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# Cybercycling for cognitive health: Comparing physical mental and combined exercise

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# Cybercycling for cognitive health:

# Comparing physical, mental and combined exercise

By

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## ABSTRACT

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Several meta-analyses of randomized controlled trials (RCT) have shown exercise to improve cognitive function in normal aging, mild cognitive impairment (MCI) and dementia (Colcombe & Kramer, 2003, O' Leary et al., 2011). Cognitive benefit from mental exercise alone is less definitive. A recent RCT (Anderson-Hanley et al., 2012) found greater benefit from three months of virtual-reality enhanced exercise than physical exercise alone among 79 independent living older adults. The current study aimed to replicate this work. In this study, six seniors that either lived or worked at Schaffer Heights were enrolled in the study. Participants were randomized into one of two conditions for three months: mental exercise (videogame only) or interactive mental and physical exercise (videogame controlled by pedaling). It has been hypothesized that simultaneous interactive mental and physical exercise will yield greater cognitive benefits than mental exercise alone. This report documents enrollee characteristics, which revealed great variability among participants. This report also documents the feasibility of methodology and splitting apart interactive mental and physical exercise. Additional time is needed in order to see any trend in the data, as this report only examines the first portion of the three month long intervention. Future research is needed to build upon this pilot work in order to test the data and methodology among the greater older adult population.

TABLE OF CONTENTS

Cybercycling for cognitive health: Comparing physical, mental and combined exercise

Today, the average lifespan continues to increase due to improved healthcare (Bunker, 2001) and economic development worldwide (Hanushek & Ludge, 2008); however, the prevalence of dementia is also on the rise (Ferri et al, 2005). Within North America alone, the prevalence of dementia is expected to triple from 3.4 million in 2001 to 9.2 million by 2040 (Ferri et al, 2005). It is expected that worldwide, dementia will increase from 24 million to 81 million by 2040 (Ferri et al, 2005). This increase in the prevalence of dementia brings to light potential threats and consequences. For example, many have questioned how this increase will affect the overall cost of health care (Thies & Bleiler, 2012). Given the current epidemic and lack of "cure," the question remains, "Can we slow the onset of dementia?"

Research represented in several meta-analyses of randomized controlled trials (RCTs) has shown that exercise can improve cognitive function in normal aging (Angevaren et at., 2008; Colcombe & Kramer, 2003), mild cognitive impairment (MCI; Baker, et al., 2010, Geda, et al. , 2010 & Lautenschlager, 2008) and dementia (Larson, 2008, Chang et al., 2010 & Scarmeas , 2009). While intervention with the both normative adults and adults diagnosed with dementia is useful, in some ways, individuals diagnosed with MCI represent a unique group for intervention. Mild cognitive impairment (MCI) can be defined as individuals who have cognitive impairment that is beyond the traditional expectation for their age; however, MCI does not interfere or impair the individual's daily life (Ward et al, 2012; Etgen et al, 2011). Additionally, many times MCI is seen as a pre-cursor to dementia (Etgen et al, 2011). Further examination of the MCI population may be useful since these individuals are already experiencing cognitive decline that is greater than expected for their age, but perhaps an exercise intervention could help to reverse or slow this decline, perhaps impacting the rates of conversion to dementia.

Recently researchers have gathered evidence that exercise has the capability to reduce cognitive decline (Heyn et al., 2004; Hillman, Erickson & Kramer, 2008), as well as slow progression of dementia (Larson, 2010). Prior research has suggested that if the onset of dementia could be delayed just a few years, that the impact on the population could be dramatic (Brookmeyer, Gray, & Kawas, 1998). For example, if the onset of dementia could be delayed by how long? within the United States the prevalence of dementia could decrease by one million cases every ten years (Brookmeyer, Gray, & Kawas, 1998). Research regarding the cognitive benefits of exercise has surged within the last decade; however, the research regarding the use of exercise as an intervention for individuals diagnosed with MCI is sparse. The focus of the current study is to examine the effect to which exercise could be a way to intervene in MCI. It is still unknown if MCI is "reversible" therefore, this intervention will shed light on the extent to which exercise could reverse or halt cognitive decline. Given the recent research, which has shown additional cognitive benefit from interactive mental and physical exercise (Anderson- Hanley et al., 2012), it is possible that a combined intervention for MCI could be even more powerful that mental or physical exercise alone. The following sections will review the benefits of physical exercise, mental exercise as well as the combined physical and mental exercise on cognitive health.

**Physical Exercise**

One question that arises regarding the benefits of exercise is: which cognitive processes does physical exercise influence? Hall et al (2001) has closely examined the physical exercise and cognitive health literature, and concluded that most researchers have found aerobic exercise to primarily influence and improve executive control. Executive control has been defined as cognitive processing that occurs primarily in the frontal lobe (Etnier & Chang, 2008). Specifically, these cognitive processes include planning, attention, working memory, organizing,

multitasking, problem solving and verbal reasoning (Etnier & Chang, 2008). Specifically this is of interest as dementia has been shown to affect executive control (Schroeter et al, 2012). In the more recent literature it has been seen that the researchers primarily evaluate cognitive control when evaluating cognitive decline in physical exercise interventions. It should also be noted that researchers have found evidence to support physiological changes (molecular and cellular) as a function of physical exercise in both non-human and human subjects (McAuley, Kramer & Colcombe, 2004). Additionally, researchers have used neuroimaging techniques to show that physical exercise can produce structural changes within the human brain (Colcombe, 2006; McAuley, Kramer & Colcombe, 2004).

Colcombe and Kramer (2003) produced a meta-analysis that included 18 different intervention studies from 1966- 2001 that involved physical exercise. In this study exercise was seen to strongly benefit cognition. In this meta-analysis exercise was seen primarily to influence executive control processes, which is similar to the findings of Hall et al (2001). This relationship between exercise and executive function has also been shown in more recent studies. In a recent study Kamijo et al (2009) recruited 24 males, 12 young and 12 old. In this study the researchers examined the P3 component of an event-related brain potential (Kamijo et al, 2009). The researchers found that reaction after moderate exercise decreased in participants of both age groups compared to the participants' reaction time after no exercise (Kamijo et al, 2009). This study suggests that light and moderate exercise can improve reaction time, or cognitive function across all age groups (Kamijo et al, 2009).

Some researchers have begun to extend this research to those with MCI. Baker and colleagues (2010) and Geda and colleagues (2010) have investigated a variety of exercise interventions for improving cognitive function in individuals with MCI. In the study conducted by Baker et al (2010) there were 33 participants diagnosed with MCI. These participants ranged

from 55 years old to 85 years old . Participants were randomly assigned to one of two conditions: high-intensity aerobic exercise or stretching control group. For each condition participants were asked to exercise for 40-45 minutes a day for four days a week for six months. The researchers found that the participants in the high-intensity aerobic exercise condition performed significantly better on the tests of executive function as compared with the participants in the stretching control condition. This study indicates that an exercise intervention has the potential to improve executive function for individuals diagnosed with MCI and who are at a high risk of cognitive decline (Baker et al, 2010).

In addition to the study conducted by Baker et al (2010), other researchers have investigated the relationship between exercise and cognition among the MCI sample. Geda et al (2010) produced a population-based case-control study in which a total of 1,324 participants completed a Physical Exercise Questionnaire. In addition, none of the 1,324 participants had dementia. In this study participants were categorized as either having normal cognition for their age or having MCI. Experts in the field conducted categorization of MCI using published criteria for diagnosis. In total, 198 participants were classified as having MCI while 1126 subjects were considered to have normal cognitive function. The results of this study suggest that an individual is less likely to suffer from MCI if he participates in moderate physical exercise in mid or late life. All of the studies presented have indicated that exercise has the potential to improve cognition (Hall et al, 2001, McAuley, Kramer & Colcombe, 2004, Colcombe & Kramer, 2003 & Kamijo et al, 2009). Furthermore, the more resent literature suggests that exercise can influence and defer cognitive decline of those diagnosed with MCI (Baker et al, 2010), in addition moderate exercise has been linked to MCI, as older adults that participate in moderate physical exercise are less likely to be diagnosed with MCI (Baker et al, 2010).

**Mental Exercise**

Researchers have also explored the possibility of mental exercise as a mechanism to reduce cognitive decline, specifically executive function, among older adults (Goldstein et al, 2007, Basak, Boot, Voss & Kramer, 2008, & Standen & Brown, 2005). Goldstein et al (1997) randomly assigned older adults (ages 69 to 90 years old) to either the video game or control conditions. In the video game condition participants were asked to play "Super Tetris" for five hours a week for a total of five weeks. In this study the researchers found that participants in the video game condition had significantly faster reaction times and felt a more positive sense of well-being in comparison to the control group. This study has led other researchers to further examine the effects of mental exercise on other cognitive functions.

Basak and colleagues continued the work of Goldstein et al (1997) in their 2008 study. The purpose of this study was to examine the extent to which cognitive training can transfer to other cognitive skills in older adults (Basak et al, 2008). In this study older adults were trained on a video game for 23.5 hours. Each participant was asked to complete a battery of cognitive tasks both before video game training and after. These tasks evaluated executive control, task switching, working memory, and visuospatial skills among other cognitive functions. In this study participants in the video-game condition improved significantly on game performance, and in executive control functions. This study indicates the potential of video-game training as a mechanism to improve cognitive control functions in older adults and that this improvement generalizes beyond the specific video game task. Finally a study conducted by Standen and Brown (2005) found that participants in the active video game participation (such as creating an independent route) yielded significantly better performance on spatial and object recognition tasks as compared with passive video game participation (such as following a route designated

by the video game). This study suggests that the cognitive benefits from mental exercise could be significantly greater with active versus passive participation (Standen & Brown, 2005).

**Combined Physical and Mental Exercise**

Malliot, Perrot, and Hartley (2011) have begun to explore the effect of combined physical and mental exercise on cognition. In this study a pretest-training-posttest design was used. Participants were randomly assigned to one of two groups: the experimental group or the control group. In the experimental group participants were subject to one hour of simultaneous physical and mental exercise training. In the control group the participants did not perform any form of exercise. In addition, both conditions completed a neuropsychological battery measuring executive function. In addition participants completed physical battery, which was used to examine the impact of the fitness portion of the program for participants in the experimental group. In this study Malliot et al (2011) found that participants in the experimental condition improved significant on executive control measures, processing speed as well as game performance. The results of this study indicate that single bouts of simultaneous physical and mental exercise yields cognitive improvements in normal aging adults in comparison with a control condition that did not participate any form of "exercise."

Kurtz et al (2009) found similar results to Malliot et al (2011) outside of the normal aging population. In this study the researchers conducted a cognitive rehabilitation intervention program with individuals diagnosed with MCI and individuals diagnosed with Alzheimer's disease. This intervention was comprised of four weeks, in which participants were in a group setting provided with "activity planning, self assertiveness training, relaxation techniques, stress management, use of external memory aids, memory training and motor exercise." After treatment, individuals diagnosed with MCI showed significant cognitive improvements, whereas individuals with AD demonstrated no significant improvements. This study indicated that

individuals with MCI have the capacity to benefit from a variety of interventions, including cognitive interventions. Specifically, this study demonstrates the potential role virtual reality, through the use of video games and other devices, may have on the improvement of cognition in individuals with MCI. Furthermore, this study examines both cognitive interventions as well as physiological interventions on motor exercise, thus the potential role of both cognitive rehabilitation and motor exercise cognitive rehabilitation warrant further research to examine individual mechanisms.

The literature examining the combined effects of virtual-reality enhanced exercise is limited, but starting to expand (Malliot et al, 2011; Kurz et al, 2009). Similarly, O'Leary et al (2011) explores the effect single bout video gaming, aerobic exercise, and exergaming (the combination of virtual and physical exercise) through the use of ERP's. In this study there were four 20 minute counterbalanced sessions. This study demonstrated that seated video game playing (mental exercise) and exergaming's ERP's did not differ from any other condition. Nonetheless, the P3 amplitude was increased relative to rest following the exercise condition in which participants were stationed on a treadmill; these results suggest an increased attention from physical exercise. This study did not show any significant change or additive benefit from this combined physical and mental exercise; however, these results may be not be conclusive, as 20 minutes may be too short to see any real benefits.

One randomized control trial has been conducted to date (Anderson-Hanley et al., 2012), which found greater cognitive benefit from three months of virtual-reality enhanced exercise than physical exercise alone among 79 independent living older adults. This finding suggests that for the same effort, interactive physical and mental exercise on a "cybercycle" can yield greater cognitive benefit than physical exercise alone on a stationary bike. A cybercycle is a stationary bike that incorporates an interactive video-game component with physical exercise. Furthermore,

in this study it was shown that fewer participants in the cybercycle condition converted to MCI (23% risk reduction; Anderson-Hanley et al., 2012). This study also found that the "cybercyclists experienced a significantly greater increase in BDNF than traditional exercisers, suggesting exercise may lead to cognitive benefits in part by way of neurotrophic effects" (Anderson-Hanley et al., 2012). The current proposal aims to replicate and extend the work of Anderson-Hanley et al. (2012) to an MCI sample as the current literature has proposed that MCI may be a precursor to dementia (Ganguli et al., 2011); nonetheless, much is still unknown in regards to how comorbid these two illnesses may be. Research has also found that MCI in limited cases may be reversible (Muangpaisan, Petcharat, & Srinonprasert, 2012.) This proposes the notion that if cognitive decline is detected early, it may have the means in which to significantly decrease the increase rates in dementia worldwide.

The current study aimed to evaluate the feasibility and preliminary cognitive effectiveness (beyond a single bout) of both an interactive combination of physical and mental exercise, and a mental exercise only intervention with older adults. This has not been tried previously in any of the above studies. Participants were randomly assigned to one of two conditions for three months (cybercycle or videogame alone). Methods included a pre and post evaluation: neuropsychological interview and neuropsychological testing. Exercise behavior was monitored throughout (minutes, miles, watts, heart rate, speed, calories and effort).

The specific methodology used in this study will help us to understand what is special about the cybercycle and the interactive physical and mental exercise in order to determine if the benefits from interactive exercise is synergistic as compared to just mental exercise alone. Furthermore, this study will test the feasibility of methods, as it is unknown if it is possible to have older adults participant in a mental exercise intervention study for three months, as thus far no literature has compared mental exercise with interactive physical and mental exercise for an

extended period of time. Furthermore, this pilot study will produce preliminary data that may suggest possible differential cognitive outcomes in the cybercycle versus videogame only. Finally, the results of this study will advance the knowledge in the field for designing a larger randomized control trial to test the interactive mental and physical exercise versus mental exercise alone.

# METHODS

## *Participants*

The sample (n=6) consisted of older adults from the Schaffer Heights community ranging from 61 to 84 years old (mean= 67.8). Schaffer Heights is an apartment style independent senior living facility located in Schenectady, NY. Of the six participants, four were female and two were male. All six participants were Caucasian and right-handed. Participation in the study was voluntary. Participants were recruited through fliers that were placed in their mailboxes at Schaffer Heights. Additionally, some of these fliers were posted in various locations within Schaffer Heights, such as elevators and hallways. All of the participants attended an information session conducted by a research team member, and that was held at Schaffer Heights. During these information sessions participants were given a brief explanation of the study and were encouraged to ask questions. After the information session if attendees were interested in participating in the study they were asked to provide their telephone number and room number in order to be contacted for a follow-up interview. In addition, if these attendees were interested in participating in the study they were given a packet of forms to fill out at their own convenience that included the informed consent, the doctor's consent, the Schenectady county legal agreement form, the demographic questionnaire and the health and fitness questionnaire (Appendix A, B, C and D). Participants were asked to complete these forms and then return them to the confidential lock box, which was located near the cybercycle in Schaffer Heights. Each potential participant was explained the risks and benefits of the study and all of the participants signed an informed consent document that had been approved by the Human Subjects Review Board at Union College prior to participation. Physician approval was also obtained before participants began the intervention.

*Procedures*

The intervention was designed to run for three months. This report details the first third of the intervention period. Participants were randomly assigned to one of two conditions: 1) the cybercycle condition or the video game condition. In the cybercycle condition, participants were exposed to both mental and physical exercise. In the video game condition participants were only exposed to mental exercise. In both conditions participants were asked not to change their current diet and exercise routines, however most participants were sedentary or had limited participation in exercise regimens. Participants were asked to "exercise" between three and five times per week for a half an hour.

In this study both conditions (cybercycle and video game) used the recumbent Expresso bike (S3R; IFH Holdings, LLC). In the cybercycle condition participants navigated themselves through the video game by pedaling. In the video game condition, the participants still sat on the recumbent Expresso bike; however, they navigated themselves through the video game by using a video game controller. Additionally, in this study both games used the same type of mental exercise regimen. Each participant played the "Proving Grounds" chase game on the cybercycle. In this game the purpose is gain points. In order to receive points the participant must first get a specific colored coin and then they must find the matching colored dragon. Different colored coins and dragons are associated with different amounts of points and difficulty. Furthermore, there are obstacles in this game that the participants must avoid, for example, if the participant enters the water there is an automatic penalty and points are lost. Participants in both conditions were asked to record specific data from the game after completing each session (Appendix H). For example they were asked to record the number of dragons caught as well as the total number of points earned. In addition, participants in the cybercycle condition were asked to record

physiological data such as distance (miles), power, heart rate, miles per hour and calories (Appendix H).

A neuropsychological battery (Appendix D) was conducted before the exercise intervention began, after a month and half of exercise and after three months of exercise. Before the intervention began participants met individually with the primary researcher to complete the neuropsychological questionnaire and the physical activity questionnaire (Appendix E). In addition, at this meeting the primary researcher provided instruction for how to use the cybercycle or video game. There were also materials left at Schaffer Heights in a three-ring binder that provided reminder instructions for logging in, how to navigate the cybercycle and video game (all of the material was covered at the individual meeting with the primary researcher).

Exercise was conducted in the conference room located on the first floor at Schaffer Heights, which was accessible to all of the participants. In this room, participants were able to exercise in private, as it was a small room with only one exercise machine; in addition, participants were able to close the door. Furthermore, participants were assigned the conference room seven days a week for an hour each day. At the end of each exercise session participants were provided with a log sheet to keep track of their progress (Appendix H). In order to make sure participants continued exercising throughout the intervention and to help trouble-shoot if any problems arose a research assistant from the Health Aging and Neuropsychology Lab at Union College called participants on Mondays and Fridays to check in.

*Measures*

The purpose of this study was to evaluate the estimated IQ, executive function and memory of each of the participants before, during after the exercise intervention. In order to evaluate estimated IQ, executive function and memory numerous psychological tests were used

in the neuropsychological battery. Five different neuropsychological tests were used: NAART, Color Trails (D'Elia, Satz, Uchiyama & White, 1996), Digit Span (Forwards and Backwards; Strauss, Sherman & Spreen, 2006), the Stroop Test (Prosper Version, 40 items; Van der Elst, Van Boxtel, Van Breukelen & Jolles, 2006), the Fuld (shortened version; ref) and the Fuld 20-minute recall.

**Estimated IQ:**

*NAART*

The NAART was used to measure the participant's estimated IQ. In this task participants were given a list of words and were asked to read them aloud. Participants were encouraged to try and pronounce all of the words even if they were just guessing. Participants were evaluated based upon their accuracy in pronunciation.

**Executive Function:**

*Color Trails* (D'Elia et al.,1996)

Color Trails test was used to measure executive function. In each testing session there were two different Color Trails tests administered "Trial One" and "Trial Two." Participants always completed trial one before trial two. In trial one participants were asked to connect yellow and pink circles numerically. Each of these circles had numbers inside of them. Participants were told to connect the circles as quickly as possible and they were evaluated as a function of time. In the second trial of the Color Trails test participants were again asked to connect different colored circles numerically as quickly as possible. In this trial, however, participants had to connect the circles numerically as quickly as possible alternating colors (pink and yellow). Again participants were evaluated as a function of time. Additionally, before each of the Color Trails trials participants were given a practice sheet.

*Digit Span* (Strauss, Sherman & Spreen, 2006)

The Digit Span was another test used in this study to evaluate executive function. Both the forwards and backwards Digit Span tests were used. In the Digit Span Forwards task the researcher read out a string of numbers a rate of one number per second. The string of numbers started with two numbers, in which the participants had to say them back in the same order in which they were given. The test was discontinued after there were two consecutive failures of the same length of digits. The Digit Span backwards was exactly the same as the Digit Span forwards, however, participants were asked to say the numbers backwards. For example, if the researcher said the numbers 7-1-9, the participant would say 9-1-7. In this test the participants were evaluated based upon accuracy.

*The Stroop Test* (Van der Elst et al., 2006)

In addition to the Digit Span, the Stroop Test (Prosper version-40 items) was used to examine participants' executive function. In the Stroop Task were shown three different pages. On each page there was a different subtest, which measured selective attention, cognitive flexibility and processing speed. On the first page participants were asked to tell the researcher the names of each of the color blocks as quickly as possible. On the second page participants were asked to read the words on the page as quickly as possible. On the third and final page participants were asked to tell the researcher the color of the ink and ignore the written word. On the third page, it should be noted that the color of the ink did not coincide with the written word. For each of these trails the participant was given a practice. Additionally, participants were evaluated based upon the time it took them to complete these tasks.

**Memory:**

*Fuld* (shortened version; ref)

In the Fuld (shortened version) participants were told that there were ten different common objects in a bag. Each participant was asked to identify each object by touch without

looking. If the participant was not able to identify the object by touch then they were asked to open their eyes and identify the object. After identifying all ten objects the researcher asked the participant to name as quickly as possible all of the different male or female names (males were asked to list male names, while females were asked to list female names). Each participant was given 60 seconds to complete this naming task. After 60 seconds each participant was asked recall all of the ten objects from the bag. If the participant was unable to recall an object the researcher reminded them of the objects missed. After twenty minutes from the initial recall participants were again asked to recall the objects from the bag. If a participant was unable to recall all of the objects for every object missed the researcher asked the participant to recognize the object from one of three items.

In addition to measuring estimated IQ, executive function and memory, mood was also examined in order to see if either condition would affect mood. Participants completed the Brunel Mood Scale after each neuropsychological testing session. This test consists of 24 different words. Participants are asked to indicate the extent to which the word describes how they are feeling at that specific moment. Participants can mark either, not at all, a little, moderately, quite a bit or extremely. Furthermore, of the 24 words each word belongs to a specific subset either: Anger, Confusion, Depression, Fatigue, Tension, or Vigor. Thus there are four words for each of these categories (Appendix F).

## RESULTS

Out of the total thirteen participants that were recruited, six completed the enrollment process. Four of the participants did not complete enrollment process because they felt as if they did not have enough time to participate. Another participant declined to participant in the study because of health reasons, this individual did not complete any of the pre-evaluation information. In addition, another participant did not respond by phone or mail after the initial information

session. The final participant declined to participate in the study because the individual refused to sign the legal agreement with the county of Schenectady, NY to use the cybercycle.

Currently, one round of neuropsychological testing has been conducted; therefore there is no way in which to compare the participants based upon pre-post evaluation individually or between groups. Because of the limited data available the results will be presented is case study format for each of the six participants.

**Characterization of Sample:**

*Ms. W*

Ms. W is a 61 year old Caucasian, right-handed female. Ms. W completed both high school and college and is currently working at Schaffer Heights. Her primary language is English, she is divorced and has two children. In the past Ms. W occasionally used a stationary exercise bike, however, she currently attends a gym twice a week and uses other cardiovascular training tools. Ms. W uses computers almost daily, and plays computer games almost daily, however, these games are mostly card games. Furthermore, Ms. W has used video games such as the wii or Nintendo very rarely.

In general, Ms. W is a very healthy woman. Ms. W does suffer from arthritis in both of her knees and asthma. In addition Ms. W has a history of cardiovascular disease in her family. Additionally her psychiatric history includes seeing a counselor and psychologist for over ten years as she suffers from depression. Currently Ms. W is taking Zoloft and Wellbutrim XL in order to treat her depression.

Ms. W was randomly assigned to the cybercycle condition. Ms. W has been exercising since the beginning of May. Thus far, the arthritis in her knees has not seemed to impact her ability to exercise. Additionally, Ms. W has remarked on her Data entry form that the experience has been extremely fun and only a little boring. In addition she noted that she was extremely

interested in scoring points. In general, Ms. W has been a very reliable participant. She has called with questions, continued her exercise regimen and filled out the appropriate paperwork.

*Mr. W*

Mr. W is an 61 year old Caucasian, right handed male. Mr. W completed high school and is now retired. Mr. W has been living at Schaffer Heights since the beginning of 2012. Mr. W's primary language is English. Furthermore, Mr. W is single and does not have any children. Mr. W has very rarely used a stationary bike, computers, nor has he played with frequency video games or computer games.

Mr. W suffers from osteoporosis; however, he notes that he is in treatment. Additionally Mr. W had to have surgery for a stomach ulcer, which occurred within the last few years. Mr. W is also pre-diabetic and is a smoker. Furthermore, Mr. W has had serious issues with alcohol including hospitalizations and rehabilitation; however, he is two years sober and attending Alcoholics Anonymous meeting. Physically Mr. W is a very active walker noting that he walks seven days a week at a striding pace. Additionally, Mr. W climbs between five and eleven flights of stairs each day. Mr. W also has an extensive psychiatric history as he has been diagnosed with paranoid schizophrenia. Mr. W was hospitalized at a psychiatric facility earlier this year, however, he notes that he is currently seeing both his psychiatrist and psychologist and taking his medication. Currently, Mr. W is taking medication for anxiety as well as sleeping aids in addition to his schizophrenia medication.

Mr. W has been assigned to the video game condition. Mr. W has completed all of his questionnaires in addition to the neuropsychological evaluation. Nonetheless, Mr. W has not been recording his data. It is unclear if he participating at all in the study. Unfortunately, Mr. W only uses a cell phone which most of the time is turned off. In addition, Mr. W does not check

his voicemail. Therefore, the research team has been out of contact with him for the few weeks. Again, it is unclear if he will complete this intervention study.

*Ms. X*

Ms. X is an 84 year old Caucasian, right-handed female. Ms. X's primary language is English. Ms. X completed a post-graduate school degree. Before retirement in 1988 Ms. X worked as a teacher and a nurse. Ms. X is married and has four children. In the past Ms. X used a stationary bike pretty regularly. Additionally, she currently uses the computer pretty regularly. Ms. X does not have any experience with video gaming; however, she plays computer games almost daily. Typically Ms. X will play the crossword, solitaire and FreeCell on the computer.

Currently Ms. X attends a chair Yoga class once a week that lasts for 75 minutes. Ms. X walks down four flights of stairs between two and three times per week. Ms. X was diagnosed with colon cancer in 1995. She underwent Chemotherapy and had a very bad reaction, however, the cancer seems to be gone. Additionally, Ms. X has suffered from numerous Transient Ischemic Attacks (TIA) within the last seven years; however, the MRI did not show any abnormalities. Additionally, Ms. X noted that she does suffer from depression. Ms. X indicated that she was not being treated for this depression and had never seen a counselor, psychologist or a psychiatrist.

Ms. X was randomly assigned to the mental exercise condition. Initially she was having trouble logging into the bike and was unable to reach the primary researcher as she was having difficulty with the telephone and had written the number down incorrectly. Currently, Ms. X seems in good fashion and high spirits to complete the intervention. Ms. X has completed all of the questionnaires, the neuropsychological testing session and has been very responsive when communication did occur.

*Mr. X*

Mr. X is a 74 year old Caucasian, right-handed male. Mr. X is married and has five children. Mr. X is a high school graduate and worked as an electrician and in the construction field until he retired in 1994. Currently, Mr. X works part-time at the front desk at Schaffer Heights. Mr. X has very rarely used a stationary bike, however, he uses computer pretty regularly. Furthermore, he has occasionally played video games (such as the Wii and Nintendo) but has very rarely played games on the computer.

Mr. X suffers from type two diabetes and is on a low sugar diet. Additionally, Mr. X has arthritis. Besides his diagnosis with diabetes he is a very healthy man. Recently he joined the YMCA and is exercising there independently three to four times per week. Additionally, Mr. X has not indicated any psychiatric history, nor has he spoke of or listed consuming and psychotropic medication. Currently, Mr. X has completed all of the paperwork and has completed the neuropsychological testing session. Unfortunately, the research team is still waiting to receive consent from his primary doctor. Until consent is given Mr. X's participation in the study has been halted.

*Ms. Y*

Ms. Y is a 63 year old Caucasian, right-handed female. Ms. Y did not complete her high school education, as she left school when she was in the eleventh grade. Ms. Y is married and does not have any children. Mr. Y has been living in Schaffer Heights for the past five years. Additionally, Ms. Y has very rarely used a stationary bike, however, she uses computers almost daily. Furthermore, Ms. Y has had no experience with video gaming, but she plays computer games almost daily.

Physically, Ms. Y suffers from high Cholesterol and has a history of cardiovascular disease. Ms. Y noted that she walks at least once a week from her home into downtown to Schenectady at a normal pace. In addition, Ms. Y climbs four flights of stairs once or twice a

week. Ms. Y also goes bowling once a week for about an hour. Ms. Y noted that she has seen a psychologist once or twice in the past. However, Ms. Y indicated that she did not have any history of anxiety or depression. Nonetheless, Ms. Y noted that she is taking a psychotropic medication Paxol.

Ms. Y was randomly assigned to the cybercycle condition and began exercising at the beginning of May 2012. Ms. Y has reported that the experience was between moderately and extremely fun. Additionally, she stated that she has been extremely interested in scoring points. Finally, on the recording sheet she marked that the game was not boring at all. Currently Ms. Y has been the top exercise in the study. Unfortunately, Ms. Y has suffered from a back injury and has not been able to exercise for the past week. It is unclear if this is a long-term injury that will prevent her from completing the study.

*Ms. Z*

Ms. Z is a 64 year old Caucasian, right-handed female. Ms. Z is married and has four children. Ms. Z completed high school, college and received her master's degree; afterwards she worked as a teacher and librarian for most of her career. Mr. Z's primary language is English. Additionally, Ms. Z has lived in Shaffer Heights for the past six months. Ms. Z has very rarely used a stationary bike and very rarely uses computers. Furthermore, Ms. Z has had no experience with video gaming or computer gaming.

Ms. Z has suffered from limited health issues. It seems that she has only suffered fro high blood pressure, however, it seems to have gone down in the recent years. Additionally, she has no psychiatric history, she only saw a counselor briefly when she went through her first divorce. Ms. Z is not currently taking any medications. The only form of exercise that Ms. Z noted was climbing five flights of stairs between two and four times per week. She also noted that she goes for a longer walk in the mall or to the downtown area but it does not occur with any regularity.

Ms. Z has been randomly assigned to the mental exercise condition. Ms. Z's doctor's consent form was just received and thus she should begin exercising by the end of May.

**Neuropsych at Baseline:**

Overall, the participants had an average education of 13.7 years with a standard deviation of 2.4. Most of the participants excelled on the digit span test, both forwards and backwards (see Table 1, 2 and 3). Additionally, participants did very well on the Fuld test, both on the immediate recall and the 20-minute delay (see Table 1, 2 and 3). There was greater variation among participants on the Color Trails test, as some were above the normative data, while others were below the normative data (see Table 1, 2 and 3).

**Log Results:**

To date, participants are asked record their data after exercising. In addition to recording the data, participants are asked to answer four of the following questions: How fun was the experience, how interested were you in scoring points, how hard was the game and was the game boring. Participants are asked to circle one of five responses: not at all (0), a little (1), moderately (2), quite a bit (3) or extremely (4). Overall, participants in both conditions have stated that the exercise was quite fun, that they were very interested in scoring points, that the game was moderately hard and that they were not bored at all (see Table 4). Additionally, only four of the six participants are actually exercising. The four participants that have begun and continued to exercise have similar data regarding duration and number of sessions (see Table 4). However, participants in the video game condition on average have scored a greater number of points (see Table 4). This can be attributed to the fact that the participants in the video game condition speed is not correlated to amount of energy exerted; therefore, participants are able to score an infinite amount of points without getting physically tired.

# DISCUSSION

Prior research has shown that exercise has the potential to improve cognition (Hall et al, 2001, McAuley, Kramer & Colcombe, 2004, Colcombe & Kramer, 2003 & Kamijo et al, 2009). More resent literature suggests that exercise has the potential to influence and defer cognitive decline among individuals diagnosed with MCI (Baker et al, 2010). However, less research has been conducted regarding the combined mental and physical exercise. Malliot et al (2011) found that participants engaging in combined mental and physical exercise improved significantly on executive control measures and processing speeds after single bouts of exercise. Furthermore, Kurtz et al (2009) found similar results outside of the normal aging population. A study conducted by Anderson-Hanley et al (2012) found greater cognitive benefit from three months of virtual-reality enhanced exercise than physical exercise along among older adults. This finding suggests that for the same effort, interactive physical and mental exercise on a "cybercycle" can yield greater cognitive benefit than physical exercise alone on a stationary bike.

The current study aims to extend upon the prior research regarding the effect of mental and physical exercise on cognition in older adults. Specifically, this study aims to test out the feasibility of conducting a three month long intervention study with normative older adults. This study aims to evaluate the methodology in hopes to be able to transfer the protocol to an MCI sample in the future. Another goal of this study is to tease apart the cybercycle in order to determine if there is something special or synergistic about the interactive mental and physical exercise.

In this study there were six participants all of whom were recruited from Schaffer Heights in Schenectady, NY. Participants were randomly assigned to one of two conditions: mental exercise or mental and physical exercise (cybercycle). Participants were asked to exercise for three to five times per week for 30minutes at a time for three months. The results of the study are

still being gathered, therefore, it is unknown if there is possible differential cognitive outcomes in the cybercycle versus videogame only. These cognitive outcomes will be measured with a pre and post neuropsychological battery. Due to the fact that the results of the study are still being gathered, the majority of this discussion will evaluate the strengths and limitations of this study as well as the future research opportunities.

*Strengths*

This pilot study has evaluated the recruitment strategy, the protocol, the questionnaires, the neuropsychological battery and the duration of the intervention for the videogame condition. This evaluation process has been of the utmost importance. It is necessary for the methodology to be found feasible in order to move forward in creating a larger randomized control trial. Furthermore, it is of great use to have a pilot study, as it is more likely that future research can build upon this and make a case for funding for a larger trial.

Additionally, the diversity in the sample is a strength. It is important in a pilot study to be able to test out the methodology on a wide range of participants in order to be confident that the methodology is sound and to uncover any particular issues in implementing the intervention. The participants in the current study had a variety of experience when it came to computer usage, gaming experience, physical activity and education. Therefore, if all of the participants in this study were able to understand and complete each condition successfully it will shed light on the fact that in a future study there will not need to be restrictions regarding these categories.

Furthermore, conducting a pilot study has allowed the researchers to ask numerous questions regarding the feasibility of a future study. For example, it was of concern if the participants in video game condition would adhere to exercise three to five times a week for three months. Additionally, no literature has shown that this specific video game “Proving Grounds” has ever been used in an intervention study for three months. Goldstein et al (1997)

exposed older adults to a five-week mental exercise intervention program and found significant cognitive benefits, however, participants played "Super Tetris." This mental exercise regime used by Goldstein et al (1997) can be classified as passive. Standen and Brown (2005) found that cognitive benefits were significantly greater with active versus passive participation. In the current study participants are exposed to a long-term mental exercise regimen similar to Goldstein et al (1997). In addition, participants in the current study are engaging in active mental exercise. Another strength of this study is the interactive component of the mental exercise in both conditions. The video game that was used forces participants to think about their location in the game and also encourages them to work hard to score more points. It is of interest to see how participants do with this specific type of video game and if the participants will have enough enjoyment from the video game to continue exercising.

*Limitations*

Ideally in any research study experimenters seek a sample that is homogeneous in many ways, to control extraneous influences. In the current study there was great diversity in the participants medical and psychiatric histories. For example, if this was not a pilot study, but a RCT of exercise effects in older adults, typically Mr. W would not have been able to participate as he is diagnosed with paranoid schizophrenia. The reason researchers typically seek out a homogeneous sample size is due to the fact that comorbid factors can affect the results of the study, for example the impact of the intervention on someone with existing cognitive challenges due to a psychiatric condition, as well as the impact of different medications could affect results. Nonetheless, researchers do not want a sample to be too homogeneous as the results will not be generalizable.

Another limitation to the current study was the communication between the researchers and the participants. Unfortunately, many of the participants could only be reached by their home

telephone as they did not use email with frequency nor did the own a cellphone. Due to these factors many times it was difficult to reach participants in order to check in and help motivate them to keep exercising. Future research could examine different mechanisms to help encourage the participants to continue. For example, the researchers could send letters of encouragement to each participant via mail or email. Additionally, the researchers could leave notes in the log in book every few days. Some notes could say good job, try adding another day of exercising next week, or call the team if you have any questions or concerns. By creating more frequent communication fewer participants may drop from the study.

Finally, one of the biggest limitations of the current study was the low sample size. Initially there were 13 individuals interested in participating in the study, however, only six continued throughout the evaluation process. Furthermore, there were five different recruitment sessions that were held at Schaffer Heights which yielded only 13 potential participants. In a future study it might be necessary to use more than one location as there are only around one hundred individuals living at Schaffer Heights. Additionally, in order to have enough power to conduct inferential statistics to evaluate the impact of interventions would require more participants.

*Future Research*

This pilot study was conducted with the hope to be able to transfer the methodology to a larger MCI sample with three conditions: cybercycle, mental exercise (video game or alternative mental exercise) and physical exercise (stationary bike). As a preliminary step for this project, last summer we placed a cybercycle at Sunnyview Rehabilitation Hospital with the intent of recruiting MCI participants. However, due to a hospital merger that affected IRB processing, this study could not be completed there as hoped. However, patients using the cybercycle in the

meantime have provided anecdotal positive feedback to staff. In the future, a study a Sunnyview would be an excellent option given the ample population of individuals diagnosed with MCI.

Furthermore, a future study may also look at an alternative form of mental exercise. This study has examined only one of many forms of mental exercise, however, it is possible that greater cognitive benefits are produced through a different form of mental exercise. For example this may include watching a television show, playing solitaire, reading the newspaper etc.

The current study aimed to evaluate the feasibility and preliminary cognitive effectiveness (beyond a single bout) of both an interactive combination of physical and mental exercise, and a mental exercise only intervention among independent living older adults. To do this participants were recruited at a local senior living facility in Schenectady, NY and were randomly assigned to one of two conditions: cybercycle or video game. Participants were asked to exercise three to five times per week for three months. Cognitive effectiveness was evaluated using a pre and post neuropsychological battery. Given that the study is still being conducted the results are unknown, however, after the three-month intervention more will be known regarding the use of the cybercycle for improving cognition in older adults. Currently, it is unknown if the benefit from this interactive form of physical and mental exercise is synergistic or if the same results can be obtained from mental exercise alone. From this study, it has been seen that older adults do have the ability to play the “proving grounds” video game. Even more, the participants in the current study have seemed to really enjoy this game (see Table 4). Additionally, it seems feasible, based upon the current status and participation, to move the same methodology and protocol to an MCI sample in the future.

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