. Or they are just skeptical of everything because they have been in an academic setting for so long, especially at Bard College where the motto is "a place to think."

I chose to find participants in the gym because they were there with intentions to workout and could understand the risks of my experiment better than someone who might have never stepped foot in the gym their whole time at Bard. This could have caused skewed results because the population that was being used already exercised more than some of the population at Bard. If I was to do this again I would try and get a more well-rounded population of participants and not just gym dwellers.

I did not only run into problems with the students, but there were administrative errors as well. Sometimes the conference rooms in the gym were being used so I had to set up a table in the yoga room. This was fine and not distracting to the participant because we were in there alone, but it does mean that not all subjects participated in the same place, which could possibly result in some error. I also could have been more forward with having people participate in my study. I was not as pushy as I should have been when recruiting. I was also unable to get the amount of people that I wanted for this study, which was frustrating. If I was to do this again I would have wanted to send in my IRB application earlier so I could have started data collection

sooner and possibly gotten more participants. I also would have liked to hang posters around the gym to help me get the attention of potential participants.

I wish that I started looking at the research the way that I did second semester the same way during the first semester. I did it much more efficiently and could have potentially gotten my literature review done quicker if I conducted my research the same way during the whole project. I started to go section by section instead of trying to find all the research I needed all at once. Finding it all at once was overwhelming and delayed my advancement of writing, but once I started going section by section, it became a much less stressful process and I was able to do my research more efficiently.

Although there are several aspects of the experiment I wish had gone differently, I think that if I were to do this experience again, I would not change much. I do still like the way that I set up the experiment and the groupings that I used. Some things could be fixed slightly here and there to improve efficiency, but I liked the process overall.

Successes

Some things did go wrong in this experiment, but other parts went very well. I may not have recruited as many participants as I had hoped, but I did get over 25 which can be considered a success. I can also say that I put a great amount of effort into my senior project. I did a lot of research and diligently collected data. I developed and executed an experiment on a larger scale than I ever had before, which not many students or people can say they were able to do in their undergraduate years.

Doing senior project was a valuable way to end my time here at Bard College, and reflect all that I have learned through the Psychology department. Although it was a difficult process

and very stressful at times, I know I will look back on it and be proud of what I was able to accomplish with this paper and experiment. It is something I will be proud of for years to come.

Future Directions

If I was to take this experiment even further, I would travel to other schools and get sample sizes from places around and at Bard. I would still use college students but I would look to get people from more diverse backgrounds, not just gym dwellers. The only thing I would change drastically about my experiment would be to make it a longitudinal study, testing subjects over a longer period of time. It would not be exceptionally long, a month maximum, allowing me to have better, more secure results if I were to monitor both cardiovascular and aerobic exercises over a long period of time. Most studies that I researched used longitudinal studies, doing the same could prove to be beneficial for my results.

I would also make sure that I get an equal gender distribution. In the current study, I only tested five males out of 29 people. I would like to see if having more male participants would show different results. Taking from the whole school population and not just the gym should also help with my success of this goal. I would also use flyers to aid in recruiting people to participate in my experiment. Perhaps if they had not seen my face, the participants' gender distribution would have been more even.

Doing this experiment on a larger scale would give me more reliable data. This experiment does contain reliable data, but a longitudinal study would demonstrate the growth that exercise has in the brain that cannot be seen through the current experiment. If I were to complete this study further over the next two years, I would lengthen the participants' role and use a greater number and variety of people.

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Appendices

Appendix A:

Consent Form

Background

Exercise is an important part of most people's lives and is ever present in our society. Thinking and participating in everyday activities are also ever present in our society. It is important to look and see if these two things can be connected

What Will Happen in this Study?

This experiment will take about 30 minutes at the most to complete. During the study you will be given a thinking activity, before you may participate in the subsequent physical activities. They will be given a demographics and exercise questionnaire. The demographics questionnaire will give the experimenter a more in depth explanation of who you are as an individual person. The exercise questionnaire will help the experimenter understand if you have ever participated in physical activity. The exercises in this experiment will either be running/jogging on a treadmill or participating in a yoga exercise.

Risk and Benefits

There will always be risks when entering the gym to workout and with the use of equipment like a treadmill. That is why this experiment will only take place while health services is open and EMS will be open as well. You will be given compensation for your participation in this experiment. As compensation you will be put into a raffle to win one of two $25 gift cards. Emails will be collected through a google survey so only the experimenter can see them.

Your Rights as a Participant

At ANYTIME you are able to stop and not complete the experiment with no questions asked. Do only what you feel comfortable. No penalty will be given to those who chose not to complete the experiment.

Anonymity

Your results from this experiment will be confidential. Data from this study may be shared on the Open Science Framework database but under no circumstances will the participants name be used.

You Must be 18 Years or Older

If you have any questions or concerns please contact me: Nicole Ellin at ne2944@bard.edu and/or my senior project advisor Kristin Lane at lane@bard.edu.

_____ _____

Signature Date

Appendix B:

Demographics Questionnaire

1. Gender
    a. Female
    b. Male
    c. Other
2. Age
    a. _____
3. What year are you currently in school? (ex. First Year, Junior, Graduate Student)
    a. _____
4. Race
    a. American Indian or Alaska Native
    b. Asian
    c. Black or African American
    d. Native Hawaiian or Other Pacific Islander
    e. White
    f. Other
    g. Prefer not to say
5. Ethnicity
    a. Hispanic or Latino
    b. Not Hispanic or Latino

Appendix C:

Exercise Questionnaire

This questionnaire will look at how often someone exercises in their everyday life. Please circle the number that applies best to you, **1 being strongly disagree and 5 being strongly agree**:

1. I don't exercise or walk regularly now and I don't plan to start in the near future.

1 2 3 4 5

2. I don't exercise or walk regularly now but I've been thinking about starting.

1 2 3 4 5

3. I'm doing moderate physical activity fewer than five times a week or vigorous activity fewer than three times a week.

1 2 3 4 5

4. I've been doing moderate physical activity 5 or more days a week, or vigorous activity at least 3 days a week, for the last 1 to 6 months.

1 2 3 4 5

5. I've been doing moderate physical activity 5 or more days a week, or vigorous activity at least 3 days a week, for 7 months or longer.

1 2 3 4 5

6. Do you exercise daily? (circle one)

a. Yes

b. No

7. If so please put how many minutes/hours you exercise for:

. _____

8. If so please put how many days a week you exercise

. _____

Appendix D:

Free Recall Test

Please look at this list of words for 90 seconds. I will inform you when the 90 seconds is done.

1. Cartoon
2. Monkey
3. Negative
4. Pie
5. Pork
6. Creature
7. Dry
8. Bonnet
9. Groom
10. Rein
11. Wander
12. Sorry
13. Cabin
14. Collapse
15. Classroom

Appendix E:

Debriefing Statement

Thank you for participating!

You just participated in a study that is looking to discover how exercise affects mental ability. I am looking to see if three sub-groups (cardiovascular, aerobic, and control) are positively correlated with explicit memory, recall memory, which was the free recall test that the participant took at the beginning of the experiment. I have hypothesized that the aerobic exercise group will perform better on the free recall test than the cardiovascular and control groups.

If you participated in Cardiovascular exercise:

You were asked to get your heart rate into a target zone because cardiovascular exercise is all about the heart and how much it works during exercise.

If you participated in Yoga:

This group was to focus on breathing while doing the yoga exercises. Aerobic exercise is airflow within the body. Yoga is a much calmer type of aerobic exercise and I wanted to see if a more focused activity helped with recall memory.

If you participated in a control video:

Most experiments use a control to compare the results of the other groups. This group did no physical activity.

Please do not share what you have done during this experiment with anybody else. It could ruin the integrity of the experiment if anyone who knows what is happening, then participates.

If you have any questions or concerns please contact me at ne2944@bard.edu or my advisor Kristin Lane at lane@bard.edu.

Appendix F

Written Protocol

At Table

Hi, would you like to participate in a psychology experiment?

"Sure"

Great! I am looking at how exercise affects mental ability and by participating you would be put in the running for one of two $25 dollar gift cards to Amazon. How old are you?

"Under 18"

I'm sorry you are unable to participate. But when you are 18 make sure you participate and help others!

"Over 18"

Perfect you are able to participate! Would you like to participate now or sign up to participate at a later time? It takes 30 min.

"Can I sign up for a time?"

Yes please sign up with your email and I will send a confirmation when your signed up

"Now is fine."

Okay let's head into the conference room

In Conference Room

Thank you again for participating in my experiment, may I ask what your name is again?

"Name"

Thanks (name), you can sit right here and I'm going to go over some stuff with you. You are about to participate in a psychology experiment that involves different types of exercise. Please know that at any time in this experiment you are able to leave for any reason with no questions asked. The experiment will take about 30 minutes in total. Your name will not be used anywhere in this experiment, I will ask for your email at the end of the experiment just so you can be added to the running for the Amazon gift card, but you can decline if you would like. Here is the consent form for you to read and sign. Let me know if you have any questions.

no questions and hands back form

Here are two more forms for you to fill out. Please let me know if you have any questions.

no questions and they hand back the forms

Thank you for filling those out. I am going to hand you a piece of paper with words on it. The words are very random and not meant to mean anything. You will have a minute and a half to read over these words. As soon as you flip the paper over I will start the timer. Do you have any questions?

no questions, they flip the paper and I start the timer. Time is up and they hand back the piece of paper.

Good job. We are now going to get started on the rest of the experiment, follow me…

Cardiovascular Group

Have you ever used a treadmill before?

"Yes"

Awesome. Then you know how to start it and how it works.

"No"

That's okay. We will start at a slow pace. When you press 'quickstart' that is how the treadmill starts. And when you push the lever on the right that dictates the speed. Push it up to get the speed to increase and you push the lever down to get it to decrease.

We will start at a slower pace and that gradually increase the speed to get your heart rate over 90 bpm. I want to have your heart rate consistently over 90 bpm for 10 minutes, so when your heart rate gets that high that will be your speed for 10 min; this could be a walk, jog, or a run. To calculate your heart rate you will grab onto these metal bars in front of you. It takes about 5-10 seconds to read the heart rate and show it on the screen. Every time the clock hits a 30 second interval you need to put your hands on the heart monitor. Remember, at any point in this experiment you are able to stop if you need or want to. Do you have any questions?

no questions

Okay let's get started. Press 'quickstart' when you are ready, push this up to go faster and down to go slower. I will be right behind you if you need anything during the exercise.

Completes the 10 minutes

Great job! We will head back to the conference room now to finish up the experiment.

Aerobic Group

Have you ever done yoga before?

"Yes"

Awesome, this is a beginner's video so it should be exercises that you have done before.

"No"

That's okay. This is a beginner's video so the exercises are at an easier level.

Do you have any questions?

no questions

Okay let's get started. Just listen to the video and complete it. It will let you know when it is done. Remember, at any point in this experiment you are able to stop if you need or want to. I will be right behind you if you have any questions during the exercise.

video over

Great job! We will now head back to the conference room to finish up the experiment.

Control Group

We are going to stay right here in the conference room and you are going to watch a video. Remember, at any point in this experiment you are able to stop if you need or want to. Do you have any questions?

no questions

Okay, watch this video. It will notify you when it is over. I will be right behind you if you have any questions.

video over

Okay, we will now finish up with the rest of the experiment.

In Conference Room

You did a great job with your exercise and we are almost done. For the next part of the experiment you will be writing down the words that you saw in the beginning of the experiment. You will have a minute and a half to write them down on the piece of paper I am about to give you. Your time will start when I hand you the paper. Do you have any questions?

no questions, they write the words in a minute and a half. They give the paper back

Thank you so much for participating in my experiment, your name will be entered into a raffle to potentially win one of two gift cards. You just participated in an experiment that is looking to see if exercise affects mental ability, or memory. There were three groups: cardiovascular, aerobic, and a control group. The cardio group was on the treadmill, the aerobic group did yoga, and the control group got to watch a video. I am looking to see if air flow in the body or if raised heart rate in the body helps with explicit memory, which is conscious recollection, which is

remembering information just given to you. Here is my debriefing statement also written out. Please read it over and let me know if you have any questions.

no questions

Thank you again, remember to please use digression when talking about my experiment to others because the data will be less valid if they know everything about the experiment. Thank you and have a great rest of your day!

Appendix G:

Liability Waiver[1]

I agree and consent to the following:

I am voluntarily participating in the Bard College Psychology Senior Project with exercise/fitness conducted by Nicole Ellin at Bard College Stevenson Athletic Gym. I understand that the program requires physical exertion that may be strenuous at times and may cause physical injury and I am fully aware of the risks and hazards involved.

I agree to assume full responsibility for any risks, injuries or damage known or unknown which I might incur as a result of participating in the program. Such injuries may include, but are not limited to: heart attacks, muscle strains, muscle pulls, muscle tears, broken bones, shin splints, heat prostration, injuries to knees, injuries to back, injuries to foot, or any other illness or soreness, including death.

I knowingly, voluntarily and expressly waive any claim I may have against Bard College, Stevenson Athletic Gym, Nicole Ellin, or Kristin Lane for injury or damages that I may sustain as a result of participating in the program.

I have read the above waiver and release of liability and fully understand its contents. I voluntarily agree to the terms and conditions stated above.

_____ _____

Signature **Date**

_____

Print Name

[1] Hampton Connecticut. (n.d.). Retrieved December 5, 2018, from http://www.hamptonct.org

Appendix H:

NIH Certificate

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Nicole Ellin** successfully completed the NIH Web-based training course "Protecting Human Research Participants."

Date of Completion: 03/02/2017

Certification Number: 1863655

NIH National Institutes of Health
Office of Extramural Research

Appendix I:

IRB Acceptance

Bard College Institutional Review Board

Date: February 10, 2019

To: Nicole Ellin (ne2944@bard.edu) Cc: Kristin Lane (lane@bard.edu) From: Sanjay DeSilva, IRB Chair

Re: The effect of exercise on mental ability.

DECISION: APPROVED

Dear Nicole,

The Bard Institutional Review Board reviewed the revisions to your proposal. Your proposal is approved through February 9, 2020. Your case number is 2019FEB10-ELL.

Please notify the IRB if your methodology changes or unexpected events arise.

We wish you the best of luck with your research.

Sanjay DeSilva desilva@bard.edu IRB Chair

PO Box 5000, Annandale-on-Hudson, New York 12504-5000 Phone 845-758-6822

Appendix J:

IRB Application

SECTION 1

Nicole Ellin, ne2944@bard.edu, 508-505-0474, Psychology Undergrad
Kristin Lane, lane@bard.edu, December 6, 2018

SECTION 2

This research qualifies for full review

Do you have external funding for this research?
No.

If so, state name of granting institution and the title of the project as it was submitted to that institution.
N/A

Start Date: December 20, 2018
End Date: December 20, 2019

Title:
The effect of exercise on mental ability.

Research Question(s):
Research shows that exercise in all age ranges help to strengthen explicit memory. Children who go to recess at school tend to do better in class than schools who do not have recess. This is seen as children grow up as well. Those who are more active in their lives overall tend to do better in school. Even at the elderly age when one goes on a walk they are strengthening their memory. Exercise and everyday mental tasks are things that are done daily in society. Hopefully, when used together, they could be beneficial for each other. That is why my research question is does exercise affect mental ability?

Specific Population:
Bard College Students

Recruitment:
Participants will be recruited from the Stevenson Athletic Center on the Bard College campus. A table will be set up next to the check in desk at the front of the gym where potential participants will be asked if they want to participate in a psychology experiment. On the table there will be candy for potential participants. If a person wants to participate immediately then they will be brought to a conference room to get started. If they do not want to participate on that day then they will be provided with times to come back to complete the experiment. They will be put into groups by who shows up first, the first person will be in the cardiovascular group, the second will be in the aerobic group, the third will be in the control group, and so on and so forth (Commitment Script, Appendix H).

Procedure:
In this experiment to explore how exercise affects mental ability two different exercises will be tested and there will also be a control group. The two exercises are cardiovascular and aerobic exercise. To figure out cardiovascular exercise the participant will walk/jog/run on a treadmill and to figure out aerobic exercise participants will be doing yoga exercises from a video. The set of events will go like this: (1) participants will be given a consent form to sign before they start any part of the experiment (Appendix A). Then to start (2) participants will be given a demographics questionnaire to be filled out (Appendix B). Once they are done with that (3) they will be given an exercise questionnaire (Appendix C). The purpose of this questionnaire is to indicate to the experimenter if the participant has ever taken part in exercise activities before, which is helpful because if they have not then the experimenter can be aware that this may be their first time doing yoga or ever going on a treadmill. If this is the case then I will make sure that they are going on a low speed until they feel comfortable to make the treadmill a little faster and if they have never done yoga I will make sure to spot them the whole time. After the questionnaires have been filled out (4) the participants will take part in the studying the words of the free recall test (Appendix D). They will be given 90 seconds to study the words and once this is done they will (5) be put into groups to either participate in the cardiovascular exercise, aerobic exercise, or the control group. If they are put in the cardiovascular group they will be brought to a treadmill and told to put their hands on the heart rate monitors, then they will start jogging on the treadmill (slow at first and then faster to raise their heart rate), then they will put their hands on the heart rate monitor again, once their heart rate is at the target rate they will continue to run consecutively for 10 minutes. If they are in the yoga group they will be taken to a yoga mat and the video will be played in front of them and they will do what the video says, the video is approximately 10 minutes. The control group will be given the video that they will be watching in the conference room that they are in, the video lasts approximately 10 minutes. Once they are done with their respective groups, they will go back to the conference room and (6) be given a loose-leaf piece of paper and a pen and they will be told to recall as many of the words as they remember from the list they studied before the experiment started, they will have 90 seconds to do this. They will have the same amount of time that they had to study because if the participant knows the words well then they will write them quickly, but if they do not know the words then I do not want to give them a long time to try and figure it out. Once they are done (7) there will be a verbal debriefing (Appendix E/F) and asked if they have any questions. The whole experiment will take 30 minutes.

Estimated Number of Participants:
50

Risks and Benefits:
There are risks within this experiment because of the use of exercise equipment. To try and lower the risk the participants will only be taken from the population of people who have entered the Stevenson Athletic Center at Bard College because they already know the risk of going to the gym in the first place. They will also be given a waiver (Appendix G) to sign so they are aware of the risk. Mr. Joe Ahern has been contacted and he has sent me in the correct direction to producing a waiver. He has also expressed his thoughts on the risk of the experiment as a whole, which he thought was low.

Consent form:
The consent form states that participants have to be 18 years or older, that they can leave at any time, and that their information will be confidential (Appendix A).

Confidentiality Procedures:
They will be briefed in the consent form (Appendix A) and told that their name will not be used anywhere in the data or experiment. I will keep their data confidential by not having the participant put their name on anything. Also if they sign up for a time to participate I will make sure that they cannot see anybody else's name that has signed up and that nobody can see their name.

Deception:
N/A

Debriefing Statement:
They will be debriefed on what the groups are in the experiment and why they had to do the specific type of exercise that they had to do. Please see Appendix E and Appendix F.