THE EFFECTS OF ACUTE EXERCISE ON CATEGORY-PROMPTED AND CONSONANT-PROMPTED WORD FLUENCY IN AN INSTITUTIONALIZED ELDERLY SAMPLE

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The effects of acute exercise on category-prompted and consonant-prompted word fluency in an institutionalized elderly sample.

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ABSTRACT

Regular bouts of strenuous exercise have been associated with improved functional status in the frail elderly. Chronic aerobic exercise has also been linked, though less conclusively, to improved cognitive functioning through improved oxygenation of the brain. A problem arises, however, if the levels of exercise necessary to achieve these improvements are too strenuous to be performed by the very frail elderly. This paper investigates a possible relationship between acute non-strenuous exercise and improved cognitive performance in a sample of institutionalized older adults. The purpose of the present study is to replicate the results from a study conducted by Stones and Dawe (1993). This study will attempt to sort out task order effects that were problematic in the Stones and Dawe study. This will help to investigate the relationships between activity on two cognitive tasks, a category-prompted word fluency test and a consonant-prompted word fluency test. The present study will also attempt to clarify the time parameters of the benefits and to assess the effect of different physical ability levels on the magnitude of the exercise effects. The hypothesis tested is that a 15-minute non-strenuous exercise intervention will be sufficient to produce improved performance on a category-prompted word fluency task but not on a consonant-prompted task.

Fifty-nine subjects volunteered from three nursing homes in the St. John's, Newfoundland area. The investigator randomly assigned subjects to one of four groups. The

two exercise groups were exposed to 15-minutes of non-strenuous exercise. The control groups viewed a 15-minute video of similar exercises. Experimental group 1 and control group 1 completed a category-prompted word fluency task at pretest, immediate posttest, and 30-minute delayed posttest. Experimental group 2 and control group 2 completed a consonant-prompted word fluency task at the three testing times.

I used a two (group) by two (task) by four (trials) by three (time) repeated measures ANOVA design to assess the effects of exercise on both of the cognitive tasks. This analysis showed no effect of exercise on either cognitive task ($p<.05$).

There was no evidence that supported previous contentions that acute exercise affects category-prompted word fluency. A review of the literature concerning acute exercise indicates that previous findings have yet to replicate improvements on the same cognitive task.

I performed two stepwise regression analyses to determine which variables contributed most significantly to the differences on the two cognitive tasks. The analysis revealed that activity propensity and financial hardship were the best predictors of category-prompted word fluency. Researchers have not directly studied the influences of these two factors on word fluency. I conclude that the relationship between acute exercise and cognitive performance is not a robust one. A more likely explanation of the relationship is that overall activity level combined with low negative affect influences cognitive functioning in later life. Perhaps by studying these relationships caregivers to the institutionalized elderly will have an indication of who would most benefit from inclusion in different activities.

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Regular exercise (referred to here as chronic exercise) has long been linked in the gerontology literature to improved functional status, particularly in the frail elderly. Strength training can maintain the muscles necessary to perform activities of daily living (i.e., sitting and standing). Similarly, there is a threshold of aerobic capacity needed to perform activities of daily living, and improving aerobic capacity through chronic exercise can help the frail elderly perform these activities more easily. Regular aerobic exercise has also been linked, though less conclusively, to improved cognitive functioning through improved oxygenation of the brain. A problem arises, however, if the levels of exercise necessary to achieve these improvements are too strenuous to be performed by the very frail elderly. Thus, it is important for researchers to identify the minimum effort required to provide benefits.

This paper investigates a possible relationship between acute non-strenuous exercise and a short-term improvement in cognitive performance in a sample of institutionalized older adults. A link between exercise and cognitive performance will be demonstrated by first reviewing the literature on the effects of chronic exercise on the cognitive performance of older adults. Next, the evidence from acute exercise studies will be reviewed. Many of the results from acute exercise studies were inconclusive due to design weaknesses. Replications of results and better-designed studies are necessary in order to establish the relationship between non-strenuous exercise and cognitive performance. The purpose of the present study is to replicate the results from a study conducted by Stones and Dawe (1993). The Stones and Dawe study found that a 15-minute non-strenuous exercise intervention was sufficient to produce improved performance on a category-prompted word fluency task. Other cognitive tasks (a consonant-prompted word fluency test and a digit symbol test) did not show similar improvements and the duration of the observed improvement on the category-prompted word fluency test was unclear. The present study will attempt to replicate these findings and will correct for the test order confound. The hypothesis tested is that a single dose of non-strenuous exercise will produce improved performance on a category-prompted word fluency task but not on a consonant-prompted word fluency task.

Research on the effect of exercise on aging and performance has emerged since gerontologists began distinguishing between usual and successful aging. In order to separate pathological changes from those that can be attributed to age, researchers have made a distinction between primary (i.e., normal) and secondary (i.e., disease-related) aging (Birren & Cunningham, 1985). Rowe and Kahn (1987) were the first to distinguish between two types of primary aging: usual and successful. These researchers discerned that primary aging does not take into account the heterogeneity among older people because of differences in lifestyle. Rowe and Kahn postulated that extrinsic factors such as diet, exercise, and nutrition may moderate the rate of aging. Thus, some individuals will experience the "usual" decrements associated with aging while others, through a variety of lifestyle factors, will be able to slow the progress of some of the usual declines and could be described as aging "successfully".

Birren and Cunningham (1985) looked at the heterogeneity among older adults at the other end of the spectrum and distinguished between two types of disease-related aging: secondary aging and tertiary aging. According to these researchers, secondary aging includes age-correlated disease processes whereas tertiary aging describes an accelerated functional deterioration that occurs during the months before death. Stones, Kozma, and Hannah (1990) stated that these four types of aging have two clear implications for age trend. The first implication is that losses on many age-dependent functions show acceleration with age and second, heterogeneity in performance tends to increase with age.

Exercise is one extrinsic factor that has been studied extensively and may contribute to heterogeneous performance among older adults. Beginning with Spirduso (1975), many researchers examined the issue of whether physical exercise could function in such a way as to slow the course of deterioration in cognitive and psychomotor performance or otherwise provide beneficial effects. Smith and Gilligan (1983), for example, claimed that "disuse accounts for about half of the functional decline (in some age-dependent functions) . . . and aging the other half" (p.91). Spirduso (1980) stated that

> exercise may prevent or postpone a commonly existing cycle: disuse decreases metabolic demands in motor and somatosensory brain tissue, which may decrease the need for circulatory flow, which may result in neuronal destruction, leading to disuse of brain tissue, and so on. (p. 860).

These two interpretations of the exercise/cognition relationship can be described as prediction models. Specifically, these authors described the moderator variable model

(Stones & Kozma, 1988). This model builds on the idea of "successful aging" by emphasizing the heterogeneity among older adults. The moderator model contends that while some people become increasingly sedentary with age others may remain active throughout the lifespan. While chronic physical *in*activity contributes to deterioration in functional performance over time, this deterioration may be postponed or even averted in individuals who retain an active lifestyle.

Another type of interpretive model researchers have used to describe the association between exercise and cognitive function is the process model. Process models attempt to provide an explanation of the underlying mechanisms that link physical activity to cognitive performance.

Dustman et al. (1984) proposed a hypoxia-reduction model, a biological process model, to explain fitness training effects on cognitive performance. Research that has supported this model contends that chronic aerobic exercise promotes cerebral metabolic activity in several ways: (1) improved overall vascularization of all areas of the brain (Dustman, Emmerson, & Shearer, 1990); (2) slowed neuronal loss (Spirduso, 1982); (3) enhanced neurotransmitter function (Dustman, Emmerson, & Shearer, 1990); and (4) preserved dopamine function (Spirduso, 1982).

A second class of process modeling that has been used in exercise research involves psychological processes. Psychological process models generally are phrased in terms of arousal and decreased susceptibility to distraction (Stones & Kozma, 1988). Tomporowski and Ellis (1986) reviewed the exercise literature and presented two competing psychological process models that attempted to explain the relationship between physical activity and cognitive functioning. The first model stated that exercise may initially facilitate attentional processes. This facilitation is achieved by directly affecting the central nervous system, but as exercise intensity or duration increases, facilitative effects may be canceled by debilitating effects or muscle fatigue. This model further stated that exercise may facilitate or impair performance depending on the level of fitness of the subjects at the point of being tested. The second model assumes that exercise *per se* does not alter cognitive functioning, but that motivational variables affect test performance. Thus, according to this second model, individuals who do not regularly exercise view exercise as more physically and psychologically stressing which might in turn produce a decrement in their performance.

Either of these psychological process models provides implications for the level or intensity of exercise and the age of individuals. For example, low-intensity or infrequent exercise may not produce changes in cognitive performance in younger or healthier subjects, however, facilitation may occur in more sedentary older individuals where low levels of exercise would not stress the frail elderly to the extent that some other exercise interventions might. The second interpretation is important in assessing studies, particularly cross-sectional exercise studies, that might utilize self-selected samples. Despite these potential contributions, Stones and Kozma (1988) noted that psychological process models require a more unified direction if they are to gain wide acceptance.

Process modeling, both psychological and biological, has been described as "reductionist" (Stones & Kozma, 1988) and indeed, researchers who have used this approach tend to speculate toward a more predictive model:

> If all had practiced a life-style that included frequent aerobic exercise, perhaps significant age-related changes in electrophysiology would have been postponed for several years. (Dustman, Emmerson, & Shearer, 1990, p. 137)

In addition, research comparing competing process models is extremely limited (Stones & Kozma, 1988). Process modeling, however, has proven key in establishing a link between physical activity and cognitive functioning. Many studies, particularly cross-sectional human studies, have been criticized for not using a "true experimental design" (Folkins & Sime, 1981). Often in the exercise literature, a quasi-experimental design is used where high- and low-fit subjects are compared across age groups. These groups usually have chosen a lifestyle of fitness in the case of the high-fit subjects and evidence has shown that these individuals may differ on other extraneous factors such as socioeconomic status or other health habits (Stones & Kozma, 1988). One method of avoiding this bias in cross-sectional exercise studies is the use of animal subject groups where animals are randomly trained into a high- or low-fit group. Many of the studies that have attempted to explain biological processes have used animal studies in extremely controlled environments and have provided convincing evidence for an association between physical activity and cognitive functioning (these studies are discussed in detail in a following section).

An alternative theoretical perspective to either prediction models or process models is the functional age model. This model does not assume that the aging process itself is affected by exercise as in the moderator model. Instead, a functional age model suggests that chronic exercise has a generalized benefit, or *tonic effect*, on the organism (Stones & Kozma, 1988). Thus, overall capability to function is influenced by both chronological age and various lifestyle factors (i.e., physical activity, diet, or smoking) but these factors contribute independently to determine the level of function (Stones & Kozma, 1988).

Stones and Kozma (1988) presented a functional age model they termed "the Tonic and Overpractice Effects (TOPE) model". These researchers provided evidence that suggested that only through the overpractice of specific psychomotor skills can physical activity slow the usual course of age deterioration. In terms of physical activity, this hypothesis means that individuals can execute familiar movements skillfully and these movements will remain unimpaired with age. In terms of cognitive performance, tasks that are performed regularly, for example oral language skills, might be unimpaired while written tasks, which likely would be performed less regularly, might be affected by age.

The TOPE model is very difficult to test in terms of cognitive performance because of the inherent challenge in determining which cognitive tasks are over practiced. In addition, there are likely vast individual differences in the cognitive skills a person utilizes regularly. A functional age model does, however, provide a meaningful higher order construct in which to embed interdependent cognitive and physical functions (Stones & Kozma, 1988). Prediction models, on the other hand, describe the type of relationship(s) among the relevant variables and tend to be more atheoretical (Stones & Kozma, 1988) Process models have already been described as reductionist in their attempt to explain why these relationships exist by merely explaining underlying processes.

The purpose of the present study is to establish if there is a relationship between acute exercise (in this case a single dose of non-strenuous exercise) and cognitive function, and so, the higher order modeling of the TOPE model is beyond the scope of this study. It is useful to look at all three of these theoretical perspectives when reviewing the literature on physical activity and cognitive function because it allows for a more complete review of the research into this area. Each perspective is best tested using a different research design. For example, while a biological process model is best tested using animal studies, which can control for such things as self-selection bias, the results may not generalize to humans. In addition, researchers have noted differing results depending on the research design used (Spirduso & Asplund, 1995). These researchers compared the results from cross-sectional and intervention studies investigating fitness and cognitive function and found that cross-sectional studies were more likely to note differences in cognitive performance than intervention studies. As was previously mentioned, cross-sectional human studies that compare high- and low-fit subjects are often confounded by a self-selection bias. Individuals who choose a lifestyle of physical activity tend to differ on a number of other variables as well, such as higher socioeconomic status and educational level, and lower incidences of smoking (Stones & Kozma, 1988). On the other hand, intervention studies have been criticized for having "severe sampling problems, poor cognitive assessment, inadequate practice provided, and participants with low fitness levels" (Spirduso & Asplund, 1995). Thus, this literature review will look at evidence from several types of research designs.

I will begin the literature review by discussing evidence of an association between chronic high-intensity exercise and cognitive performance from animal studies, cross-sectional human studies, and intervention studies. This will be followed by a review of the literature linking chronic non-strenuous exercise and cognitive performance. Finally, I will look at studies that have looked at the relationship between acute exercise and cognitive performance.

Before beginning the review of the literature, I will define some key terms. Exercise programs designed for older adults in order to maintain or improve fitness are recommended at a moderate intensity (more than 50% VO_2max - maximum oxygen intake) for up to 60 minutes per day, every day (Haskell, Montoye, & Orenstein, 1985). Exercise programs designed for adults between the ages of 25 and 65 are recommended for more than 30 minutes at moderate intensity at least every other day (Haskell, Montoye & Orenstein, 1985).

Beginning with these recommendations, but also generalizing from the exercise literature, I defined chronic exercise as exercise performed at least three times a week for at least four weeks. Acute exercise refers to exercise that is not performed regularly. Specifically, the exercise is not performed at a frequency or over a period of time that would likely produce fitness effects. Aerobic exercise refers to exercise in which the primary source of power is oxygen, this depends on the type and duration of the exercise. Thus aerobic exercises are those that require continuous and rhythmic use of large muscles for at least 15 minutes (American College of Sports Medicine, 1986). Anaerobic exercise means, literally, without oxygen and refers to exercise where oxygen is not the major energy source, such as weight training. In this paper, I defined strenuous exercise as aerobic exercise that exceeds 70% VO_2max (maximum oxygen intake) or muscularly strenuous exercise meant to be performed until fatigue. Much of the literature does not measure VO_2max or assess other fitness variables that can serve as estimates of VO_2max such as heart rate. In such cases, I imply the intensity level based on the researcher's account of the intended intensity and the goals of the exercise protocol. Non-strenuous exercise refers to exercise that is not intended to produce fitness effects. While physiological changes such as increased heart rates are expected, the non-strenuous exercise is not performed at an intensity or for a duration that would likely cause fitness effects.

Relationship Between Central Nervous System (CNS) Health and Chronic Exercise

The research on exercise, performance, and aging is difficult to interpret because the exercise regimes vary substantially from study to study. Historically, researchers have focussed on the effects of chronic aerobic exercise on older adults. Before delving into the literature linking physical activity to cognitive performance, I will provide a brief overview of the relationship between physical activity and physiological functioning in older adults.

The effects of chronic exercise on physiological functioning in older adults

Research has identified regular exercise as one of the most important health practices associated with health and longevity among the aged (Palmore, 1970). Further, studies have identified inactivity as a risk factor for all-cause mortality (Paffenbarger, Hyde, Wing, & Hsieh, 1986), cardiovascular disease, (Paffenbarger, Wing, & Hyde, 1978) and cancer (Blair et al., 1989). There is convincing evidence that indicates chronic exercise is associated with gains in physical performance. Some observed gains in physical performance include improved aerobic capacity (e.g., Adams & deVrie, 1973; deVrie, 1970), improved skeletal muscle strength (e.g., Grimby & Saltin, 1983; Stamford, 1973), and reduced occurrence of some age-related diseases such as osteoporosis (e.g., Aloia et al., 1978; Sogaard, Danielson, Thorling, & Mosekilde, 1994).

Dustman, Emmerson, and Shearer (1990) postulated that chronic aerobic exercise prevents and may in fact reverse age-related losses associated with inactivity. Ample evidence indicates that chronic aerobic exercise improves aerobic capacity in older adults. DeVries (1970) found evidence of improved oxygen transport capacity, percentage body fat, physical work capacity, and both systolic and diastolic blood pressure in older men after a 6-week aerobic training regimen. These findings have been replicated for both men and women in many studies (e.g., Adams & deVrie, 1973; Blumenthal et al., 1989; Cunningham, Rechnitzer, Howard, & Donner, 1987; Hopkins, Murrah, Hoeger, & Rhodes, 1990; Madden, Blumenthal, Allen, & Emery, 1989; Schwartz et al., 1991; Sidney & Shephard, 1978; Takeshima, Tanaka, Kobayashi, Watanabe, & Kato, 1993). In a review of this research, Buchner, Beresford, Larson, LaCroix, and Wagner (1992) estimated that modest improvements ranging from 5% to 20% maximum oxygen intake have been observed in older adults after three to twelve months of chronic exercise. This relationship was found to be particularly relevant to older adults as improved aerobic capacity in the frail elderly would improve functional status when aerobic capacity has fallen below the threshold needed for daily activities (Buchner et al., 1992). There is also recent evidence that shows older adults can maintain improvements achieved in the early stages of an exercise program for up to two years (Morey et al., 1991).

Researchers have also observed gains in skeletal muscle strength in older adults as a result of chronic exercise. Typical age-related declines in strength range from 30% to 40%

in the back, legs, and arms (Grimby & Saltin, 1983). Studies have shown increases in the strength of older adults after chronic resistance training (Fiatarone et al., 1990; Stamford, 1973). Current research of skeletal muscle gains has focussed on antioxidant enzyme responses to exercise and aging. This research has shown that while aging may affect antioxidant and metabolic capacities in skeletal muscle, regular exercise can preserve the function of these enzymes (Cartee, 1994; Ishihara & Taguchi, 1993; Ji, Wu, & Thomas, 1991). Maintenance of muscle strength in older adults is important for independent functioning. Many daily tasks require a degree of muscle strength and so it is necessary to maintain the minimal muscle strength to perform these tasks if independent functioning is to be maintained.

In addition to declines in aerobic capacity and muscle strength, aging is associated with a progressive decline in bone density that can lead to osteoporosis. This decline has been observed in both males and females after age 30 (Rowe & Kahn, 1987). Several studies have indicated that chronic exercise programs can reduce bone loss (Aloia et al., 1978; Krolner, Toft, Pors Nielson, & Tondevold, 1983). Osteoporosis is a debilitating illness that affects the autonomy of older adults dramatically. Recent research has tried to identify extrinsic factors such as exercise and diet that can maintain or reverse loss. For example, some of the current research focuses on how exercise buffers against loss in bone density (Chen, Yeh, Aloia, Tierney, & Sprintz, 1994; Sogaard, et al.,1994; Tate et al., 1990; Yeh, Aloia, Tierney, & Sprintz, 1993).

This discussion outlines only some of the ways in which chronic exercise has been associated with improved physiological functioning. The evidence is quite conclusive in determining that physical activity is associated with physiological benefits that, in turn, can lead to prolonged independent functioning in older adults. Looking at this association simply at the process level, one can surmise that if chronic exercise can lead to physiological improvements then it is likely that these physiological changes may also occur in the brain. Thus, physical activity may also cause physiological changes that could affect cognitive functioning. A minimal level of cognitive functioning is as important to independent functioning as physical functioning for even the most mundane activity involves both attention and memory processes. By maintaining a level of cognitive functioning through exercise, independent living may likewise be maintained.

The Effects of Chronic Exercise on Cognitive Performance

The relationship between chronic exercise and cognitive performance is far less clear. Some age-related changes in the brain that affect performance include decreased vascularization, neuron loss, and electrophysiological changes. Research has presented evidence suggesting that aerobic fitness training results in more efficient oxygen transport and the delivery of oxygen to consumer cells, including brain cells (deVries, 1975). Researchers have suggested several ways in which chronic exercise and increased oxygenation may moderate age-related decrements in cognitive performance. To reiterate from the discussion on biological process models above, these explanations include improved overall vascularization of all areas of the brain (Dustman, Emmerson, & Shearer, 1990), slowed neuronal loss (Spirduso, 1982); enhanced neurotransmitter function (Dustman, Emmerson, & Shearer, 1990); and preserved dopamine functioning (Spirduso, 1982). The most extensive review of the literature linking exercise and cognitive function is by Dustman, Emmerson, and Shearer (1994). A search using the Social Science Citation Index failed to find a more comprehensive review. Dustman, Emmerson, and Shearer (1994) approached this research from a process modeling perspective. Although this approach may lack the higher order modeling preferred by some researchers, the studies reviewed provide convincing evidence for a link between physical activity and cognitive functioning.

In Dustman, Emmerson, and Shearer's (1994) review of the literature, they evaluated support for the hypothesis that aerobic exercise is beneficial to CNS health, which would result in improved cognitive functioning, and presented several predictions. For example, they predicted that aerobic exercise training in animals would be associated with neurobiological changes that would improve behavioural functioning. Compared on measures believed to reflect CNS health, physically active humans and animals would perform better than sedentary matched controls. Adopting a more aerobically active lifestyle would result in improvements on these same measures on previously sedentary individuals. Finally, prolonged exercise that extends through a large portion of adult life should slow the rate at which CNS efficiency declines during the aging process. A summary of their findings follows. There is convincing evidence from this review that chronic exercise likely has some effect on age-related declines in cognitive performance.

Evidence associating chronic exercise and cognitive performance from animal studies

The animal studies reviewed provide support for the prediction that physical exercise leads to health benefits for the central nervous system. Animal studies provide fundamental evidence for a clear association between physical activity and cognitive performance because the studies generally use true experimental research designs (as defined by Campbell & Stanley, 1963) and they can control for self-selection bias. Also, they can investigate biological processes that cannot be used in human studies to provide an explanation for why such a relationship might exist. It should be noted that the exercise programs are at an exercise intensity, frequency, and duration to produce significant improvements in aerobic capacity. Some of the electrophysiological changes Dustman, Emmerson, and Shearer noted in this review include: changes in basic properties of the CNS; improved neurotransmitter functioning with a preservation of dopaminergic cells in old animals who began exercising in middle age; increased vascularization of activated brain areas and an increase in cell hypertrophy and complexity; faster transmission of information throughout the periphery and within the brain indicated by faster nerve conduction times and earlier event-related (ERP) latencies; and a reduction of CNS excitation such that inhibition played a stronger role in behaviour.

Looking first at the evidence from cross-sectional animal intervention studies, Samorajski, Rolsten, Przykorska, and Davis (1987) compared mature, middle-aged, and old mice who had participated in spontaneous wheel running for 12 weeks to age-matched sedentary controls. This study found that the exercised mice had an increased life span and a small increase in norepinephrine. A second study compared mature and old rats both of whom had been exposed to an exercise regime of treadmill running five days per week for 10 weeks to age-matched controls who were placed on the treadmill but the treadmill was not turned on (Tümer, Hale, Lawler, & Strong, 1992). This study found improved GABA and cholinergic synthesis for the mature animals but not the old animals. Tümer et al. speculated that this difference may have reflected reduced plasticity of the older brain. These two studies indicate a clear relationship between physical activity and changes in some basic CNS properties. This cross-sectional research design is ideal for determining age differences because not only can pretest and posttest measures be compared within groups, comparisons can be made between age-matched control groups and across age groups. Thus, cohort differences can be separated from changes occurring as a result of the intervention.

Improved neurotransmitter functioning has been demonstrated in intervention studies that did not compare across age groups. Specifically, some such studies have found an association between aerobic exercise and the maintenance of dopamine receptor sites. Gilliam et al. (1984) found a greater number of dopamine receptor sites in rats who were either endurance or interval trained on an exercise wheel for 12 weeks than they found in rats who had no training but who had their food restricted to maintain the weight at the same level as the exercised rats. Rats were studied over a similar period of time, 12 weeks, in a separate study (MacRae, Spirduso, Walters, Farrar, & Wilcox, 1987). This study compared endurance training (running on an exercise wheel for 12 weeks) to low-intensity training (running for five minutes per day) and found that endurance training appeared to exert a protective effect on D2 dopamine receptors during the life span. The low-intensity exercise, however, did not elicit significant changes. The MacRae et al. study provided support that chronic, high-intensity exercise can provide benefits for dopamine function. Other studies also found endurance exercise to be associated with improved neurotransmitter functioning (e.g., Bauer, Rogers, Miller, Bove, and Tyce [1989] who found significant increases in free and conjugated dopamine [DA] and in conjugated norepinephrine [NE] at rest after 12 weeks of treadmill running; Brown and Van Huss [1973] who found NE levels in the brain to be significantly higher in rats who had participated in free wheel running; Brown et al. [1979] who found NE and 5-HT levels significantly higher in several brain areas after eight weeks of treadmill running; DeCastro and Duncan [1985] who found whole brain DA levels significantly higher following eight weeks of reinforced wheel running; and Fordyce and Farrar [1991a, 1991b] who found enhanced hippocampal cholinergic activity following 14 weeks of reinforced treadmill running).

Further evidence from animal intervention studies showed changes in brain structure and vasculature within motor-related areas of the rodent brains following programmed exercise (Dustman, Emmerson, & Shearer, 1994). For example, Pysh and Weiss (1979) allowed one group of mice to engage in free running and climbing while a second group had their activity restricted. Examination of the Purkinje cells of the cerebellum showed larger dendritic trees and a greater number of spines in the active mice compared to the mice whose activity was restricted. An increase in dendritic trees allows for greater vascularization of the brain (Dustman, Emmerson, & Shearer, 1990). Gentile, Beheshti, and Held (1987) also found evidence for an increase in cell hypertrophy and complexity in exercised animals. Black and colleagues furthered this research by looking at vascularization in areas within the cerebellar cortex in a series of studies (Black, Greenough, Anderson, & Isaacs, 1987; Black, Isaacs, Anderson, Alcantara, & Greenough, 1990; Isaacs, Anderson, Alcantara, Black, & Greenough, 1992). These researchers looked at structural changes in the brain as a result of two kinds of exercise. Rats were exposed to one month of either repetitive exercise, motor learning, or an inactive condition. Exercised rats demonstrated a shorter diffusion distance from blood vessels in the molecular layer of paramedian lobules (PMLs - angiogenesis) when compared to rats housed individually or rats who participated in a motor learning task. An increased volume of the molecular layer per Purkinje neuron and increased blood vessels sufficient to maintain diffusion distance (synaptogenesis) was found in the rats taught complex motor skills. The investigators estimated that the exercised animals had made approximately 10 times the number of locomotor movements than had been made by rats taught motor skills or the control rats. Dustman, Emmerson, and Shearer (1994) speculated that the function of the angiogenesis observed in the exercised rats was to provide additional nutrition to cells that experienced high rates of activation during running.

Further evidence from animal intervention studies pointed to an increase in the speed of information transmission within the central and peripheral nervous system of rodents. Retzlaff and Fontaine (1965) found that conduction velocities of large fiber, fast-conducting sciatic nerves were 37% faster for rats exposed to endurance training than for sedentary rats. This study also provided evidence for improved longevity by finding increased conduction velocities of large fiber nerves in "geriatric" aged, exercised rats when compared to age-matched controls. Increased speed of information processing, measured using visually evoked potential (VEPs) and somatosensory evoked potential (SEPs), was demonstrated in exercised rats who were exposed to an enriched environment in a separate experiment (Spencer, Mattson, Johnson, & Albee, 1993).

Other electrophysical changes Dustman, Emmerson, and Shearer (1994) found to be associated with exercise included improved excitatory/inhibitory balance of older-aged animals. Inhibition is important in all behaviour, so a lessening of inhibitory strength within the CNS would be expected to adversely affect physical and cognitive functioning (Dustman, Emmerson, & Shearer, 1990, 1994). Some studies have shown reduced excitability through electroencephalographic (EEG) and behavioural measures in rodents who had participated in long-term endurance programs when compared to non-exercised animals (Nikiforova, Patchev, & Nikolov, 1989; Nikiforova, Patchev, Nikolov, & Cheresharov, 1988).

Increased behavioural speed in exercised animals provides evidence that the CNS changes illustrated translate into changes in behaviour. Spirduso and Farrar (1981) compared young and old exercised rats to age-matched controls. The exercise protocol consisted of six months of daily running. These researchers found that exercised rats were faster on some escape/avoidance measures than sedentary animals and that age-related loss in quickness was smaller for trained animals. Samorajski et al. (1985) found similar results when they compared mature, middle-aged, and old mice. Exercised mice were exposed to spontaneous wheel running for up to 12 months. Control animals had no wheel running. The results showed improved performance on passive-avoidance memory and that improved memory was greater for middle-aged and old than for young adults.

In summary, Dustman, Emmerson, and Shearer (1994) provided compelling evidence from controlled animal studies that chronic exercise can have benefits for the central nervous system. Electrophysiological improvements found included modifications of brain structure observed in the neurotransmitters, vasculature, and the excitation/inhibition balance. Long-term exercise continuing into old age has also been linked to slowed DA loss that is typical in aging animals and humans. Improved cognitive performance has been demonstrated through increased speed measured through nerve conduction, ERP component latency, and time to execute behavioural responses. In their review, Dustman, Emmerson, and Shearer (1994) concluded that "It seems most probable that the electrophysiological and behavioral improvements were manifestations of underlying changes in neurobiology that occurred as a result of strenuous exercise." (p. 153). Several of the studies cited compared the effect of exercise on cognitive performance across age groups. These animal studies allow researchers to identify age-changes clearly because these cross-sectional studies are not biased by self-selection as is the case in many cross-sectional human studies. An investigation of human studies is necessary because of the weakness inherent in animal studies concerning their generalizability to humans. For example, a recommendation that exercise benefits are optimal when exercise begins in middle-age may not generalize to humans because middle-age in a rat is not comparable to middle-age in a human due to the shorter life span of the rat.

Evidence associating chronic exercise and cognitive performance from cross-sectional human studies

Human cross-sectional studies yielded similarly optimistic outcomes as those presented in the animal studies. Dustman, Emmerson, and Shearer (1994) found that when humans exercise, structural and chemical changes within the CNS closely parallel those reported for aerobically-trained animals. In their review, these researchers evaluated studies where individuals with an active lifestyle were compared to those with a more sedentary lifestyle. The review provided evidence that suggested vigorous exercise is associated with faster information processing and task execution reflected by earlier ERP component latencies and quicker response times; better performance on cognitive tasks that require effortful rather than automatic processing or on tasks that measure fluid rather than crystallized intelligence; stronger inhibition as suggested by measures of cortical coupling and augmenting, reduction of visual and somatosensory stimuli, and fewer seizures in individuals with epilepsy; and finally, a relative preservation of CNS functioning in old age illustrated by measures of electrophysiological functioning, response speed, and cognitive functioning.

Researchers use electrophysiological measures such as EEGs and ERPs to measure neurobiological changes in humans. The EEG reflects the spontaneous electrical activity of the brain, most likely from dendritic processes in the upper cortical layers (Glaser, 1963). ERPs, on the other hand, are electrical potentials that are elicited by repeating stimulus events such as flashes of light, clicks, tones, or shocks to the hand or wrist, and by stimuli that require a higher level of cognitive evaluation (Dustman, Emmerson, & Shearer, 1990). A variety of ERPs have been used in studies of aging including early latency brain stem auditory and somatosensory evoked potentials (SEPs) which provide information regarding neural transmission from lower brain stem structures to the cortex; middle latency components (classical sensory evoked potentials) which reflect the arrival and initial processing of sensory input to primary receiving areas (Beck, 1975); and long-latency components (visually evoked potentials [VEPs]) which are sensitive to arousal, attention, and habituation. Evidence linking neurobiological changes with exercise provided a biological basis from which improved cognitive functioning could be explained.

Dustman et al. (1990) used electrophysiological measures to examine relationships between aerobic fitness and CNS functioning. These researchers compared high- and low-fit young adults (21-31 years of age) and high- and low-fit older adults (50-62 years of age). Fitness was estimated by measuring subjects' VO_2max. Subjects were administered electrophysiological tests including EEGs, VEPs to three intensities of flash, and visual P3 ERPs; and several cognitive tests including the Wechsler Adult Intelligence Scale (WAIS) vocabulary, reaction time, Stroop colour interference, symbol digit, and trails B. The results showed age differences in EEGs that were interpreted as reflecting weakened inhibition in old age and a breakdown of "functional autonomy" in areas of the older brain. The results also indicated that the physically fit elderly subjects did not differ from young adults on cortical coupling values which supported Dustman et al.'s (1990) hypothesis that endurance exercise can modulate excitation/inhibition relationships in humans as it appears to do in rodents. The ERP findings from the Dustman et al. (1990) study indicated that participation in aerobic fitness activities over a relatively long period of time is associated with enhanced speed in responding to visual signals and the processing of visual information. The results from the P3 component latencies also revealed that fitness level is related to visual processing speed. Performance of high-fit subjects was superior to that of low-fit subjects on all of the cognitive tests with the exception of the vocabulary sub-test of the WAIS.

Reaction time has been used in many studies as an indicator of cognitive function. The Dustman et al. (1990) study already discussed showed faster reaction times in high-fit subjects when compared to low-fit subjects. This finding was supported in many other cross-sectional studies. Focussing first on cross-sectional studies that compared across age groups, Spirduso (1975) found that physically active subjects had faster reaction times than subjects who were not physically active. This researcher also found that on most measures, performance of old (50-70 years old) active subjects was more like that of young subjects (20-30 years old) than of old inactive subjects. Several other studies supported Spirduso's (1975) findings (e.g., Clarkson, 1978; Offenbach, Chodzko-Zajko, & Ringel, 1990; Rikli & Busch, 1986; Spirduso & Clifford, 1978; Spirduso, MacRae, MacRae, Prewitt, & Osborne, 1988).

Researchers have relied on a variety of methods to assess fitness and have used varying criteria to assign individuals to high- and low-fit groups. Three of the above studies classified physically active subjects on the basis of participation in regular physical activity over the past two to three years (young subjects) or for most of their adult lives (10-30 years) (Clarkson, 1978; Rikli & Busch, 1986; Spirduso & Clifford, 1978). In the Spirduso et al. (1988) study, high-fit subjects in all age groups had walked, jogged, or ran at least three miles per day, three days per week, for at least five years. Offenbach et al. (1990) measured fitness using a composite of cardiovascular, pulmonary, hemodynamic, biochemical, and anthropometric variables, all of which are shown to correlate well with VO_2max. Regardless of the method or criteria used, the studies that compare young high- and low-fit adults to older high- and low-fit adults found an association between physical activity and faster reaction times and generally this association was stronger in the older groups. Special note should be taken of the Rikli and Busch (1986) study because these researchers not only compared old active and inactive subjects to young active and inactive subjects, but they also included old golfers. Golf is considered to be a non-strenuous activity that does not make excessive cardiovascular demands nor excessive muscular demands (Fox, Bowers, & Foss, 1989). The reaction times of the old golfers fell between the old active and the old inactive subjects.

Other studies also found evidence linking physical activity to faster reaction times in older adults (Clarkson-Smith & Hartley, 1989, 1990). These studies, however, did not compare subjects across age groups, instead age was used as a covariate. In both studies age and exercise were found to affect each performance variable (i.e., reaction time) directly. Indirect effects of age on performance, mediated through exercise, were also found. Thus, the main hypothesis of these studies, that exercise contributes to cognitive performance, was supported.

In addition to faster reaction times, improved cognitive performance has been demonstrated through tasks that require effortful processing and tasks that measure fluid rather than crystallized intelligence.[1] Cross-sectional studies provide evidence for an association between chronic exercise and these cognitive measures. For example, Powell and Pohndorf (1971) studied 71 men between the ages of 34 and 75 and compared exercisers (running for at least three years) to non-exercisers (relatively sedentary during this time) on a measure of fluid intelligence. These researchers found some support (though not statistically significant) for an association between exercise and better fluid intelligence. Stronger support for this association has since been found (Chodzko-Zajko, Shuler, Solomon, Heinl, & Ellis, 1992; Dustman et al., 1990; Elsayed, Ismail, & Young, 1980; Spirduso et al., 1988).

Elsayed, Ismail, and Young (1980) compared high- and low-fit subjects across two age groups, young (mean age=25) and old (mean age=53). Fitness was assessed using physiological values including VO_2max. High-fit subjects were shown to have significantly higher scores for fluid intelligence than their age-matched peers. Fitness level was not found to be related to crystallized intelligence. The Dustman et al. (1990) study used similar procedures and confirmed these findings with improvements shown in reaction time, Stroop colour interference, symbol digit, and trails B (this study has already been described in the discussion on improved reaction time).

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[1] Crystallized intelligence is shown in tasks requiring language skills and the utilization of long established habits (Cattell, 1943). Fluid intelligence is shown in tasks requiring sensorimotor coordination, new learning, and speedy performance (Cattell, 1943). Fluid intelligence is generally thought to show a fast increase in performance, an early peak, and a rapid decline during adulthood and aging (Riegel, 1977).

The Spirduso et al. (1988) study supported the above findings in measurements of reaction time and fluid intelligence. A discrepancy between the Dustman et al. (1990) study and the Spirduso et al. (1988) study was found, however, in regards to two cognitive tasks: symbol digit and trailmaking tasks. The latter researchers found that physically active and inactive people performed similarly on these two tasks.

Chodzko-Zajko et al. (1992) compared high- and low-fit subjects between the ages of 60 and 88. Fitness was assessed similarly to the Offenbach, Chodzko-Zajko, and Ringel (1990) study using a battery of physiological measures that correlate well with VO_2max. Subjects were asked to perform a variety of memory tasks that were distributed along an automatic-to-effortful continuum. The results showed that high-fit subjects performed better on effortful tasks and no fitness effects were found on automatic tasks or on a test of crystallized intelligence.

To summarize, these studies indicated that a lifestyle of regular, chronic exercise was associated with faster reaction times (Baylor & Spirduso, 1988; Clarkson-Smith & Hartley, 1990; Dustman et al. 1990; Rikli & Busch, 1986; Spirduso, 1975; Spirduso & Clifford, 1978; Spirduso et al. 1988) in older adults. This fitness effect was not as profound in young adults (Clarkson, 1978; Rikli & Busch, 1986; Shay & Roth, 1992). Researchers found strong support for a relationship between fitness status and cognitive performance on measures of mental flexibility and fluid intelligence (Dustman et al., 1990; Elsayed, Ismail, & Young, 1980; Powell & Pohndorf, 1971) or effortful as opposed to automatic processing (Chodzko-Zajko et al., 1992) in elderly subjects. Spirduso et al. (1988) was the only study where this association was not supported. Similar patterns were observed using these cognitive tasks as was seen in the reaction time studies. An association was found between fitness and cognitive performance on older subjects but this association was not found with younger adults (Christensen & Mackinnon, 1993; Stones & Kozma, 1989a). Maintenance of CNS functioning in old age was also found to be associated with physical fitness (Dustman et al., 1990).

Dustman, Emmerson, and Shearer (1994) noted two fairly robust findings that could be taken from the cross-sectional human studies:

> (a) for most cognitive/neuropsychological measures, individuals who maintained high levels of fitness performed better than people who exercised infrequently; (b) studies that also included comparisons of young with older adults demonstrated significant age effects on measures that were shown to differentiate high- from low-fit subjects.

However, human cross-sectional studies have one severe limitation, self-selection bias. Because subjects are not randomly assigned to groups but instead are self-selected, differences may be due to factors other than the participation in physical activity (e.g., socioeconomic factors, or health habits).

Evidence associating chronic exercise and cognitive performance from human intervention studies

The last set of studies reviewed by Dustman, Emmerson, and Shearer (1994) were intervention studies using human subjects. The support for a relationship between endurance exercise and improved cognitive functioning was not as strong when individuals were randomly assigned to active or inactive groups. Intervention studies using chronic exercise generally involved selection of volunteers from the community who were reasonably healthy for their age and randomly assigning them to an aerobic exercise group or to a control group. Dustman, Emmerson, and Shearer (1994) reviewed 13 studies and found only four that reported physical fitness training to have a beneficial effect on response times or on efficiency of cognitive processing (Dustman et al., 1984; Hawkins, Kramer, & Capaldi, 1992; Ismail & El-Nagger, 1981; Rikli & Edwards, 1991); seven of the studies found no relationship between exercise and neurocognitive functioning (Blumenthal et al., 1989; Blumenthal & Madden, 1988; Gitlin et al., 1992; Hill, Storandt, & Malley, 1993; Madden et al., 1989; Panton, Graves, Pollack, Hagberg, & Chen, 1990; Pierce, Madden, Siegel, & Blumenthal, 1993); and the two remaining studies provided only weak or limited support for a relationship (Emery & Gatz, 1990; Hassmen, Ceci, & Backman, 1992).

Beginning first with the studies that found exercise to have an effect on reaction times or cognitive performance, Ismail and El-Nagger (1981) found improvements in successive and simultaneous modes of cognitive processing in middle-aged men after subjects participated in four months of regular jogging or running. Improvements were not noted for age- and health-status matched control subjects over the four-month duration. Fitness was measured using VO_2max. Aerobically active subjects increased their VO_2max by an average of 19%.

Gains in VO_2max (27%) were also noted in older subjects who were exposed to four months of walking and these subjects demonstrated substantial improvement in cognitive-neuropsychological functioning (Dustman et al., 1984). Aerobically trained subjects demonstrated improvements on simple reaction time and on several other cognitive tasks (e.g., the digit span, dots, Stroop colour interference, and critical flicker fusion threshold tests) when compared to control subjects.

These findings were supported in Rikli and Edward's (1991) study. Subjects were older adults and were self-selected into exercise and control groups. The exercise group participated in 36 months of a walking/dance exercise protocol while the controls participated in a hobby class for the same duration. The step test (number of steps completed during a two minute period) was used to determine fitness status. A 47% gain in fitness was achieved on this test by the exercised group. This study found that exercisers performed better on simple and complex reaction time tasks at posttest when compared to controls.

The fourth study to show chronic exercise to have a positive effect on cognitive performance was the Hawkins, Kramer, and Capaldi (1992) study. These researchers found that only six weeks of aquatics training was adequate to see some cognitive improvements in older adults. Fitness training effects were not measured in this study.

Two studies found weak or limited support for the findings from the previous four studies. Emery and Gatz (1990) studied the effects of four months of aerobic exercise on psychological and cognitive well-being in a group of older adults. Subjects were randomly assigned to one of three groups: an aerobic exercise training group, a social activity control group, or a waiting list group. The exercise program included 20 to 25 minutes of aerobic exercise and was held three times a week, yet evidence of improved physiological functioning was minimal. However, among the exercise group, reductions in diastolic blood pressure were found to be related to greater writing speed and increased mastery. Decreased weight among exercisers was correlated with enhanced performance on two tests of writing speed (copying numbers and words). Thus, the association of improved physiological functioning with increased cognitive functioning and mastery was consistent with the studies previously cited, but clearly the support is weak.

Hassmen, Ceci, and Backman (1992) conducted the second study that was cited in the Dustman, Emmerson, and Shearer (1994) review as providing limited support for an association between physical activity and cognitive functioning. These researchers assessed exercise intensity using the Ratings of Perceived Exercise (RPE) scale devised by Borg (1970). The RPE scale was a subjective rating scale which has been used to regulate exercise intensity. The sample included 32 healthy older women. The subjects were assigned to either an exercise group or a non-exercised control group and subdivided into two different age groups, 55-65 and 66-75 years. The exercise protocol consisted of three months of walking at three self-rated intensities of exercise. VO_2max was used as an objective measure of fitness and improvements of 11% on average were found for exercised subjects. Four cognitive tasks were given including: a face recognition task, simple reaction time, complex reaction time, and digit span. Improvements were found in digit span performance after training in the exercise groups but not in the controls. These improvements were not replicated for the reaction time tasks or the face recognition task.

Despite these positive findings, seven other studies did not find that aerobic exercise training had a beneficial effect on neurocognitive functioning and those changes in fitness were only minimally related to positive changes in cognitive functioning. For example, Blumenthal and colleagues have done a series of studies (Blumenthal et al., 1989, 1991; Blumenthal & Madden, 1988; Blumenthal, Schocken, Needels, & Hindle, 1982a; Blumenthal, Williams, Needels, & Wallace, Madden et al., 1989) looking at the effects of aerobic exercise training on psychological, behavioural, and cognitive functioning. In 1988, Blumenthal and Madden looked at the effect of three months of jogging on reaction time of middle-aged adults. The results did not show a change in reaction time as a result of exercise training, however, a relationship between VO_2max and reaction time was noted at pretesting. Reaction time was faster for subjects who had a higher VO_2max. In 1989, these researchers did two studies both of which did not find psychological or cognitive performance had changed in older subjects after four months of aerobic training on a bicycle ergometer. It is interesting to note that in both studies subjects perceived they had improved on several measures. Subject reported improvements have been found in other studies that did not find a corresponding objective improvement (Pierce et al., 1993; Hill, Storandt, & Malley, 1993). In the Hill, Storandt, and Malley (1993) study, although there was no change found for most measures, the data suggested that exercise may have enhanced memory which declined in the non-exercised control subjects.

There are several possible explanations for why there are not consistent findings in the intervention studies. For example, the duration of the exercise training may not be sufficient to consistently observe measurable changes in CNS which can be demonstrated through cognitive behaviour. Another factor that may be of importance is the age at which individuals begin a routine of regular exercise. There is some evidence that the ability of the older brain to undergo neurobiological change is reduced (Mori, 1993; Black, Polinsky, & Greenough, 1989; Tümer, Hale, Lawler, & Strong, 1992). Thus, an exercise program started at a younger age may prove to be of more benefit to CNS functioning than an exercise program started in old age. Spirduso and Asplund (1995) suggested that practice effects could be another explanation for the discrepant findings. These authors suggested that the intervention studies that have shown an improvement in cognitive performance may actually be measuring acquisition of skills necessary to perform the cognitive tasks rather than measuring the effects of exercise. Despite the more tentative findings of the human intervention studies, the evidence presented from the animal studies and the cross-sectional human studies provide ample evidence for an association between chronic strenuous exercise and cognitive functioning. It is the interest of this paper, however, to attempt to determine the lowest level of exercise that is needed to produce improvements in cognitive functioning, thus, research looking at non-strenuous exercise is also assessed.

Evidence associating chronic non-strenuous exercise and cognitive performance

There has been some limited research done on the effects of non-strenuous exercise on cognitive functioning in the elderly. Spasoff et al. (1978) reported that 64% of nursing home residents "sat for hours doing nothing". These researchers also found that after a year in the institution, individuals became even more inactive. It is unlikely that inactive, older individuals will be motivated to adhere to a fitness regime that requires quite strenuous activity. DeVries (1970) recommended vigorous walking for 30 to 60 minutes daily. A fitness program such as this is often viewed as too strenuous for the frail elderly. Thus, older adults are often prescribed a training program consisting of regular non-strenuous stretching exercises.

There have been relatively few studies that have investigated the effects of multiple doses of non-strenuous exercise. The studies using chronic bouts of non-strenuous exercise are also difficult to interpret because of the variability in the number of bouts, the intensity of exercise, and the initial functioning level of subjects. Despite these challenges, some studies have indicated improvements in physiological and cognitive functioning after chronic non-strenuous exercise.

Powell (1974) conducted an intervention study to investigate the effects of exercise therapy upon certain cognitive and behavioural characteristics of institutionalized geriatric mental patients. Subjects were screened prior to admission to the program and were disqualified from participating based on three health factors: (1) hypertension, (2) history of heart trouble for which drugs were being administered, and (3) debilitating arthritis. For this study, subjects were divided into two treatment groups and one control group. One of the treatment groups participated in 12 weeks of "mild exercise including brisk walking and calisthenics and rhythmical movements involving large muscle movement of the arms, legs, and trunk." (p. 158). Powell did not indicate whether this exercise program led to improved fitness, however, given the limitations of the subject population (i.e., geriatric, mental patients), it is likely that the exercise protocol was non-strenuous. The second treatment group participated in 12 weeks of social therapy including arts and crafts work, social interaction, music therapy, and game playing with no accompanying physical activity. Both therapy groups met for one hour periods, five days per week.

The results of this study showed significant improvements in the Progressive Matrices Test and the Wechsler Memory Scale in the exercise group compared to the control group and the social therapy group. No significant differences were found for the third cognitive test, the Memory-for-Designs (MFD) test, nor for either of the two behavioural scales. Thus, this study provided evidence that chronic non-strenuous exercise may be associated with improved cognitive functioning in an institutionalized elderly sample.

Myers and Hamilton (1985) evaluated the Canadian Red Cross Society's Fun and Fitness Program, a program designed for reasonably healthy but inactive senior citizens who wish to have a more active lifestyle. The program consisted of prescribed warm-up and cool-down periods as well as stretching, flexibility, general mobility, and low-intensity aerobic-type exercises which involved slow rhythmic movements using all body parts. Classes were conducted approximately once a week and lasted approximately one and a half to two hours. The stated objectives of the program as stated in Myers and Hamilton's (1985) evaluation were as follows: (1) to facilitate physical, emotional, and intellectual well-being; (2) to maintain suppleness so that everyday activities remain possible; (3) to bring about a general improvement in physical condition; (4) to increase knowledge and control of the body; and (5) to facilitate enjoyable interaction in a group setting. There were three groups of elderly subjects included in the study: seniors from the community, seniors living in seniors' apartment complexes, and institutionalized seniors. There were no start-up groups available during the study-period, so a true intervention design could not be used. Instead, a quasi-experimental design was used where the groups were compared to those of other research samples and to survey data of seniors in the general population on physical activity patterns.

Outcome variables included a physical assessment, patterns of physical activities, activities of daily living, social functioning, and cognitive functioning.

Although one of the stated purposes of the exercise protocol in Myers and Hamilton's (1985) study was to improve physical condition, the results of this study did not find a relationship between length of time in the program and the physical variables which included grip strength, shoulder flexibility, balance, hip flexibility, and bending. One explanation Myers and Hamilton provided for this finding was that the exercise protocol was not frequent enough. Therefore, this exercise protocol could be considered non-strenuous according to the definition provided at the beginning of this paper.

Benefits were observed on some of the other outcome variables in this study. For example, a positive relationship between length of time in the program and increased participation in other physical activities was found. Myers and Hamilton (1985) provided a psychological process model to explain the results. They concluded that the Fun and Fitness class, given the increased physical participation of the sample as a whole, acted as a motivator. The findings indicated a positive relationship between length of time in the program and perceptions of improvement, or at least maintenance of one's capabilities in performing activities of daily living for all three sample groups. Availability and familiarity, but also similarities between participants with respect to background and interests, are put forth as possible explanations for the observed improvement in social functioning.

In terms of cognitive functioning, Myers and Hamilton (1985) assessed two memory-related tasks using a list of 20 words. Length of time in the Fun and Fitness program was found to be a highly significant predictor of recognition scores. Although this finding was not duplicated for recall scores, this association approached significance. The researchers postulated that many of the recommended exercises frequently used in the classes may indirectly foster cognitive stimulation by encouraging such skills as concentration, recall, and drawing associations. It should also be noted that it is possible that recognition tasks were practiced more on a daily basis and this result may reflect the resistance to age deterioration of overpracticed tasks as suggested by the TOPE model.

Stacey, Kozma, and Stones (1985) evaluated the effects of a similar exercise protocol on simple cognitive performance and on psychological well-being in persons more than fifty years of age. This study was unique in assessing the effects of non-strenuous exercise because it compared 29 new members of a senior's fitness group to 37 members who had been active for a year or more. The mean age of the two groups was 58 and 62 respectively. Cognitive performance was assessed by measuring reaction time and by the Digit Symbol sub-test of the WAIS. Psychological measures included the Memorial University of Newfoundland Scale of Happiness (MUNSH) (Kozma & Stones, 1980) and the Spielberger State and Trait Anxiety Inventories (Spielberger, Gorsuch, & Lushene, 1975). Subjects were initially tested within three weeks of the fall restart of the exercise program. Subjects were tested again six months later. The fitness program consisted of a weekly exercise period of one hour. A brief warm-up period was followed by a half hour of flexing, balancing, and aerobic activity. The remainder of the exercise time was spent on self-monitored swimming. This exercise protocol was considered non-strenuous because of the frequency of the exercise. As I have previously stated, aerobic benefits were only expected if exercise was performed at least three times a week (ACSM, 1986). Fitness assessments included measurements of weight, flexibility, balance, and aerobic power. Three measurements improved from pretest to posttest: flexibility, balance, and activity level. Improvement in aerobic power was not found. The researchers postulated that one session a week was insufficient to produce a change on this variable. So we can conclude that this study assessed a non-strenuous exercise program.

The cognitive and psychological findings from the Stacey, Kozma, and Stones (1985) study revealed main pretest to posttest effects on reaction time and the digit symbol task and a main group effect on reaction time and group by pretest to posttest interactions of happiness and trait anxiety. The interactions on the psychological variables indicated that new members improved their level of happiness to the level of old members. The group and treatment main effects on reaction time indicated that initial advantages by experienced exercisers were maintained. The presence of pre-treatment differences in favour of the experienced exercisers make it unlikely that the changes were solely due to practice. Improvement on the digit symbol task by both groups was consistent with an overall finding that exercise can inhibit loss in performance on simple cognitive tasks. However, a lack of a statistically significant group main effect on performance on the digit symbol task or a group by treatment interaction on this task makes it difficult to rule out practice as the explanatory factor for this finding. Thus, although this study provided evidence that suggested chronic non-strenuous exercise was associated with some physiological and psychological benefits the evidence suggesting that non-strenuous exercise was related to cognitive improvements was inconclusive.

Stevenson and Topp (1990) studied the effects of a nine-month, moderate-intensity exercise program (60-70% VO_2max) and a nine-month, low-intensity exercise program (20-40% VO_2max) on a volunteer sample of individuals over the age of 60. The purpose of studying two levels of exercise intensity was to determine the lowest level of exercise that will produce improvements in quality of life. The researchers measured quality of life by measuring life satisfaction, health perception, self-reported sleep patterns, mental status, and selected cardiovascular parameters. This study does not provide evidence that indicated moderate-intensity exercise was superior to low-intensity exercise on any of these variables. The study reported improvements in a variety of areas in both exercise conditions including: self-reported sleep, health perceptions, cardiovascular fitness, oxygen consumption, and maximum work capacity. Mental status was one of the measured outcome factors and was measured using the Strub and Black (1977) mental status test which is an adaptation of the Wechsler Memory Scale (WMS) (1972); other cognitive tests included visual reproduction, digit span, verbal memory, and verbal pairs (association) tests (Weschler, 1987). The results indicated improvements in attention/concentration for both groups with no difference between the two intensity groups. Short-term memory function showed a similar pattern. Therefore, higher cognitive functioning was shown to improve over time for both groups. The test forms and problems presented each time were varied to decrease test-effect bias. Thus, specific cognitive improvements were not evaluated. Although this study did not compare these two exercise groups to a non-exercised control group the results provided some indication that implementation of chronic non-strenuous exercise may elicit similar long-term improvements as does more strenuous exercise.

Finally, an experimental group of 20 elderly subjects who participated in eight weeks of non-strenuous aerobic exercise was compared to 27 subjects who maintained their usual level of activity in a study conducted by Mills (1994). The exercise program consisted of stretching and strengthening chair exercises. The results of this study showed an increase in flexibility of the ankles and the right knee. However, no significant difference was found in muscle strength. Balance was another outcome variable in this study. Balance can be considered an indicator of cognitive functioning, as good balance requires both cognitive and motor skills such that central monitoring of feedback from multiple-body systems is coupled with corrective muscular action (Stones & Kozma, 1988). A significant difference in balance was found between the experimental group and control group with an improvement of 22% noted for the experimental group.

Therefore, of six studies that looked at chronic non-strenuous exercise, all showed at least some indication for improved cognitive functioning. There were certain limitations to the design of most of the studies. Powell (1974) used a true intervention design, however, the sample was geriatric mental patients and thus, it is difficult to generalize from this unique group. The Myers and Hamilton study (1985) was a quasi-experimental design. Subjects were not randomly assigned, but rather were self-selected into the exercise program and a control group was not possible. Both the Stacey, Kozma, and Stones (1985) study and the Stevenson and Topp (1990) study could not rule out practice as an explanatory factor for cognitive differences because neither study used a non-exercised comparison group and the two intensity groups both showed improvements. Clearly, better designed studies are necessary to determine whether or not chronic non-strenuous exercise is associated with cognitive improvements, but these studies provide at least an indication that there may, in fact, be such an association.

Acute Exercise and Cognitive Performance

Given these conclusions, the purpose of the current study becomes particularly challenging. The purpose of this study is to investigate the effects of a single dose of non-strenuous exercise on the cognitive performance of the frail elderly. A pretest-posttest control group design is a true experimental design (Campbell & Stanley, 1963) and differences between groups can indicate a clear relationship between non-strenuous exercise and cognitive functioning. A weakness in this design, however, is that without comparing across age groups, age effects cannot be established.

Evidence from single dose intervention studies (acute non-strenuous exercise)

There has been evidence that links a single dose of exercise to a short-term gain on some cognitive tasks but not others. A single dose exercise protocol facilitates a randomized control design. It is unclear from the research which types of cognitive tasks might be influenced by non-strenuous exercise. Also, the duration of the effects is not apparent.

Diesfeldt and Diesfeldt-Groenendijk (1977) used a single dose exercise intervention design on an institutionalized elderly population (average age 82) who were suffering from memory disorders or were disoriented. These researchers found a positive relationship between acute exercise and memory performance. In this study, subjects in the experimental condition participated in "movement therapy". Movement therapy consisted of a 40-minute exercise session that included 15-minutes of light bending and stretching for the arms, legs and trunk and also a game consisting of throwing and kicking a large ball. The exercise protocol did not lead to an increase in the fitness of the subjects. During the pretest, the researchers tested both groups under identical circumstances. Subjects were tested a second time (posttest) four weeks after the pretesting. During the second testing session, testing occurred shortly after the exercise session for the exercise group. Three psychological tests were used: an immediate free-recall task, a test for visuomotor coordination, and a recognition task. The results indicated improvement in the free-recall test for the exercise condition when compared to the control condition. This improved recall capacity was not accompanied by a comparable change in recognition capacity. Recognition performance remained stable in the exercise group and sometimes even decreased as in the control group. Diesfeldt and Diesfeldt-Groenendijk suggested that improved retrieval was demonstrated in recall tasks and was not demonstrated in recognition tasks. Recognition tasks provided the subject with a restricted selection of alternatives and also, because the item to be recognized was presented, only a faint or incomplete trace was required to respond correctly. The conclusion drawn from this study was that exercise as a therapeutic intervention can be beneficial to the mental and cognitive functioning of demented elderly.

Molloy, Beerschoten, Borrie, Crilly, and Cape (1988) found similar results when they investigated the acute effects of exercise on memory, mood, and cognitive function following a 45-minute exercise condition versus a 45-minute control condition. The exercise protocol was not vigorous enough to maintain a raised heart rate, was not intended to improve cardiovascular fitness, and was only administered once. Memory and cognitive tests included a recognition test, the digit symbol test, the digit span test, a logical memory test, a category-prompted word fluency test (the SET test, Isaacs & Akhtar, 1972), a mood test, a depression scale, and a mini mental state examination. The results indicated that there was improvement following exercise for the logical memory test but similar improvements were not found on any of the other cognitive tests. This improvement indicated enhanced short-term memory following mild exercise.

Stones and Dawe (1993) also used a single dose intervention design where the intervention consisted of a non-strenuous exercise protocol on an elderly population. This exercise intervention consisted of a single 15-minute bout of mild exercise. The subjects in this study were institutionalized and the subjects were older than in previous studies, (i.e., mainly persons in their eighties). The researchers randomly assigned subjects to either an exercise condition or a control condition. In the exercise condition, subjects participated in the exercises while the subjects in the control condition viewed a 15-minute video of similar exercises. The subjects completed three cognitive tasks: a category-prompted word fluency task (adapted from the SET test, Isaacs & Akhtar, 1972), a consonant-prompted word fluency task (similar to the category-prompted task except initial letter categories were used), and the symbol digit task, (similar to the digit symbol task of the WAIS only the target items were symbols and the response items were digits). The researchers administered these tests at pretest, immediate posttest and delayed posttest. The exercise group performed significantly better than the control group on the category-prompted task when measured immediately following the intervention. This difference was not found on the delayed posttest or on any other task.

Thus, there are indications that even very short durations of acute exercise may be capable of eliciting short-term cognitive improvements in some groups. Clarification is still needed to determine which types of cognitive functioning are affected and which are not. Where there is an effect, it is not apparent from the literature how long these effects last.

The association between exercise and cognitive functioning remains equivocal. The reviews of the studies investigating chronic and acute exercise find improvements in some areas of cognitive functioning and not in others. It is possible that there is a general activating influence due to the exercise that stimulates neurophysiological functioning (Diesfeldt & Diesfeldt-Groenendijk, 1977). However, this would not explain why there is not a general improvement across all tasks. There may be differences in the cognitive demands between the tasks. This is the case for most of the tasks. The recall task (Diesfeldt & Diesfeldt-Groenendijk), the logical memory task (Molloy et al., 1988), and the category-prompted word fluency test (Stones & Dawe, 1993) all require the use of retrieval. The two word fluency tests used in the Stones and Dawe study (1993) used two different prompts: the first used semantic cues and the second, consonant cues. Only the test using semantic cues elicited an improvement. There has been evidence suggesting that storage of attribute codes according to meaning becomes comparatively more important with age and that storage, according to structural attribute codes, becomes less prevalent (Schonfield & Stones, 1979). The differences found in the Stones and Dawe (1993) study may be due to these cognitive differences. Thus, the TOPE model may best explain these differences; improvements are observed only in the tasks that are overpracticed. Another possibility is that if acute exercise has an activating effect, then this effect is very short-lived. No differences were found between the category-prompted task and the other tasks on the 30-minute delayed posttest. This indicates that any possible enhancement effects had already been extinguished. The gains observed on the category-prompted task could be due to either exercise-induced arousal or to social facilitation associated with the intervention. Since the exercise intervention was associated with a small but significant increase in heart rate of two beats per minute, there was some support that arousal did occur. This does not eliminate the possibility of an interaction between the exercise instructor and the subject; the interaction between the instructor and the participant was much less in the control condition than in the exercise condition.

A further weakness in the design of the Stones and Dawe (1993) study is that the researchers did not vary the order of the tests. The category-prompted test was always presented first. It is therefore unclear whether the duration of the effect may have only lasted for a few minutes or if the differences were due to differing cognitive demands of the various tests. Further research is necessary to sort out some of these inconsistencies.

The Present Study

Evidence supporting an association between acute non-strenuous exercise and cognitive function appears to be less conclusive than the evidence supporting a link of chronic exercise. However, as is apparent from the Stevenson and Topp (1990) finding, improvement in fitness level may be achieved from even very mild exercise. It is possible that elderly populations are more sensitive to acute bouts of exercise. As this review has shown, research with older populations has provided evidence that positive effects can be achieved in some areas of cognitive functioning.

The purpose of the present study is to further investigate the positive effects found in elderly populations regarding cognitive functioning and to attempt to answer some of the questions already presented. The present study will attempt to replicate the results found in the Stones and Dawe (1993) study. This study will: (1) control the effects of task order, (2) help to clarify the time parameters of the benefit, and (3) assess the effect on different physical activity levels. The hypothesis that will be tested is that acute non-strenuous exercise leads to short-term cognitive improvements demonstrated through a category-prompted word fluency task. No predictions are made concerning the consonant-prompted word fluency task because it is unclear from the original study if the lack of effects was due to task order effects.

The study uses a pretest-posttest control design. The interventions, both the exercise protocol and the video used in the control conditions, are the same as those used in the Stones and Dawe study (1993). A measure of heart rate will be taken to test for an exercise effect. By administering only one cognitive task to each participant, I will control for task order. I will use the same two cognitive tasks that were used in the original study: the category-prompted word fluency task and the consonant-prompted word fluency task. To help clarify the time parameters of the benefit, a measurement is taken 30 minutes after the intervention. Since effects from acute exercise were not always found for healthy individuals, I will measure activity propensity. This study will investigate the relationship between activity propensity and the degree of improved performance on the category-prompted word fluency test. A repeated measures ANOVA will be used to assess the hypothesis. The hypothesis will be supported if a statistically significant between group interaction of exercise and the number of words generated on the category-prompted word fluency task is found. It is expected that if a difference is found, the difference will be more profound for subjects with a lower activity propensity.

METHOD

Subjects

Fifty-nine subjects volunteered from three nursing homes in St. John's, Newfoundland. I recruited 20 subjects from both the Agnes Pratt Home and St. Luke's Home. Nineteen subjects were recruited from Glenbrook Lodge. These homes house patients in need of varying care (e.g., nurses controlling medication to chronic care). Volunteers recruited for this study required the least amount of care in the respective homes. I was aware that most of the volunteers ate dinner in a central dining room with other residents from the homes (this information was not formally collected for purposes of this study, however, many interviews were scheduled after meals). There were variations in the amount of care required by the subjects. The staff provided me with a list of potential subjects from each home. I instructed the staff that potential subjects should be mentally capable of understanding the purpose of the study and physically capable of completing the exercise protocol if necessary. The staff was shown the exercise intervention and potential subjects were eliminated if the intervention was felt to be too taxing for that individual. Mental competency was screened using the Short Mental Status Questionnaire, (Robertson, Rockwood & Stolee, 1982). Subjects were told that they may be asked to perform some light stretching exercises and must be capable of moving short distances independently (i.e., the distance that could be traveled in approximately two minutes with minimal assistance or, if a walker or wheelchair was required then the subject must be capable of using the aid independently). Past researchers have determined that the exercise intervention is safe for frail elderly individuals (Stones & Dawe, 1993).

The age of the subjects ranged from 72 years to 98 years. The average age of the participants was 84.22 (sd=5.73) with a median age of 85. Eighty-eight percent (n=52) of the sample was female compared to 12% (n=7) who were male. Subjects were randomly assigned to one of four conditions. There were two experimental conditions and two control conditions in the study.

Materials

Materials consisted of the Short Mental Status Questionnaire, two cognitive ability tasks, a heart rate monitor, and the SENOTS Program and Battery. Samples of all the paper measures are provided in Appendix I.

The Short Mental Status Questionnaire

The test-retest reliability of the Short Mental Status Questionnaire is 0.89 (Robertson, Rockwood & Stolee, 1982). This test has also been validated against a physician's clinical assessment (Robertson, Rockwood & Stolee, 1982).

Cognitive tasks

The present study also utilized two cognitive ability tasks. The first task was a category-prompted word-fluency task which was also used in the Stones and Dawe (1993) study. Subjects were prompted to list as many items in each of four categories (i.e., colours, animals, fruits and towns) that they can think of in 60 seconds. The test used in the Stones and Dawe (1993) study was adapted from the SET test. A highly significant correlation has been found between the original SET test and other psychological tests, including the Mill Hill vocabulary scale, Raven's progressive coloured matrices and the Crichton rating scale (Isaacs & Akhtar, 1972). The second task was a consonant-prompted word fluency task. This task was very similar to the category-prompted task only subjects are asked to list as many items that they can think of starting with a particular letter of the alphabet (e.g., T, D, P, M). Subjects were prompted using the same four prompts in the same order at all three testing times in both the category-prompted and the consonant-ptompted word fluency tests. Each of the four prompts is referred to as a trial in this study.

Heart rate

Heart rate was assessed in order to determine whether or not there was any improvement in fitness using a heart rate monitor that attaches to the subjects' finger.

SENOTS program and battery

The SENOTS battery includes five dimensions, the MUNSH (a happiness/depression scale), financial hardship, physical symptoms, activity limitations, and activity propensity (MUNAIS). The MUNAIS test and the measure of activity limitations were used to control for the varying ability levels of the subjects. Stones and Kozma (1989b) assessed the reliability of the five subscales of the SENOTS program and battery. These researchers found that the alpha levels for all the subscales exceed 0.73 with the exception of the Financial Hardship subscale (Stones and Kozma 1989b). The reliability coefficients fo the five subscales were: MUNSH α=.92; Financial Hardship α=.67; Physical Symptoms α=.78; Activity Limitation α=.91; MUNAIS α=.79. The SENOTS scale proved capable of distinguishing between community and institutionalized elderly, thus providing evidence for concurrent validity.

Procedure

A proposal of the study was reviewed and approved by the Ethics Committee of the Faculty of Science at Memorial University of Newfoundland. Appendix II provides the approval form.

I approached the administrators at three nursing homes in the St. John's, Newfoundland area. I presented each administrator with a brief outline of the proposed study.

I informed the administrator what would be expected from the subjects. The administrator was provided with samples of all the materials used and the purpose of each was explained. In addition, the exercise protocol was described to the administrator as involving "light stretching exercises" performed while seated and two minutes of walking. The administrator was also asked to provide a testing room and access to a television and a VCR. Each administrator signed a consent form indicating their full knowledge and co-operation in the project. A sample of the administrator consent form is presented in Appendix III.

I approached subjects on an individual basis with the exception of the St. Luke's Home. Potential participants from the St. Luke's Home attended a group presentation. Names were collected at the presentation and I approached subjects individually in the weeks following the presentation.

I introduced myself to each subject and stated that I was from the Gerontology Centre at Memorial University. The subject was asked whether or not he or she would be interested in participating in a study that I was conducting as part of my program. The potential subjects were told the amount of time that would be required (one half hour meeting, and one 45-minute meeting) and were told that if they agreed to participate that they were free to end their participation at any time. The potential subjects were also told that they may be asked to perform 15-minutes of light exercise which included light stretching exercises performed in a chair and two minutes of walking. If the subject was in a wheelchair they were asked if they thought they could walk with assistance, if they could not, they were asked if they could propel their wheelchair independently. I asked each subject to sign a consent form (Appendix III). When signing was not possible due to a physical ailment, a nurse witnessed the verbal consent. The nurse then signed the consent form and it was noted on this form that the nurse witnessed verbal consent.

I tested subjects in their own rooms whenever possible. When this was not possible, I tested the subjects in a private room provided by each Home.

Subjects were initially screened using the Short Mental Status Questionnaire (three individuals were eliminated from the study based on this screening). Questions were asked verbally and I marked down the responses on a piece of paper. I administered the SENOTS program and battery in the same fashion to those subjects who passed the first criteria. I then arranged to meet with the subject at a later time, usually the following day.

All eligible subjects were randomly assigned to one of four groups. Fourteen individuals were assigned to exercise group 1 who received the category-prompted task and 15 individuals were assigned to exercise group 2 who received the consonant-prompted task. Fourteen and 16 individuals (respectively) were assigned to the corresponding control groups. At the next meeting I measured heart rate immediately preceding and immediately following the intervention and again 30 minutes after the second testing period.

The two experimental groups were exposed to the exercise intervention. The exercise intervention consisted of gentle stretching of all the major muscle groups and a brief walk (approximately two minutes; Appendix IV provides a guideline of the exercise protocol). When the subject was in a wheelchair, I asked the individual to push the wheelchair for the same length of time (approximately two minutes). The entire exercise intervention lasted approximately 15 minutes. The exercise protocol is considered acute because of the frequency of the sessions (a single dose) and thus though it is expected that it will produce an exercise effect (i.e., increased heart rate) it will not produce a corresponding fitness effect (i.e., increased aerobic power).

Experimental group 1 completed the category-prompted task at pretest, immediately following exercise (immediate post-test) and 30-minutes following the end of the intervention (delayed post-test). I sat and talked with the subjects in all four groups during the 30 minutes between the immediate posttest and the delayed posttest. During the testing, I asked the subject to say aloud the words he or she could think of in the various categories. I recorded the words with a pen and paper as they were being said, also the words listed were recorded on audio tape and the list was checked for accuracy at a later time. Experimental group 2 completed the consonant-prompted task in the same fashion at the three testing times.

The two control groups viewed a 15-minute video of similar exercises. I instructed the control groups not to engage in any physical activity during the video. Control group 1 was used as a comparison to experimental group 1 and thus the subjects were administered the category-prompted task at the three testing times. Control group 2 also watched the video but instead were asked to complete the consonant-prompted task at the three testing times.

RESULTS

Contextual Information

Some initial contextual information was collected from each subject which included demographic information and specific details about the subject's ability and activities. Table 1 provides the frequency distributions of these particulars. As this table indicates, most of the sample were widowed and 51% (n=30) of the subjects had completed high school or more. In addition to this demographic information, subjects were asked if they required any ambulatory aids such as a wheelchair, a cane, or a walker. Half of the individuals could walk independently. The other half of the sample were fairly evenly divided between those who used a cane or a walker and those who were in wheelchairs. Finally, subjects were asked if they regularly attended fitness classes. Approximately two-thirds of the subjects said that they regularly attended fitness classes.

Chi-square tests were performed to assess if the distribution to either condition or to task differed by ambulatory level or fitness class participation. These tests revealed no significant differences. Similar statistical comparisons of the other contextual information was not possible because of the small proportion of individuals in some groups (i.e., men or married individuals). Because of these small proportions it is very unlikely that differences in the distribution of these variables will affect the results. Table 1 provides the frequency distributions of the contextual variables by condition and by task (separately).

Table 1.
Frequency Distributions (n) of Contextual Information by Condition and by Task

	Condition		Task		Total
	Exercise	Control	Category	Consonant	n (%)
Gender:					
Male	3	4	2	5	7 (12.0%)
Female	26	26	26	26	52 (88.0%)
Marital Status:					
Married	1	1	2	0	2 (3.4%)
Widowed	26	23	22	27	49 (83.1%)
Divorced/Separated	0	0	0	0	0 (0.0%)
Never Married	2	6	4	4	8 (13.6%)
Education:					
Eighth Grade or less	9	9	8	10	18 (30.5%)
Part High School	7	4	5	6	11 (18.6%)
High School Grad	6	9	9	6	15 (25.4%)
Part University	5	6	4	7	11 (18.6%)
University Grad	2	2	2	2	4 (6.8%)
Ambulatory Level:					
Walk Independently	15	17	18	14	32 (54.2%)
Walker or Cane	9	4	6	7	13 (22.0%)
Wheelchair	5	9	4	10	14 (23.7%)
Fitness Class Participation:					
Regularly attends	18	19	19	18	37 (62.7%)
Does not regularly attend	11	11	9	13	22 (37.3%)
TOTAL:	29	30	28	31	59 (100%)

I also administered the SENOTS battery at the same meeting in which the contextual information was collected. The means and standard deviations from this test battery are presented in Table 2. This table compares these means to means found in the institutionalized sample of Stones and Kozma's (1989b) study. The mean scores of the sample on the happiness dimension measured by the MUNSH were significantly higher than what was previously found in an institutionalized sample (t=11.21, df=79.14, p<.01). A smaller yet still significant difference was also found on the MUNAIS, a measure of activity propensity, (t=8.47, df=82.77, p<.01). The mean score of the MUNAIS was significantly higher in the present sample than in the archival sample. Mean scores on measures of financial hardship, physical symptoms, and activity limitations were slightly lower in the present sample when compared to the archival sample (t=-1.51, df=81.05, p<.01; t=-2.16, df=81.31, p<.01; t=-2.67, df=82.71, p<.01 respectively).

Table 2.
Means and Standard Deviations from Five Dimensions of SENOTS Battery: Sample Data vs. Archival Data

Variable	Sample Data Mean	Sample Data sd	Archival Sample[1] Mean	Archival Sample[1] sd
MUNSH	12.36**	10.35	4.8	13.45
Financial Hardship	4.68**	0.93	5	1.1
Physical Symptoms	9.33**	1.74	9.95	2.05
Activity Limitations	10.02**	1.89	10.85	2.55
MUNAIS	18.86**	1.77	16.45	2

[1] Stones & Kozma (1989) Data
**$p<.01$

Exercise Effects

The physiological effects of the exercise (i.e., heart rate) were assessed immediately before each administration of the word fluency task. Table 3 provides the mean heart rate (beats per minute) at each time and for each condition. There was an increase of approximately five beats per minute for the two exercise conditions from pretest to posttest. A two (condition) by two (task) by three (time) repeated measures ANOVA was performed to determine whether or not there was an effect of exercise. This analysis is shown in Table 4 and indicated a statistically significant main effect of time. This effect is assumed to be due to the increase observed in the exercise group as reflected in the significant condition by time interaction. A Tukey Test for Honestly Significantly Difference (Tukey-HSD) was used to assess if the condition by time interaction indicated a statistically siginificant difference in the mean heart rate of exercisers at immediate posttest. This test revealed that the mean heart rate for exercisers at immediate posttest was, indeed, significantly higher than the mean heart rate at any other testing time for both the category-prompted and the consonant-prompted groups.

Table 3.
Mean Heart Rates (bpm) at Three Times of Measurement
(Standard Deviations in Parentheses)

		Time of Measurement		
Task	**Condition**	**Pretest**	**Immediate Posttest**	**Delayed Posttest**
Category-prompt	Exercise	74.07 (8.91)	79.36 (9.90)	71.84 (9.83)
	Control	71.43 (7.71)	69.92 (7.53)	70.75 (7.66)
Consonant-prompt	Exercise	70.93 (12.08)	77.67 (8.91)	69.18 (11.03)
	Control	70.86 (13.69)	66.73 (9.28)	66.84 (16.00)

Table 4.
Summary Table for Repeated Measures ANOVA: Testing Exercise Effects

Source of Variation	SS	df	MS	F	p
Within Cells	2290.48	88	26.03		
Time	192.94	2	96.47	3.71	<.05
Condition x Time	422.82	2	211.41	8.12	<.001
Task x Time	42.33	2	21.16	0.81	n.s.
Condition x Task x Time	50.40	2	25.20	0.97	n.s.

Main Analysis

Table 5 provides the mean number of words subjects produced at all four trials for both the exercise and the control groups on the two cognitive tasks. The mean number of words generated ranges from 7.33 (sd=2.46) to 13.14 (sd=4.75). There is an increase in the mean number of words subjects thought of from pretest to immediate posttest in all but one trial (trial 2 for control group receiving consonant-prompted task).

In order to test the hypothesis that an acute bout of exercise will increase the mean number of words listed a two (condition) by two (task) by four (trials) by three (time) repeated measures ANOVA with repeated measures on the last two variables was used. The interactions involving condition (exercise or control) and time are necessary to support the hypothesis. Table 6 provides the summary data from this ANOVA analysis.

Table 5.
Mean Number of Words Listed Across Four Trials on the Category-Prompted and Consonant-Prompted Tasks at Three Times of Measurement
(Standard Deviations in Parentheses)

			Time of Measurement		
Task	**Condition**	**Trial**	**Pretest**	**Immediate Posttest**	**Delayed Posttest**
Category-prompt	Exercise	1	8.78 (2.81)	9.71 (3.43)	10.21 (3.58)
		2	10.00 (3.28)	10.57 (3.86)	11.07 (5.33)
		3	8.64 (3.75)	9.07 (5.11)	9.14 (4.55)
		4	10.21 (4.38)	11.29 (5.89)	10.64 (4.96)
		Total	37.64 (13.24)	40.64 (15.64)	41.07 (16.82)
	Control	1	11.86 (3.97)	12.79 (3.14)	13.46 (4.18)
		2	10.86 (3.89)	11.50 (4.22)	12.15 (4.93)
		3	9.79 (3.26)	10.18 (3.54)	10.15 (4.98)
		4	11.14 (4.38)	13.14 (4.75)	12.69 (5.04)
		Total	43.64 (13.48)	47.71 (12.60)	48.46 (17.16)
Consonant-prompt	Exercise	1	8.53 (3.44)	9.13 (3.29)	9.14 (3.59)
		2	7.33 (2.46)	9.13 (3.87)	8.64 (2.76)
		3	8.53 (3.80)	10.13 (4.24)	9.50 (3.58)
		4	8.33 (2.92)	9.13 (4.27)	8.93 (3.15)
		Total	32.73 (10.18)	37.53 (14.07)	36.21 (10.82)
	Control	1	8.13 (3.65)	8.94 (4.07)	10.07 (5.25)
		2	8.75 (4.33)	8.50 (3.76)	9.36 (4.52)
		3	9.19 (3.75)	10.38 (4.03)	9.79 (3.12)
		4	8.75 (3.26)	9.69 (3.93)	9.79 (3.38)
		Total	34.81 (12.56)	37.50 (14.79)	39.00 (15.00)

Table 6.
Summary Table of Repeated Measures ANOVA:
Testing for Condition, Task, Trial and Time Effects

Source of Variation	SS	df	MS	F	p
Between Subjects Effect					
Within Cells	7254.31	51	142.24		
Condition	183.28	1	183.28	1.29	n.s.
Task	423.08	1	423.08	2.97	n.s.
Condition x Task	60.94	1	60.94	0.43	n.s.
'Trials' Within Subjects Effect					
Within Cells	1486.06	153	9.71		
Trials	62.38	3	20.79	2.14	n.s.
Condition x Trials	22.83	3	7.61	0.78	n.s.
Task x Trials	183.93	3	61.31	6.31	p<.001
Condition x Task x Trials	42.34	3	14.11	1.45	n.s.
'Time' Within-Subjects Effect					
Within cells	500.66	102	4.91		
Time	108.41	2	54.21	11.04	p<.001
Condition x Time	5.31	2	2.65	0.54	n.s.
Task x Time	2.91	2	1.45	0.30	n.s.
Condition x Task x Time	4.06	2	2.03	0.41	n.s.
'Time x Trials' Within-Subjects Effect					
Within Cells	1031.79	306	3.37		
Time x Trials	21.93	6	3.65	1.08	n.s.
Condition x Time x Trials	12.85	6	2.14	0.63	n.s.
Task x Time x Trials	15.85	6	2.64	0.78	n.s.
Condition x Task x Time x Trials	7.85	6	1.31	0.39	n.s.

This analysis revealed no statistically significant interactions by condition and support for the hypothesis was not found. A statistically significant task by trial interaction, however, was noted. This reflects the variation of the number of words listed within trials and between the two tasks. Compared to the consonant-prompted task, the category-prompted task elicited more words (across testing times) for trial 1 (category $\bar{x}$=11.14, sd=3.64 versus consonant $\bar{x}$=8.91, sd=3.35), trial 2 (category $\bar{x}$=11.02, sd=3.93 versus consonat $\bar{x}$=8.59, sd=3.26) and trial 4 (category $\bar{x}$=11.05, sd=4.68 versus consonant $\bar{x}$=9.03, sd=3.12). At Trial 3, however, the mean number of words listed decreased for the category-prompted task ($\bar{x}$=9.54, sd=3.99) and increased for the consonant-prompted task ($\bar{x}$=9.55, sd=3.45).

A Tukey test was conducted comparing the mean number of words produced at each trial by task (i.e., time of measurement is not a variable). This analysis revealed only one true difference ($p<.01$). Trial 4 of the category-prompted task yielded significantly more words than trial 2 of the consonant-prompted task. The mean number of words generated did not differ significantly at any other trial even across tasks.

The repeated measures ANOVA also revealed a statistically signicant main effect of time. A Tukey test indicated a significant increase ($p<.01$) in the mean number of words subjects thought of from pretest ($\bar{x}$=37.05, sd=12.75) to immediate posttest ($\bar{x}$=40.68, sd=14.56) and from pretest to delayed posttest ($\bar{x}$=41.05, sd=15.37). Figure 1 shows the mean scores at pretest, immediate posttest and delayed posttest by condition and task. No interactions involving time were noted.

Analyses of New Items

The findings were explored further and the responses were classified as either previously listed or new items. Table 7 provides the mean number of new words generated from pretest to immediate posttest and from posttest to delayed posttest. Similar to the main analysis, a repeated measures ANOVA was conducted. The hypothesis, again, was not supported as no interaction by condition was found.

This ANOVA revealed three statistically significant main effects; condition, trials, and time (Table 8 provides the summary table of results). Subjects in the control condition generated more new words (across trials and time of measurement) on average ($\bar{x}$=5.06, sd=2.57) than subjects in the exercise condition ($\bar{x}$=4.68, sd=5.06). Comparing the means that elicited the main effect of time, it is apparent that more new words were generated from pretest to immediate posttest ($\bar{x}$=5.42, sd=2.77) than from immediate posttest to delayed posttest ($\bar{x}$=4.16, sd=2.52). Looking now at the main effect of trials, a Tukey test revealed that more new words were generated on the fourth trial ($\bar{x}$=5.67, sd=3.08) than on trial one ($\bar{x}$=4.41, sd=2.61; $p<.01$) and trial two ($\bar{x}$=4.64, sd=3.34; $p<.05$).

Figure 1. Mean Number of Words Listed

Time by Task by Condition

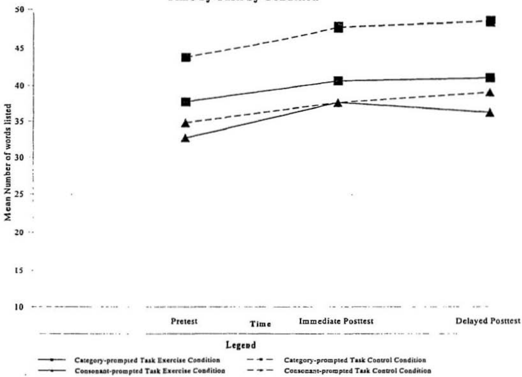

Table 7.
Mean Number of New Words Generated at Immediate Posttest and Delayed Posttest for both Category- and Consonant-Prompted Tasks
(Standard Deviations in Parentheses)

			Time of Measurement	
Task	**Condition**	**Trial**	**Immediate Posttest**	**Delayed Posttest**
Category-prompted	Exercise	1	2.79 (1.85)	1.78 (1.05)
		2	3.71 (2.02)	3.14 (2.91)
		3	2.57 (2.41)	1.50 (1.61)
		4	4.86 (3.96)	3.07 (2.30)
	Control	1	4.57 (1.95)	2.77 (2.31)
		2	4.14 (2.18)	3.54 (1.76)
		3	3.07 (1.73)	1.92 (1.55)
		4	7.43 (3.57)	4.15 (2.34)
Consonant-prompted	Exercise	1	6.67 (3.24)	5.29 (2.97)
		2	7.20 (3.99)	5.00 (2.60)
		3	7.60 (3.64)	5.93 (2.53)
		4	6.73 (3.39)	5.64 (3.23)
	Control	1	5.25 (3.02)	5.14 (3.78)
		2	5.38 (3.36)	5.36 (3.34)
		3	7.38 (4.19)	6.07 (3.32)
		4	6.56 (3.90)	6.00 (3.01)

Table 8.
Summary Table of Repeated Measures ANOVA:
Testing for New Words Listed by Condition, Task, Trial and Time

Source of Variation	SS	df	MS	F	p
Between Subjects Effect					
Within Cells	1925.36	51	37.75		
Condition	815.94	1	815.94	21.61	<.001
Task	9.43	1	9.43	0.25	n.s.
Condition x Task	40.28	1	40.28	1.07	n.s.
'Trials' Within-Subjects Effect					
Within Cells	597.91	153	3.91		
Trials	199.45	3	66.48	17.01	p<.001
Condition x Trials	12.31	3	4.10	1.05	n.s.
Task x Trials	14.46	3	4.82	1.23	n.s.
Condition x Task x Trials	16.65	3	5.55	1.42	n.s.
'Time' Within-Subjects Effect					
Within cells	225.95	51	4.43		
Time	55.69	1	55.69	12.57	p<.001
Condition x Time	0.67	1	0.67	0.15	n.s.
Task x Time	81.97	1	81.97	18.50	p<.001
Condition x Task x Time	0.16	1	0.16	0.04	n.s.
'Time x Trials' Within-Subjects					
Within Cells	758.05	153	4.95		
Time x Trials	10.14	3	3.38	0.68	n.s.
Condition x Time x Trials	12.61	3	4.20	0.85	n.s.
Task x Time x Trials	77.67	3	25.89	5.23	<.01
Condition x Task x Time x	11.42	3	3.81	0.77	n.s.

Two statistically significant interactions were found, a two-way task by time interaction and a three-way interaction of task by time by trials. Looking first at the two-way interaction, a Tukey test revealed that subjects generated more new words on the consonant-prompted task from both pretest to immediate posttest ($\bar{x}$=6.58, sd=3.11) and from immediate posttest to delayed posttest ($\bar{x}$=5.55, sd=2.55) than the category-prompted task at these two times (pretest to immediate posttest $\bar{x}$=4.14, sd=1.57 versus immediate posttest to delayed posttest $\bar{x}$=2.72, sd=1.50; $p<.01$). This post hoc test also revealed that subjects produced more new words on the consonant-prompted task from pretest to immediate posttest than from immediate posttest to delayed posttest ($p<.05$).

Figure 2 illustrates the three-way interaction. A Tukey test (see Table 9) revealed that the subjects generated more new words on average on the consonant-prompted task at immediate posttest than the category-prompted task at delayed posttest on all four trials ($p<.01$). Subjects also thought of more new words in the consonant-prompted task at immediate posttest than on the category-prompted task at immediate posttest on all but the fourth trial.[2] The mean number of new words produced on the fourth trial of the category-prompted task at immediate posttest did not differ significantly from the number of new words listed on the consonant-prompted task at immediate posttest at trials 1, 2, 3, or 4.

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[2] All differences are significant at $p<.01$, with the exception of the difference between the mean number of new words generated at immediate posttest for the consonant-prompted task at trial 1 ($\bar{x}$=5.94, sd=2.07) and the mean number of new words generated at immediate posttest for the category-prompted task at trial 2 ($\bar{x}$=3.93, sd=2.07) which are significantly different at $p<.05$.

Figure 2. Mean Number of New Words Generated

Task by Trial by Time Interaction

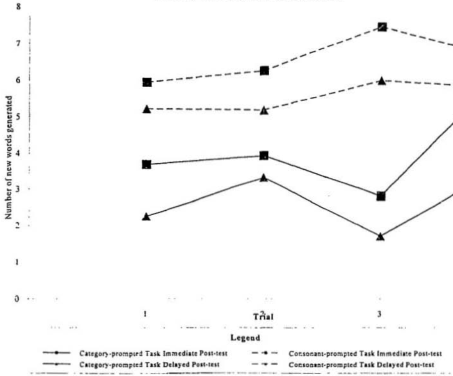

Table 9.
Mean Differences in New Words Generated

(Refer to Figure 3)	$\bar{x}$	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Category-Immediate posttest-Trial 3	1.70						*	*	**	**	**	**	**	**	**	**	**
2. Category-Immediate posttest-Trial 1	2.26								**	**	**	**	**	**	**	**	**
3. Category-Delayed posttest-Trial 3	2.82								**	**	**	**	**	**	**	**	**
4. Category-Immediate posttest-Trial2	3.33										**	**	**	**	**	**	**
5. Category-Immediate posttest-Trial4	3.59										*	**	**	**	**	**	**
6. Category-Delayed posttest-Trial 1	3.68										*	**	**	**	**	**	**
7. Category-Delayed posttest-Trial 2	3.93											*	*	*	**	**	**
8. Consonant-Delayed posttest-Trial 2	5.18																**
9. Consonant-Delayed posttest-Trial 1	5.21																**
10. Consonant-Delayed posttest-Trial 4	5.82																
11. Consonant-Immediate posttest-Trial 1	5.94																
12. Consonant-Delayed posttest-Trial 3	6.00																
13. Category-Immediate posttest-Trial 4	6.14																
14. Consonant-Immediate posttest-Trial 2	6.26																
15. Consonant-Immediate posttest-Trial 4	6.64																
16. Consonant-Immediate posttest-Trial 3	7.48																

*$p<.05$
**$p<.01$

Supplementary Analysis

The demographic variables (gender, age, marital status, and education), ambulatory level, fitness class participation, facility, the SENOTS battery data and the exercise/control variable were included in a stepwise regression analysis selecting for the category-prompted task only. The purpose of this analysis was to determine which variables are the best predictors of scores on the category-prompted task. A similar analysis was not conducted for the consonant-prompted task because the correlation matrix revealed only education level to be significantly related to the number of words produced and this relationship was not particularly strong ($r=.33$, $p<.05$).

Table 10 provides the results from the regression analysis for the category-prompted task. This analysis revealed that two subtests of the SENOTS battery, namely, the MUNAIS (measuring activity propensity) and financial hardship contributed to the largest proportion of the variance at all three testing times. In fact, these two variables explained 50% of the variance on the category-prompted task. Looking at the correlations, it is apparent that ability level was positively related to the mean number of words generated on the category-prompted task. Thus, the higher the activity level as scored on the MUNAIS, the more words the subject could generate. Conversely, financial hardship was negatively related to the mean number of words listed. So, the greater the financial hardship, the fewer words generated.

Table 10.
Results from Stepwise Regression Analysis for Category-Prompted Task

Time	Step	Variable	B	F	R^2	r
Pretest	1	MUNAIS	0.56	10.67**	0.32	0.56**
	2	Finance	-0.42	10.37***	0.49	-0.51**
Immediate Posttest	1	Finance	-0.56	10.40**	0.31	-0.56**
	2	MUNAIS	-0.48	10.72***	0.49	0.52**
Delayed Posttest	1	MUNAIS	0.59	12.59***	0.35	0.60**
	2	Finance	-0.39	11.19***	0.50	-0.49**

** $p<.01$
*** $p<.001$

DISCUSSION

This study did not replicate the findings of the Stones and Dawe (1993) study. There was no evidenc from the current study that provides support for the hypothesis that acute non-strenuous exercise was associated with a short-term improvement in cognitive performance. The present study followed the exercise protocol from the original study very closely. The individuals sampled were similar according to the demographic variables collected. The results indicated that the number of words generated on the category-prompted task corresponded to the original study. Also, a comparable exercise effect was found between the two studies. The only differences in the research designs between the two studies were: (1) a different sample (2) the addition of the SENOTS battery, (3) a different tester, and (4) subjects were only given one cognitive task, either the consonant-prompted task or the category-prompted task. I will first interpret the results, then I will assess each of the differences listed above in turn. The results indicated a clear exercise effect and a probable practice effect. There appears to be no clear explanation for the discrepant results. It seems that the effect was not a robust one and further research is necessary to determine the reasons behind the differences.

Interpretation of the Results

This study found clear exercise effects. The heart rate showed an increase of approximately five beats per minute for the exercise group from pretest to immediate posttest and then returned approximately to resting levels at delayed posttest. This exercise effect was somewhat higher than the two beats per minute found in the Stones and Dawe (1993) study. Resting heart rates cannot be compared statistically between the two studies because the standard deviations were not provided in the Stones and Dawe study.

Only one interaction, a trial by task interaction, was found to be statistically significant in the repeated measures ANOVA. The post hoc test on the trial by task interaction indicated that for most trials there was no difference between the mean number of words subjects thought of between tasks. The only statistically significant difference that was found was a difference between the category-prompted task at trial 4 and the consonant-prompted task at trial 2. Although subjects tended to think of more words on the category-prompted task than the consonant-prompted task, for the most part, these differences were not significant. Because the categories in the category-prompted task and the letters in the consonant-prompted task were always presented in a fixed order, these results only indicated differences in the difficulty between the particular category and letter. In other words, subjects found it easier to think of a number of different towns (trial 4 of the category-prompted task) than to think of a number of different words starting with the letter "D" (trial 2 of the consonant-prompted task).

There was also evidence of practice effects in the current study indicated by the main effect of time found on the repeated measures ANOVA. Looking at the mean number of words listed across both tasks, the number increased from pretest ($\bar{x}$=37.05, sd=12.75) to immediate posttest ($\bar{x}$=40.68, sd=14.56). The post hoc test revealed a statistically significant difference in the mean number of words generated from pretest to immediate posttest and from pretest to delayed posttest ($\bar{x}$=41.05, sd=15.37) but not from immediate posttest to delayed posttest. It is possible that the increase from pretest to immediate posttest is due to subjects' practice of the task. The reader should note, however, that practice effects were not found in the Stones and Dawe (1993) study.

A further analysis looked at the mean number of new words generated on each task across testing times. This analysis revealed that the main differences regarding new words generated occurs between tasks. No effects occurred between conditions. Subjects were able to generate significantly more new words from pretest to immediate posttest on the consonant-prompted task compared to the category-prompted task across all trials.

The last analysis investigated the influence of some extraneous variables. The contextual information (i.e., demographic variables, facility, ambulatory level, and fitness class participation) and the scores on the SENOTS battery were analyzed in a stepwise regression to determine if by controlling for a combination of these extraneous variables an effect by condition from pretest to immediate posttest might be found. While a statistically significant effect by condition was not found, this analysis did provide insight into the relationships between variables. These relationships are described later in this discussion.

Differences Between the Present Study and the Stones and Dawe (1993) Study

As I mentioned at the beginning of this section there were four differences in the research design of the present study to that of the Stones and Dawe study. To reiterate, the differences are: (1) a different sample, (2) more pre-measures were taken in the form of the SENOTS program and battery, (3) a different tester, and (4) the subjects were only given one cognitive task, either the consonant-prompted task or the category-prompted task. I will now review the implications of these differences.

Difference between samples

The present study used a larger and broader sample than the original study. The original study tested 20 residents from one nursing home compared to the present study where 59 residents from three nursing homes were tested. At the same time, however, there were more groups in the present study, thus, the number of subjects in each group were only slightly different (i.e., 10 in each group in the original study versus 15 in each group in the present study).

Comparing the present sample to the Stones and Dawe (1993) sample on demographic variables, I found the two samples to be quite similar. The gender split was approximately the same in the original sample (15%, n=3 males and 85%, n=17 females) as in the present sample (12%, n=7 males and 88%, n=52 females). The mean age and age range was also strikingly similar in the two studies. The mean age of the subjects in the Stones and Dawe (1993) study was 84.5 years (range=76-93) whereas the mean age of the present study was 84.2 years (range=73-98). Although the measures of education were different in the two studies, it appears that the samples were similar on this factor as well. The Stones and Dawe sample had an average of 9.3 years of formal education whereas 31% (n=18) of the current sample stated that they had eighth grade or less and a further 19% (n=11) stated they had not completed high school. It is unlikely that these sample groups differ significantly in the years of formal education. Given these similarities in the demographic variables, it is doubtful that the discrepant findings are due to differences between the samples on these grounds.

One definite difference between the two samples was that individuals in wheelchairs were permitted to participate in the current study. However, because subjects were randomly assigned to control groups or exercise groups regardless of ambulatory level, it is unlikely that this would affect the results. Comparing the distribution of subjects on this variable by condition, it was found that there were more subjects in wheelchairs (n=9) in the control condition than in the exercise condition (n=5) and this trend was reversed for those who require ambulatory aides (i.e., a cane or a walker): Nine subjects who required aides were assigned to the exercise condition (n=9) and four were assigned to the control condition. A chi-square test confirmed that the distribution of subjects by ambulatory level to condition was not significantly different (χ^2=3.17, df=2, p=.20). Looking at the correlation between ambulatory level and the number of words produced (controlling for task) no significant relationship was found at pretest ($r=-.06$, $p=.65$), immediate posttest ($r=-.06$, $p=.68$), or delayed posttest ($r=-.12$, $p=.70$). In addition, one would expect that if ambulatory level had influenced the results then it would have emerged as a contributing factor in the stepwise regression. The fact that ambulatory level does not contribute to the variance in this analysis, combined with the low correlation between this factor and the outcome measures, rules out the possibility that the inclusion of individuals of different ambulatory levels in the present study explains the discrepant results from the original Stones and Dawe (1993) study.

A second difference between the two studies is that data was collected in the current study to indicate whether or not subjects regularly participated in fitness classes. This measure was an informal measure, where subjects were simply asked, "Do you regularly attend fitness classes?", thus no measure of frequency or duration of participation was collected. Again, a chi-square test confirmed that there were no differences in the distribution of subjects who said they regularly attended fitness classes from subjects who said they did not regularly attend such classes by condition ($\chi^2=.01$, $df=1$, $p=.92$). Also, fitness class attendance was not correlated to the outcome measures (controlling for task) at pretest ($r=-.02$, $p=.91$), immediate posttest ($r=.04$, $p=.81$), or at delayed posttest ($r=.05$, $p=.70$). Finally, participation in a fitness class did not contribute to the variance in the stepwise regression analysis. Thus, previous participation in a fitness class does not explain the contradictory findings.

Other measures were taken in the SENOTS program and battery in the current study that were not collected in the Stones and Dawe (1993) study, so differences between the samples based on these factors cannot be directly assessed.

The administration of the SENOTS program and battery

There is a possibility that the administration of the SENOTS program and battery affected the results. This is unlikely, however, because it was administered prior to the testing time (at least a day before) and it is improbable that the administration of this test had effects that endured for this length of time.

Different tester

Another difference between the two studies is that the tester was different. It is possible that the interaction between the subject and the tester biased the results in some unknown fashion. Future research could control for this possible biasing effect by blinding the tester to what condition the subject was assigned.

Task order

The final difference between the original study and the current study is the administration of the two cognitive tests. In the former study subjects were administered three cognitive tasks in the same order each time whereas in the current study subjects were administered only one of two cognitive tasks. This difference in research design could only explain a discrepancy in the effects on the consonant-prompted task because the category-prompted task was presented first in the original study and so the administration of this task was identical in the two studies. Only the administration of the consonant-prompted task truly varied in the second study and the results did not differ with respect to this task across studies.

Conclusion of comparison

Based on this comparison between the present study and the original study I submit that the results from both studies are inconclusive. They did not replicate the Stones and Dawe (1993) study even though the conditions were kept very similar.

Interpretation of the Stepwise Regression Analysis

The SENOTS program and battery was administered because it was thought that an exercise intervention might have more of an effect on cognitive performance for individuals who were less active and the SENOTS program provides a measure of activity limitations and a measure of activity propensity. A stepwise regression analysis will control the factors with the highest correlation to the outcome measures by keeping them constant. Thus, it was predicted that the effect would increase once activity propensity was controlled. I will now look at the possible influence of some of these pre-measures on the results.

T-tests revealed that the scores on the MUNSH (a measure of happiness) and the MUNAIS (a measure of activity propensity) were both higher than one would expect in an institutionalized sample (Stones & Kozma, 1989b). Conversely, the scores found for financial hardship, physical symptoms, and activity limitations were all significantly lower than one would expect in an institutionalized sample (Stones & Kozma). However, it is important to look at the scores themselves (refer to Table 2), and although they are significantly different, it is clear that the differences on the latter three measures mentioned are quite minor.

Although the MUNSH scores were much higher than were found in the Stones & Kozma (1989b) study there have been instances where comparable scores have been obtained in institutionalized samples (Kozma & Stones, 1980). Thus, it is possible that the subjects from the original study reflected the more typical institutionalized sample and that they were more unhappy than the present sample. However, according to the results, this possibility seems unlikely. First, the MUNSH scores correlated (controlling for task) with the number of words listed at immediate posttest ($r=.39$, $p<.05$). However, the MUNSH scores did not correlate with outcome measures at pretest ($r=.24$, $p=.24$) or at delayed posttest ($r=.34$, $p=.10$). Again, if this factor were to have a strong influence on the outcome of the study then one would expect that this variable would be one of the factors contributing to the variance in the stepwise regression and this was not the case.

Further evidence supporting the contention that happiness is not a predictive factor of word fluency comes from a study conducted by Arbuckle and Gold (1993). This study included measures of happiness from the MUNSH test and word fluency from the SET test. The SET test, as was previously mentioned, was adapted to form the category-prompted word fluency task used in the present study. These researchers failed to find a relationship between category-prompted word fluency and happiness scores on the MUNSH. Therefore, even if it is the case that the present sample was unusually happy, it appears unlikely that this factor would influence the results.

Two other variables measured on the SENOTS test were found to affect the number of words generated on the category-prompted task, the MUNAIS (a test of activity propensity) and financial hardship. These variables correlated quite strongly with the category-prompted task at all three testing times (see Table 10). Those that had a higher propensity for activity and had fewer financial concerns could generate more words than those who were less likely to be active and had more financial concerns. In fact, these two factors explained almost 50% of the variance at all three testing times. Both of these factors are only single indicators and on their own they are not particularly informative. Therefore, a factor analysis was performed on the scores of the SENOTS program and battery as an aide to interpret these findings.

The factor analysis revealed two factors. The first factor was a measure of negative affect (misery), with physical symptoms, financial hardship, and happiness showing the highest loadings (see Appendix V for loadings). Indicators of activity, namely the MUNAIS and the activity limitation measure, contributed most prominently to the second factor. This finding suggests that a combination of low overall misery and high overall activity might be important factors contributing to word fluency on a category-prompted task. Further research on the influence of these factors is necessary to confirm this postulation. It should be noted that once the scores on the MUNAIS and financial hardship were controlled in the stepwise regression the exercise intervention still did not emerge as a contributing factor to the number of words listed, so again, this finding does not help to explain the discrepant findings from the Stones and Dawe study.

This finding does provide some insight into what might lead to improved cognitive function. Future research could look at the manner in which activity, negative affect, and word fluency are related to each another. It may be the case that a program which is targeted toward overall activity combined with a program to stimulate positive affect, rather than simply physical exercise, may influence cognitive functioning. Thus, the present findings suggest that a combination of factors likely predicts cognitive functioning, that physical activity may simply be an indicator of a more encompassing activity factor and that this activity factor combined with a psychological factor of negative affect are more reliable predictors of cognitive functioning. More research is necessary to determine what combination of variables is most predictive of cognitive functioning in older adults and also how these factors relate to each other as predictors of cognitive function.

Looking again at some of the previous acute exercise research it should be reiterated that there have been no replication studies where acute exercise has been shown to affect the same cognitive tasks. Previous studies of the effects of acute exercise on cognition have included several cognitive tasks. Diesfeldt and Diesfeldt-Groenendijk (1977) tested immediate free-recall, total recall, recognition capacity, and a posting-box error test. Of these four cognitive tests, effects were found only on the total recall scores. Molloy et al. (1988) included the same memory task that was used in the Diesfeldt and Diesfeldt-Groenendijk (1977) study. This tests for immediate free-recall, total recall, and recognition. The Molloy et al. study also included a color slide test, a digit-symbol test, a digit-span test, a logical memory test, a word fluency test (category-prompted), a mood test, a depression test, and a mini mental state exam. Of the nine cognitive tasks tested, these researchers only found an effect on logical memory. The Diesfeldt and Diesfeldt-Groenendijk (1977) results were not replicated as there was no total recall effect observed. Similar results were found in the Stones and Dawe (1993) study. The only effects found were on the category-prompted word fluency task. The Molloy et al. (1988) study used the same test and did not find an effect.

Conclusions

In conclusion, there is no evidence from the present study that supports previous contentions that acute exercise affects category-prompted word fluency. A review of the literature concerning acute exercise indicates that previous findings are not robust and that other even small changes in design can result in discrepant findings. None of the successful studies have found effects on the same cognitive tasks. This study showed that activity propensity and financial hardship, which are thought to be indicators of overall activity and negative psychological affect respectively, were the most predictive variables of performance on a category-prompted word fluency task. This finding combined with the inconsistent findings from previous research suggests that perhaps acute exercise alone is not associated with cognitive functioning but rather that exercise may simply be one indicator of an overall activity factor and that this, combined with psychological indicators of negative affect lead to improved cognitive functioning in the short term. Thus, although the evidence from chronic exercise studies indicates there are physiological benefits from participation in regular exercise into older adulthood, the evidence from this study and previous acute exercise studies indicates that the relationship between exercise and cognitive function is not as direct. Spirduso and Asplund (1995) reached a similar conclusion in their recent review of the exercise and cognitive performance literature. They concluded:

> But part of the failure (to find a robust relationship) may also be due to the prospect that the contribution of exercise *alone* is insufficient to maintain cognitive function throughout aging. Rather, it may be that it is the constellation of good health habits, exercise, and high socioeconomic and educational status that are robustly related to cognition in the elderly. (p. 407)

This possibility introduces many questions. The two most important questions are, "What combination of factors best predicts cognitive performance in older adults?" and "In what way are these variables related?" Perhaps by studying the answers to these questions caregivers to the institutionalized elderly will have an indication of who would most benefit from inclusion in different activities.

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APPENDIX I
Instruments

MENTAL STATUS QUESTIONNAIRE

1. What is your full name? ____________________
2. What is your address? ____________________
3. What year is this? __________
4. What month is this? __________
5. What day of the week is this? __________
6. How old are you? __________
7. What is the name of the Prime Minister of Canada? __________
8. When did the first World War start? __________
9. Remember these three items. I will ask you to recall thma few minutes. bed, chair, window. (Have subject repeat).
10. Count backwards from 20 to 1. __________
11. Repeat the three items I asked you to remember. __________

The SENOTS Battery

Happiness/Depression (MUNSH)

Here are the first questions. They are about how things have been going for you recently. During the past month, have you felt...

1.	On top of the world?	Yes	No
2.	In high spirits?	Yes	No
3.	Particularly content with your life?	Yes	No
4.	Lucky?	Yes	No
5.	Bored?	Yes	No
6.	Very lonely or remote from other people?	Yes	No
7.	Depressed or very unhappy?	Yes	No
8.	Flustered because you didn't know what was expected of you?	Yes	No
9.	Bitter about the way your life has turned out?	Yes	No
10.	Generally satisfied with the way your life has turned out?	Yes	No

The next questions have to do with more general life experiences.

11.	This is the drearist time of my life.	Yes	No
12.	I am just as happy as when I was younger.	Yes	No
13.	Most of the things I do are boring or monotonous.	Yes	No
14.	The things I do are as interesting to me as they ever were.	Yes	No
15.	As I look back on my life, I am fairly well satisfied.	Yes	No
16.	Things are getting worse as I get older.	Yes	No
17.	I often feel lonely.	Yes	No
18.	Little things bother me more this year.	Yes	No
19.	I am quite satified with living in this city.	Yes	No
20.	I sometimes feel that life isn't worth living.	Yes	No
21.	I am as happy now as I was when I was younger.	Yes	No
22.	Life is hard for me most of the time.	Yes	No
23.	I am satisfied with my life today.	Yes	No
24.	My health is the same or better than most people of my age.	Yes	No

Financial Hardship

The next questions have to do with money matters.

1.	I worry about my finances	Yes	No
2.	Money is tight.	Yes	No
3.	The clothes I want are priced beyond my means.	Yes	No
4.	I sometimes have problems affording the essentials of life.	Yes	No

Physical Symptoms

The next questions have to do with your health.

1.	I sometimes feel dizzy or feel my heart pounding.	Yes	No
2.	I sometimes find myself trembling.	Yes	No
3.	I sometimes feel weak all of a sudden.	Yes	No
4.	I get breathless or feel my heart pounding if I exert myself at all.	Yes	No

5. I often have a cough. Yes No
6. I get chest pains when I cough or breath deeply. Yes No
7. My ankles sometimes swell up. Yes No

Activity Limitation

The next questions are about activities that might cause you problems.

1. Health problems prevent me from doing my own shopping. Yes No
2. I have difficulty cutting my own toe nails. Yes No
3. I have difficulty getting my shoes on and off. Yes No
4. Health troubles limit my spare time activities. Yes No
5. Health troubles stop me from doing regular chores. Yes No
6. Health troubles stop me from getting about. Yes No
7. I sometimes have problems dressing myself. Yes No

Activity Propensity (MUNAIS)

The last questions have to do with you activities.

1. I do most if not all my own housework. Yes No
2. I do most or all of my own work around the house and garden. Yes No
3. I get my own groceries. Yes No
4. I see my family and relatives at least once a week. Yes No
5. I get phone calls from my family at least once a week. Yes No
6. A family member or relative drops by to see me most weeks. Yes No
7. I usually get together with my family at special times like Xmas or birthdays. Yes No
8. I belong to a church or community group. Yes No
9. I attend residence events (like bingo or card parties) Yes No
10. I read newspapers or magazines. Yes No
11. I write letters and read my mail. Yes No
12. I frequently go shopping. Yes No

Category-Prompted Word Fluency Test

COLOURS:

ANIMALS:

FRUITS:

TOWNS:

Consonant-Prompted Word Fluency Test

T:

D:

P:

M:

APPENDIX II

Ethics Committee Approval Form

Memorial
University of Newfoundland

Department of Psychology

February 4, 1994

TO: Susan Underhill, Psychology

FROM: Dr. Mary L. Courage, Chairperson
Faculty of Science Ethics Committee

SUBJECT: Research Proposal

The Ethics Committee of the Faculty of Science has reviewed your research proposal titled: "Acute Exercise: Effect on Semantically cued Memory in Mursing Home Residents" It is our view that the procedures you describe meet the requirements for ethically acceptable research with human subjects. The approved application forms are enclosed. A copy of those forms should be presented if and when you apply for authorization to pay subjects.

Mary L. Courage, Ph.D
Associate Professor

encl.

cc: Dr. W. McKim
Acting Head
Department of Psychology

St. John's, Newfoundland, Canada A1B 3X9 • Tel.: (709) 737-8496 • Fax: (709) 737-2430

APPENDIX III

Samples of Consent Forms

Memorial
University of Newfoundland

Gerontology Centre

Mr. Don Green
Agnes Pratt Home
239 Topsail Road
St. John's, Nfld.
A1E 2B4

January 24, 1994

ATTN: Mr. Green

The Gerontology Centre at Memorial University would like to invite the participation of Agnes Pratt in a research study entitled "Acute Exercise: Effects of Semantically Cued Memory in Nursing Home Residents". Recent research on older adults has suggested that even light exercise like easy stretching of major muscle groups can improve thinking power for short periods. I am conducting a study concerning this particular area.

The study requires a number of older adult volunteers who are willing to participate. Participation would require approximately 30-45 minutes of the residents time, the completion of 4 short questionnaires and may involve 15 minutes of light stretching exercises.

I would greatly appreciate the co-operation of Agnes Pratt for this study. All of the information provided by the residents will be kept in the strictest of confidence. Names will not appear on any of my materials. My interest is in group, not individual scores. The participants will be informed of his/her right to withdraw from this study at any time should he/she find it necessary. If you have any questions regarding my project, please feel free to contact me at 579-6418.

Sincerely,

Susan Underhill
Psychology Masters Candidate

I have been informed as to the nature of this study and do hereby give my consent for Susan Underhill to enter Agnes Pratt and conduct her study.

Signature: ______________________

Date: February 1st /94

Memorial
University of Newfoundland

Gerontology Centre

February, 1994

Dear Friend,

The Gerontology Centre at Memorial University would like to invite your participation in a research study entitled "Acute Exercise: Effects of Semantically Cued Memory in Nursing Home Residents". Recent research on older adults has suggested that even light exercise like easy stretching of major muscle groups can improve thinking power for short periods. I am conducting a study concerning this particular area.

The study requires a number of older adult volunteers who are willing to participate. Participation would require approximately 30-45 minutes of your time, the completion of 4 short questionnaires and may involve 15 minutes of light stretching exercises.

I would greatly appreciate your participation in this study. All of the information you provide will be kept in the strictest of confidence. Your name will __not__ appear on any of my materials. My interests is in group, not individual scores. You have the right to withdraw from this study at any time should you find it necessary. If you have any questions regarding my project, please feel free to contact me at 579-6418.

Sincerely,

Susan Underhill
Psychology Masters Candidate

I have been informed as to the nature of this study and do hereby give my consent to be a participant. I understand that I am free to withdraw before, during or after this study.

Signature: ____________________

Tel. No.: ____________________

Date: ____________________

APPENDIX IV

Guidelines for Exercise Protocol

GUIDELINES FOR EXERCISE PROTOCOL

Warm Up:		(All exercises performed seated)
		-5 x deep breaths
Stretching:		(All exercises performed seated)
	Neck	-5 x head rotations
	Shoulder	-5 x shoulder rolls right/left
	Arms	-5 x palms up, palms down
		-5 x arm lifts (from shoulder up)
		-reach behind head, hold 5 counts
		-5 x arms out at side, touch chest
	Wrist	-5 rotations/reverse
	Fingers	-touch fingers to thumb/reverse
		-5 x open/close fist
	Waist	-5 x lean forward back in chair
		-5 x lean side in chair right/left
	Hips	-5 x bicycle legs
		-5 x leg extension
	Ankle	-5 x point/flex
Aerobic:		
		Walk for 2 minutes
		(If in wheelcnair, then push wheelchair independently for 2 minutes)
Cool Down:		(All exercises performed seated)
		-5 x deep breaths

APPENDIX V

Factor Loadings on SENOTS Program and Battery

Factor Loadings of the SENOTS Battery and Program
(Quartimax Rotation)

<u>Factor I:</u> <u>Negative Affect</u>

Physical Symptom
Financial Hardship
MUNSH
Activity Limitation
MUNAIS

<u>Factor II:</u> <u>Overall Activity Level</u>

MUNAIS
Activity Limitation
MUNSH
Physical Symptoms
Financial Hardship