DANCING AND THE AGING BRAIN: THE EFFECTS OF A 4-MONTH BALLROOM DANCE INTERVENTION ON THE COGNITION OF HEALTHY OLDER ADULTS

BY

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DISSERTATION

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CHAPTER 1

INTRODUCTION

The world is currently witnessing one of the greatest demographic events of the twentieth century: population aging. The development of new technologies and improvements in health care, combined with decreasing fertility and mortality rates, have favored human longevity. According to the World Health Organization, the proportion of people aged 60 and older is growing faster than any other age group. In 2025, there will be about 1.2 billion people over the age of 60 in the world (World Health Organization [WHO], 2002). Increased longevity involves new demands for policies and services, posing key challenges for governments and for society as a whole. Still more significant are the implications for the individual, given that aging involves progressive changes in a person's physical and mental apparatus. Greater life expectancy leads to an increased incidence of age-related neurodegenerative disorders, sensory impairment, physical disabilities, and functional limitations. However, what seems to most profoundly affect elderly adults is cognitive decline. Although several cognitive domains, such as processing speed, working memory capacity, inhibitory function, and long-term memory are negatively affected by aging, other domains seem to be spared (e.g., verbal abilities, world knowledge or crystallized intelligence, and implicit memory) (Salthouse, 1996; Park & Schwarz, 2000; Park et al., 2001; Park et al., 2002; Ballesteros et al., 2009). Furthermore, declines in cognitive performance seem to be associated with changes in brain structure and white and gray matter integrity (Raz, 2000). For example, studies have demonstrated that age-induced volume reduction is more pronounced in prefrontal gray matter (Raz et al., 2005; Resnick et al., 2003). Correspondingly, performance decrements are usually observed in tasks involving the frontal lobes (Park & Reuter-Lorenz, 2009; Park et al., 2002). In another study, Rosen et al. (2003) observed that low verbal memory scores were associated with smaller entorhinal and hippocampal volumes in elderly individuals.

Epidemiological studies suggest that in addition to genetics, lifestyle and environmental factors such as eating habits, sleep quality, stress management, social contact, and physical activity significantly improve quality of life, increase longevity, and decrease the incidence cognitive impairment (Larson et al., 2006; Hertzog et al., 2009; Yates et al., 2008; Schneiderman et al., 2005). Throughout history, several nonscientific claims have been made that "an active body makes for a healthy mind." Indeed, several studies have documented the critical role of physical activity in preserving healthy brain functioning across the adult lifespan (Spirduso & Clifford, 1978; Voss et al., 2011; Yaffe et al., 2009; Rovio et al., 2010). Studies have examined the influence of aerobic exercise on the aging brain (Kramer et al., 1999; Colcombe & Kramer, 2003; Colcombe et al., 2004), showing that fitness is positively associated with increased volumes in the frontal and temporal cortices (Colcombe et al., 2003, 2006) and in the hippocampi of older adults (Erickson et al., 2009, 2011), and with increased functional connectivity between regions of the default-mode network (Voss et al., 2010). Exercise has also been associated with decreased anxiety (Russo-Neustadt, 2009) and improved mood (Arent et al., 2000), and has been shown to reduce the prevalence of diseases such as Depression, Alzheimer's and Parkinson's disease (Pope et al., 2003, Strawbridge et al., 2002, Blay et al., 2007), as well as deficits induced by stroke (Cotman et al., 2009).

Finally, fitness training has been shown to largely influence various cognitive processes. The largest positive impact is generally observed for executive control processes, such as planning, inhibition, working memory, and multitasking (Colcombe and Kramer, 2003). Dustman et al. (1984) investigated the effects of a 4-month aerobic exercise program on neuropsychological performance (i.e., in tests assessing processing speed, inhibitory control, and memory). Healthy but sedentary elderly participants were randomized to three different groups: an aerobic training group (walking and slow jogging), an exercise control group (strength and flexibility), and a non-exercise control group. The results pointed out to a significantly greater improvement in the neuropsychological test battery for the aerobic group when compared to either control group. Kramer et al. (1999) studied 124 sedentary adults, randomly assigned to either an aerobic exercise group (walking) or a control group (stretching and toning). The results indicated that the aerobic group significantly improved on tasks requiring executive control. Specifically, subjects in the walking group were faster at switching between tasks, showed a decreased attentional interference effect, and were faster at stopping a prepotent response, all of which depend on executive control processes. In an fMRI study, Colcombe et al. (2004) examined the effects of a 6-month aerobic training program on brain activation patterns using the Eriksen flanker paradigm. When compared to control participants (toning and stretching group), participants in the aerobic group (walking) showed a significant increase in activity in areas involved in attentional control and conflict resolution, accompanied by greater reduction in anterior cingulate cortex (ACC) activation. These results suggest that aerobic training leads to increased efficiency of conflict and error monitoring. Prakash et al. (2011) examined the relationship between cardiorespiratory fitness and the recruitment of cortical regions involved in attentional control, using a modified version of the Stroop task. The results indicated that higher fitness levels were associated with better performance in the Stroop task and an increase in prefrontal activation. Interestingly, this increase in neural recruitment was specifically observed for the most challenging task condition, suggesting that fitness is associated with a selective up-regulation resulting from increased task demands. Studies have also suggested that aerobic exercise produces significant changes in ERP patterns of older adults. Dustman et al. (1990) compared younger and older adults with different fitness levels, in terms of electroencephalographic activity (EEG), event-related brain potentials (ERPs) and cognitive measures. The authors observed that performance of older high-fit participants was superior to performance of sedentary age-matched controls. Overall, fitness was associated with better performance despite the age group. However, for the P300 ERP component, fitness differences were exacerbated in the older adults group. Similarly, Hillman et al. (2006), using a task-switching paradigm, demonstrated that high-fit participants (both young and old) had shorter P300 latencies and larger P300 amplitudes than sedentary participants, as well as faster reaction times. These results reflect a beneficial effect of fitness on different aspects of information processing and on the ability to utilize attentional resources.

Although observational (Dik et al., 2003; Rovio et al., 2005; Richards et al., 2003), cross-sectional (Dustman et al., 1990; Hillman et al., 2006; Colcombe & Kramer, 2003), and longitudinal (Colcombe et al., 2004, 2006; Dustman et al., 1984; Erickson et al., 2011) studies support the view of an overall beneficial effect of exercise on brain health, some studies have not been able to replicate such effect (Verghese et al., 2003; Wilson et al., 2002; Yamada et al., 2003). The fact that physical activity parameters (frequency, intensity, and duration) vary across studies might explain the conflicting results in the literature. Another problematic issue is how physical activity is measured. Most epidemiological studies, for example, employ subjective, self-report instruments (Larson et al., 2006; Podewils et al., 2005; Yaffe et al., 2001), which may misestimate activity level. In this context, Parker et al. (2008) argued that an important distinction can be made between studies of structured exercise programs and studies promoting what has been denoted “lifestyle physical activity” (e.g., gardening and cycling). Although the benefits of exercise are well reported and acknowledged, long-term commitment to structured exercise programs is challenging and usually leads to high dropout rates. Thus, engaging in activities that promote an active lifestyle might be more advantageous for older adults (Parker et al., 2008). Verghese et al. (2003) examined the influence of cognitive and physical leisure activities on the risk of developing dementia in a prospective, 21-year study, and reported that dancing was the only physical activity reliably associated with a lower risk of dementia. Among the cognitive activities, reading, playing board games, and playing musical instruments were also associated with a lower risk of dementia. It has been proposed that higher levels of education reduce later susceptibility to dementia due to an increased cognitive reserve (Katzman, 1993; Stern et al., 1999; Stern, 2006). Verghese et al. (2003) argued that participation in leisure activities, similar to education, may increase cognitive reserve, reducing the incidence and delaying the onset of dementia. Yet, an important point must be stressed with respect to the result of the Verghese et al. (2003) study. Dance is not an exclusively physical activity. Like in many other leisure activities, cognitive, social, and physical mechanisms overlap in dance.

Dance is a universal human behavior (Sachs, 1937), deeply linked to our instinctive impulse to communicate and move. In fact, Bramble and Lieberman (2004) suggest that dance may be as old as walking and running. For centuries, the physical, cognitive, intellectual, artistic, and social benefits of dancing have been widely advertised. Dance has also been established as a therapeutic tool for the treatment of Parkinson’s disease (Fallik, 2007; Earhart, 2009; Hackney & Earhart, 2009), overweight children (Murphy et al., 2009) and patients with serious mental illness (Hackney & Earhart, 2010). In more recent years, the growing interest in the study of human movement brought dance into the focus of the cognitive sciences. Since the discovery of mirror neurons in monkeys (Rizzolatti & Craighero, 2004), many studies have investigated equivalent regions in the human brain, providing evidence for a human mirror neuron system or, more broadly, an action observation network (AON; Cross et al., 2009). The brain regions that compose the AON include the supplementary motor area (SMA), the ventral premotor cortex (vPM), the inferior parietal lobule (IPL), and posterior superior temporal sulcus/middle temporal gyrus (pSTS/pMTG) (Rizzolatti et al., 1996). Increasing evidence from behavioral and neuroimaging studies suggest that action understanding might be explained by the covert simulation of another person's movements (Fadiga et al., 1995, 1999; Jeannerod, 2001) and several research groups have used dance learning and observation to understand the AON (Cross, 2010; Cross et al., 2006; Brown et al., 2006). For example, one pioneering study investigated the specificity of the AON for observing one's own movement repertory compared to an unfamiliar and untrained movement repertory (Calvo-Merino et al., 2005). In this study, expert ballet dancers, capoeira dancers, and non-dancer control participants passively viewed ballet and capoeira dance clips while undergoing fMRI scanning. The authors reported significantly greater activity within the AON when dancers observed the movement style consistent with their expertise. A second study by Calvo-Merino and colleagues (2006) examined the effects of visual compared to motor experience on AON activity during action observation and concluded that actual physical experience is a necessary prerequisite for robust activation of the AON. Other studies have addressed different aspects of dance, such as the mental representation of dance movements in long-term memory (Schack, 2004) and goal postures and their role in motor planning (Rosenbaum, 2010).

In addition, studies employing dance as an intervention in old age have focused on improvement of cardiovascular parameters, proprioception, muscle strength, posture, balance, and fall risk (Hopkins et al., 1990; Estivill, 1995; Adiputra et al., 1996; Marmeleira et al., 2009;

Crotts et al., 1996; Shigematsu et al., 2002; Federici et al., 2005; Hui et al., 2009; Kreutz, 2008; Zhang et al., 2008; Sofianidis et al., 2009; McKinley et al., 2008; Krampe et al., 2010), with very few studies addressing cognitive abilities. Verghese (2006) assessed cognitive and motor performance of 24 healthy, older social dancers (mean duration of dancing was 36.5 + 26.5 years, range 3–75 years, median 30 years) compared to 84 non-dancers (matched for age, sex, and education) and did not observe significant differences in cognitive performance between the groups, as measured by a neuropsychological test battery. However, dancing was associated with better balance and gait. Alpert et al. (2009) evaluated the impact of jazz dance class on balance, cognition, and mood (specifically depression) in 13 healthy, community-dwelling older adults, over a 15-week period. Differences in mean scores of the Mini-Mental State Exam (MMSE) and the Geriatric Depression Scale were not significant. However, balance scores showed an increasing trend. Coubard et al. (2011) examined the influence of contemporary dance (CD) on attentional control in 110 healthy older adults. CD was compared to two other motor interventions: fall prevention training and Tai Chi Chuan. Three components of attentional control were assessed through different tests: setting attention (arithmetic word problems), suppressing attention (Stroop test), and switching attention (Rule shift cards sorting test). Results indicated that older adults trained in CD once a week for 5.7 months improved their switching attention. Setting and suppressing attention did not benefit from CD training. In addition, no significant improvements were observed in the other motor training programs. An important aspect of this study is that it focused solely on motor activity, not physical fitness. In other words, cardiovascular and/or strength performance was not measured. Finally, Kattenstroth et al. (2010) studied the impact of multi-year amateur ballroom dancing in a group of 24 healthy elderly subjects who had an average record of regular dancing of 16.5 y ears. Besides analyzing posture and balance parameters, the authors also measured attentional, perceptual, and sensorimotor performance. Results indicated that in each of the different categories investigated, the dance group showed a superior performance when compared to the non-dancer control group. Although the dance group had higher scores in the two tests assessing cognitive performance, namely the Raven Standard Progressive Matrices (RSPM, a measure of fluid intelligence) and the Geriatric Concentration Test (AKT, a non-verbal test of selective attention and concentration), the largest advantage was found for posture and balance parameters, in line with previous findings. In a more recent study, Kattenstroth et al. (2013) investigated the effects of a 6-month senior dance program in a group of 35 healthy older adults. Again, the authors performed a broad assessment, which included measures of cognition, subjective well-being, motor and postural performance, as well as cardiorespiratory fitness. The results indicated that only the dance group, when compared to the control group, improved performance in most of the tasks. Interestingly, dancers showed an overall improvement in cognition. However, no differences were found between groups with respect to cardiorepiratory performance.

1.1 Justification and goal

Given the dramatic demographic changes the world is experiencing, with the elderly population increasing continuously, there is an urgent need for interventions or activities that facilitate an independent lifestyle in old age. Maintenance of independence in elderly individuals has been linked to the concept of "successful aging", describing an avoidance of disease and disability, a preservation of high physical and cognitive function, and a sustained engagement in social and productive activities (Rowe & Kahn, 1997). Similarly, according to the WHO, "health" refers to physical, mental, and social well-being. Thus, for successful, healthy aging, programs that promote mental health and social connections are as important as those that improve physical health (WHO, 2002). In this context, dance emerges as a promising activity for elderly individuals, once it encompasses all these domains. Specifically, dance comprises physical activity, motor coordination, balance, memory, attention, perception, emotions, affection, social interaction, acoustic stimulation, and musical experience. Furthermore, dancing elicits multisite brain activations (Brown et al., 2006), implicating the involvement of widespread interacting brain networks. Finally, dance has a great natural appeal to people, resulting in high compliance with little attrition (Kattenstroth et al., 2010). Thus, advancing the knowledge about the cognitive and functional benefits of dance may enable the planning of future interventions to protect elderly individuals against the deleterious effects of aging.

Very few studies have addressed the effects of dance on the cognition of older adults. As discussed previously, it is well documented that physical fitness is associated with enhanced cognitive abilities. Still, intervention studies employing dance as an aerobic activity and looking into its effects on cognitive measures are still lacking. Thus, given the limited literature on the subject, the present study investigated the effects of a 4-month ballroom dance intervention on different cognitive abilities of healthy older adults, as well as on balance, cardiorespiratory fitness, psychosocial variables, and sleep pattern. To extend the cognitive processes that were examined in previous studies, the present study employed a broad cognitive battery that assessed attention, executive function, working memory, visuomotor coordination, spatial processing, speed of processing, sequential learning, and reasoning.

CHAPTER 2

METHODOLOGY

2.1 Participants

Sixty-five community-dwelling older adults of both genders participated in the study. Participants were recruited as they joined the *Older Adults in Movement* dance project sponsored by the government of Rio de Janeiro, Brazil, and implemented by the Special Division of Healthy Aging and Quality of Life. The government advertises the project via its official website and local media. Participants were also recruited through word of mouth, fliers, and newspaper advertisement. Eligible participants had to (1) be between 60 and 80 years of age, (2) score $\geq$ 24 on the Mini-Mental State Exam (MMSE), a test used to screen for cognitive impairment (Folstein et al., 1975), (3) score $\leq$ 4 on the Geriatric Depression Scale (GDS-15) to rule out possible depression (Sheikh & Yesavage, 1986), (4) have normal color vision, (5) have corrected visual acuity of at least 20/40, (6) report being currently sedentary (which was defined as having been physically active for 30 min or less, no more than two times a week, in the last 6 months), and (7) sign an informed consent form approved by the Institutional Review Board of the University of Illinois. It is important to note that the MMSE score is influenced by the years of education a participant has. Brucki et al. (2003) analyzed a Brazilian sample and proposed reference values for studies evaluating cognition. Therefore, the following values were used in the present study: illiterates = 20 points; 1 – 4 years of education = 25; 5 – 8 years = 26.5; 9 – 11 years = 28; and more than 11 years = 29 points. In addition, participants completed a questionnaire where they were further screened for neurological and psychiatric conditions (e.g., multiple sclerosis, brain tumor, and Parkinson's disease) and the use of any medication that might influence cognition, balance, mood, and/or sleep. The questionnaire was also used to control for frequency of participation in physical and cognitive leisure activities, and ensure that groups were matched with respect to leisure activity profile. Questions were based on a validated leisure activity scale (Verghese et al., 2003). Subjects were interviewed regarding participation in 5 cognitive activities (reading books or newspapers, writing for pleasure, doing crossword puzzles, playing board games or cards, and playing musical instruments) and 6 physical activities (swimming, bicycling, walking, climbing more than two flights of stairs, doing housework, and babysitting). Subjects reported the frequency of participation as “daily,” “several days per week,” “once weekly,” “monthly,” “occasionally,” or “never.” For each activity, subjects received seven points for daily participation; four points for participating several days per week; one point for participating once weekly; and zero points for participating monthly, occasionally, or never. The units of the scales were thus activity-days per week. The activity-days for each activity were summed to generate a cognitive-activity score, ranging from 0 to 35, and a physical-activity score, ranging from 0 to 42.

To comply with the regulations of the Brazilian National Health Council, participants were not compensated for their participation in the study.

2.2 Procedures

Participants were randomly assigned to participate in a ballroom dance group, a no-contact control group, or a walking group. Participants were allocated to the different groups as they joined the study at different moments during subject recruitment and the actual implementation of the dance and walking interventions. Therefore, the interventions started with different numbers of participants in each group. Specifically, the walking group started with 23 participants, the no-contact control group with 24, and the walking group with 8. Subject recruitment and randomization ended when a sample size of 25 was reached in the dance and walking groups and a sample size of 15 in the walking group. Groups were matched for age, years of education, and leisure. Table 1 presents the demographic information for the sample and the results of the ANOVAs performed to assess possible group differences with respect to age, years of education, and leisure activity profile. Participants in the dance and walking groups attended at least 29 sessions from a total of 32 (90% compliance rate).

To assess the effects of the dance intervention on cognitive, cardiorespiratory, functional (i.e., motor), psychosocial, and sleep pattern variables, participants completed the experimental assessment at two time-points: one week before beginning the 4-month intervention and one week after the completion of the intervention. The experimental protocol consisted of a neuropsychological battery, a test of cardiorespiratory fitness, a group of tests used to evaluate balance control, and scales assessing anxiety, psychological well-being, perceived stress, and sleep quality.

2.2.1 Ballroom Dance group

The ballroom dance group met for two hours, two times a week (on nonconsecutive days). Ballroom dance classes were conducted by a certified dance instructor. Classes always started and ended with approximately 5 minutes of stretching exercises for the purpose of warming up and cooling down. Although different rhythms (e.g., samba, bolero) were taught, the methodological structure was always the same. At the beginning of each class, the instructor demonstrated the movement or dance sequence to be worked on during the class. The instructor repeated the sequence several times and the students tried to reproduce it along with the instructor, until the sequence was learned. As soon as the students were able to execute the movement sequence satisfactorily, the instructor put on the musical selection of the day and the students reproduced the trained sequence along with the music (i.e., musicality exercise). Next, the men were arranged in a circle and the women were divided into groups. One at a time, each group of women was called to form dance couples with the men and practice together the dance sequence that had been previously worked on individually. The musical selection was put on again so the couples could dance the sequence to the music. As the sequence was concluded, the men remained at their original positions and the women moved on to the next dance partner, in a counterclockwise direction. This was done until the women reached their initial dance partner. The next group of women was called and the process was repeated. After all the groups of women practiced the dance sequence, the instructor put on different musical selections and the students were encouraged to dance freely (i.e., the students chose the movements and dance steps they wanted to execute). The instructor signaled the partner exchange moments so different dance couples could be formed. By the end of the class, the instructor gathered the students, gave and received feedback.

2.2.2 Walking group

The walking group met for one hour, two times a week (on nonconsecutive days), for four months. A single walking group was formed and, thus, participants walked together. This group served as an active control group and was used to match groups for social contact. Sessions were administered by a professional exercise trainer and took place in a park. In order to match the dance and walking groups in terms of the amount of physical activity performed in each session, a pedometer was used. The average number of steps in a dance class and in a 10-

minute walk was calculated. To match the average of 3,000 steps of a 2-hour dance class, participants would have to walk approximately 40 minutes. Therefore, the following walking routine was established: in the first 2 weeks, participants walked for 20 minutes; five-minute increments were then added each week, until a total of 40 minutes of continuous exercise was reached. Similarly to the dance classes, the walking sessions always started and ended with approximately 5 minutes of stretching exercises.

2.2.3 No-contact group

The no-contact group served as a second passive control group. Participants in the no-contact group only met with the investigator on the two testing occasions and did not interact with one another.

2.3 Cognitive assessment

Cognitive functioning was assessed through a neuropsychological battery, which included a number of computer-based tests that were completed in a Pentium 4 desktop PC (attached to a 15-inch monitor) and in an iPad, and tests that were performed on a foam mat. The PC tests were programmed with the E-prime software (Psychology Software Tools, www.pstnet.com) and the iPad tasks belonged to the BrainBaseline battery (Cognitive Media, 2010), an iPad application that consists of a series of interactive game-based assessments. The BrainBaseline application was translated to Portuguese. Since the PC tests were developed in English, only those tests that do not have a language component (i.e., that do not require recognizing words on the screen during the test) were used in the study. In addition, to ensure participants' comprehension, the investigator went over the instructions of every test, with each participant individually. Each test took 5-15 minutes to complete. During the testing session, participants sat approximately 50 cm from the PC monitor and held the iPad with their hands on both sides and used their thumbs to respond. Participants performed six tests from the BrainBaseline battery, four PC tests, and two tests using the foam mat. The whole assessment took approximately 1 hour to complete. The cognitive tests fell into seven general categories: attention, executive function, working memory, visuomotor coordination, spatial processing, speed of processing, sequential learning, and reasoning. Tests are briefly described below.

2.3.1 Brain Baseline tests

2.3.1.1 Trail Making

This is a test of attention, executive functions, visuomotor coordination, and spatial processing. It is an implementation of the classic Trails A/B test. In the first part (Part A), targets were all numbers and participants used their finger to connect numbered circles in ascending order as quickly as possible, without lifting the finger from the iPad screen. Part one essentially measures processing speed. In the second part (Part B), participants switched between connecting numbers and letters in sequence (e.g., 1–A–2–B–3–C…etc). Part B measures aspects of executive control. Prior to each part, participants completed a practice block consisting of an abbreviated (10 circles instead of 20) version of each task. Practice was followed by a single experimental block. Errors were scored if participants lifted their finger once the task had begun and if they accidentally went out of sequence. Task performance was assessed by the total time taken to complete each part of the test. Additionally, cost measures were created by subtracting the total time in part A from the total time in part B, and errors in part A from errors in part B.

2.3.1.2 Flanker

The Flanker test measures attention and executive functions. Specifically, it measures the ability to respond to relevant information while ignoring irrelevant or conflicting information. At the beginning of each trial, participants were presented with a central fixation cross for 500 ms. Immediately after, a flanker display consisting of 5 arrows was presented for 2000 ms or until a response was made. On half of the trials, the flanking arrows (two on each side) pointed in the same direction as the target arrow (congruent trial; e.g. > > > > >) and on the other half they pointed in the opposite direction (incongruent trial; e.g. > > < > >). Participants were instructed to focus on the central arrow and to report as quickly and accurately as possible whether it pointed to the right or left, while ignoring flanking distractors. Participants completed 20 practice trials followed by 100 test trials. Previous studies have found that subjects respond more slowly (and sometimes less accurately) on incongruent trials, an effect known as flanker interference Response slowing on the incongruent trials has been shown to reduce with fitness training. The dependent measures were Response Time (RT) and accuracy (for each trial type), and flanker interference. Flanker interference was calculated by subtracting RT for compatible trials from RT for incompatible trials. Interference for accuracy was calculated by subtracting accuracy for incompatible from accuracy for compatible trials.

2.3.1.3 Digit Span

This test measures working memory capacity. At the beginning of the block of trials, participants were presented with a black fixation cross for 500 milliseconds. Following the offset of the fixation cross, a single digit appeared at fixation and remained on the screen for 1000 milliseconds. Following the presentation of the first digit, a numeric keypad appeared and participants were instructed to key in the number that they had just been presented with. Directly following this, the next trial began and participants were now presented with two digits centered on fixation, one of which was the one presented on the previous trial, along with a new digit. In this case, the digits remained on the screen for 2000 milliseconds, after which time the numeric keypad appeared and participants again keyed in the numbers they had just seen. This sequence continued, with a single additional number being added on each trial and a 1000 millisecond increase in the presentation duration of the number array, until participants made an error. Following a single error, the test was discontinued. Participants were given one practice block, in which they performed the digit span task either until they made an error or reached a span of five digits. They then completed a single test block. The primary measure of this test was the number of digits correctly remembered.

2.3.1.4 Simple Reaction Time (SRT)

This task measures visuomotor coordination and speed of processing. Participants were instructed to respond as quickly as possible to the appearance of a target stimulus (a red circle) on the screen. At the beginning of the block of trials, participants were presented with a blank screen and were asked to monitor the screen for the presentation of the target. Participants were told to withhold a response until the target appeared, at which point they should respond as quickly as possible with a button press. The presentation of each target was followed by a variable delay period of 3000, 3500, 4000, 4500, 5000, 5500, 6000 ms before the presentation of the next target. No response after a 1500 ms delay and premature responses (i.e., responses made prior to a target appearing) were counted as errors. Participants completed 7 practice trials followed by 21 test trials. Mean Response Time (RT) in correct trials and accuracy were the measures of performance.

2.3.1.5 Spatial Working Memory (SPWM)

This test measures spatial short term memory. Each trial began with the presentation of a central fixation point for 1500 ms. Immediately following central fixation, 2 or 3 black dots appeared on the screen for 500 ms, at locations that were randomly determined on each trial. Participants were told to remember the location of each dot in the memory array. After a 1000 ms delay, a single red probe dot appeared at one location on the screen and participants were asked to determine whether or not the location of this red dot matched one of the locations occupied by one of the black dots in the memory array. On half of the trials, the red probe dot matched the location of one of the memory items. The probe dot remained on the screen for 2000 ms or until the participant responded. Participants completed 8 practice trials, followed by 60 test trials. Overall RT and accuracy were considered the primary measures of performance.

2.3.1.6 Go-No Go

This is a Go–No Go reaction time task that measures speed of processing and inhibition abilities. Participants responded to a centrally presented schematic happy or sad face. Participants responded as quickly as possible with a button press for a happy face (go trials), but withheld their response for the sad face (no–go trials). The delay between faces was varied randomly (500, 640, 800, 950, 1100, 1250, 1400, 1550, 1700, and 1850 ms). Go trials represented 80% of total trials. Participants completed 10 practice trials followed by 50 test trials. Mean RT and accuracy on correct go trials, and accuracy on no-go trials were considered the measures of performance.

2.3.2 PC tests

2.3.2.1 Task Switching

Task switching tests the ability to keep two tasks in mind at once and rapidly switch between tasks. Participants were asked to judge whether a number was odd or even, or whether it was high or low (i.e., larger or smaller than 5). The color of the screen indicated which task participants had to perform on each trial. Randomly, the numbers 1, 2, 3, 4, 6, 7, 8, and 9 were presented, one at a time, for 1500 ms at the center of the screen on a pink or blue background. If the digit was on a blue background, participants had to respond as quickly as possible whether the number was low ("Z" key) or high ("/" key) (<5 was low, >5 was high). If the digit was presented on a pink background, participants had to respond as quickly as possible whether the digit was odd ("Z" key) or even ("/" key). First, participants completed 2 practice single task blocks of 40 trials each (1 block of odd/even and 1 block of high/low), followed by the respective single task blocks (also 40 trials each). Then participants completed a practice dual task block of 64 trials in which they switched from one task to another every five trials. Finally, participants completed a dual task block of 160 trials. During this block, it was randomly determined on each trial whether a trial required participants to respond high/low or odd/even.

An important measure of performance is task-switch cost. Task-switch cost is an index of an aspect of executive control. A smaller switch cost indicates a greater ability to switch between two different tasks. Local switch cost refers to the difference in performance for trials when the preceding trial involved the same task (non-switch trial) and those when the preceding trial was of the other task (switch trial), during the dual task block. Local switch costs were calculated by subtracting the response time (RT) for non-switch trials from the response time for switch trials. Switch cost was also calculated for the accuracy variable, where the accuracy for the switch trials was subtracted from accuracy for the non-switch trials. Global switch cost, on the other hand, refers to the difference in performance between non-switch trials from a dual task block and single trials from a single task block. Performance on non-switch trials is usually slower and less accurate when they are presented in the context of having to periodically switch between tasks (i.e., dual task block) than in a block of all non-switch trials (i.e., single task block). Global switch costs were calculated by subtracting the RT for single trials (single task block) from the RT for non-switch trials (dual task block). Global switch costs were also calculated for the accuracy variable, where the accuracy for the non-switch trials was subtracted from accuracy for the single trials. In addition, RT and accuracy were analyzed for the different trial types (single task trials, non-switch, and switch trials).

2.3.2.2 Dot Comparison

The dot comparison task assesses the speed of visual processing. Participants were required to compare two patterns of dots presented side-by-side as quickly and accurately as possible, and determine whether the two patterns were identical or different. The Z key was pressed if the two patterns were the same, and the / key if they were different. On half of the trials, there was a subtle difference between the two patterns. The task was self-paced with a practice session (one block of 10 trials) and a test session of three blocks (36 trials each) that increased in difficulty (the number of dots making up the patterns increased across blocks: block 1 = 4 dots, block 2 = 6 dots, and block 3 = 8 dots). Performance measures were RT, accuracy, and cost (calculated by subtracting the RT in Block 1, the easiest block, from Block 3, the hardest block, and accuracy in Block 3 from Block 1).

2.3.2.3 Manual Sequence

This task measures sequential learning. Participants viewed a display with four rectangles and a star presented inside one of the four rectangles. Participants were instructed to respond as quickly as possible by pressing the key corresponding to the rectangle with a star inside. The keys that corresponded to the four squares were: V, B, N, and M. Participants used their index finger to press V (corresponding to the first rectangle), their middle finger to press B (corresponding to the second rectangle), their ring finger to press N (corresponding to the third rectangle), and their pinky to press M (corresponding to the fourth rectangle). A sequence of 10 locations of stars was randomly generated for each participant and repeated for 20 cycles. A learning effect index was created by subtracting the mean RT of the last sequence from that of first sequence, and the mean accuracy of the first sequence from that of the last. Overall RT and accuracy were also calculated.

2.3.2.4 Raven's Matrices

Raven's Advanced Matrices is a reasoning test. Participants were presented with a complex visual pattern with a piece cut out of it. The task was to indicate the missing piece that completed the pattern. The full version of the Raven's was divided into two sub-tests of approximately equal difficulty, with each test containing 18 items. One sub-test was administered before the intervention and the other sub-test, at the end of the intervention. The administration order of the sub-tests was counterbalanced across subjects. In each sub-test participants were given two practice questions. The test was self-paced and participants had 10 minutes to complete each 18-item sub-test. The primary measure of performance is overall accuracy.

2.3.3 Memory Span tests

Two foam mats made up of separate, interlocking tiles were used in two different memory span tasks. One mat included tiles with pop-out numbers (1 through 9) and the other mat consisted of nine solid colored tiles.

2.3.3.1 Forward Memory Span: participants heard a series of numbers and were asked to remember them in sequence. Participants were then instructed to repeat the sequence by stepping on the numbers on the mat. After each correct response, a single number was added to the sequence, and the test continued until participants made a mistake. The number of digits correctly remembered was recorded.

2.3.3.2 Spatial Forward Memory Span: the investigator presented a sequence by stepping on different colored squares and participants were instructed to repeat the sequence (i.e., step on the exact same squares). Again, after each correct response, an additional spatial location was included in the sequence, and the test continued until participants made a mistake. The number of spatial locations correctly remembered was recorded.

2.4 Cardiorespiratory fitness assessment

Participants completed the Rockport 1-mile walking test, a measure of cardiovascular fitness appropriate for older adults. The Rockport test highly correlates with other estimates of maximal oxygen uptake (VO_{2max}). Specifically, the test's validity coefficients (ranging from r =

0.88 to r = 0.92) compare favorably to those of other VO_{2max} prediction tests (Kline et al., 1987). The formula that generates the final VO_{2max} estimate takes into account: age, gender, weight, heart rate (HR), and time to complete the 1-mile walk.

2.5 Functional assessment: balance control

Two tests were used to measure balance: the Berg Balance Scale (BBS, Berg et al., 1989) and the Timed Up-and-Go test (TUG, Podsiadlo & Richardson, 1991). The BBS is a 14-tem scale designed to measure balance in older adults. Performance is assessed in tasks such as standing unsupported, sitting unsupported, standing with eyes closed, standing with feet together, reaching forward with outstretched arm, retrieving object from the floor, turning 360 degrees, standing on one foot, among others. The total score ranges from 0 to 56 points and the lower the score, the greater the risk of falls. The TUG is a measure of mobility. The test measures, in seconds, the time taken by an individual to stand up from an arm chair, walk a distance of 3 meters, turn, walk back to the chair, and sit down. Participants wear their regular footwear and no physical assistance is given. Participants walk through the test once before being timed in order to become familiar with the test. The normal time required to finish the test is between 7–10 seconds. Higher values of time and number of steps represent a higher risk of falls.

2.6 Psychosocial assessment: anxiety, psychological well-being, and perceived stress

2.6.1 The Beck Anxiety Inventory (BAI, Beck et al., 1988) was used to assess participants' anxiety levels. The BAI is a 21-item multiple-choice, self-report inventory. The items describe emotional, physiological, and cognitive symptoms of anxiety (e.g., numbness, hot and cold sweats, and feelings of dread). Participants were asked to report the extent to which they had experienced each of the 21 symptoms in the week of the assessment. Each item had four possible answer choices: Not at All, Mildly, Moderately, and Severely. The following values were assigned to each response: Not at All = 0; Mildly = 1; Moderately = 2, and; Severely = 3. The values of the 21 items were then summed, yielding a total score ranging between 0 and 63 points. Higher scores indicated higher anxiety levels. The version of the BAI that was used had been translated and validated for the Brazilian population.

2.6.2 Ryff's Psychological Well-Being Scales (Ryff, 1989) is a theoretically grounded, self-report instrument that measures multiple facets of psychological well-being. It consists of 84 statements (original version) reflecting six dimensions of psychological well-being: autonomy, environmental mastery, personal growth, positive relations with others, purpose in life, and self-acceptance. Items from the separate dimensions are mixed into one continuous scale. Participants rated statements about how they felt about themselves and their lives, using a six-point format: strongly disagree (1), moderately disagree (2), slightly disagree (3), slightly agree (4), moderately agree (5), strongly agree (6). Each dimension was scored separately, by summing up the values of the 14 statements belonging to each dimension. High scores indicated high self-ratings on that dimension. A version in Portuguese was used.

2.6.3 The Perceived Stress Scale (PSS, Cohen et al., 1983) is a measure of the degree to which situations in one's life are appraised as stressful. The items are designed to tap how unpredictable, uncontrollable, and overloaded participants find their lives. In each of 14 questions, participants were asked to estimate how often they felt a certain way during the previous month using a scale of 0 to 4, with 0 indicating "never" and 4 indicating "very often". An overall score was obtained by reversing responses to the four positively stated items (items 4, 5, 7, & 8) and then summing across all scale items. High scores indicated high stress levels. The PSS has been translated to Portuguese and has been specifically validated for elderly subjects.

2.7 Sleep pattern assessment

The Pittsburgh Sleep Quality Index (PSQI, Buysse et al., 1989) is commonly used to assess the quality and patterns of sleep in older adults. It measures seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction over the last month. Participants self-rated each of these seven components of sleep. Scoring of the answers was based on a 0 (no difficulty) to 3 (severe difficulty) scale, where 3 reflected the negative extreme. The component scores were then summed to produce a global score, ranging from 0 to 21. Higher scores indicated worse sleep quality. A version in Portuguese, validated for the Brazilian population, was used.

2.8 Predictions

Studies have shown that executive control processes, including multi-tasking, working memory, and inhibition, show the largest benefit from aerobic training in late life (Colcombe & Kramer, 2003; Colcombe et al., 2004; Kramer et al., 1999). Given that dancing is also an aerobic activity, the first prediction of the study was that both dancers and walkers would show improvements in the tasks that involved executive functions: Trails, Flanker, Digit Span, Spatial Working Memory, Go-No Go, Task Switching, and the Memory Span tasks performed with the feet.

Performance in simple reaction time tasks, such as Simple Reaction Time, and in the Dot Comparison task, which measures speed of visual processing, depends less on executive control processes. However, Colcombe & Kramer (2003) demonstrated that even these categories of tasks show reliable benefits from fitness training (even if to a lesser extent). In addition, electrophysiological studies (Hillman et al., 2004; Dustman et al., 1990) have shown that adults that engage in aerobic exercise exhibit faster P3 latency, which suggests that aerobic exercise may influence processing speed. Given these findings, another prediction was that the dance and walking groups would both show improvements in the Simple Reaction Time and Dot Comparison tasks after the intervention, when compared to the no-contact control group.

Learning coordinated movement sequences, as well as decision-making and thinking abstractly (both of which are reasoning skills), are cognitive abilities that are involved in dancing. In this context, a third prediction of the study was that only dancers, when compared to walkers and no-contact controls, would show improvements in the Sequential Learning task and in the Raven's Matrices task.

Finally, improvements in the functional (balance), psychosocial (anxiety, psychological well-being, and stress), sleep pattern, and cardiorespiratory fitness variables would be observed in the dance and walking groups. No difference would be observed in the no-contact group in any of these variables.

2.9 Chapter 2 Table

Table 1 – Sample Demographics

Group	N	Age	Education	Leisure	
				Cognitive	Physical
Dance	25 (4 men)	69.36 (7.02)	13.04 (3.63)	8.76 (5.29)	9.56 (4.55)
No-contact	25 (1 man)	68.40 (7.56)	11.84 (4.06)	7.12 (5.51)	11.12 (4.91)
Walking	15 (0 men)	66.66 (7.78)	12.00 (3.09)	7.46 (3.20)	11.40 (4.48)
ANOVA result		p = .569	p = .139	p = .488	p = .378

Means and SDs (in parentheses) are given.

CHAPTER 3

RESULTS

To test these predictions, mean RT (only of correct trials) and accuracy values of the cognitive tests, and the scores of the cardiorespiratory test, functional tests, psychosocial, and sleep pattern scales were entered into repeated measures analyses of variance (ANOVAs) separately, with Group (Dance x No-contact x Walking) as the between-subjects factor and Time-point (Pre x Post) as the within-subjects factor. Outliers (i.e., participants with scores outside the range of 2 standard deviations from the mean) were removed from the analyses (Zimmerman, 1994). Analyses were conducted using SPSS (Version 20). Effect sizes, as measured by partial eta-squared (η^2_p), were computed. The significance level was set at $p < 0.05$. Of interest were significant Group x Time-point interactions, which are reported below. Other significant results were not included here, since differences between groups as a function of the intervention were the main focus of the study. Table 2 summarizes the results of the analyses performed for the measures of each task, across the 3 groups, and Table 3 shows group performance scores. The number of subjects included in each analysis is given in Table 2. In addition, the results of each task are described separately. Mean and Standard Error (SE) are plotted for each variable analyzed. Practice blocks were not included in any of the analyses.

3.1 Cognitive assessment

3.1.1 BrainBaseline tests

3.1.1.1 Trail Making

Separate repeated measures ANOVAs were run for Total Time and Errors, for parts A and B, with Time-point as the within-subjects factor. No significant Group x Time-point interactions were observed for Total Time in part A ($p = .544$), Total Time in part B ($p = .240$), Errors in part A ($p = .186$), or Errors in part B ($p = .663$). For the cost analyses, no Group x Time-point interactions were observed for Total Time ($p = .884$) or Errors ($p = .928$).

3.1.1.2 Flanker

RT and accuracy data were entered in repeated measures ANOVAs with Group as the between-subjects factor, and Time-point and Condition (congruent x incongruent) as within-subjects factors. For RT, there were no significant Group x Time-point ($p = .845$) or Group x Time-point x Condition ($p = .180$) interactions. The same pattern of results was observed for accuracy: no significant Group x Time-point ($p = .313$) or Group x Time-point x Condition ($p = .667$) interactions. Interference data were analyzed through a repeated measures ANOVA with Group as the between-subjects factor and Time-point and as the within-subjects factor. No Group x Time-point interactions were observed for RT interference ($p = .650$) or accuracy interference ($p = .124$).

3.1.1.3 Digit Span

No significant Group x Time-point interaction was observed with respect to the number of digits remembered ($p = .995$).

3.1.1.4 Simple Reaction Time (SRT)

RT and accuracy data were analyzed in separate repeated measures ANOVAs. The analyses did not reveal any significant Group x Time-point interactions for RT ($p = .638$) or accuracy ($p = .178$).

3.1.1.5 Spatial Working Memory (SPWM)

RT and accuracy data were entered in repeated measures ANOVAs with Group as the between-subjects factor, and Time-point and Condition (match x no-match) as within-subjects factors.

The RT ANOVA revealed no significant Group x Time-point ($p = .863$) or Group x Time-point x Condition ($p = .851$) interactions. The same pattern was observed for the accuracy data, with no significant Group x Time-point ($p = .186$) or Group x Time-point x Condition ($p = .327$) interactions.

3.1.1.6 Go-No Go

Go RT, Go accuracy, and No-go accuracy data were entered in separate repeated measures ANOVAs with Group as the between-subjects factor and Time-point as the within-subjects factors.

The RT analysis did not reveal a significant Group x Time-point interaction ($p = .559$). Similarly, the accuracy analyses did not reveal any Group x Time-point interaction for Go accuracy ($p = .856$) or No-go accuracy ($p = .249$).

3.1.2 PC tests

3.1.2.1 Task Switching

Separate repeated measures ANOVAs were run for the RT and accuracy measures, with Group as the between-subjects factor, and Time-point and Trial Type (single task trials x non-switch trials x switch trials) as within-subjects factors.

No significant Group x Time-point interaction was observed for RT ($p = .958$) or accuracy ($p = .103$). Similarly, there were no significant Group x Time-point x Trial Type interactions for RT ($p = .404$) or accuracy data ($p = .134$).

Local cost data were entered into repeated Measures ANOVAS but no significant Group x Time-point interactions were observed for either RT ($p = .606$) or accuracy ($p = .644$). In addition, no significant Group x Time-point interactions were observed for global RT cost ($p = .157$) or global accuracy cost ($p = .093$).

3.1.2.2 Dot Comparison

RT and accuracy were analyzed in separate repeated measures ANOVAs. Difficulty was included as an additional within-subjects factor. In the RT analysis, there were no significant Group x Time-point ($p = .746$) or Group x Time-point x Difficulty ($p = .380$) interactions. The accuracy analyses revealed a different pattern of results. Although there was no significant Group x Time-point x Difficulty ($p = .060$) interaction, a significant Group x Time-point interaction [$F(2,62) = 6.53$, $p = .003$, $\eta^2_p = .174$] was observed (Figure 1). Post-hoc analyses indicated that the groups did not differ at pre-testing [$F(2,62) = .254$, $p = .776$, $\eta^2_p = .008$], but at post-testing the dance group was significantly more accurate than the no-contact group ($p = .050$). The dance and walking groups did not differ at post-testing ($p = .527$), nor did the no-contact and walking groups ($p = .648$). The cost analysis was not significant for the Group x Time-point interactions for RT ($p = .071$) or accuracy ($p = .480$).

3.1.2.3 Manual Sequence

Mean RT and mean accuracy were entered in repeated measures ANOVAs with Group as the between-subjects factor and Time-point as the within-subjects factor. The RT analysis did not reveal a significant Group x Time-point interaction ($p = .951$). Similarly, no Group x Time-point interaction was observed for accuracy ($p = .615$). In addition, no significant Group x Time-point interaction was observed in the RT learning index ANOVA ($p = .610$) or in the accuracy learning index ANOVA ($p = .936$).

3.1.2.4 Raven's Matrices

Accuracy data were analyzed with Group as the between-subjects factor and Time-point as the within-subjects factor. A significant Group x Time-point interaction [$F(2,58) = 6.47$, $p = .003$, $\eta^2_p = .177$] was observed (Figure 2). Post-hoc analyses indicated that the groups did not differ at pre-testing [$F(2,58) = 1.27$, $p = .287$, $\eta^2_p = .041$], but at post-testing the dance group was significantly more accurate than the no-contact group ($p = .010$). The dance and walking groups did not differ at post-testing ($p = .789$), nor did the no-contact and walking groups ($p = .130$).

3.1.3 Memory Span tests

Scores were entered in separate repeated measures ANOVAs with Group as the between-subjects factor and Time-point as the within-subjects factor.

3.1.3.1 Forward Memory Span

A significant Group x Time-point interaction [$F(2,62) = 26.80$, $p < .001$, $\eta^2_p = .464$] was observed (Figure 3). Post-hoc analyses indicated that the groups did not differ at pre-testing [$F(2,62) = .113$, $p = .893$, $\eta^2_p = .004$], but at post-testing the performance of the dance group improved significantly when compared to the no-contact ($p < .001$) and walking ($p < .001$) groups. The no-contact and walking groups did not differ at post-testing ($p = .971$).

3.1.3.2 Spatial Forward Memory Span

Similarly, a significant Group x Time-point interaction [$F(2,62) = 48.62$, $p < .001$, $\eta^2_p = .611$] was observed in the spatial locations sub-task (Figure 4). Post-hoc analyses indicated that the groups did not differ at pre-testing [$F(2,62) = .669$, $p = .516$, $\eta^2_p = .021$], but the performance of the dance group improved significantly over time, when compared to the no-contact ($p < .001$) and walking ($p < .001$) groups. The no-contact and walking groups did not differ at post-testing ($p = .536$).

3.2 Cardiorespiratory fitness assessment

Estimated VO_2 scores from the Rockport 1-mile walking test were analyzed in the same way as the previous data. A significant Group x Time-point interaction was observed [$F(2,62) = 7.71$, $p = .001$, $\eta^2_p = .199$]. Post-hoc analyses indicated that there were no differences between groups at pre-testing [$F(2,62) = .160$, $p = .852$, $\eta^2_p = .005$] but the dance group and the walking group both improved at post-testing in relation to the no-contact group ($p < .001$ and $p = .010$, respectively), and were not different from each other ($p = .906$). Figure 5 illustrates this result.

3.3 Functional assessment: balance control

BBS and TUG scores were analyzed in separate ANOVAs. The analyses did not reveal any significant Group x Time-point interactions for the BBS ($p = .743$) or the TUG ($p = .502$).

3.4 Psychosocial assessment: anxiety, perceived stress, and psychological well-being

3.4.1 BAI scores were analyzed and a significant Group x Time-point interaction was observed [F(2,62) = 21.15, p < .001, η^2_p = .406]. Post-hoc analyses showed that groups did not differ at pre-testing [F(2,62) = .077, p = .926, η^2_p = .002] and that the score of the dance group decreased significantly across time-points, as illustrated by Figure 6. Specifically, the mean score of the dance group was significantly lower than the score of the no-contact (p = .001) and walking (p = .005) groups. The no-contact and walking groups were not different from each other at post-testing (p = .990).

3.4.2 The same pattern of results was observed in the PSS analysis. There was a significant Group x Time-point interaction [F(2,62) = 29.62, p < .001, η^2_p = .489] and subsequent analyses showed that groups were not different at pre-testing [F(2,62) = .310, p = .735, η^2_p = .010] but the score of the dance group was significantly lower at the second time-point when compared to the no-contact (p < .001) and walking (p < .001) groups. The no-contact and walking groups did not differ from each other (p = .466). Figure 7 illustrates the result.

3.4.3 Scores of the six distinct dimensions of psychological well-being that comprise the Ryff scales (autonomy, environmental mastery, personal growth, positive relations with others, purpose in life, and self-acceptance) were analyzed in separate ANOVAs.

A significant Group x Time-point interaction was observed for autonomy [F(2,62) = 12.08, p < .001, η^2_p = .281], positive relations with others [F(2,62) = 23.83, p < .001, η^2_p = .435], and self-acceptance [F(2,62) = 29.74, p < .001, η^2_p = .360] (Figure 8). Post-hoc analyses indicated that groups were not different at pre-testing for autonomy [F(2,62) = 1.02, p = .366, η^2_p = .032], positive relations with others [F(2,62) = .757, p = .473, η^2_p = .024], and self-acceptance [F(2,62) = .304, p = .739, η^2_p = .010]. However, the score of the dance group increased significantly across time-points in these dimensions. For autonomy, the dance group scored significantly higher than the no-contact ($p = .005$) and walking ($p = .015$) groups at post-testing, and the no-contact and walking groups did not differ from each other ($p = 1.00$). Similarly, for positive relations with others, the dance group significantly differed from the no-contact ($p = .001$) and walking ($p = .055$) groups, but the no-contact and walking groups did not differ from each other ($p = .535$). Finally, for self-acceptance, the dance group scored significantly higher when compared to the no-contact ($p < .001$) and walking ($p = .048$) groups, but the no-contact and walking groups did not differ from each other ($p = .419$).

No significant interactions were observed for the three other dimensions: environmental mastery ($p = .335$), personal growth ($p = .338$), and purpose in life ($p = .813$).

3.5 Sleep pattern

As in the previous analyses, PSQI scores were entered in a repeated measures ANOVA with Group as the between-subjects factor and Time-point as the within-subjects factor. The analysis showed a significant Group x Time-point interaction [$F(2,62) = 30.02$, $p < .001$, $\eta^2_p = .492$] and post-hoc analysis indicated that groups did not differ at pre-testing [$F(2,62) = 2.90$, $p = .062$, $\eta^2_p = .086$] but the score of the dance group decreased significantly at post-testing when compared to the walking group ($p = .018$). The dance and no-contact groups did not differ from each other ($p = .089$), nor did the no-contact and walking groups ($p = .615$).

3.6 Additional analyses

3.6.1 Analysis of Covariance (ANCOVA)

Although groups were not statistically different with respect to the years of formal education received, the dance group was, on average, two years more educated than the no-contact group. Therefore, in order to control for possible education effects, analyses of covariance (ANCOVAs) were run for all the measures in the study, with Group and Time-point as fixed factors and Education as a covariate. The results of the ANCOVAs did not differ from the results of the ANOVAs and, thus, are not reported here.

3.6.2 Perception of Improvement

At the conclusion of the intervention, subjects were asked whether they thought they had improved in each of the domains assessed in the study (i.e. cognitive, functional, psychosocial, and sleep pattern). There were three possible answer choices: Yes (if participants thought their performance clearly improved after 4 months), No (if participants thought it did not improve), and Unsure (if participants did not remember how they had performed 4 months before or if they were not sure their performance had improved). Possible differences between groups with respect to their perception of improvement in each domain were then analyzed. Due to the relatively small sample size of the walking group (which would consequently yield expected frequencies smaller than 5), and in order to provide reliable results, Fisher's Exact Test was used as an alternative to the Chi-Square test.

There was no significant association between group and perception of improvement in any of the domains analyzed: cognitive ($p = .950$), functional ($p = .965$), psychosocial ($p = .680$), and sleep pattern ($p = .377$). Figure 10 illustrates the percentage frequency distribution of each response, in each group, and for each domain.

3.6.3 Principal Components Analysis (PCA)

Despite the lack of statistically significant results described previously, data from the BrainBaseline cognitive battery was further analyzed using Principal Components Analysis (PCA). For each* task, the measures that best represented the underlying cognitive constructs were selected for the purpose of the PCA. A total of eight measures were selected: RT cost (Part B – Part A) from the Trail Making task; RT interference from Flanker task, memory span score from the Digit Span task; mean RT from the Simple Reaction Time (SRT) task; accuracy on match and no-match trials from the SPWM task; Go RT and No-go accuracy from the Go-No Go task. Only data from the first time-point were included in the PCA.

PCA was conducted with orthogonal rotation (varimax) on the eight selected measures. Bartlett's test of sphericity χ^2 (28) = 47.40, p = .012, indicated that correlations between measures were sufficiently large for PCA. Three components had eigenvalues over Kaiser's criterion of 1 and in combination explained 58.66% of variance. The loadings of each measure suggest that component 1 corresponded to processing speed (Go RT, mean RT from the Simple Reaction Time task), component 2 corresponded to executive functions (Trail Making RT cost, Flanker RT interference), and component 3 corresponded to memory (SPWM match and no-match accuracy). Digit Span score and No-go accuracy had loadings < .40 and were, thus, discarded. Table 4 shows the final factor loadings after rotation.

The results from the PCA were used to form composite scores that corresponded to the three specific cognitive domains (as expressed by the three PCA components). Composite scores were calculated for processing speed, executive functions, and memory by summing the standardized z scores from each of the relevant tasks. Subsequent repeated-measures ANOVAs were performed using these composite scores. However, no significant Group X Time-point interactions were observed for the processing speed ($p = .445$), executive functions ($p = .984$), and memory ($p = .787$) composite scores.

3.7 Chapter 3 Figures and Tables

Table 2 – Summary of main results

Measure		Group x Time-Point	Group x Time-Point x Condition	N
Trail Making	Total Time A	p = .122, F = 2.18, df = (2,53)		D = 20, NC = 23, W = 13
	Total Time B	p = .279, F = 1.30, df = (2,54)		D = 21, NC = 23, W = 13
	Errors A	p = .544, F = .616, df = (2,57)		D = 23, NC = 24, W = 13
	Errors B	p = .240, F = 1.46, df = (2,55)		D = 22, NC = 23, W = 13
	Cost Time	p = .977, F = 0.23, df = (2,54)		D = 20, NC = 24, W = 13
	Cost Errors	p = .494, F = .714, df = (2,54)		D = 22, NC = 22, W = 13
Flanker	RT	p = .845, F = .169, df = (2,53)	p = .180, F = 1.77, df = (2,53)	D = 20, NC = 23, W = 13
	Acc	p = .313, F = 1.19, df = (2,51)	p = .667, F = .408, df = (2,51)	D = 21, NC = 22, W = 11
	RT Interference	p = .650, F = .434, df = (2,54)		D = 21, NC = 23, W = 13
	Acc Interference	p = .124, F = 2.16, df = (2,54)		D = 21, NC = 23, W = 13
Digit Span	Number of Digits	p = .995, F = .005, df = (2,56)		D = 24 NC = 22 W = 13
Speed	RT	p = .638, F = .452, df = (2,58)		D = 25, NC = 23, W = 13
	Acc	p = .178, F = 1.77, df = (2,57)		D = 24, NC = 23, W = 13
SPWM	RT	p = .863, F = .147, df = (2,53)	p = .851, F = .161, df = (2,53)	D = 23, NC = 20, W = 13
	Acc	p = .186, F = 1.73, df = (2,50)	p = .327, F = 1.14, df = (2,50)	D = 21, NC = 19, W = 13
PMS	Go RT	p = .599, F = .588, df = (2,54)		D = 22, NC = 22, W = 13
	Go Acc	p = .856, F = .156, df = (2,55)		D = 23, NC = 22, W = 13
	No-Go Acc	p = .249, F = 1.42, df = (2,51)		D = 21, NC = 22, W = 11
Task Switching	RT	p = .958, F = .043, df = (2,61)	p = .404, F = 1.01, df = (4,122)	D = 25, NC = 24, W = 15
	Acc	p = .103, F = 2.35, df = (2,61)	p = .280, F = 1.28, df = (4,122)	D = 24, NC = 25, W = 15
	Local cost RT	p = .606, F = .505, df = (2,62)		D = 25, NC = 25, W = 15
	Local cost Acc	p = .644, F = .443, df = (2,58)		D = 25, NC = 25, W = 11
	Global cost RT	p = .157, F = 1.91, df = (2,62)		D = 25, NC = 25, W = 15
	Global cost Acc	p = .093, F = 2.47, df = (2,62)		D = 25, NC = 25, W = 15
Dot	RT	p = .746, F = .294, df = (2,57)	p = .380, F = 1.06, df = (4,114)	D = 20, NC = 25, W = 15
	Acc	p = .003 *, F = 6.53, df = (2,62)	p = .060, F = 2.77, df = (4,124)	D = 25, NC = 25, W = 15
	Cost RT	p = .071, F = 2.75, df = (2,62)		D = 25, NC = 25, W = 15
	Cost Acc	p = .480, F = .504, df = (2,62)		D = 25, NC = 25, W = 15
Manual Sequence	RT	p = .951, F = .050, df = (2,58)		D = 22, NC = 24, W = 15
	Acc	p = .615, F = .490, df = (2,62)		D = 25, NC = 25, W = 15
	Learning Index RT	p = .610, F = .499, df = (2,59)		D = 23, NC = 24, W = 15
	Learning Index Acc	p = .936, F = .066, df = (2,62)		D = 25, NC = 25, W = 15
Ravens	Acc	p = .003 *, F = 6.47, df = (2,58)		D = 24 NC = 22 W = 15
Memory Span	Digits	p < .001 *, F = 26.80, df = (2,62)		D = 25 NC = 25 W = 15
	Spatial Locations	p < .001 *, F = 48.62, df = (2,62)		
Cardio-respiratory Fitness	Rockport	p = .001 *, F = 7.71, df = (2,62)		D = 25 NC = 25 W = 15
Functional	BBS	p = .743, F = .298, df = (2,62)		D = 25 NC = 25 W = 15
	TUG	p = .502, F = .697, df = (2,62)		

Table 2 (cont.)

Psychosocial	BAI	p < .001 *, F = 21.15, df = (2,62)	
	PSS	p < .001 *, F = 29.62, df = (2,62)	
	Ryff AU	p < .001 *, F = 12.08, df = (2,62)	D = 25
	PRO	p < .001 *, F = 23.83, df = (2,62)	NC = 25
	SA	p < .001 *, F = 29.74, df = (2,62)	W = 15
	EM	p = .335, F = 1.11, df = (2,62)	
	PG	p = .338, F = 1.10, df = (2,62)	
	PL	p = .813, F = .208, df = (2,62)	
Sleep Pattern	PSQI	p < .001 *, F = 35.36, df = (2,62)	D = 25 NC = 25 W = 15
Perception of Improvement	Cognitive	p = .950	D = 25
	Functional	p = .965	NC = 25
	Psychosocial	p = .680	W = 15
	Sleep pattern	p = .377	
PCA Composite scores	Processing Speed	p = .445, F = .821, df = (2,60)	D = 23, NC = 25, W = 15
	Executive Functions	p = .984, F = .016, df = (2,58)	D = 23, NC = 23, W = 15
	Memory	p = .787, F = .241, df = (2,59)	D = 23, NC = 24, W = 15

RT = Response Time, Acc = Accuracy, D = Dance, NC = No-contact, W = walking, AU = Autonomy, PRO = Positive Relations with Others, SA = Self-acceptance, EM = Environmental Mastery, PG = Personal Growth, PL = Purpose in Life. * indicates a statistically significant result (p < .05) favoring the dance group.

Table 3 – Group means across all cognitive tasks. Standard errors are shown in parentheses.

Measure		Pre-Testing			Post-Testing		
		Dance	No-Contact	Walking	Dance	No-Contact	Walking
Trail Making	Total Time A	70072.47 (6541.20)	83654.83 (5576.37)	87469.42 (9753.49)	90453.04 (10321.21)	89621.41 (7194.37)	75232.53 (7506.84)
	Total Time B	112262.65 (10730.94)	114656.08 (9777.54)	113770.46 (17415.92)	118479.56 (12251.64)	109579.00 (9603.42)	102963.92 (18381.49)
	Errors A	7.50 (.961)	7.20 (1.02)	10.61 (1.26)	8.91 (1.84)	6.13 (.887)	9.50 (1.45)
	Errors B	7.50 (.861)	9.56 (1.28)	10.14 (1.27)	8.39 (1.33)	7.45 (.916)	7.14 (.837)
	Cost Time	37167.87 (13616.08)	29761.20 (12722.31)	30705.07 (17764.27)	21571.0476 (13114.13)	19957.5833 (8734.22)	25750.5714 (14926.61)
	Cost Errors	.21 (1.13)	2.50 (1.39)	-.38 (1.10)	.66 (1.38)	1.52 (1.03)	-2.35 (1.36)
Flanker	RT Congruent	702.94 (33.84)	686.43 (27.58)	786.35 (46.74)	673.98 (19.83)	675.98 (41.44)	711.08 (34.87)
	RT Incongruent	699.29 (30.01)	683.03 (22.48)	796.54 (43.07)	705.09 (22.96)	687.08 (41.32)	787.81 (53.33)
	Acc Congruent	.96 (.009)	.95 (.017)	.94 (.017)	.97 (.008)	.90 (.049)	.91 (.048)
	Acc Incongruent	.95 (.010)	.91 (.025)	.93 (.037)	.96 (.008)	.89 (.049)	.91 (.047)
	RT Interference	-34.04 (49.59)	-3.40 (12.22)	10.18 (26.15)	31.10 (7.45)	11.10 (10.33)	71.24 (43.95)
	Acc Interference	.007 (.006)	-.008 (.028)	.075 (.062)	.006 (.005)	.007 (.0108)	-.067 (.064)
Digit Span	Number of Digits	5.45 (.561)	5.28 (.358)	5.38 (.289)	5.60 (.483)	5.22 (.278)	5.30 (.346)
Speed	RT	502.87 (25.96)	415.74 (16.08)	467.92 (28.97)	473.52 (27.44)	416.88 (15.00)	458.41 (25.07)
	Acc	.96 (.013)	.93 (.018)	.90 (.036)	.89 (.041)	.96 (.013)	.90 (.036)
SPWM	RT Match	1057.80 (39.60)	905.97 (45.33)	893.09 (66.62)	1054.25 (46.28)	940.10 (42.16)	902.63 (66.68)
	RT No-Match	1132.38 (48.10)	983.81 (46.79)	958.91 (54.41)	1113.58 (42.94)	977.65 (47.33)	964.74 (57.42)
	Acc Match	.74 (.029)	.59 (.044)	.65 (.052)	.80 (.032)	.68 (.043)	.63 (.054)
	Acc No-Match	.64 (.039)	.67 (.036)	.63 (.056)	.65 (.039)	.63 (.040)	.63 (.067)

Table 3 (cont.)

Measure		Pre-Testing			Post-Testing		
		Dance	No-Contact	Walking	Dance	No-Contact	Walking
PMS	Go RT	701.69 (22.35)	650.92 (19.75)	716.48 (30.40)	699.67 (26.87)	647.06 (18.69)	670.01 (26.89)
	Go Acc	.97 (.011)	.96 (.012)	.94 (.022)	.97 (.009)	.96 (.011)	.95 (.019)
	No-Go Acc	.90 (.022)	.93 (.015)	.81 (.051)	.92 (.019)	.92 (.014)	.84 (.048)
Task Switching	RT Single	709.14 (19.20)	654.41 (14.06)	694.08 (21.86)	672.58 (34.54)	662.94 (15.64)	719.67 (17.98)
	RT Non-Switch	791.67 (19.70)	773.00 (21.09)	718.62 (31.68)	799.34 (35.68)	747.61 (22.62)	723.34 (37.16)
	RT Switch	883.50 (23.23)	797.38 (27.09)	777.98 (39.49)	857.13 (41.74)	778.29 (26.72)	728.28 (28.44)
	Acc Single	.82 (.030)	.86 (.024)	.86 (.030)	.82 (.040)	.86 (.023)	.66 (.055)
	Acc Non-Switch	.60 (.030)	.53 (.034)	.50 (.044)	.58 (.037)	.53 (.031)	.47 (.042)
	Acc Switch	.54 (.033)	.49 (.035)	.50 (.050)	.55 (.036)	.48 (.031)	-.42 (.928)
	Local cost RT	91.83 (14.47)	58.52 (7.91)	59.35 (27.12)	57.78 (17.99)	50.28 (8.13)	29.62 (23.27)
	Local cost Acc	.058 (.015)	.046 (.016)	.007 (.024)	.030 (.013)	.048 (.018)	-.002 (.021)
	Global cost RT	82.53 (31.65)	144.76 (40.17)	24.54 (45.82)	126.75 (25.64)	84.67 (31.79)	3.67 (32.67)
	Global cost Acc	.248 (.051)	.328 (.032)	.355 (.047)	.236 (.037)	.327 (.034)	.189 (.069)
Dot	RT	3429.82 (201.81)	3088.08 (210.30)	3702.94 (295.35)	3822.33 (321.75)	3189.22 (204.55)	3822.03 (298.67)
	Acc	.88 (.010)	.88 (.016)	.89 (.015)	.91 (.007)	.87 (.016)	.89 (.013)
	Cost RT	1125.48 (156.06)	1065.92 (143.64)	1032.55 (185.11)	208.97 (468.08)	1166.28 (141.43)	888.88 (208.62)
	Cost Acc	-.031 (.015)	.043 (.009)	.019 (.019)	.014 (.009)	.026 (.010)	.012 (.013)
Manual Sequence	RT	734.04 (52.64)	692.42 (51.38)	839.30 (72.89)	814.99 (66.73)	784.88 (64.99)	908.45 (42.75)
	Acc	.978 (.004)	.971 (.007)	.974 (.008)	.980 (.003)	.973 (.007)	.982 (.006)
	Learning Index RT	449.12 (78.41)	612.19 (229.50)	937.53 (338.06)	575.65 (99.63)	869.37 (252.41)	908.65 (243.62)
	Learning Index Acc	.012 (.024)	-.032 (.028)	-.033 (.045)	.008 (.023)	-.036 (.028)	-.020 (.029)

Table 3 (cont.)

Measure		Pre-Testing			Post-Testing		
		Dance	No-Contact	Walking	Dance	No-Contact	Walking
Ravens	Acc	.246 (.032)	.189 (.036)	.301 (.082)	.368 (.031)	.183 (.026)	.322 (.086)
Memory Span	Digits	5.84 (.324)	5.64 (.403)	5.60 (.423)	9.48 (.424)	5.96 (.414)	5.80 (.438)
	Spatial Locations	6.40 (.378)	6.72 (.348)	6.00 (.569)	9.60 (.365)	6.88 (.388)	6.20 (.449)
Cardio-respiratory Fitness	Rockport	13.34 (1.13)	12.76 (.737)	13.59 (1.35)	18.40 (1.20)	12.54 (.628)	17.68 (1.44)
Functional	BBS	55.64 (.151)	55.92 (.055)	55.93 (.066)	56.00 (.000)	55.96 (.040)	55.93 (.066)
	TUG	11.60 (.519)	12.06 (.533)	11.32 (.516)	9.45 (.230)	10.28 (.490)	10.96 (.526)
Psychosocial	BAI	9.40 (1.34)	8.80 (1.49)	9.66 (2.01)	3.00 (.583)	8.76 (1.21)	8.53 (1.45)
	PSS	17.92 (1.56)	16.40 (1.32)	18.33 (3.04)	7.12 (.566)	14.52 (1.28)	17.06 (2.44)
	Ryff AU	68.20 (2.03)	67.80 (1.92)	64.20 (1.35)	76.56 (.979)	66.48 (2.94)	66.40 (2.07)
	PRO	61.48 (1.46)	61.36 (2.77)	65.26 (2.27)	74.68 (1.05)	62.72 (2.86)	66.46 (2.03)
	SA	63.92 (1.46)	62.56 (2.69)	65.20 (2.41)	75.12 (1.09)	62.32 (2.68)	66.73 (2.55)
	EM	68.28 (2.15)	67.04 (2.01)	61.33 (3.29)	72.16 (1.80)	68.56 (2.12)	62.80 (3.03)
	PG	68.24 (1.53)	68.76 (1.40)	65.20 (2.03)	71.20 (2.03)	67.84 (1.80)	66.53 (1.89)
	PL	68.12 (1.52)	61.44 (2.77)	63.40 (1.80)	73.84 (1.27)	62.72 (3.06)	66.06 (2.06)
Sleep Pattern	PSQI	9.76 (.619)	7.20 (.770)	8.53 (1.17)	4.60 (.483)	6.72 (.696)	7.80 (1.11)

RT = Response Time, Acc = Accuracy, AU = Autonomy, PRO = Positive Relations with Others, SA = Self-acceptance, EM = Environmental Mastery, PG = Personal Growth, PL = Purpose in Life.

Figure 1 – Mean accuracy for the three groups as a function of time-point. Error bars represent plus and minus 1 standard error.

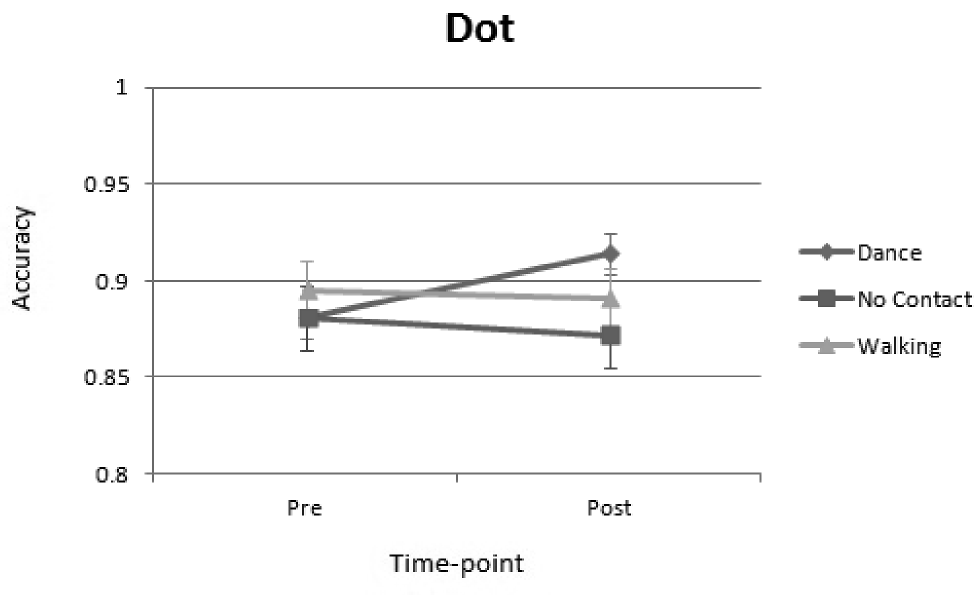


Figure 2 – Mean accuracy for the three groups as a function of time-point. Error bars represent plus and minus 1 standard error.

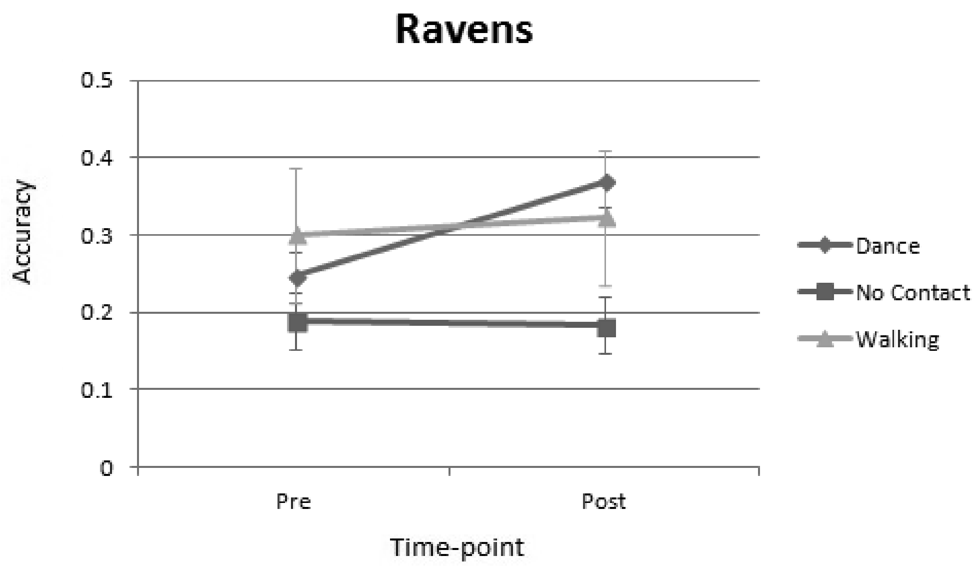


Figure 3 – Memory span scores for the three groups as a function of time-point. Error bars represent plus and minus 1 standard error.

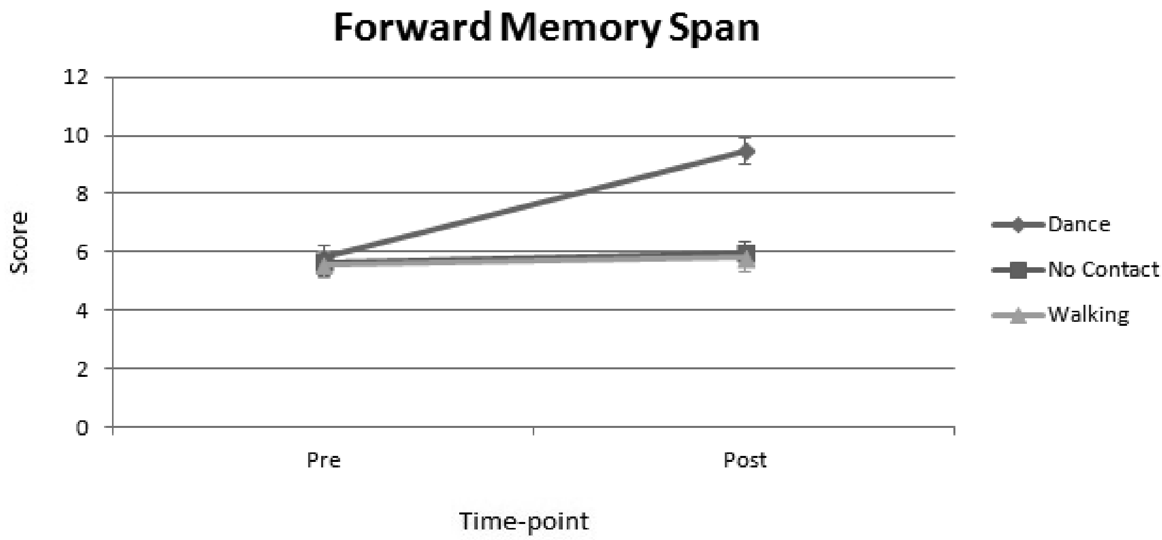


Figure 4 – Memory span scores for the three groups as a function of time-point. Error bars represent plus and minus 1 standard error.

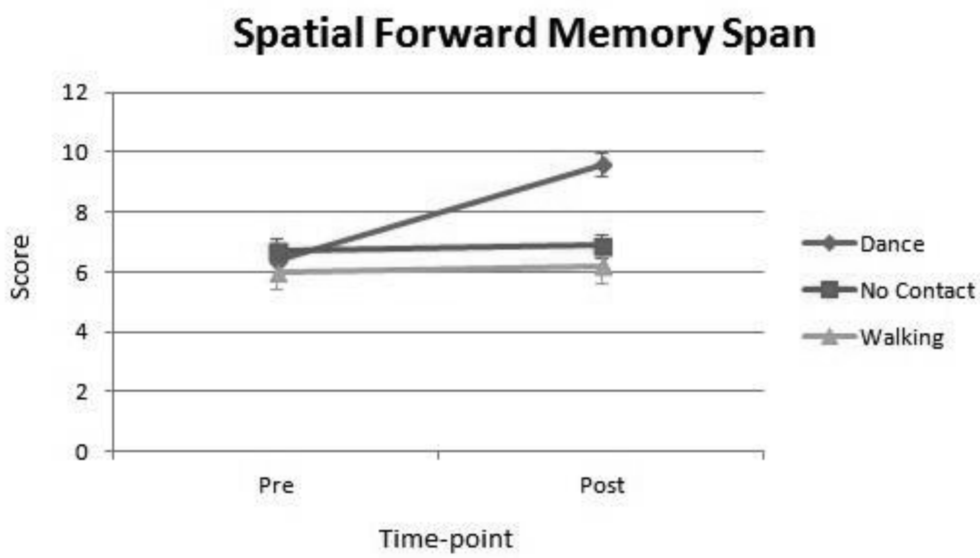


Figure 5 – Estimated VO2 max for the three groups as a function of time-point. Error bars represent plus and minus 1 standard error.

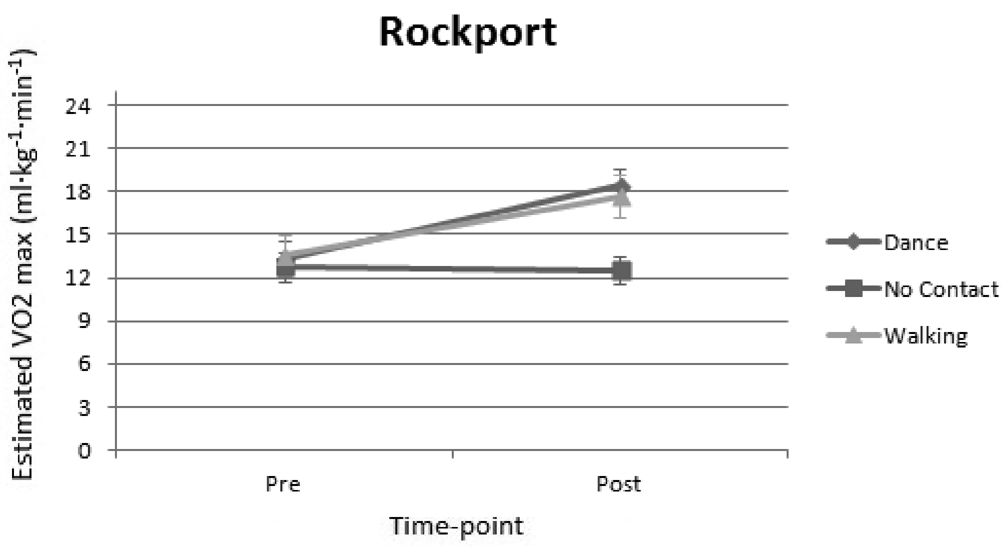


Figure 6 – BAI scores for the three groups as a function of time-point. Error bars represent plus and minus 1 standard error.

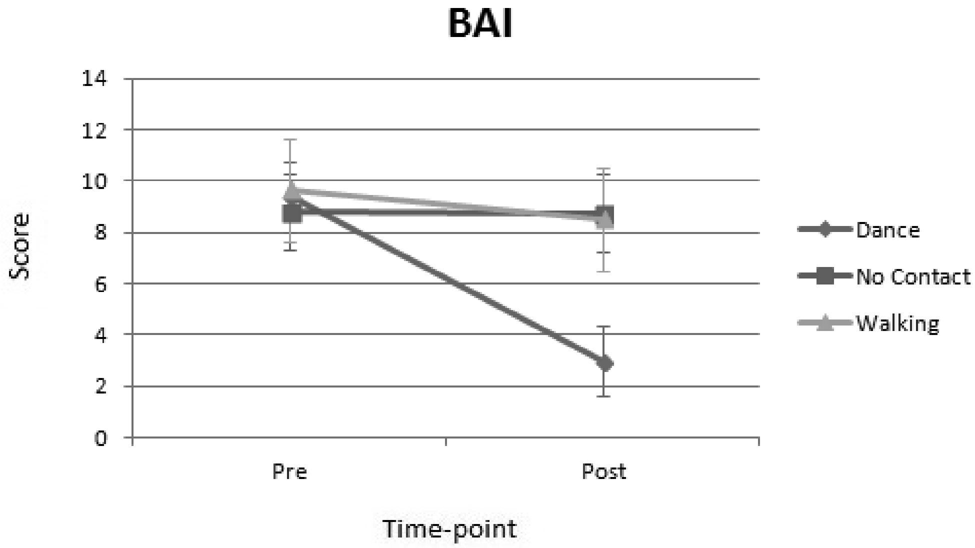


Figure 7 – PSS scores for the three groups as a function of time-point. Error bars represent plus and minus 1 standard error.

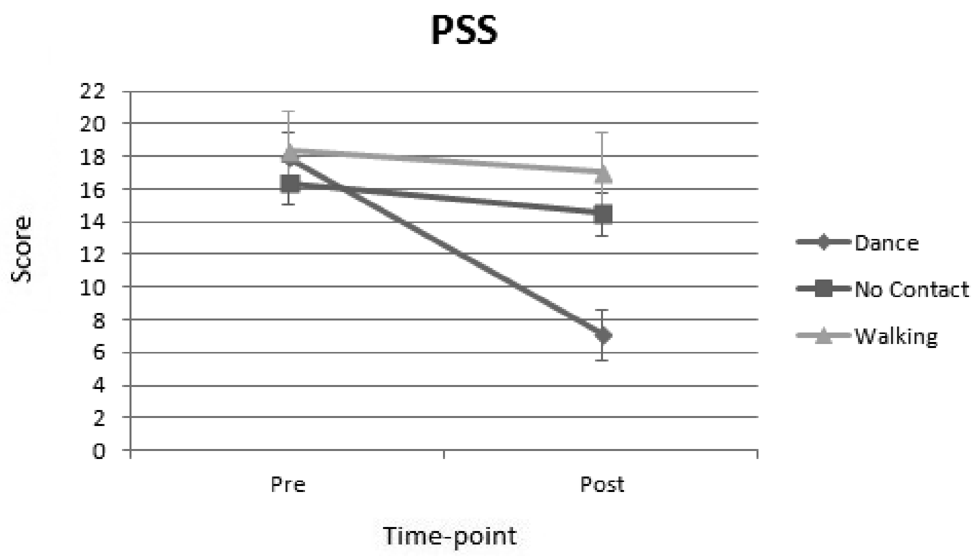


Figure 8 – Ryff scores from three dimensions, for the three groups as a function of time-point. Error bars represent plus and minus 1 standard error.

Figure 9 – PSQI scores for the three groups as a function of time-point. Error bars represent plus and minus 1 standard error.

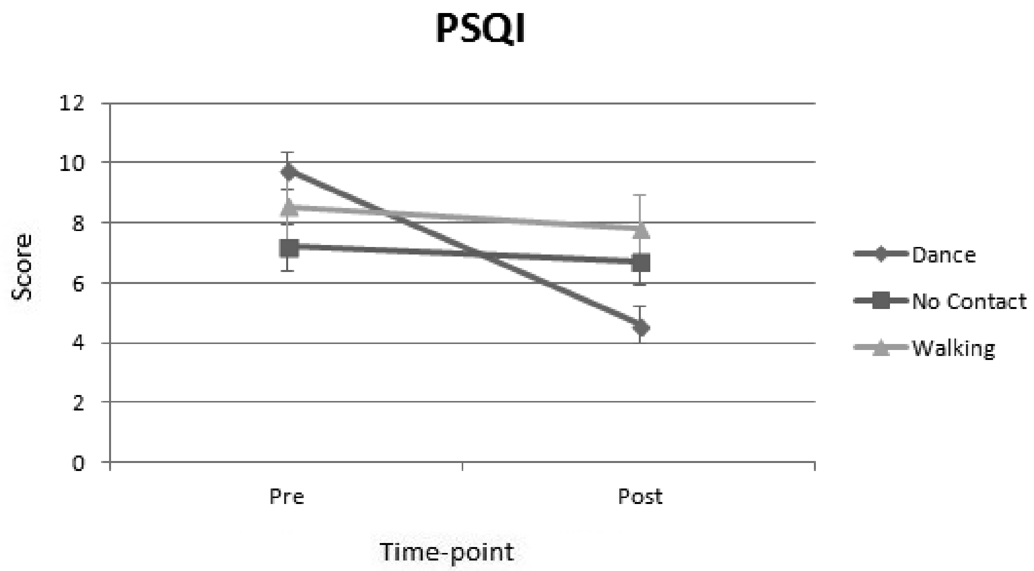


Figure 10 – Percentage frequency distribution of "yes", "no", and "unsure" responses across the three groups, in each domain.

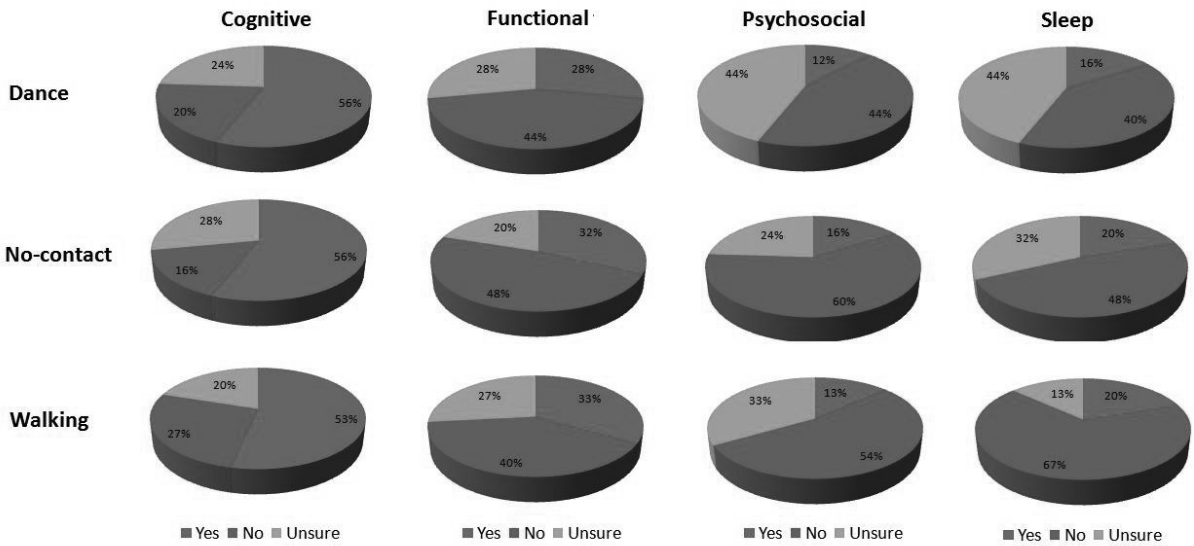


Table 4 – Summary of the Principal Components Analysis for the BrainBaseline data.

Measure	Processing Speed	Executive Functions	Memory
Go RT	**.784**		
SRT RT	**.488**	.204	
Span Score	.331	-.116	
Cost RT B – A		**.807**	-.143
RT interference	-.398	**.646**	.284
No-go accuracy	-.203	-.563	.374
No-match accuracy	-.157		**.838**
Match accuracy	.434	-.153	**.695**
Eigenvalues	1.66	1.58	1.44
% variance	20.83%	19.82%	18.01%

In bold are factor loadings > .40.

CHAPTER 4

DISCUSSION

The present study examined the effects of a 4-month ballroom dance intervention on the cognition of healthy older adults. Specifically, the goal of the study was to determine if dancers would outperform non-dancers in tests of attention, executive function, working memory, visuomotor coordination, spatial processing, speed of processing, sequential learning, and reasoning, as well as on balance, cardiorespiratory fitness, psychosocial variables, and sleep pattern. Previous studies were cross-sectional (Verghese, 2006; Kattenstroth et al., 2010), lacked a control group (Alpert et al., 2009), or did not focus on aerobic fitness (Coubard et al., 2011). Thus, in an attempt to fill specific gaps in the literature and overcome limitations of previous studies, the present study randomly assigned 65 healthy, sedentary elderly adults to a ballroom dance group, a no-contact control group, or a walking group, and performed a broad assessment consisting of cognitive tests that had not been previously employed, along with different psychosocial and functional instruments. Of primary interest were interactions between Group and Time-point, indicating whether dancers differed from walkers and no-contact controls as a function of the 4-month intervention. The results obtained partially supported the initial predictions and will be discussed next.

Although the literature regarding the effects of dance on cognition is limited, the prediction that both dancers and walkers would show significant improvements across the different domains analyzed was based on the extensive literature of the benefits of physical activity on overall brain health (Kramer & Erickson, 2007; Colcombe & Kramer, 2003; Russo-Neustadt, 2009; Arent et al., 2000; Pope et al., 2003, Strawbridge et al., 2002). Specifically, the aim of the present study was to provide a physical activity that was aerobic in nature and which would consequently improve cardiorespiratory fitness. Cohen (1984) argued that dance is mostly an anaerobic activity, with minimal aerobic gain. It has also been suggested that dance can be similar to interval training, making it both aerobic and anaerobic. For example, ballet involves squatting and holding poses, which are anaerobic in nature. However, it also uses continuous, rhythmic movements that characterize aerobic exercise. In this sense, it seems that dance is not an aerobic activity *per se*, but critically depends on the specific style and rhythm accompanying it. In the present study, the styles and musical rhythms selected for the dance intervention were mostly fast-paced, in an attempt to ensure that participants were performing an aerobic activity. The results of cardiorespiratory fitness assessment confirmed the efficacy of the two interventions, as increases in VO_{2max} levels were observed in both dancers (37.93% increase) and walkers (30.09% increase), when compared to no-contact controls, after four months.

Based on previous work by Colcombe and Kramer (2003), it was expected that aerobic fitness would subsequently have a robust and positive influence on cognition. More specifically, the prediction was that both dancers and walkers would show improvements primarily in those tasks that involved executive control processes and simple reaction time. In this context, the lack of statistically significant results for all the tasks comprising the BrainBaseline battery was unexpected. However, a theoretical speculation can be made. As a mobile application, the BrainBaseline is able to avoid some common experiment administration issues (such as limited personnel, space, and time constraints) and is extremely practical (Lee et al., 2012). More importantly, the fact that tasks can be completed reasonably fast (unlike tasks performed in a controlled laboratory setting) makes it attractive to users. The downside of such practicality is that the reduced number of trials in each task results in low power. In this sense, it might be the case that the tasks were not sensitive enough to detect possible differences between groups. Lee et al. (2012) used the BrainBaseline application to examine cross-sectional age differences in cognitive function. The authors were able to replicate specific patterns of age-related differences in cognition with data obtained from more than 15,000 participants, showing that the low power of the tasks can be circumvented by having a large sample (Appendix I shows test-retest reliability scores for the BrainBaseline tests). The relatively small sample size of the present study (as compared to the Lee et al. study) may not have been able to overcome this critical issue.

Despite the BrainBaseline unexpected results, two significant results were observed for the cognitive tests performed in the PC. First, the performance of the dance group significantly improved in the Ravens Matrices test after the 4-month intervention. Therefore, as hypothesized, the dance group outperformed the walking and control groups in one of the tasks that measured a cognitive ability specific to dancing (i.e., reasoning). In addition, the dance group also improved over time in the Dot Comparison task. It is interesting to note, however, that dancers showed improved accuracy when compared to walkers and no-contact controls, not reaction time (as originally predicted). One possible explanation as to why the dance intervention preferentially affected accuracy and not speed of processing relates to the methodology employed in the intervention. The dance instructor particularly emphasized movement accuracy rather than execution speed. Participants were constantly encouraged to reproduce the movement sequences several times until they were executed proficiently. Thus, this emphasis on accuracy rather than on speed may have been reflected in the result of the Dot Comparison test. In fact, it may even be argued that the cognitive abilities trained when movement sequences are learned (by observation and repetition) transfer to more global measures of visual information processing.

The absence of significant results for the Task Switching task is not in accordance with the study's predictions. As mentioned previously, the largest fitness-induced benefits have been shown to occur for executive-control processes, such as switching between tasks (Colcombe & Kramer, 2003). The lack of significant improvements in the dance and walking groups in the Task Switching task may be due to distinct reasons. First, the sample size of the walking group was considerably smaller than that of the other groups, as a result of a higher drop-out rate. In this sense, it may be the case that possible differences across time-points were undetectable. On the other hand, the lack of a significant result in the dance group may be explained, again, by the specific methodology adopted in the intervention. Coubart et al. (2011) examined the impact of contemporary dance (CD) improvisation, fall prevention training, and Tai Chi Chuan on attentional control of older adults. The study focused exclusively on motor activity and, therefore, did not measure cardiovascular performance. The authors observed that older adults trained in CD once a week for 5.7 months improved their switching attention, when compared to the other motor training groups. The authors argued that it was the higher attentional demand, flexibility, and creativity exercised in improvisation that differentiated between CD and the other groups. In the present study, improvisation was not stressed. Thus, since switching was not explicitly trained, differences were not observed across time-points in the task that specifically assessed this component of attentional control. Nonetheless, it could also be the case that the interventions used in the present study were just too short to produce cognitive benefits for the PC and Brainbaseline cognitive tasks.

With respect to the Manual Sequence task, the lack of significant results was also unexpected. Learning coordinated movement sequences was another ability that was specific to dancing and, therefore, dancers were expected to show improvements in this task after the intervention. However, a tentative explanation can be proposed. Maybe leaning a motor sequence with the legs (such as in dancing) is an ability that is not transferred to other limbs (or, in this case, the fingers). In other words, maybe sequence learning is specific to the body part used to execute it. Along this vein, it could be hypothesized that significant differences would be observed if dancers performed the sequence learning task with their feet. The results of the two memory span tasks performed with the feet support this idea and might offer some further insight into this question.

The results obtained in the two forward memory span tasks performed with the feet clearly illustrated the superior performance of the dance group when compared to the other two groups. One interesting point must be stressed in the discussion of these results. Memory enhancements are observed for self-performed actions. Engelkamp (1998) demonstrated this enactment effect by showing that individuals remember tasks they act out better than verbal tasks. The motor component of the task seems to be critical for the memory benefits of enactment (Peterson & Mulligan, 2010). In this context, it is reasonable to suppose that the superior performance of the dance group in the two memory span tasks performed with the feet is a result of the intense motor training involved in the intervention. In fact, reenactment was a core part of the dance class. As discussed previously, participants of the dance group extensively trained movement sequences by observing the instructor and repeating the sequences themselves. Reenactment is, undoubtedly, a core difference between the dance and walking groups and provides a plausible explanation as to why no significant difference was observed in the walking group in the two memory span tasks performed with the feet.

Older people typically experience loss of balance and are at a greater risk for falling. This is due to changes in muscular strength, loss of flexibility, and decreased reaction time that may occur with aging. In fact, diminished balance is a multifaceted problem. It can be caused by degeneration of the visual and vestibular sensory systems, degeneration of proprioception, impairment of central processing or a combination of these factors (Hess & Woollacott, 2005). Exercise is a well-established intervention to reduce falls in cognitively intact older adults. In present study, however, a ceiling effect was observed for the Berg Balance Scale. Similarly, no significant results were observed for the Timed Up & Go test, which measures mobility. It seems that both instruments might be more sensitive when used with elderly adults who have some kind of functional impairment. The participants of the present study were highly functional. Consequently, no significant differences were observed in the functional assessment.

In contrast, significant differences were observed in the psychosocial and sleep pattern measures. Studies have demonstrated the antidepressant effects of physical activity and have linked exercise habits to an increased resistance to psychological stressors (Salmon, 2001). Furthermore, physical activity has been shown to reduce anxiety (Russo-Neustadt, 2009; Dunn et al., 2001) and improve mood (Arent et al., 2000). A recent study evaluated the effectiveness of tango dancing (as compared to mindfulness meditation) in reducing symptoms of psychological stress, anxiety, depression, and in promoting well-being (Pinniger et al., 2012). The results indicated that depression levels were significantly reduced in the tango and meditation groups, relative to waiting-list controls. Moreover, stress levels were significantly reduced only in the tango group. One important characteristic of dance is that it helps individuals express feelings that are difficult to accept (Svoboda, 2007). The expressive nature of dance, therefore, may provide the mechanism through which psychological benefits occur. Similarly, Toneatto and Nguyen (2007) argue that an activity requiring awareness of its execution (such as dancing) weakens the association between negative thoughts and emotions. In this sense, dancing shifts an individual's attentional focus, attenuating psychological distress. Finally, dance also provides an environment where music, exercise, and touch interact, all of which have been shown to improve physical and mental health (Keogh et al., 2009; Boso et al., 2006). Thus, it was highly anticipated that the dance group would significantly improve in measures of anxiety, perceived stress, and psychological well-being. It is interesting to note that the dance group specifically improved in the psychological well-being dimensions that most closely related to the social aspect of the activity: autonomy, positive relations with others, and self-acceptance. The lack of improvements observed in the walking group across the different measures in the psychosocial assessment was not predicted and will be discussed shortly.

No previous study analyzed the effect of dance on sleep pattern. However, it is widely acknowledged that stress and anxiety considerably affect sleep quality. For example, stress can modify sleep-wakefulness cycles. In fact, adequate sleep is crucial for proper brain function. Spiegel et al. (1999) argue that lack of sleep may even potentiate age-related disorders. In this sense, the sleep pattern assessment in the present study was closely related to the psychosocial assessment, as decreases in anxiety and stress levels would be expected to consequently cause an increase in the sleep quality index. This was indeed observed. The dance group showed significant improvements in sleep quality after the 4-month intervention. Again, no significant difference was observed in the walking group, which is not in accordance with the original prediction.

Although the psychosocial and sleep pattern results had all been anticipated and predicted, a relevant factor needs to be taken into account in the discussion of lack of significant results in the walking group across these domains, and also in the cognitive assessment. As discussed previously, the sample size of the walking group was considerably smaller when compared to the other two groups. However, although the sample size may have influenced the results (or lack of) to some extent and despite the fact that the intervention was brief when compared to previous studies, it is the multimodal nature of dance that seems to be really driving the results obtained in the present study. Actually, the specific prediction that improvements in the functional, psychosocial, and sleep pattern variables would be larger for the dance group than for the walking control group was based on the premise that dance has a multifaceted nature; it involves social, physical, cognitive, emotional, and musical aspects, all of which might play a determinant role in overall physical and psychological well-being. The fact that only the dance group improved across time in psychosocial and sleep pattern measures supports this idea. The ways through which the inherent characteristics of dance interact with measures of overall well-being can be examined through two distinct, but equally important perspectives. These perspectives are discussed next.

First, although dancing and walking are both physical activities, a major difference between them is the context in which they take place (in general and in the context of the present study). Dance can be thought of as an enriched environment, because of the variety and richness of its content (involving motor coordination, memory, emotions, affection, and social interaction), when compared to walking. In animal models, environmental enrichment is believed to provide increased sensory, motor, and cognitive demands. In fact, enriched environmental housing has been shown to reduce age-related declines in rats (Hilbig et al., 2002). In this context, Kattenstroth et al. (2010) proposed that dance represents an equivalent environment for humans. It can be argued that the amount and quality of social interaction in the dance and walking groups were not equivalent in the present study. Therefore, the social and emotional components of the dance intervention may have affected the results to a greater extent than the improvements in aerobic fitness. In other words, the results were a product of a social effect rather than of a fitness effect.

Second, dance involves not only physical activity, but also extensive motor training, which may have differentially affected the outcomes of the present study. Since the pioneer research by Spirduso (1975), physical interventions have been found to benefit cognition. Several studies have shown that physical fitness, based on cardiovascular and/or strength conditioning, can have a beneficial impact on cognition (Kramer et al., 2005; Kramer and Erickson, 2007; Hillman et al., 2008). In contrast to physical activity, motor activity is defined as the motor learning of skills, such as balance, motor coordination, motor flexibility, and motor speed. It seems reasonable to suppose that motor fitness may rely on perceptual and higher-level cognitive processes, such as attention, in order to ensure proper motor control (Smith & Baltes, 1999). In animal models, neurophysiological activity patterns have been found to differ between physical and motor fitness (Anderson et al., 1994). Accordingly, it is possible that physical fitness and motor fitness impact cognition in different ways. Only one study in the literature compared the neural correlates of physical fitness and motor activity in older adults. In an fMRI cross-sectional study, Voelcker-Rehage and colleagues (2010) investigated how different levels of physical and motor fitness affected brain functioning in older adults. Results indicated that the two forms of fitness were differentially associated with cognitive performance and brain activation patterns. For higher levels of cognitive performance, high physically fit older adults specifically activated areas related to executive control, while highly motor-fit older adults activated areas involved in visuospatial processing. In this sense, it can be argued that the dance intervention involved significantly more motor training than the waking intervention, which could have, in turn, influenced the results observed in the present study.

The results presented here suggest that the positive effects of dance are reflected in psychosocial measures, such as anxiety, stress, psychological well-being, and sleep pattern. Ultimately, the study of the benefits of dance aims at developing interventions and strategies that facilitate and maintain an independent lifestyle in old age. However, dance can be useful not only in the fight against the ailments of old age, but also in the fight against stress and anxiety, major villains of our post-modern society. Nevertheless, more longitudinal studies are needed to thoroughly understand the effects of dance on functional and structural measures of brain health.

REFERENCES

Adiputra, N., Alex, P., Sutjana, D., Tirtayasa, K., and Manuaba, A. (1996). Balinese dance exercises improve the maximum aerobic capacity. *Journal of Human Ergology (Tokyo), 25,* 25–29.

Alpert, P., Miller, S., Wallmann, H., Havey, R., Cross, C., Chevalia, T., Gillis, C., & Kodandapari, K. (2009). The effect of modified jazz dance on balance, cognition, and mood in older adults. *Journal of the American Academy of Nurse Practitioners, 21,* 108–115.

Anderson, B. J., Alcantara, A. A., Isaacs, K. R., Black, J. E., & Greenough, W. T. (1994) Glial hypertrophy is associated with synaptogenesis following motor-skill learning, but not with angionesis following exercise. *Glia, 11,* 73–80.

Arent, S. M., Landers, D. M., & Etnier, J. L. (2000). The effects of exercise on mood in older adults: A meta-analytic review. *Journal of Aging and Physical Activity, 8,* 407-430.

Ballesteros, S., Nilsson, L-G., & Lemaire, P. (2009). Ageing, cognition, and neuroscience: An introduction. *European Journal of Cognitive Psychology, 21 (2/3),* 161–175.

Beck, A. T., Epstein, N., Brown, G., & Steer, R. A. (1988). An inventory for measuring clinical anxiety: Psychometric properties. *Journal of Consulting and Clinical Psychology, 56,* 893–897.

Berg, K., Wood-Dauphinee, S., Williams, J. I., & Gayton, D. (1989). Measuring balance in the elderly: Preliminary development of an instrument. *Physiotherapy Canada, 41,* 304–311.

Blay, S., Andreoli, S., Fillenbaum, G., & Gastal, F. (2007). Depression morbidity in later life: prevalence and correlates in a developing country. *The American Journal of Geriatric Psychiatry, 15,* 790–799.

Borg, G. (1985). *An Introduction to Borg's RPE Scale*. Ithaca, NY: Mouvement.

Boso, M., Politi, P., Barale, F., & Enzo, E. (2006). Neurophysiology and neurobiology of the musical experience. *Functional Neurology, 21,* 187–191.

Bramble, D. M., & Lieberman, D. E. (2004). Endurance running and the evolution of *Homo*. *Nature, 432,* 345–352.

Brown, S., Martinez, M. J., & Parsons, L. M. (2006). The Neural Basis of Human Dance. *Cerebral Cortex 16,* 1157–1167.

Brucki, S. M. D., Nitrini, R., Caramelli, P., Bertolucci, P. H. F., & Okamoto, I. H. (2003). Sugestões para o uso do mini-exame do estado mental no Brasil. *Arquivos de Neuropsiquiatria, 61,* 777–781.

Buysse, D. J., Reynolds, C. F. 3rd, Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Research, 28,* 193–213.

Calvo-Merino, B., Glaser, D. E., Grezes, J., Passingham, R. E., & Haggard, P. (2005). Action observation and acquired motor skills: an fMRI study with expert dancers. *Cerebral Cortex, 15,* 1243–1249.

Calvo-Merino, B., Grèzes, J., Glaser, D. E., Passingham, R. E., & Haggard, P. (2006). Seeing or doing? Influence of visual and motor familiarity in action observation. *Current Biology, 16,* 1905–1910.

Cohen, A. (1984). Dance--Aerobic and Anaerobic. *Journal of Physical Education, Recreation & Dance, 55,* 51-53.

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior, 24,* 385–396.

Colcombe, S. J., Erickson, K. I., Raz, N., Webb, A. G., Cohen, N. J., & McAuley, E. (2003). Aerobic fitness reduces brain tissue loss in aging humans. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences, 55,* 176–180.

Colcombe, S. J., Erickson, K. I., Scalf, P. E., Kim, J. S., Prakash, R., McAuley, E., Elavsky, S., Marquez, D. X., Hu, L., & Kramer, A. F. (2006). Aerobic exercise training increases brain volume in aging humans. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences, 61,* 1166–1170.

Colcombe, S., & Kramer, A. F. (2003). Fitness effects on the cognitive function of older adults: a meta-analytic study. *Psychological Science, 14,* 125–130.

Colcombe, S. J., Kramer, A. F., Erickson, K. I., Scalf, P., McAuley, E., & Cohen, N. J. (2004). Cardiovascular fitness, cortical plasticity, and aging. *Proceedings of the National Academy of Sciences of the U.S.A., 101,* 3316–3321.

Cotman, C. W., Smith, A. D., Schallert, T., & Zigmond, M. J. (2009). Exercise in neurodegenerative disease and stroke. In P. R. Hof & C. V. Mobbs (Eds.), *Handbook of the Neuroscience of Aging* (pp. 609–617). London: Academic Press.

Coubard, O. A., Duretz, S., Lefebvre, V., Lapalus, P., & Ferrufino, L. (2011). Practice of contemporary dance improves cognitive flexibility in aging. *Frontiers in Aging Neuroscience, 3,* 1–12.

Cross, E. S. (2010). Building a dance in the human brain: Insights from expert and novice dancers. In B. Bläsing, M. Puttke, & T. Schack (Eds.), *The Neurocognition of Dance: Mind, Movement and Motor Skills* (pp. 177–202). New York: Psychology Press.

Cross, E. S., Hamilton, A. F., & Grafton, S. T. (2006). Building a motor simulation de novo: observation of dance by dancers. *Neuroimage, 31,* 1257–67.

Cross, E. S., Kraemer, D. J., Hamilton, A. F., Kelley, W. M., & Grafton, S. T. (2009). Sensitivity of the action observation network to physical and observational learning. *Cerebral Cortex, 19,* 315–326.

Crotts, D., Thompson, B., Nahom M., Ryan, S., & Newton, R. A. (1996). Balance abilities of professional dancers on select balance tests. *The Journal of Orthopaedic and Sports Physical Therapy, 23,* 12–17.

Dik, M. G., Deeg, D. J. H., Visser, M., & Jonker, C. (2003). Early life physical activity and cognition at old age. *Journal of Clinical and Experimental Neuropsychology, 25,* 643–653.

Dunn, A. L., Trivedi, M. H., & O'Neal, H. A. (2001). Physical activity dose-response effects on outcomes of depression and anxiety. *Medicine and Science in Sports and Exercise, 33,* S587–S597.

Dustman, R. E.,Emmerson, R. Y., Ruhling, R. O., Shearer, D. E., Steinhaus, L. A., Johnson, S. C., Bonekat, H. W., & Shigeoka, J. W. (1990). Age and fitness effects on EEG, ERPs, visual sensitivity, and cognition. *Neurobiology of Aging, 11,* 193–200.

Dustman, R. E., Ruhling, R. O., Russell, E. M., Shearer, D. E., Bonekat, H. W., Shigeoka, J. W., Wood, J. S., & Bradford, D. C. (1984). Aerobic exercise training and improved neuropsychological function of older individuals. *Neurobiology of Aging, 5,* 35–42.

Earhart, G. (2009). Dance as therapy for individuals with Parkinson disease. *European Journal of Physical and Rehabilitation Medicine, 45,* 231–238.

Engelkamp, J. (1998). Memory for actions. Hove, U.K.: Psychology Press/Taylor & Francis.

Erickson, K. I., Prakash, R. S., Voss, M. W., Chaddock, L., Hu, L., Morris, K. S., White, W. M., Wojcicki, T. R., McAuley, E., & Kramer, A. F. (2009). Aerobic fitness is associated with hippocampal volume in elderly humans. *Hippocampus,19,* 1030–1039.

Erickson, K. I., Voss, M. W., Prakash, R. S., Basak, C., Szabo, A., Chaddock, L., Kim, J. S., Heo, S., Alves, H., White, S. M., Wojcicki, T. R., Mailey, E., Vieira, V. J., Martin, S. A., Pence, B. D., Woods, J. A., McAuley, E., & Kramer, A. F. (2011). Exercise training increases size of hippocampus and improves memory. *Proceedings of the National Academy of Science of the U.S.A., 108,* 3017–22.

Estivill, M. (1995). Therapeutic aspects of aerobic dance participation. *Health Care for Women International, 16,* 341–350.

Fadiga, L., Buccino, G., Craighero, L., Fogassi, L., Gallese, V., & Pavesi, G. (1999). Corticospinal excitability is specifically modulated by motor imagery: a magnetic stimulation study. *Neuropsychologia, 37,* 147–58.

Fadiga, L., Fogassi, L., Pavesi, G., & Rizzolatti, G. (1995). Motor facilitation during action observation: a magnetic stimulation study. *Journal of Neurophysiology, 73,* 2608–2611.

Fallik, D. (2007). Finding new life through movement: how a modern dance company helps Parkinson's disease patients loosen tight joints and lift spirits. *Neurology 3,* 30–33.

Federici, A., Bellagamba, S., & Rocchi, M. (2005). Does dance-based training improve balance in adult and young old subjects? A pilot randomized controlled trial. *Aging Clinical and Experimental Research, 17,* 385–389.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12,* 189–198.

Hackney, M., & Earhart, G. (2009). Effects of dance on movement control in Parkinson's disease: a comparison of Argentine tango and American ballroom. *Journal of Rehabilitation Medicine, 41,* 475–481.

Hackney, M., & Earhart, G. (2010). Social partnered dance for people with serious and persistent mental illness: a pilot study. *The Journal of Nervous and Mental Disease, 198,* 76–78.

Hertzog, C., Kramer, A. F., Wilson, R. S., & Lindenberger, U. (2009). Enrichment effects on adult cognitive development: Can the functional capacity of older adults be preserved and enhanced? *Psychological Science in the Public Interest, 9,* 1–65.

Hess, J. A., & Woollacott, M. (2005). Effect of high-intensity strength-training on functional measures of balance ability in balance-impaired older adults. *Journal of Manipulative and Physiological Therapeutics, 28,* 582–590.

Hilbig, H., Bidmon, H. J., Steingruber, S., Reinke, H., & Dinse, H. R. (2002). Enriched environmental conditions reverse age-dependent gliosis and losses of neurofilaments and extracellular matrix components but do not alter lipofuscin accumulation in the hindlimb area of the aging rat brain. *Journal of Chemical Neuroanatomy, 23,* 199–209.

Hillman, C. H., Belopolsky, A. V., Snook, E. M., Kramer, A. F., & McAuley, E. (2004). Physical activity and executive control: Implications for increased cognitive health during older adulthood. *Research Quarterly for Exercise and Sport, 75,* 176–185.

Hillman, C. H., Erickson, K. I., & Kramer, A. F. (2008). Be smart, exercise your heart: exercise effects on brain and cognition. *Nature Reviews. Neuroscience, 9,* 58–65.

Hillman, C. H., Kramer, A. F., Belopolsky, A. V., & Smith,D. P. (2006). A cross-sectional examination of age and physical activity on performance and event-related brain potentials in a task switching paradigm. *International Journal of Psychophysiology, 59,* 30–39.

Hopkins, D. R., Murrah, B., Hoeger, W. W., & Rhodes, R. C. (1990). Effect of low-impact aerobic dance on the functional fitness of elderly women. *Gerontologist, 30,* 189–192.

Hui, E., Chui, B., & Woo, J. (2009). Effects of dance on physical and psychological well-being in older persons. *Archives of Gerontology and Geriatrics, 49,* e45–e50.

Jeannerod, M. (2001). Neural simulation of action: a unifying mechanism for motor cognition. *Neuroimage, 14,* S103–S109.

Kattenstroth, J. C., Kalisch, T., Holt, S., Tegenthoff, M., & Dinse, H. R. (2013). Six months of dance intervention enhances postural, sensorimotor, and cognitive performance in elderly without affecting cardio-respiratory functions. *Frontiers in Aging Neuroscience, 5,* pii: 1.

Kattenstroth, J. C., Kolankowska, I., Kalisch, T., & Dinse, H. R. (2010). Superior sensory, motor, and cognitive performance in elderly individuals with multi-year dancing activities. *Frontiers in Aging Neuroscience, 2,* pii: 31.

Katzman, R. (1993). Education and the prevalence of dementia and Alzheimer's disease. *Neurology, 43,* 13–20.

Keogh, J. W., Kilding, A., Pidgeon, P., Ashley, L., & Gillis, D. (2009). Physical benefits of ancing for healthy older adults: a review. *Journal of Aging & Physical Activity, 17,* 479–500.

Kline, G. M., Pocari, J. P., Hintemeister, R., Freedson, P. S., Ward, A., McCarron, R. F., Ross, J. & Rippe, J. M. (1987). Estimation of VO2max from a one-mile track walk, gender, age, and body weight. *Medicine and Science in Sports and Exercise 19,* 353–359.

Kramer, A. F., Colcombe, S. J., McAuley, E., Scalf, P. E., & Erickson, K. I. (2005). Fitness, aging and neurocognitive function. *Neurobiology of Aging, 26 (Suppl.1),* 124–127.

Kramer, A. F., & Erickson, K. I. (2007). Effects of physical activity on cognition, well-being, and brain: Human interventions. *Alzheimer's & Dementia, 3,* S45–S51.

Kramer, A. F., Hahn, S., Cohen, N., Banich, M., McAuley, E., Harrison, C., Chason, J., Vakil, E., Bardell, L., Boileau, R. A., & Colcombe, A. (1999). Aging, fitness, and neurocognitive function. *Nature, 400,* 418–419.

Krampe, J., Rantz, M. J., Dowell, L., Schamp, R., Skubic, M., & Abbott, C. (2010). Dance-based therapy in a program of all-inclusive care for the elderly: an integrative approach to decrease fall risk. *Nursing Administration Quarterly, 34,* 156–161.

Kreutz, G. (2008). Does partnered dance promote health? The case of tango Argentino. *The Journal of the Royal Society for the Promotion of Health, 128,* 79–84.

Larson, E. B., Wang, L., Bowen, J. D., McCormick, W. C., Teri, L., Crane, P., & Kukull, W. (2006). Exercise is associated with reduced risk for incident dementia among persons 65 years of age and older. *Annals of Internal Medicine, 144,* 73–81.

Lee, H., Baniqued, P. L., Cosman, J., Mullen, S., McAuley, E., Severson, J., and Kramer, A. F. (2012). Examining cognitive function across the lifespan using a mobile application. *Computers in Human Behavior, 28,* 1934–1946.

Marmeleira, J. F., Pereira, C., Cruz-Ferreira, A., Fretes, V., Pisco, R., & Fernandes, O. M. (2009). Creative dance can enhance proprioception in older adults. *The Journal of Sports Medicine and Physical Fitness, 49,* 480–485.

McKinley, P., Jacobson, A., Leroux, A., Bednarczyk, V., Rossignol, M., & Fung, J. (2008). Effect of a community-based Argentine tango dance program on functional balance and confidence in older adults. *Journal of Aging and Physical Activity, 16,* 435–453.

Murphy, E., Carson, L., Neal, W., Baylis, C., Donley, D., & Yeater, R. (2009). Effects of an exercise intervention using Dance Dance Revolution on endothelial function and other risk factors in overweight children. *International Journal of Pediatric Obesity, 4,* 205–214.

Park, D. C., Davidson, L., Lautenschlager, G., Smith, A. D., Smith, P., & Hedden, T. (2002). Models of visuospatial and verbal memory across the adult lifespan. *Psychology and Aging, 17,* 299–320.

Park, D. C., Polk, T. A., Mikels, J. A., Taylor, S. F., & Marshuetz, C. (2001). Cerebral aging: Integration of brain and behavioural models of cognitive function. *Dialogues in Clinical Neuroscience, 3,* 151–165.

Park, D. C., & Reuter-Lorenz, P. (2009). The adaptive brain: Aging and neurocognitive scaffolding. *Annual Review of Psychology, 60,* 173–196.

Park, D. C., & Schwarz, N. (Eds.). (2000). Cognitive aging: A primer. Philadelphia, PA: Psychology Press.

Parker, S. J., Strath, S. J., & Swartz, A. M. (2008). Physical activity measurement in older adults: Relationships with mental health. *Journal of Aging and Physical Activity, 16,* 369–380.

Peterson, D. J., & Mulligan, N. W. (2010). Enactment and retrieval. *Memory & Cognition, 38,* 233–243.

Pinniger, R., Brown, R. F., Thorsteinsson, E. B., & McKinley, P. (2012). Argentine tango dance compared to mindfulness meditation and a waiting-list control: A randomised trial for treating depression. *Complementary Therapies in Medicine, 20,* 377–384.

Podewils, L. J., Guallar, E., Kuller, L. H., Fried, L. P., Lopez, O. L., Carlson, M., & Lyketsos, C. G. (2005). Physical activity, apoe genotype, and dementia risk: findings from the Cardiovascular Health Cognition Study. *American Journal of Epidemiology, 161,* 639–351.

Podsiadlo, D., & Richardson, S. (1991). The Timed "Up & Go": A test of basic functional mobility for frail elderly persons. *Journal of the American Geriatrics Society, 39,* 142–148.

Pope, S., Shue, V., & Beck, C. (2003). Will a healthy lifestyle help prevent Alzheimer's disease? *Annual Review of Public Health, 24,* 111–132.

Prakash, R. S., Voss, M. W., Erickson, K. I., Lewis, J. M., Chaddock, L., Malkowski, E., Alves, H., Kim, J., Szabo, A., White, S. M., Wójcicki, T. R., Klamm, E. L., McAuley, E., & Kramer, A. F. (2011). Cardiorespiratory fitness and attentional control in the aging brain. *Frontiers in Human Neuroscience, 4,* 229.

Raz, N. (2000). Aging of the brain and its impact on cognitive performance: integration of structural and functional findings. In F. I. Craik & T. A. Salthouse (Eds.), *The Handbook of Aging and Cognition* (pp. 1–90). Hillsdale, NJ: Erlbaum.

Raz, N., Lindenberger, U., Rodrigue, K. M., Kennedy, K. M., Head, D., Williamson, A., Dahle, C., Gerstorf, D., & Acker, J. D. (2005). Regional brain changes in aging healthy adults: General trends, individual differences and modifiers. *Cerebral Cortex, 15,* 1676–1689.

Resnick, S. M., Pham, D. L., Kraut, M. A., Zonderman, A. B., & Davatzikos, C. (2003). Longitudinal magnetic resonance imaging studies of older adults: a shrinking brain. *The Journal of Neuroscience, 23,* 3295–3301.

Richards, M., Hardy, R., & Wadsworth, M. E. J. (2003). Does active leisure protect cognition? Evidence from a national birth cohort. *Social Science and Medicine, 56,* 785–792.

Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. *Annual Review of Neuroscience, 27,* 169–192.

Rizzolatti, G., Fadiga, L., Matelli, M., Bettinardi, V., Paulesu, E., & Perani, D. (1996). Localization of grasp representations in humans by pet: 1. Observation versus execution. *Experimental Brain Research, 111,* 246–252.

Rosen, A. C., Prull, M. W., Gabrieli, J. D., Stoub, T., O'Hara, R., Friedman, L., Yesavage, J. A., & deToledo-Morrell, L. (2003). Differential associations between entorhinal and hippocampal volumes and memory performance in older adults. *Behavioral Neuroscience, 117,* 1150–1160.

Rosenbaum, D. (2010). Shall we dance? Action researchers and dancers can move together. In B. Bläsing, M. Puttke, & T. Schack (Eds.), *The Neurocognition of Dance: Mind, Movement and Motor Skills* (pp. 41–52). New York: Psychology Press.

Rovio, S., Kåreholt, I., Helkala, E. L., Viitanen, M., Winblad, B., Tuomilehto, J., Soininen, H., Nissinen, A., & Kivipelto, M. (2005). Leisure-time physical activity at midlife and the risk of dementia and Alzheimer's disease. *Lancet Neurology, 4,* 705–711.

Rovio, S., Spulber, G., Nieminen, L. J., Niskanen, E., Winblad, B., Tuomilehto, J., Nissinen, A., Soininen, H., & Kivipelto, M. (2010). The effect of midlife physical activity on structural brain changes in the elderly. *Neurobiology of Aging, 31,* 1927–1936.

Rowe, J., & Kahn, R. (1997). Successful aging. *The Gerontologist, 37,* 433–440.

Russo–Neustadt, A. (2009). Exercise: Optimizing function and survival at the cellular level. In P. R. Hof & C. V. Mobbs (Eds.), *Handbook of the Neuroscience of Aging* (pp. 603–608). London: Academic Press.

Ryff, C. D. (1989). Happiness is everything, or is it? Explorations on the meaning of psychological well-being. *Journal of Personality and Social Psychology, 57,* 1069–1081.

Sachs, C. (1937). *World history of the dance*. New York: Norton.

Salmon, P. (2001). Effects of physical exercise on anxiety, depression and sensitivity to stress: a unifying theory. *Clinical Psychology Review, 21,* 33–61.

Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review, 103,* 403–28.

Schack, T. (2004). The cognitive architecture of complex movement. *International Journal of Sport and Exercise Psychology; Special Issue Part II: The Construction of action – New Perspectives in Movement Science, 2,* 403–438.

Schneiderman, N., Ironson, G., & Siegel, S. D. (2005). Stress and health: psychological, behavioral, and biological determinants. *Annual Review of Clinical Psychology, 1,* 607–28.

Sheikh, J. I., & Yesavage, J. A. (1986). Geriatric Depression Scale (GDS): Recent evidence and development of a shorter version. *Clinical Gerontologist, 5,* 165–171.

Shigematsu, R., Chang, M., Yabushita, N., Sakai, T., Nakagaichi, M., Nho, H., & Tanaka, K. (2002). Dance-based aerobic exercise may improve indices of falling risk in older women. *Age and Ageing, 31,* 261–266.

Smith, J. & Baltes, P.B. (1999). Trends and profiles of psychological functioning in very old age. In P. B. Baltes & K. U. Mayer (Eds.), *The Berlin Aging Study* (pp. 197–226). New York: Cambridge University Press.

Sofianidis, G., Hatzitaki, V., Douka, S., & Grouios, G. (2009). Effect of a 10-week traditional dance program on static and dynamic balance control in elderly adults. *Journal of Aging and Physical Activity, 17,* 167–180.

Spiegel, K., Leproult, R., & Van Cauter, E. (1999). Impact of sleep debt on metabolic and endocrine function. *Lancet, 354,* 1435-1439.

Spirduso, W. W. (1975). Reaction and movement time as a function of age and physical activity level. *Journal of Gerontology, 30,* 435–440.

Spirduso, W. W., & Clifford, P. (1978). Replication of age and physical activity effects on reaction and movement time. *Journal of Gerontology, 33,* 26–30.

Stern, Y. (2006). Cognitive reserve and Alzheimer disease. *Alzheimer Disease and Associated Disorders, 20,* 112–117.

Stern, Y., Albert, S., Tang, M. X., & Tsai, W. Y. (1999). Rate of memory decline in AD is related to education and occupation: cognitive reserve? *Neurology, 53,* 1942–1947.

Strawbridge, W. J., Deleger, S., Roberts, R. E., & Kaplan, G. A. (2002). Physical activity reduces the risk of subsequent depression for older adults. *American Journal of Epidemiology, 156,* 328–34.

Svoboda, E. (2007). Dance helps you process feelings you may have trouble dealing with in conscious, verbal terms. *Psychology Today, 40,* 61–63.

Toneatto, T., & Nguyen, L. (2007). Does mindfulness meditation improve anxiety and mood symptoms? A review of controlled research. *Canadian Journal of Psychiatry, 52,* 260–266.

Verghese, J. (2006). Cognitive and mobility profile of older social dancers. *Journal of the American Geriatrics Society, 54,* 1241–1244.

Verghese, J., Lipton, R. B., Katz, M. J., Hall, C. B., Derby, C. A., Kuslansky, G., Ambrose, A. F., Sliwinski, M., & Buschke, H. (2003). Leisure activities and the risk of dementia in the elderly. *New England Journal of Medicine, 348,* 2508–2516.

Voelcker-Rehage, C., Godde, B., & Staudinger, U. M. (2010). Physical and motor fitness are both related to cognition in old age. *The European Journal of Neuroscience, 31,* 167–176.

Voss, M. W., Erickson, K. I., Prakash, R. S., Chaddock, L., Malkowski, E., Alves, H., Kim, J. S., Morris, K. S., White, S. M., Wójcicki, T. R., Hu, L., Szabo, A., Klamm, E., McAuley, E., & Kramer, A. F. (2010). Functional connectivity: a source of variance in the relationship between cardiorespiratory fitness and cognition. *Neuropsychologia, 48,* 1394–1406.

Voss, M. W., Nagamatsu, L. S., Liu-Ambrose, T., & Kramer, A. F. (2011). Exercise, brain, and cognition across the lifespan. *Journal of Applied Physiolog*y, April 28, doi:10.1152/japplphysiol.00210.2011.

Wilson, R. S., Bennett, D. A., Bienias, J. L., Aggarwal, N. T., Mendes De Leon, C. F., Morris, M. C., Schneider, J. A., & Evans, D. A. (2002). Cognitive activity and incident AD in a population-based sample of older persons. *Neurology, 59,* 1910–1914.

World Health Organization. (2002). Active Aging: A policy framework. Retrieved from http://whqlibdoc.who.int/hq/2002/who_nmh_nph_02.8.pdf

Yaffe, K., Barnes, D., Nevitt, M., Lui, L.-Y., & Covinsky, K. (2001). A prospective study of physical activity and cognitive decline in elderly women: women who walk. *Archives in Internal Medicine, 161,* 1703–1708.

Yaffe, K., Fiocco, A. J., Lindquist, K., Vittinghoff, E., Simonsick, E. M., Newman, A. B., Satterfield, S., Rosano, C., Rubin, S. M., Ayonayon, H. N., & Harris, T. B. (2009). Predictors of maintaining cognitive function in older adults: the Health ABC study. *Neurology, 72,* 2029–2035.

Yamada, M., Kasagi, F., Sasaki, H., Masunari, N., Mimori, Y., & Suzuki, G. (2003). Association between dementia and midlife risk factors: the radiation effects research foundation adult health study. *Journal of the American Geriatrics Society, 51,* 410–414.

Yates, L. B., Djoussé, L., Kurth, T., Buring, J. E., & Gaziano, J. M. (2008). Exceptional longevity in men: modifiable factors associated with survival and function to age 90 years. *Archives of Internal Medicine, 168,* 284–90.

Zhang, J., Ishikawa-Takata, K., Yamazaki, H., Morita, T., & Ohta, T. (2008). Postural stability and physical performance in social dancers. *Gait & Posture, 27,* 697–701.

Zimmerman, D. W. (1994). A note on the influence of outliers on parametric and nonparametric tests. *Journal of General Psychology, 121,* 391–401.

APPENDIX A

Mini-Mental State Exam (MMSE)

Orientation:

(1) year .... ( )
(1) season .... ( )
(1) day (week) .... ( )
(1) day (month) .... ( )
(1) month .... ( )
(1) state .... ( )
(1) city .... ( )
(1) neighborhood .... ( )
(1) street or place .... ( )
(1) floor .... ( )

Registration:

(3) repeat the words: chair -- shoe -- bicycle .... ( )

(give 1 point for each correct answer. Repeat until the person can say all three. Say that you will ask him/her to recall them later)

Attention and Calculation:

(5) [100-7] 5 times successively (93-86-79-72-65) .... ( )
(correct first error but not subsequent errors. Give 1 point for each correct answer)

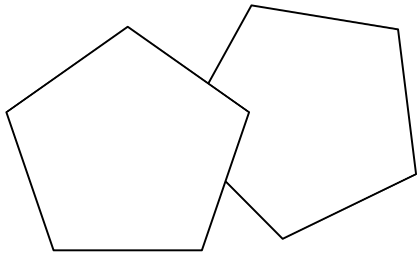
(5) WORLD / DLROW .... ( )
(alternative: spell WORLD backwards)

Recall:

(3) chair -- shoe -- bicycle .... ( )
(ask for the three words repeated earlier. Give 1 point for each correct answer)

Language:

(2) name a watch and a pencil .... ( )
(1) repeat the following: "no ifs, ands, or buts" .... ( )
(3) follow a 3-stage command: "take this paper in your right hand,
fold it in half, and put it on the floor .... ( )
(1) read and obey the following: "close your eyes" .... ( )
(1) write a sentence .... ( )
(1) copy the design (two pentagons) .... ( )



Total Score: (____/ 30)

Score Ranges
24-30 Normal
18-23 Mild dementia
10-17 Moderate dementia
<10 Severe dementia

Appendix B

Geriatric Depression Scale (GDS-15)

Circle the answer that best describes how you felt over the past week		
1. Are you basically satisfied with your life?	yes	no
2. Have you dropped many of your activities and interests?	yes	no
3. Do you feel that your life is empty?	yes	no
4. Do you often get bored?	yes	no
5. Are you in good spirits most of the time?	yes	no
6. Are you afraid that something bad is going to happen to you?	yes	no
7. Do you feel happy most of the time?	yes	no
8. Do you often feel helpless?	yes	no
9. Do you prefer to stay at home, rather than going out and doing things?	yes	no
10. Do you feel that you have more problems with memory than most?	yes	no
11. Do you think it is wonderful to be alive now?	yes	no
12. Do you feel worthless the way you are now?	yes	no
13. Do you feel full of energy?	yes	no
14. Do you feel that your situation is hopeless?	yes	no
15. Do you think that most people are better off than you are?	yes	no
TOTAL SCORE		

Appendix C

Questionnaire

Office Use:
Near Vision: ____ Far: ____ Color: ____

Name: ____________________________________

Date of Birth: ______________ Age: _____________

Telephone: ____________________

Marital status: __________________

Gender: M ( ) F ( )

Handedness: Left ( ) Right ( )

Education (years): __________

How would you describe your general health? Circle the number that corresponds to your answer.

1 2 3 4 5 (Poor → Excellent)

Do you wear glasses/contacts on a regular basis? Y N

Have you been diagnosed with an attention or memory problem? Y N

Have you been diagnosed with:

Depression Y N

Multiple Sclerosis Y N

Brain tumor Y N

Parkinson's disease Y N

Are you currently taking any medication? Y N

If so, which one? ___________________________

What dosage? _____________________________

Approximately how many hours a week do you exercise? __________

(sedentary = 30 min or less, no more than two times a week, in the last 6 months)

Blood pressure: _______________

Heart rate: _______________

Leisure Activity / Frequency

	Daily	**Several days per week**	**Once weekly**	**Monthly**	**Occasionally**	**Never**
Playing board games						
Reading						
Playing a musical instrument						
Doing crossword puzzles						
Writing						
Doing housework						
Walking						
Climbing stairs						
Bicycling						
Swimming						
Babysitting						

Appendix D

Berg Balance Scale (BBS)

1. SITTING TO STANDING

INSTRUCTIONS: Please stand up. Try not to use your hand for support.
( ) 4 able to stand without using hands and stabilize independently
( ) 3 able to stand independently using hands
( ) 2 able to stand using hands after several tries
( ) 1 needs minimal aid to stand or stabilize
( ) 0 needs moderate or maximal assist to stand

2. STANDING UNSUPPORTED

INSTRUCTIONS: Please stand for two minutes without holding on.
( ) 4 able to stand safely for 2 minutes
( ) 3 able to stand 2 minutes with supervision
( ) 2 able to stand 30 seconds unsupported
( ) 1 needs several tries to stand 30 seconds unsupported
( ) 0 unable to stand 30 seconds unsupported
If a subject is able to stand 2 minutes unsupported, score full points for sitting unsupported. Proceed to item #4.

3. SITTING WITH BACK UNSUPPORTED BUT FEET SUPPORTED ON FLOOR OR ON A STOOL

INSTRUCTIONS: Please sit with arms folded for 2 minutes.
( ) 4 able to sit safely and securely for 2 minutes
( ) 3 able to sit 2 minutes under supervision
( ) 2 able to able to sit 30 seconds
( ) 1 able to sit 10 seconds
( ) 0 unable to sit without support 10 seconds

4. STANDING TO SITTING

INSTRUCTIONS: Please sit down.
( ) 4 sits safely with minimal use of hands
( ) 3 controls descent by using hands
( ) 2 uses back of legs against chair to control descent
( ) 1 sits independently but has uncontrolled descent
( ) 0 needs assist to sit

5. TRANSFERS

INSTRUCTIONS: Arrange chair(s) for pivot transfer. Ask subject to transfer one way toward a seat with armrests and one way toward a seat without armrests. You may use two chairs (one with and one without armrests) or a bed and a chair.
( ) 4 able to transfer safely with minor use of hands
( ) 3 able to transfer safely definite need of hands

( ) 2 able to transfer with verbal cuing and/or supervision
( ) 1 needs one person to assist
( ) 0 needs two people to assist or supervise to be safe

6. STANDING UNSUPPORTED WITH EYES CLOSED

INSTRUCTIONS: Please close your eyes and stand still for 10 seconds.
( ) 4 able to stand 10 seconds safely
( ) 3 able to stand 10 seconds with supervision
( ) 2 able to stand 3 seconds
( ) 1 unable to keep eyes closed 3 seconds but stays safely
( ) 0 needs help to keep from falling

7. STANDING UNSUPPORTED WITH FEET TOGETHER

INSTRUCTIONS: Place your feet together and stand without holding on.
( ) 4 able to place feet together independently and stand 1 minute safely
( ) 3 able to place feet together independently and stand 1 minute with supervision
( ) 2 able to place feet together independently but unable to hold for 30 seconds
( ) 1 needs help to attain position but able to stand 15 seconds feet together
( ) 0 needs help to attain position and unable to hold for 15 seconds

8. REACHING FORWARD WITH OUTSTRETCHED ARM WHILE STANDING

INSTRUCTIONS: Lift arm to 90 degrees. Stretch out your fingers and reach forward as far as you can. (Examiner places a ruler at the end of fingertips when arm is at 90 degrees. Fingers should not touch the ruler while reaching forward. The recorded measure is the distance forward that the fingers reach while the subject is in the most forward lean position. When possible, ask subject to use both arms when reaching to avoid rotation of the trunk)
( ) 4 can reach forward confidently 25 cm (10 inches)
( ) 3 can reach forward 12 cm (5 inches)
( ) 2 can reach forward 5 cm (2 inches)
( ) 1 reaches forward but needs supervision
( ) 0 loses balance while trying/requires external support

9. PICK UP OBJECT FROM THE FLOOR FROM A STANDING POSITION

INSTRUCTIONS: Pick up the shoe/slipper, which is in front of your feet.
( ) 4 able to pick up slipper safely and easily
( ) 3 able to pick up slipper but needs supervision
( ) 2 unable to pick up but reaches 2-5 cm(1-2 inches) from slipper and keeps balance independently
( ) 1 unable to pick up and needs supervision while trying
( ) 0 unable to try/needs assist to keep from losing balance or falling

10. TURNING TO LOOK BEHIND OVER LEFT AND RIGHT SHOULDERS WHILE STANDING

INSTRUCTIONS: Turn to look directly behind you over toward the left shoulder. Repeat to the right. (Examiner may pick an object to look at directly behind the subject to encourage a better twist turn)
( ) 4 looks behind from both sides and weight shifts well
( ) 3 looks behind one side only other side shows less weight shift

( ) 2 turns sideways only but maintains balance
( ) 1 needs supervision when turning
( ) 0 needs assist to keep from losing balance or falling

11. TURN 360 DEGREES

INSTRUCTIONS: Turn completely around in a full circle. Pause. Then turn a full circle in the other direction.
( ) 4 able to turn 360 degrees safely in 4 seconds or less
( ) 3 able to turn 360 degrees safely one side only 4 seconds or less
( ) 2 able to turn 360 degrees safely but slowly
( ) 1 needs close supervision or verbal cuing
( ) 0 needs assistance while turning

12. PLACE ALTERNATE FOOT ON STEP OR STOOL WHILE STANDING UNSUPPORTED

INSTRUCTIONS: Place each foot alternately on the step/stool. Continue until each foot has touched the step/stool four times.
( ) 4 able to stand independently and safely and complete 8 steps in 20 seconds
( ) 3 able to stand independently and complete 8 steps in > 20 seconds
( ) 2 able to complete 4 steps without aid with supervision
( ) 1 able to complete > 2 steps needs minimal assist
( ) 0 needs assistance to keep from falling/unable to try

13. STANDING UNSUPPORTED ONE FOOT IN FRONT

INSTRUCTIONS: (DEMONSTRATE TO SUBJECT) Place one foot directly in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot. (To score 3 points, the length of the step should exceed the length of the other foot and the width of the stance should approximate the subject's normal stride width)
( ) 4 able to place foot tandem independently and hold 30 seconds
( ) 3 able to place foot ahead independently and hold 30 seconds
( ) 2 able to take small step independently and hold 30 seconds
( ) 1 needs help to step but can hold 15 seconds
( ) 0 loses balance while stepping or standing

14. STANDING ON ONE LEG

INSTRUCTIONS: Stand on one leg as long as you can without holding on.
( ) 4 able to lift leg independently and hold > 10 seconds
( ) 3 able to lift leg independently and hold 5-10 seconds
( ) 2 able to lift leg independently and hold L 3 seconds
( ) 1 tries to lift leg unable to hold 3 seconds but remains standing independently.
( ) 0 unable to try of needs assist to prevent fall

( ) TOTAL SCORE (Maximum = 56)

Appendix E

Beck Anxiety Inventory (BAI)

Below is a list of common symptoms of anxiety. Please carefully read each item in the list. Indicate how much you have been bothered by that symptom during the past month, including today, by circling the number in the corresponding column next to each symptom.

	Not At All	Mildly but it didn't bother me much	Moderately - it wasn't pleasant at times	Severely – it bothered me a lot
Numbness or tingling	0	1	2	3
Feeling hot	0	1	2	3
Wobbliness in legs	0	1	2	3
Unable to relax	0	1	2	3
Fear of worst happening	0	1	2	3
Dizzy or lightheaded	0	1	2	3
Heart pounding/racing	0	1	2	3
Unsteady	0	1	2	3
Terrified or afraid	0	1	2	3
Nervous	0	1	2	3
Feeling of choking	0	1	2	3
Hands trembling	0	1	2	3
Shaky / unsteady	0	1	2	3
Fear of losing control	0	1	2	3
Difficulty in breathing	0	1	2	3
Fear of dying	0	1	2	3
Scared	0	1	2	3
Indigestion	0	1	2	3
Faint / lightheaded	0	1	2	3
Face flushed	0	1	2	3
Hot/cold sweats	0	1	2	3
Column Sum				

Grand score = ________

Appendix F

Ryff Scales of Psychological Well-being

The following set of questions deals with how you feel about yourself and your life. Please remember that there are no right or wrong answers.

Circle the number that best describes your present agreement or disagreement with each statement.	Strongly Disagree	Disagree Somewhat	Disagree Slightly	Agree Slightly	Agree Somewhat	Strongly Agree
1. Most people see me as loving and affectionate.	1	2	3	4	5	6
2. Sometimes I change the way I act or think to be more like those around me.	1	2	3	4	5	6
3. In general, I feel I am in charge of the situation in which I live.	1	2	3	4	5	6
4. I am not interested in activities that will expand my horizons.	1	2	3	4	5	6
5. I feel good when I think of what I've done in the past and what I hope to do in the future.	1	2	3	4	5	6
6. When I look at the story of my life, I am pleased with how things have turned out.	1	2	3	4	5	6
7. Maintaining close relationships has been difficult and frustrating for me.	1	2	3	4	5	6
8. I am not afraid to voice my opinions, even when they are in opposition to the opinions of most people.	1	2	3	4	5	6
9. The demands of everyday life often get me down.	1	2	3	4	5	6
10. In general, I feel that I continue to learn more about myself as time goes by.	1	2	3	4	5	6
11. I live life one day at a time and don't really think about the future.	1	2	3	4	5	6
12. In general, I feel confident and positive about myself.	1	2	3	4	5	6
13. I often feel lonely because I have few close friends with whom to share my	1	2	3	4	5	6

concerns.						
14. My decisions are not usually influenced by what everyone else is doing.	1	2	3	4	5	6

Circle the number that best describes your present agreement or disagreement with each statement.	Strongly Disagree	Disagree Somewhat	Disagree Slightly	Agree Slightly	Agree Somewhat	Strongly Agree
15. I do not fit very well with the people and the community around me.	1	2	3	4	5	6
16. I am the kind of person who likes to give new things a try.	1	2	3	4	5	6
17. I tend to focus on the present, because the future nearly always brings me problems.	1	2	3	4	5	6
18. I feel like many of the people I know have gotten more out of life than I have.	1	2	3	4	5	6
19. I enjoy personal and mutual conversations with family members or friends.	1	2	3	4	5	6
20. I tend to worry about what other people think of me.	1	2	3	4	5	6
21. I am quite good at managing the many responsibilities of my daily life.	1	2	3	4	5	6
22. I don't want to try new ways of doing things - my life is fine the way it is.	1	2	3	4	5	6
23. I have a sense of direction and purpose in life.	1	2	3	4	5	6
24. Given the opportunity, there are many things about myself that I would change.	1	2	3	4	5	6
25. It is important to me to be a good listener when close friends talk to me about their problems.	1	2	3	4	5	6
26. Being happy with myself is more important to me than having others approve of me.	1	2	3	4	5	6
27. I often feel overwhelmed by my responsibilities.	1	2	3	4	5	6

28. I think it is important to have new experiences that challenge how you think about yourself and the world.	1	2	3	4	5	6
29. My daily activities often seem trivial and unimportant to me.	1	2	3	4	5	6
30. I like most aspects of my personality.	1	2	3	4	5	6
31. I don't have many people who want to listen when I need to talk.	1	2	3	4	5	6

Circle the number that best describes your present agreement or disagreement with each statement.	Strongly Disagree	Disagree Somewhat	Disagree Slightly	Agree Slightly	Agree Somewhat	Strongly Agree
32. I tend to be influenced by people with strong opinions.	1	2	3	4	5	6
33. If I were unhappy with my living situation, I would take effective steps to change it.	1	2	3	4	5	6
34. When I think about it, I haven't really improved much as a person over the years.	1	2	3	4	5	6
35. I don't have a good sense of what it is I'm trying to accomplish in life.	1	2	3	4	5	6
36. I made some mistakes in the past, but I feel that all in all everything has worked out for the best.	1	2	3	4	5	6
37. I feel like I get a lot out of my friendships.	1	2	3	4	5	6
38. People rarely talk to me into doing things I don't want to do.	1	2	3	4	5	6
39. I generally do a good job of taking care of my personal finances and affairs.	1	2	3	4	5	6
40. In my view, people of every age are able to continue growing and developing.	1	2	3	4	5	6
41. I used to set goals for myself, but that now seems like a waste of time.	1	2	3	4	5	6
42. In many ways, I feel disappointed about my achievements in life.	1	2	3	4	5	6

43. It seems to me that most other people have more friends than I do.	1	2	3	4	5	6
44. It is more important to me to "fit in" with others than to stand alone on my principles.	1	2	3	4	5	6
45. I find it stressful that I can't keep up with all of the things I have to do each day.	1	2	3	4	5	6
46. With time, I have gained a lot of insight about life that has made me a stronger, more capable person.	1	2	3	4	5	6
47. I enjoy making plans for the future and working to make them a reality.	1	2	3	4	5	6
48. For the most part, I am proud of who I am and the life I lead.	1	2	3	4	5	6

Circle the number that best describes your present agreement or disagreement with each statement.	Strongly Disagree	Disagree Somewhat	Disagree Slightly	Agree Slightly	Agree Somewhat	Strongly Agree
49. People would describe me as a giving person, willing to share my time with others.	1	2	3	4	5	6
50. I have confidence in my opinions, even if they are contrary to the general consensus.	1	2	3	4	5	6
51. I am good at juggling my time so that I can fit everything in that needs to be done.	1	2	3	4	5	6
52. I have a sense that I have developed a lot as a person over time.	1	2	3	4	5	6
53. I am an active person in carrying out the plans I set for myself.	1	2	3	4	5	6
54. I envy many people for the lives they lead.	1	2	3	4	5	6
55. I have not experienced many warm and trusting relationships with others.	1	2	3	4	5	6
56. It's difficult for me to voice my own opinions on controversial matters.	1	2	3	4	5	6
57. My daily life is busy, but I derive a sense of satisfaction from keeping up with	1	2	3	4	5	6

everything.						
58. I do not enjoy being in new situations that require me to change my old familiar ways of doing things.	1	2	3	4	5	6
59. Some people wander aimlessly through life, but I am not one of them.	1	2	3	4	5	6
60. My attitude about myself is probably not as positive as most people feel about themselves.	1	2	3	4	5	6
61. I often feel as if I'm on the outside looking in when it comes to friendships.	1	2	3	4	5	6
62. I often change my mind about decisions if my friends or family disagree.	1	2	3	4	5	6
63. I get frustrated when trying to plan my daily activities because I never accomplish the things I set out to do.	1	2	3	4	5	6
64. For me, life has been a continuous process of learning, changing, and growth.	1	2	3	4	5	6

Circle the number that best describes your present agreement or disagreement with each statement.	Strongly Disagree	Disagree Somewhat	Disagree Slightly	Agree Slightly	Agree Somewhat	Strongly Agree
65. I sometimes feel as if I've done all there is to do in life.	1	2	3	4	5	6
66. Many days I wake up feeling discouraged about how I have lived my life.	1	2	3	4	5	6
67. I know that I can trust my friends, and they know they can trust me.	1	2	3	4	5	6
68. I am not the kind of person who gives in to social pressures to think or act in certain ways.	1	2	3	4	5	6
69. My efforts to find the kinds of activities and relationships that I need have been quite successful.	1	2	3	4	5	6
70. I enjoy seeing how my views have changed and matured over the years.	1	2	3	4	5	6
71. My aims in life have been more a source of satisfaction than frustration to	1	2	3	4	5	6

me.						
72. The past had its ups and downs, but in general, I wouldn't want to change it.	1	2	3	4	5	6
73. I find it difficult to really open up when I talk with others.	1	2	3	4	5	6
74. I am concerned about how other people evaluate the choices I have made in my life.	1	2	3	4	5	6
75. I have difficulty arranging my life in a way that is satisfying to me.	1	2	3	4	5	6
76. I gave up trying to make big improvements or changes in my life a long time ago.	1	2	3	4	5	6
77. I find it satisfying to think about what I have accomplished in life.	1	2	3	4	5	6
78. When I compare myself to friends and acquaintances, it makes me feel good about who I am.	1	2	3	4	5	6
79. My friends and I sympathize with each other's problems.	1	2	3	4	5	6
80. I judge myself by what I think is important, not by the values of what others think is important.	1	2	3	4	5	6

Circle the number that best describes your present agreement or disagreement with each statement.	Strongly Disagree	Disagree Somewhat	Disagree Slightly	Agree Slightly	Agree Somewhat	Strongly Agree
81. I have been able to build a home and a lifestyle for myself that is much to my liking.	1	2	3	4	5	6
82. There is truth to the saying that you can't teach an old dog new tricks.	1	2	3	4	5	6
83. In the final analysis, I'm not so sure that my life adds up to much.	1	2	3	4	5	6
84. Everyone has their weaknesses, but I seem to have more than my share.	1	2	3	4	5	6

Appendix G

Pittsburgh Sleep Quality Index (PSQI)

Instructions:

The following questions relate to you usual sleep habits during the past month only. Your answers should indicate the most accurate replay for the majority of days and nights in the past month. Please answer all questions.

1. During the past month, what time have you usually gone to bed at night?

   BED TIME_________

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

   NUMBER OF MINUTES________

3. During the past month, what time have you usually gotten up in the morning?

   GETTING UP TIME________

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

   HOURS OF SLEEP PER NIGHT________

For each of the remaining questions, please check the box below the best response. Please answer all questions.

5. During the past month, how often have you had trouble sleeping because you…

   a. Cannot get to sleep within 30 minutes

Not during the past month	Less than once a week	Once or Twice a week	Three or more times a week

   b. Wake up in the middle of the night or early morning

Not during the past month	Less than once a week	Once or Twice a week	Three or more times a week

   c. Have to get up to use the bathroom

Not during the past month	Less than once a week	Once or Twice a week	Three or more times a week

d. Cannot breath comfortably

Not during the past month	Less than once a week	Once or Twice a week	Three or more times a week

e. Cough or snore loudly

Not during the past month	Less than once a week	Once or Twice a week	Three or more times a week

f. Feel too cold

Not during the past month	Less than once a week	Once or Twice a week	Three or more times a week

g. Feel too hot

Not during the past month	Less than once a week	Once or Twice a week	Three or more times a week

h. Had bad dreams

Not during the past month	Less than once a week	Once or Twice a week	Three or more times a week

i. Have pain

Not during the past month	Less than once a week	Once or Twice a week	Three or more times a week

j. Other reason(s), please describe

____

____

How often during the past month have you had trouble sleeping because of this?

Not during the past month	Less than once a week	Once or Twice a week	Three or more times a week

6. During the past month, how would you rate your sleep quality overall?

Very Good	Fairly Good	Fairly Bad	Very Bad

7. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?

Not during the past month	Less than once a week	Once or Twice a week	Three or more times a week

8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

Not during the past month	Less than once a week	Once or Twice a week	Three or more times a week

9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

No problem at all	Only a very slight problem	Somewhat of a problem	A very big problem

10. Do you have a bed partner or room mate?

No bed partner or room mate	Partner/ room mate in other room	Partner in same room, but not same bed	Partner in the same bed

If you have a bed partner or room mate, ask him/her how often in the past month you have had…

a. Loud snoring

Not during the past month	Less than once a week	Once or Twice a week	Three or more times a week

b. Long pauses between breaths while asleep

Not during the past month	Less than once a week	Once or Twice a week	Three or more times a week

c. Legs twitching or jerking while you sleep

Not during the past month	Less than once a week	Once or Twice a week	Three or more times a week

d. Episodes of disorientation or confusion during sleep

Not during the past month	Less than once a week	Once or Twice a week	Three or more times a week

e. Other restlessness while you sleep; please describe

____

____

Not during the past month	Less than once a week	Once or Twice a week	Three or more times a week

Appendix H

Perceived Stress Scale (PSS)

The questions in this scale ask you about your feelings and thoughts during THE LAST MONTH. In each case, you will be asked to circle the number representing HOW OFTEN you felt or thought a certain way. Although some of the questions are similar, there are differences between them and you should treat each one as a separate question. The best approach is to answer fairly quickly. That is, don't try to count up the number of times you felt a particular way, but rather indicate the alternative that seems like a reasonable estimate.

0 = Never   1 = Almost Never   2 = Sometimes   3 = Fairly Often   4 = Very Often

In the last month..						
1	How often have you been upset because of something that happened unexpectedly?	0	1	2	3	4
2	How often have you felt that you were unable to control the important things in your life?	0	1	2	3	4
3	How often have you felt nervous and "stressed"?	0	1	2	3	4
4	How often have you dealt successfully with day to day problems and annoyances?	0	1	2	3	4
5	How often have you felt that you were effectively coping with important changes that were occurring in your life?	0	1	2	3	4
6	How often have you felt confident about your ability to handle your personal problems?	0	1	2	3	4
7	How often have you felt that things were going your way?	0	1	2	3	4
8	How often have you found that you could not cope with all the things that you had to do?	0	1	2	3	4
9	How often have you been able to control irritations in your life?	0	1	2	3	4
10	How often have you felt that you were on top of things?	0	1	2	3	4
11	How often have you been angered because of things that happened that were outside of your control?	0	1	2	3	4
12	How often have you found yourself thinking about things that you have to accomplish?	0	1	2	3	4
13	How often have you been able to control the way you spend your time?	0	1	2	3	4
14	How often have you felt difficulties were piling up so high that you could not overcome them?	0	1	2	3	4

Appendix I

BrainBaseline Test-Retest Reliability Scores

Test	DV	r	p
Trail Making	Time A	r = 0.67	p < .001
	Errors A	r = 0.25	p < .001
	Time B	r = 0.74	p < .001
	Errors B	r = 0.38	p < .001
Flanker	Congruent RT	r = 0.85	p < .001
	Incongruent RT	r = 0.79	p < .001
	RT Interference	r = 0.62	p < .001
	Overall RT	r = 0.84	p < .001
Digit Span	Number of Digits	r = 0.35	p < .001
Speed	RT	r = 0.81	p < .001
SPWM	Acc	r = 0.59	p < .001
PMS	RT	r = 0.63	p < .001
	Errors	r = 0.47	p < .001

Scores from 125 individuals aged 60-85, collapsed across gender. Values represent the correlation (Pearson's r) between user scores on first and second runs of each test, for the primary dependent variable (DV) in each test.