EFFECTS OF ACUTE EXERCISE ON NEUROPSYCHOLOGICAL PERFORMANCE IN AN ELDERLY POPULATION

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Effects of
Acute Exercise on
Neuropsychological Performance
in an Elderly Population

by

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Dedicated to my three special boys:

Andrew

Graham

Peter.

ABSTRACT

The effects of a single 15-minute bout (i.e. acute) of nonstrenuous exercise on three neuropsychologic tests were evaluated using a randomized pre-post experimental design. Two tests measured memory recall performance; the modified Set test and the Word Fluency test. The third was a test of psychomotor performance; the Symbol Digit test. Twenty nursing home residents (aged 76-93 years) were assigned randomly to an exercise or passive intervention condition, with the tests administered pre-intervention, immediately post-intervention, and again after a 30-minute delay. Significant results were obtained on the modified Set test, which is a word fluency test with semantic cues. The scores at both post-tests were significantly elevated over the pretest score in the exercise group ($p < .01$), whereas the control group scores did not differ significantly across times of measurement. The magnitude of exercise-induced gain (i.e., approximately 20% over the pretest level) was such that the effects of acute exercise are indicated to have meaningfully facilitated semantic recall in nursing home residents. Demographic studies indicate that the 75 and over age group will show the greatest growth rate within the senior population thus increasing the demand for institutionalized care. The findings of this study indicate that aspects of memory can be improved using exercise which can be readily incorporated into daily nursing home care; this may help maintain the independence of this frail group.

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF APPENDICES

LIST OF TABLES

Table

LIST OF FIGURES

Figure

1.0 INTRODUCTION

Demographic studies of population growth indicate that by the years 2010-2020, Canada's population will be an aged population (McDaniel, 1986). Nearly one in every five Canadian will be aged 65 years or more. Not only is this age group increasing in proportion to the rest of the population but life expectancy itself is increasing. The population aged 75 and over will show the greatest growth rate within the senior population (Stone & Fletcher, 1986). Old age is associated with widowhood, one-person families, reduced income, greater risk of poverty, outliving one's children, increasing frailty, a reduced ability to care for oneself, progressive deterioration of body functions and a decreasing resistance to disease (Kane, Evans, & MacFadyen, 1990). It is estimated that beyond the age 65, 80% of persons have at least one or more chronic condition (Williams, 1983). The ill elderly are living longer and as a result increase the need for institutional type care (Kane et al., 1990). Wingard, Jones, and Kaplan (1987) report that old age combined with chronic disease conditions was one of the main predictors for institutionalization.

The need for institutional care is projected to increase as a result of the combination of the demographic revolution and complex needs of many older individuals. Unfortunately, institutionalization has been recognized as having negative effects such as depersonalization, isolation, stimulus deprivation, and even death (Kane et al., 1990).

Booth (1986) and Spasoff et al., (1978) found that institutionalized individuals tend to become inactive, passive, and difficult to motivate. Inactivity is significant because it contributes to a deterioration of physical and mental abilities. The less active the individual the greater the decline of physical and neuropsychological ability. Institutionalized individuals may also suffer inactivity if nursing home staff have an unsupportive attitude towards promoting exercise. Myers and Gonda (1986) recognize that one of the barriers to participation in physical exercise in elderly subjects is a perception by staff that exercise programs are recreational rather than therapeutic and therefore "out of the province of serious professional concerns" (p.183). Nursing home staff may also perceive the incorporation of exercise into daily routines as an addition to their already heavy workloads and therefore hesitate to encourage and assist residents in exercise routines. These barriers, in addition to others such as fear of a risk to health, lack of encouragement by physicians, and myths about exercise and aging identified by Myers and Gonda (1986), operate to discourage institutionalized elderly from participating in physical activity. Staff of nursing homes often carry out the daily activities of residents for the residents rather than encouraging the individuals to do it themselves. Routine daily activities are opportune times to incorporate exercise and movement (LaRocque & Campagma, 1983; Myers & Hamilton, 1986).

In general, the effects of exercise on neuropsychological functioning have been found to affect mood, behaviour, intelligence, reasoning, psychomotor performance, and memory. The effects have been positive or negative depending on the intensity, type and duration of exercise and the test administered. The current review and research will specifically consider the literature that has evaluated the effects of low to moderately intense exercise on memory and psychomotor performance.

The discussion of the literature on exercise and its effects on neuropsychological performance have been grouped according to the effects of two types of exercise; chronic and acute. Effects of chronic exercise must be viewed differently from those of acute exercise because of the different physiological and psychological states produced. As defined by Stones and Kozma (1988), chronic exercise refers to regular exercise over several weeks or more and acute exercise is defined as a single bout or one-time session of exercise.

Chronic effects are the result of regular exercise over a prolonged period and have a training effect. The effects of this type of exercise have been attributed to 1) improved oxygen transport and use, 2) turnover of neurotransmitters, and 3) an increase in glucose metabolism at the cellular level, which is believed to facilitate neuropsychological performance (Dustman et al., 1984). Fitness or endurance effects can be measured by maximal oxygen uptake (VO_2 max) which McArdle, Katch, and Katch (1986) recognize , as the single best measure of ones ability to utilize oxygen.

Effects of acute exercise are attributed to activity induced arousal of the central nervous system or facilitation of mental processes. This arousal lasts for a relatively short time and is believed to increase neuropsychological performance up to an optimal point and then to deteriorate with further increases in physical arousal (Tomporowski & Ellis, 1986).

2.0 LITERATURE REVIEW

This section is devoted to a review of research that attempts to evaluate the effect of low to moderately intense, aerobic exercise on neuropsychological performance. Studies of effects of chronic exercise will be presented first followed by studies of effects of acute exercise.

Effects of Chronic Exercise on Neuropsychological Performance

Recent research on chronic exercise and its effect on neuropsychological performance have reported beneficial effects. More than half of the studies reviewed, however, have used a comparative design which confounds internal validity. Spirduso (1975) reported that a group of 60 male subjects older than 60 years who had maintained a lifestyle of aerobic training were not significantly slower in simple and choice reaction time than college age subjects. Spirduso and Clifford (1978) replicated these findings and also showed that within-subject and between-subject variance, both of which have been consistently reported to be greater in older individuals were in fact not statistically different from the variability seen in young men. Rikli and Busch (1986) extended the findings to include female samples. Baylor and Spirduso (1988), Clarkson (1978) and MacRae, Crum, Giessman, Greene, and Ugolini (1988) also found reaction times of older physically fit men and women to be faster than those of sedentary individuals. Spirduso, MacRae, MacRae, Prewitt, and Osborne (1988) suggest that chronic exercise may also exert a protective effect on aspects of the central nervous system. In their study they found simple reaction time of older physically active women to be significantly faster than that of younger inactive women. Elaysed, Ismail, and Young (1980) found that a 4-month program of aerobic exercise improved elderly subjects performance on two measures of fluid intelligence (i.e., intelligence resulting from normal biological development factors) but did not affect subjects performance on measures of crystallized intelligence (intelligence resulting from learning and acculturation). Stacey, Kozma and Stones (1985) found further evidence that exercise can inhibit loss in neuropsychological performance on simple cognitive tasks. Clarkson and Kroll (1978) completed a study which contrasted different levels of exercise with different ages and found better fitness levels to positively affect reaction time. Powell and Pohndorf (1971) did not find significant effects of exercise on neuropsychological performance but did find that regular exercisers scored higher as a group on mental decrement tests than did nonexercisers.

Unfortunately, as stated earlier, the comparative type of study confounds the internal validity because individuals age very differently, and considerably more between-subjects variability exists in samples of older individuals. Within the older age groups there exists drastically different levels of health, physical fitness, nutrition, and a host of other factors between the individuals. Therefore a comparison of neuropsychological performance of 20-year-olds with 70-year-olds is not just a comparison of young and old individuals (Birren & Schaie, 1990).

The design of choice to control confounding problems to internal validity of the comparative designs is an experimental design. This design tests cause and effect because of the use of a control group, random assignment of subjects and the pre-postmeasurement given to the control and experimental groups. The strength of the experimental design lies in the ability of random selection to minimize confounding. Unfortunately, only about half of the total of studies reviewed examined the effects of exercise using an experimental design. Dustman et al., (1984) evaluated the neuropsychological performance of 55-70 year old sedentary subjects. The aerobically trained subjects demonstrated significant improvement on the neuropsychologic test battery compared to the controls. Significant improvement was seen on tests measuring response time, visual organization, memory, and mental flexibility. Powell (1974) examined neuropsychological function in institutionalized geriatric mental patients and found significant improvement from an exercise intervention on two of three neuropsychologic tests (intellectual impairment and memory). Stamford, Hambacher, and Fallica (1974) also tested institutionalized mental geriatric mental patients and found a positive training effect on neuropsychological performance from a program of aerobic exercise. Subjects significantly improved on two of four of the tests (a general information test, WAIS) and a questionnaire. In the Functional Age and Physical Activity (FAPA) study by Stones and Kozma (1988), exercise intervention led to a significant improvement in generalized functional capabilities which included a neuropsychological component.

A number of studies did not find an effect of exercise on neuropsychological performance. Panton, Graves, Pollock, Hagberg and Chen (1990) found that 6 months of aerobic training in a group 70-79 years of age did not improve reaction time. An endurance training effect was indicated by an improved VO_2 max of 20.4 percent. Blumenthal and Madden (1988) investigated memory performance in a group of male subjects (mean age 43.32 years) and did not find a significant change in reaction time performance to a memory-search task. The aerobic exercise group had a gain of 15 percent in VO_2 max. Blumenthal et al., (1989) investigated the effects of a 4 month program of aerobic exercise training in subjects with an average age of 67 years and did not find a significant effect on reaction time performance but did observe a 11.6 percent improvement in VO_2 max. Panton et al., (1984) Blumenthal and Madden, (1988), Blumenthal et al., (1989), and Dustman et al.,(1984) were the only studies included in this review which used VO_2 max to indicate the fitness gain in the subjects. Dustman et al., (1984) however, was the only one of these four studies to find a significant improvement on simple reaction time. This suggests that complex reaction time (reaction time involving more than one response) may not be affected by chronic exercise. Improvements on simple reaction time may also be related to fitness level. The subjects in the Dustman et al., (1984) study were less fit at the onset of that study than were the subjects in Panton et al., (1984), Blumenthal and Madden (1988) and Blumenthal et al., (1989) studies.

In general, all the intervention type studies have implemented aerobic exercise for several months and describe the intensity as moderate. Aerobic exercise involves the presence of oxygen in the muscle cells to assist in the metabolism of free fatty acids into sources of energy for muscle contraction. It is also characterized by the ability to maintain a constant level of exercise for an extended period of time. Common aerobic activity includes walking, swimming, running, and bicycling. Dustman et al.,(1984) associated improvement in neuropsychological performance with an increase in oxygen circulating to the brain as a result of aerobic activity. Powell (1974) and Stamford, Hambacher and Fallica (1974) demonstrated that fitness training may be useful as a means of reversing or arresting the cognitive degeneration of aging in psychogeriatric, institutionalized populations. It could be argued that the positive effects observed in these studies may be due to the unique situation of being institutionalized and/or receiving medical treatment. However, Dustman et al., (1984), and Stones and Kozma (1988) found similar positive effects of exercise performance in non-institutionalized elderly subjects.

Although neuropsychological function declines with age (Birren & Schaie, 1990), college age, middle age (fifties) and old age (late seventies) subjects all improved on neuropsychologic tests as a result of exercise conditioning. Comparative studies of both young and old subjects, found that older fit subjects performed better on neuropsychological function tests than older unfit subjects and performed more like the young unfit subjects (Elsayed, Ismail & Young, 1980; Clarkson & Kroll, 1978; Rikli & Busch, 1986; Spirduso, 1975; Spirduso & Clifford, 1978). Aging appears to have a negative effect on neuropsychological performance; however, fitness training appears to slow the deleterious effect of aging on neuropsychological performance (Spirduso et al., 1988). The work of Myers and Hamilton (1986), with elderly nursing home residents suggests that mild intensity exercise may positively effect mental performance as well as independence and physical ability

In summary, some studies have demonstrated a positive relationship of the effects of chronic exercise on neuropsychological performance while other studies did not find a relationship. The studies which did find a positive relationship of chronic exercise on neuropsychological performance in elderly subjects found improvement onmemory, and psychomotor tasks. Four of the studies did not find a relationship of the effects of chronic exercise on complex reaction time, a component of psychomotor performance. Dustman et al., (1984) did find a relationship of chronic exercise on simple reaction time. Age and fitness level were found to be important variables affecting neuropsychological performance. Subjects with a higher fitness level performed better on measures of neuropsychological performance than less fit or unfit subjects. Neuropsychological performance declines with aging but can be improved as a result of aerobic exercise of moderate intensity performed more than once a week for several months. Less fit subjects improved more on tests of neuropsychological performance than the more fit subjects. Older fit subjects performed as well as young unfit college age subjects on neuropsychologic tests. Improvements were seen in both men and women and in psychogeriatric institutionalized and non-institutionalized normal subjects.

Effects of Acute Exercise on Neuropsychological Performance

Relatively little research has evaluated the effects of acute exercise as a source of arousal for neuropsychological functioning (Tomporowski & Ellis, 1986). Arousal refers to a state of responsiveness to sensory stimulus. A number of studies have demonstrated a significant relationship of the effects of acute exercise on neuropsychological performance in college age subjects (Levitt & Gutin, 1971; Lichtman & Poser, 1983; Sjoberg, 1980; and Weingarten & Alexander, 1970). Effects of acute exercise were also tested in college age subjects by McAdam and Wang (1967) and Gutin (1966). A significant difference between exercisers and nonexercisers on performance of neuropsychologic tasks was not observed. McAdam and Wang (1967), however, did find a trend in favour of the exercisers.

Levitt and Gutin (1971) found that neuropsychological performance increased up to an optimal point, as measured by pulse rates, and then to deteriorate with further exertion. Weingarten and Alexander (1970) and Sjoberg (1980) found the more fit subjects to perform better on neuropsychologic tests than subjects of average and less fitness levels as measured by VO_2 max. Gutin (1966) did not find a significant between group relationship of exercise to neuropsychological performance but did find a significant relationship within groups to improvement in fitness and neuropsychological performance. Diesfeldt & Diesfeldt-Groenendijk (1977), and Molloy, Beerschoten, Borrie, Crilly, and Cape (1988) were among the first to report neuropsychological gain after acute exercise in a geriatric sample.

Diesfeldt and Diesfeldt-Groenendijk (1977) tested the acute effects of lightphysical exercise on neuropsychological performance in 40 psychogeriatric patients (34 female and 6 male) with a mean age of 82 years. The exercise group carried out 40 minutes of light exercise, sitting in a chair; this exercise was intended not to fatigue the individuals. The recall score rose significantly from pre-test to post-test as a result of participation in movement therapy. Physiological measures were not recorded therefore it cannot be assumed that the change was associated with an increase in arousal.

Molloy et al., (1988) administered a 9-measure neuropsychologic battery of tests before and after each of 45-minute nonstrenuous exercise and rest conditions to 15 subjects (mean age 66 years). Although the use of a multi-measure battery in a cross-over design confounds effects due to exercise with those of fatigue and practice, the Mini-Mental State Examination, and memory for prose did show significant improvement post-exercise. Both tasks emphasize the retrieval of meaningfully organized information. Also, six of the eight scores on neuropsychologic function showed greater improvement following exercise compared to the control intervention.

In summary, there is relatively little research which has tested the effects of acute exercise on elderly subjects. Diesfeldt and Diesfeldt-Groenendijk (1977) and Molloy et al., (1988) reported a significant improvement in neuropsychological performance from acute effects of exercise in the elderly. Effects of acute exercise are similar to effects of chronic exercise in several ways: positive effects were found in college age groups, institutionalized and non-institutionalized, and normal and psychogeriatric subjects; low to moderate intensity exercise is sufficient to cause apositive effect, and physically fit subjects perform better on neuropsychologic tests than less and unfit subjects. Performance on neuropsychologic tests improve up to a certain exertion level and then begin to decrease with further exertion.

3.0 DEVELOPMENT OF THE PRESENT STUDY

Rationale for the Present Study.

The practical importance of induced arousal from acute exercise should not be minimized. It is especially important for frail, old-old persons for whom an intensity of exercise sufficient to produce a chronic training effect is not recommended because the arousal induced by nonstrenuous exercise may facilitate neuropsychological performance. If the facilitation due to a single "bout" of nonstrenuous exercise is fairly substantial, and the facilitation can be easily repeated and incorporated conveniently into daily routines of care which institutions provide to the elderly, the cumulative benefit may be of practical significance.

The present study specifically attempts to extend the findings of Molloy et al., (1988) by providing additional evidence that aspects of neuropsychologic performance benefit from acute exercise. Their findings were obtained with an active and predominately young-old sample which was exposed to a substantial exercise session (45 minutes) and a lengthy task administration procedure (30 minutes on each of four occasions). The present study extends the age range of the target population to the old-old (i.e., mainly persons in their eighties), but also requires a shorter exercise bout and test administration than used by Molloy et al., (1988). This study is modeled on Molloy's et al., (1988) but is modified for older, and frailer subjects by implementing an exercise session similar to that used by Diesfeldt and Diesfeldt-Groenendijk (1977) and which has been used successfully and safely in nursing homes by the

Canadian Red Cross Society (Myers & Hamilton, 1986). Diesfeldt and Diesfeldt-Groenendijk found a positive effect of acute exercise in an old-old sample of psychogeriatric subjects from light exercise carried out sitting in a chair. Myers and Hamilton (1986) implemented a program of low intensity exercise which was designed for institutionalized frail elderly and have suggested that neuropsychological performance may be facilitated.

Rationale for Data Collection Instruments

Data collection instruments are based on those used by Molloy et al., (1988) and Diesfeldt and Diesfeldt-Groenendijk (1977). The data collection instruments (described further in the methods section) were chosen from the verbal and psychomotor spheres of neuropsychological performance. Word fluency was used to assess verbal functioning because of its correlation with vocabulary and memory scales, and its sensitivity to organic sources (biologic factors) of neuropsychologic decrement (Isaacs & Akhtar, 1972; Schonfield & Stones, 1979).

Two word fluency tests, a modified Set test and the Word Fluency test were selected to test ability to recall with word and initial letter prompts (Bowles & Poon, 1985). Word fluency tests scores correlated well with Standardized Wechsler Memory Scale scores (Schonfield & Stones, 1979). The Word Fluency test used in the present study is also similar to the word fluency test in the Western Aphasia Battery (Kertez, 1982). The two tests differ with respect to age dependency: the Set test, or Word Fluency with semantic (word) prompts, is sensitive to neuropsychologic decrement but deteriorates less with age than the word fluency with initial letter prompts (Isaacs & Akhtar, 1972 and Schonfield & Stones, 1979). The latter was included in the battery so as to assess ability to recall using an initial letter prompt which appears to access a different memory store.

The performance test selected, Symbol Digit coding, is a variant on the Digit Symbol task which is a subsection of the standardized Wechsler Adult Intelligence

Scale. This test has been shown to be sensitive to the effects of chronic exercise andneuropsychological decrement (Dustman et al.,1984; Stones & Kozma, 1989; Wechsler, 1958). The effects of exercise on the Symbol Digit task has been attributed to a facilitation of visual scanning rather than to the psychomotor aspect of performance (Stones & Kozma, 1989).

The three tests were also chosen because of the brevity of test administration, which is an important consideration for obtaining cooperation from elderly subjects who are easily fatigued. Total time to administer the three tests should not take more than 15 minutes thus not tiring the subjects while also testing the effects immediately after the exercise.

Rationale for the Selected Exercise

Exercise programs of low intensity, short duration are safer for the frail elderly and are more likely to be incorporated into daily routines of older nursing home residents. Older, frail residents are also more likely to comply with low intensity exercise that has been tailored to their individuals needs (Myers & Gonda, 1986). Diesfeldt and Diesfeldt-Groenendijk (1977) and Molloy et al., (1988) have found a positive effect on neuropsychological performance from low to moderate intensity, acute exercise in older subjects. Brief exercise and assessment sessions will be used so as to not unduly fatigue the frail elderly subjects in this study.

Purpose of the Present Study

The purpose of the present study is to test the hypothesis that a single bout of low intensity (acute) exercise facilitates aspects of neuropsychological performance in an experimental group of relatively inactive residents (aged 70+) of a nursing home both immediately post exercise and after a 30-minute delay.

4.0 METHODS

Setting and Subjects

The setting for this study was a 150 bed nursing home in the city of St. John's, N.F., Canada, which provides institutional care for elderly clients. Care is provided at three levels depending on the ambulatory, mental and health status of the individual. Well, ambulatory clients that did not test positive for mental confusion were selected for this study. This institution was selected because of its convenience and accessibility and the availability of suitable subjects within it. A sample of 20 male and female residents over the age of 70 years was chosen according to pre-determined selection criteria. One half of the 20 subjects was assigned to the control group and the other half to the experimental group. To promote homogeneity of the sample only those who have resided in the institution for more than six months and lead sedentary lifestyles were selected. A sedentary lifestyle would exclude those who were currently active in a physical fitness program. Human ethics protocol required that consent be obtained from the institution, the individual selected for the study, and the attending physician. Permission was obtained from the Administration of the nursing home and suitable subjects were identified. Potential participants were then approached by the appropriate institution staff person regarding willingness to participate in this research study. The physician's written permission was also obtained for each individual (see Appendix A).

Written consents (see Appendix B) were then obtained from those who were willing to participate in the study. Prior to signing the consent form the researcher explained what would be involved in the study. Reassurance was given that; (1) there were no known risks associated with participating, (2) participation was voluntary and refusal to participate involved no penalty, (3) one could withdraw from this study at any time without penalty and, (4) that any information obtained was confidential. Individuals agreeing to participate were then randomly assigned to a control or experimental condition.

Eligibility for the study required that subjects be alert, and not suffer from neuropsychological impairment as determined by the Saskatchewan Short Mental Status Questionnaire (see Appendix C). Clients scoring greater than 7 on this questionnaire, according to Robertson, Rockwood, and Stolee (1982), were considered free of neuropsychological impairment. The mental status questionnaire (MSQ) is a short verbal test consisting of ten questions which evaluates 1) orientation to time, place and person 2) general information and 3) recent and remote memory. From the total possible score of 10, a score of seven or more is classified as normal whereas a score of 3-6 is associated with moderate dementia and 0-2 with severe dementia.

The MSQ is a modification of several short MSQ's. Robertson et al. (1982) reports that this test is reproducible with a test-retest correlation of 0.89. When validated against a physical clinical assessment the instrument was shown to be well within acceptable limits for use in field surveys.

This MSQ tends to underestimate the prevalence of neuropsychological impairment whereas some other forms of the MSQ tend to overestimate. In

Robertson's et al. (1982) study all subjects scoring under 7 were found clinically to have neuropsychological and memory impairment. Only two false positive (18.2%) were made for the diagnosis of dementia.

Adequate hearing was also necessary for subjects to respond to the interviewer.

Data Collection Instruments

Subjects were pre- and post-tested using the following measures: 1) the Set test which is a word fluency test with semantic or word cuing prompts, 2) the Word Fluency test (WF) with consonant or initial letter cuing prompts and 3) the Symbol Digit (SD) coding.

The three tests were pretested in a pilot study using 10 subjects from another nursing home in St. John's and two changes were needed. When no time limit was set all elderly subjects with a MSQ score above seven achieved high scores on the Set test, a time limit of 60 seconds was therefore imposed. Failing eyesight in elderly individuals made reading the regular size print of the Symbol Digit test difficult so the test was printed in large print to make it easy to read. Instructions for the three tests were easily explained to the subjects and the tests did not take more than 15 minutes in total for administration, thus not tiring the subjects.

1. **The Set Test**

The Set test or Word Fluency Test with semantic categories (see Appendix D) is a simple, rapid test of mental function developed by Isaacs and Akhtar (1972). Subjects are required to recall (identify and retrieve) items from four different categories or sets (i.e., colours, animals, fruit, towns). It is easily administered and yields a simple numerical result.

The original Set test imposes a limit of 10 responses per category for a total possible maximum score of 40 without a time limit. However, in the present case the Set Test was modified by counting all category instances within 60 seconds of each prompt in order to increase sensitivity at the upper level of the response range.

2. **Word Fluency Test**

The Word Fluency test (see Appendix E) is similar to the Western Aphasia Battery test and the Set test. It involves recall but differs from the Set test in that it has letter prompts rather than words. It is brief and simple to administer and the subject is challenged to generate as many words as possible beginning with a particular letter within a time limit of 60 seconds. Three letters were used for each test run; the first letter being easier than the second and the second easier than the third. The letters B, I, and Q were used for the pretest; A, O, and J for post-test 1; and W, N, and V for post-test 2.

3. Symbol Digit Test

The Symbol Digit(SD) test (see Appendix F) is similar to the digit symbol subtest of the Wechsler Adult Intelligence Scale (Wechsler, 1958) with the exception that the target items are symbols and the response items are digits rather than vice versa. This test is a performance test with the individual writing appropriate digits to match the given symbols. A key is supplied for the subject and a time limit of 90 seconds is given to complete the test.

Procedure

Subjects for both groups, had finished eating the mid-day meal approximately one to one and one half hour prior to participation in this study. Pre study activity ranged from resting, reading, crocheting, writing, or chatting with a room mate or visitor. Immediately prior to testing each subject's pre study activity, medication use, history of smoking, marital status, active medical diagnosis, mental status, blood pressure and pulse were recorded. Tests were administered on an individual basis in a familiar, quiet location, with no distractions. The test battery was presented to each subject three times in all; pre-exercise (time 1), immediate post-exercise (time 2), and 30 minutes after exercise (time 3). Figure 1 presents a flow diagram of the present study. The sequence of tests remained constant, starting with the modified Set test, followed by Word Fluency with an initial letter prompt, and ending with the Symbol Digit task. Actual testing time for each individual took approximately 10 minutes. However, the complete interview session lasted approximately one hour per individual.

Identification of
possible participants

Determine eligible subjects
according to selection criteria

Select 20 subjects

Obtain informed consent of client
and the physician's consent

**Random assignment
of 10 subjects per group**

Experimental Group

Obtain demographic
and medical data.
Administer the mental
status questionnaire

10 Subjects
Pretest with
Set, WF & SD
tests, B/P, P

15 minute Exercise Session

Immediate post-test
using Set, WF & SD
tests, B/P, P

30-minute delay
post-test using the
Set, WF, & SD tests

Control Group

Obtain demographic
and medical data.
Administer the mental
status questionnaire

10 Subjects
Pretest with
Set, WF, & SD
tests, B/P, P

15 minute Video

Immediate post-test
uSngWF,& SD
tests, B/P, P

30-minute delay
post-test using the
Set, WF, & SD tests

Figure 1. Flow Diagram of the Study.

The exercise protocol was similar to that of the Canadian Red Cross Seniors Fun and Fitness Program (Myers & Hamilton, 1986) but was implemented on an individual basis without music. The exercise session was sandwiched between a warm-up period (neck stretching and deep breathing) and a cool-down period (resting while seated), each lasting approximately two minutes. Individuals remained seated for the stretching, flexing, and low intensity aerobic type exercises which involved slow rhythmic movements and was followed by a short walk. The exercise session lasted approximately 15 minutes. Consideration was given to the fact that subjects were not active exercisers and were over 70 years of age. Subjects were closely observed for any signs of exertion and a rigorous program of exercise was avoided. The exercise was not rigorous enough to maintain a raised heart rate and was not intended to improve cardiovascular fitness. Subjects in the control group watched a 15 minute video of similar exercises. Both groups of subjects remained seated from post-test 2 to the 30 minute delayed test and engaged in passive activity (e.g., crocheting, reading, or discussion unrelated to the experimentation).

Immediately after the control or exercise session (time 1), blood pressure and pulse were recorded along with a repeated administration of the three neuropsychological tests (time 2). Approximately 30 minutes later (time 3) the three neuropsychological tests were repeated again. The control and experimental treatments and interviews were all conducted by the investigator. Tests were scored after all the data were collected.

Statistical Analysis

Analysis was by a 2 (group) by 3 (times) ANOVA. The null hypothesis tested and discussed in the next section was that there would be no difference on task performance as a result of being assigned to the experimental or control group.

5.0 RESULTS

Of the 20 subjects, 16 were female and 4 were male. All were caucasian. Nine females and 2 males were widowed. Five females were single and 1 divorced. One male was divorced. One male and female were married to each other. The mean age of the total sample was 85 years (range 76-93 years). The average length of time living in the institution was 38 months. The subjects had an average of 9 years of formal education, ranging from 3-15 years. The values described here are not atypical for persons in this age cohort. Average values with standard deviations for each group are given in Table 1.

Immediately prior to and after the exercise or control intervention, the blood pressure (B/P) was measured to determine if there were any adverse effects from the exercise intervention. T test results revealed that the two groups were similar on these measures, and the means with standard deviations are given in Table 2.

The physiologic effect of the exercise was assessed by pulse rate immediately before and after the intervention. No significant differences were obtained between the groups at pre-intervention ($t[18]=1.4, p<.05$). The mean increase by the exercise group was from 69.2 to 71.2 beats per minute (see Table 2) by post-intervention

Table 1. Characteristics of Study Population
(Standard deviations in parenthesis)

VARIABLES	CONTROL GROUP MEANS	EXPERIMENTAL GROUP MEANS
Sex	1 male, 9 females	3 males, 7 females
Time living in institution (months)	37.5 (36.3)	38.2 (34.4)
Education (years)	9.11 (4.41)	9.67 (3.07)
Age (years)	85.1 (6.09)	83.9 (4.8)

Table 2. Blood Pressure and Pulse at Time 1 and Time 2
(Standard deviations in parenthesis)

VARIABLES		CONTROL GROUP MEANS	EXPERIMENTAL GROUP MEANS
Pre-test blood pressure	- systolic	137 (9.6)	140 (20.3)
	- diastolic	74 (8.7)	75 (6.9)
Post-test blood pressure	- systolic	136 (10.6)	145 (15.7)
	- diastolic	72 (6.9)	73 (8.2)
Pre-test pulse		74 (5.9)	69 (8.7)
Post-test pulse		75 (5.7)	71 (9.4)

($t[9]=2.74$, $p<.05$), with no significant difference between corresponding means for the control group (means of 74.1 and 74.7 beats, respectively; $t[9]=1.33, p<.05$). The increase by the exercise group evidences the physiological arousal induced by the intervention.

Analysis of the results of the neuropsychologic battery revealed no significant between-group difference on any measure at pre-test (see table 3). ANOVA was a 2 (group) by 3 (time) design, with repeated measures on the second factor. Multivariate statistics indicated a significant effect of time ($p<.001$) and a significant interaction ($p<.05$), but no groups effect. ANOVAs showed a significant effect of time of measurement on all three tasks: modified Set test ($F[2,36]=10.72, p<.001$), Word Fluency with an initial letter prompt ($F[2,36]=11.21$, $p<.001$) and Symbol Digit ($F[2,36]=10.91, p<.001$). Tables 4 and 5 give the summaries the ANOVAs for the Word Fluency and Symbol Digit tests. On the two latter tasks, the pretest was lower than both post-measures ($p<.05$ by Tukey's Honestly Significant Difference test). Figures 2 and 3 show graph comparisons of the control and experimental groups for each test and Table 3 contains the means and Standard deviations.

The groups by time interaction (Table 6) was significant only for the modified Set test ($F[2,36]=5.57$, $p<.01$). Multiple comparisons with the Set test data indicate no significant differences across times of measurement within the control group, but significant differences between the pre-test and both post-tests in the exercise group ($p<.01$) (see Figure 4). The means and standard deviations are shown in Table 3.

Table 3. Means of the Neuropsychologic Tests at Three Times of Measurement (Standard Deviations in Parenthesis).

Test	Group	Time 1	Time 2	Time 3
Set	Control	43.8 (12.6)	45.8 (12.2)	43.5 (10.8)
	Exercise	40.1 (13.1)	49.4 (16.4)	46.6 (15.3)
Word Fluency	Control	14.5 (7)	19.6 (7)	21.3 (10)
	Exercise	14.9 (7.5)	19.5 (10.5)	20 (10)
Symbol Digit	Control	15.7 (8)	20.3 (8)	19.9 (9)
	Exercise	23.2 (10)	25.7 (11)	27.8 (12)

Table 4. Summary of the Analysis of Variance for the Word Fluency Test

Source	Degrees of Freedom	MS	P(F)
Between Groups	1	2.15	NS
Residual Error (a)	18	215.15	
Within Subject over Time	2	197.15	<.001
Within Subject and Group over Time)	2	4.25	NS
Residual Error (b)	36	17.62	

NS = Not Significant

Table 5. Summary of the Analysis of Variance for the Symbol Digit Test

Source	Degrees of Freedom	MS	P(F)
Between Groups	1	721.07	NS
Residual Error (a)	18	286.06	
Within Subject over Time	2	108.95	<.001
Within Subject and Group over Time	2	9.02	NS
Residual Error (b)	36	9.98	

NS = Not Significant

Table 6. Summary of the Analysis of Variance for the Set Test

Source	Degrees of Freedom	MS	P(F)
Between Groups	1	15	NS
Residual Error (a)	18	519.55	
Within Subject over Time	2	160.12	<.001
Within Subject and Group over Time	2	83.15	<.05
Residual Error (b)	36	14.93	

NS = Not Significant

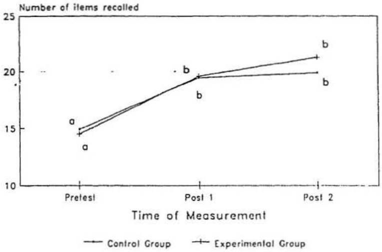

Figure 2. Word Fluency Test: Two Groups at Three Times of Measurement. Averages within a group with dissimilar letters in the superscript differ significantly ($\underline{P} < .05$).

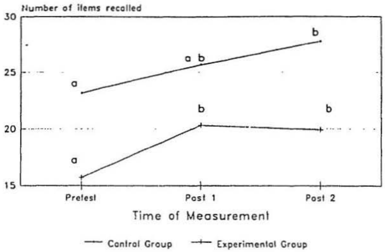

Figure 3. Symbol Digit Test: Two Groups at Three Times of Measurement. Averages within a group with dissimilar letters in the superscript differ significantly ($\underline{P} < .05$).

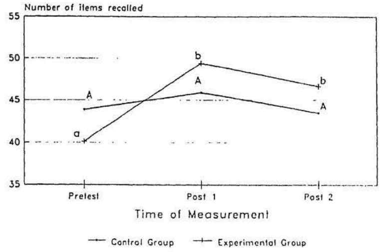

Figure 4. Modified Set Test: Two Groups at Three Times of Measurement. Averages within a group with dissimilar letters in the superscript differ significantly ($\underline{P} < .05$).

6.0 DISCUSSION

There were no significant differences in the socio-demographic variables between the exercise and control groups. This supports the notion that the effects obtained are not a result of differences in the two groups.

An increase in pulse rate by the exercise group from pre-test to post-test indicates a physiological effect from the exercise session. The increase of only two beats per minute indicates that the exercise was of low intensity. Low intensity exercise has significant implications when considering exercise programs for frail elderly. Low intensity exercise would not unduly fatigue frail, sedentary subjects over the age of 70 years and may be more appealing to them. Myers and Gonda (1986) found a lower attrition rate of elderly individuals who participated in low intensity, individualized programs. Diesfeldt and Diesfeldt-Groenendijk (1977) also used low intensity exercise for subjects while sitting in a chair and found exercise to positively affect neuropsychological performance.

The two groups were also homogenous on pre-test measures of the neuropsychologic test battery. The more similar the groups the more probable that effects obtained are a result of the intervention. Post-exercise analysis revealed that the groups by time interaction was significant only for the modified Set test. The Word Fluency with initial letter prompts and the Symbol Digit were lower at both post-measures than the pre-test measures suggesting that a practice effect was present for these tests. A practice effect was not apparent for the Set test within the control group.

Multiple comparisons with the modified Set test data indicate no significant difference across times of measurement within the control group, but significant differences between the pre-test and both post-tests in the exercise group. The findings indicate that nonstrenuous exercise facilitated meaningfully cued recall that persisted at least a full half-hour (see Figure 4). The increase over the pre-test level in the number of items retrieved by the exercise group was approximately 20% (i.e., 23% and 16% at immediate and delayed post-test, respectively). It is likely that this gain was due to the exercise intervention, considering that there was an absence of practice effects in the control group.

An increase in heart rate of two beats per minute suggests there was an effect of acute exercise on physiologic arousal, because a corresponding increase was not observed in the control group. Tomporowski and Ellis (1986) have suggested that positive effects of acute exercise on neuropsychological performance are a result of induced physiological arousal. While an effect due to the interaction between the exercise instructor and the participant can not be totally ruled out as a factor contributing to the arousal the findings are consistent with the hypothesis that acute exercise induces a physiological arousal, that contributes to the facilitation in Set test performance.

The reasons for an effect to be seen on the modified Set test and not with the Symbol Digit and the structurally prompted Word Fluency tests are unclear. One reason may be that the tests measure different psychologic functions and that the area aroused by exercise may be the area which the Set test measured. It could also be possible that the exercise session of this study was not of sufficient duration or intensity to cause an arousal on these latter two tasks. Another possibility to consider is the fact that these tasks followed the modified Set test in each administration. If the induced arousal dissipates rapidly after the cessation of exercise, any facilitation could be higher on the task presented first. Results from Molloy et al., (1988), however, indicate that the order of the tasks may be less important than the nature of the tasks. In their study, the order effect was found to be insignificant ie. there was no significant difference in the baseline scores between the first and second administration of any tests or whether the exercise or control group performed first. Evidence from the present study also suggests that the gain on the modified Set test lasted to the delayed post-test. This suggestion may be questioned on the ground that the probability of subsequent retrieval of an item increases after its prior retrieval (Schacter, 1987). Another possible explanation concerns the differential sensitivity of the tasks to intervention and practice. Strong practice effects may either inhibit or increase variability in the response to other forms of facilitation (McGeogh & Irion, 1952). The control group data showed the Set test not to be sensitive to practice. In contrast, both the other tasks showed a gain across times of measurement, suggesting the presence of practice effects that may diminish the sensitivity to intervention effects.

7.0 IMPLICATIONS

The gain in aspects of neuropsychological performance, from acute exercise, in the old-old age group is very encouraging from a practical perspective because exercise is a relatively low cost and non-obtrusive intervention. The positive effects of low intensity exercise could prove very beneficial for the promotion of independence and self-esteem of institutionalized elderly. The small sample size used in this study raises a number of residual questions; unfortunately a larger group was not available in the setting selected for this study.

The Canadian Red Cross Society, Seniors Fun and Fitness Program permits brief doses of nonstrenuous low intensity exercise which may be repeated easily throughout the day. The effects of frequent brief doses of exercise should also be compared to the effects of longer but less frequent doses. Myers and Hamilton (1986) have suggested that longer less frequent sessions of exercise facilitate memory in geriatric populations. These results are also of special significance because they have been tested in a group of old-old (ages 70+) normal institutionalized elderly which does not appear to have been sampled in previous literature.

The Canadian Fitness Survey, Government of Canada (1982) found that participation in exercise decreased particularly after the age of 65 and being institutionalized may discourage further participation in exercise which places the older individual at greater risk than normal. Booth (1986) and Spasoff et al., (1978) found institutionalized individuals inactive, passive and difficult to motivate. In addition to this institutional staff tend to see exercise as recreational rather than therapeutic and therefore outside of their concern (Myers & Gonda, 1986). A program of exercise which would involve little time and effort could be more easily reproduced, cost effective, and more appealing for institutionalized elderly.

The results of this study may have more specific implications for the everyday functioning of the elderly. The nonstrenuous exercise offered in this study and also by the Canadian Red Cross Fun and Fitness Program could easily be repeated and incorporated into the daily routine of institutionalized, frail seniors. Even though these exercises were geared towards independent ambulatory residents they can also be used for more physically dependent residents who may be bed ridden. Exercise of this type could easily be directed or carried out by nurses, nursing aides or recreational personnel in the routine daily care of clients (ie. range-of-motion exercises carried out in conjunction with the daily bath and walking of clients). The findings are important for the frail elderly for whom intense exercise or exercise of longer duration would not be appealing or recommended. The arousal induced by nonstrenuous exercise may facilitate neuropsychological performance up to 30 minutes or more. If there is marked improvement due to a single "bout" of nonstrenuous exercise, and the exercise can be repeated with regularity, the cumulative benefit may be of practical use in the daily care of institutionalized, sedentary elderly and also in long term benefits of promoting independence. Careful consideration however, must be given to tailor the exercise to fit individual needs as there is such a diversified range of limits and needs within this age group.

Exercise which is easily incorporated into daily routines and which is appealing to frail elderly may make the implementation of such programs more workable. Further studies in this area are needed to compare brief doses of exercise to longer but less frequent doses which may prove to be a cost-effective way to facilitate everyday memory in sedentary nursing home residents.

In conclusion, the results of this study are exploratory, due to the small sample size. They do however, confirm the inference from Molloy et al.(1988) that acute exercise benefits aspects of neuropsychological performance. The results have special significance for the older frail institutionalized elderly.

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APPENDIX A

PHYSICIAN'S CONSENT FORM

I am a graduate student in the Faculty of Community Medicine at Memorial University of Newfoundland and am studying acute effects of exercise on neuropsychological performance in a population of institutionalized elderly.

The exercise to be used for this study will include range of motion, stretching, and walking, similar to what is used in the Canadian Red Cross Society Fun and Fitness Program for Seniors. The Red Cross Program is designed for inactive, elderly people and can be completed in a standing position or sitting in a chair.

Your client has already been contacted and is willing to participate, and has given consent for me to contact you. Rules of confidentiality will be observed rigorously and data released in statistical form only.

Protocol requires that I have the client's physician's approval indicating that this exercise session should not pose any problems to his/her health or treatments. If, in your assessment (name) will not be adversely affected by this program of exercise, please sign the statement below

I will collect the signed consent forms from Mrs.______ , the Director of Nursing.

If you wish further information on this study please contact me at 722-8496 (home) of through the Community Medicine Department at 737-6693.

Thank-you for your cooperation.

Yours truly,

Doreen Dawe, R.N., B.N.

I, _____________ give permission for _______________ to take part in this study.

APPENDIX B

CONSENT TO PARTICIPATE IN RESEARCH

INVESTIGATOR: Doreen Dawe, R.N., B.N.

You are being asked to participate in a research project. Participation in this project is entirely voluntary. You may decide not to participate or may withdraw from the project at any time.

Confidentiality of information concerning participants will be maintained by the investigator. The investigator will be present at all times, during the session, should you have any problems or questions.

Information section.

1. Purpose of the study:

The purpose of this study is to determine if exercise or watching T.V. can make you more alert. You will either participate in a 20 minute light exercise session or view a 20 minute program on exercise. An interview will be given before the exercise or the viewing of the program, immediately after the exercise or viewing is completed, and again 30 minutes later.

2. Description of procedures and tests:

Exercise

The exercise session will follow the exercises used in the well established Canadian Red Cross Society Fun and Fitness Program for seniors.

Warm-up; breathing exercises
head and neck stretches
Exercises for the shoulders and arms hands
Exercises for the trunk and back
Exercises for the waist and abdomen
Exercises for the hips legs
Walking
Cool down

Total time involved for exercise will be approximately 15 minutes.

APPENDIX B (continued)

Film on Exercise

The program of exercise is a 15 minute video demonstrating proper movements which seniors can do to keep fit.

Interviews

Three brief, simple interviews will be given during this study. The interviews will consist of three sets of questions. Each interview should take less than 15 minutes to complete.

3. Duration of subjects participation:

Total time should be approximately one hour and 15 minutes.

15 minutes for the first interview
15-20 minutes of exercise or watching the film
15 minutes for the second interview
15 minutes for the third interview

4. Possible risk, discomfort or inconvenience:

No risks or discomforts are anticipated.

The major requirement will be the time involved to complete the study.

To guard your well being, your Doctor's consent will be required before you take part.

5. Benefits which the subject may receive:

You may receive no benefit from taking part except the enjoyment of participating.

Appendix B (continued)

I, ____________________, the undersigned, agree to participate in the study of the effects of exercise.

I have had an opportunity to ask questions and my questions have been answered and I understand what is involved in the study. I realize that participation is voluntary and that I may withdraw from the study at any time.

I give ____________________ permission to contact my physician, Dr. ________________ for clearance to participate in this study.

____
(signature of participant) (Date) ______________

To be signed by the investigator:

To the best of my ability I have fully explained to the subject the nature of the study. I have invited questions and provided answers. I believe that the subject fully understands the implications and voluntary nature of the study.

____
(signature of the investigator) (date) ______________

Phone Number________________

APPENDIX C

SASKATCHEWAN SHORT MENTAL STATUS QUESTIONNAIRE

Score

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 them in a few minutes......bed, chair, window.
10. Count backwards from 20 to 1
11. Repeat the three items I asked You to remember.

Scoring: Each item correct = 1
Any uncorrected error = 0
Total possible points = 10

APPENDIX D

THE SET TEST

	SCORE
1. "I want you to tell me all the colours you can think of.	____
2. "I want you to tell me all the animals you can think of."	____
3. "I want you to tell me all the fruit you you can think of."	____
4. "I want you to tell me all the names of towns in N.F. you can think of."	____

SCORE: Maximum - 40
Each Set - 10

NOTE: Questions are repeated as often as necessary but no help is offered. The end point is reached when the subject can't list any more or begins to repeat himself. Subject will often say "I can't think of any more".

APPENDIX E

WORD FLUENCY TEST.

I will say a letter of the alphabet, then I want you to give me as many words that begin with that letter as you can. For example, if I say "T", you might say "toy", tight, train". The first letter is B. Please say as many words as you can that begin with the letter B.

[PATIENTS ARE GIVEN 60 SECONDS TO PRODUCE ASSOCIATIONS TO EACH LETTER. IF NO RESPONSE IS GIVEN AFTER 15 SECONDS SAY "Can you say any word that starts with a B?"

RECORD ALL RESPONSES. INDICATE WITH A CHECK MARK IF THE RESPONSE IS CORRECT AND AN X IF IT IS INCORRECT.]

Thank-you. The next letter is I. Please say as many words as you can that begin with I.

Thank-you. The next letter is Q. Please say as many words as you can that begin with Q.

Pretest letters: B I Q
Post-test 1 letters: A O J
Post-test 2 letters: W N V

Sample of the form used:

<u>RESPONSES</u>

B	I	Q
________	________	________
________	________	________
________	________	________

TOTAL CORRECT:

TOTAL INCORRECT:

APPENDIX F

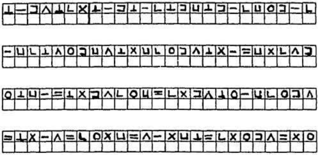
SYMBOL DIGIT TEST

Look at these squares. In the top half there is a symbol matched with a number, in the square directly below it.

										score
Symbol	—	⊥	⊐	L	⊔	O	∧	X	=	
	1	2	3	4	5	6	7	8	9	

Look at the squares below and you will see the top squares have the symbol and the bottom squares are empty. We will practice with the first seven squares and then you can complete the rest. You have ninety seconds to fill in as many as you can.

Samples



Note: An enlarged version of this test was used in this study.

APPENDIX G

INDIVIDUAL SCORES OBTAINED ON THE NEUROPSYCHOLOGICAL TESTS

CONTROL GROUP

	MODIFIED SET TEST			WORD FLUENCY WITH CONSONANT CUES			SYMBOL DIGIT CODING		
SUBJECT	PRE TEST	POST TEST 1	Post TEST 2	PRE TEST	POST TEST 1	POST TEST 2	PRE TEST	POST TEST 1	POST TEST 2
1	52.00	49.00	44.00	12.00	19.00	8.00	29.00	34.00	41.00
2	25.00	27.00	27.00	18.00	14.00	23.00	39.00	43.00	43.00
3	46.00	44.00	46.00	12.00	30.00	31.00	24.00	29.00	32.00
4	39.00	41.00	37.00	9.00	14.00	17.00	22.00	26.00	27.00
5	40.00	37.00	36.00	16.00	27.00	27.00	26.00	21.00	29.00
6	63.00	54.00	55.00	13.00	17.00	10.00	7.00	12.00	12.00
7	30.00	36.00	33.00	6.00	11.00	5.00	21.00	21.00	21.00
8	61.00	72.00	63.00	33.00	32.00	36.00	25.00	24.00	27.00
9	48.00	49.00	50.00	15.00	19.55	20.00	25.00	26.00	27.00
10	34.00	49.00	44.00	15.00	11.00	22.00	14.00	21.00	19.00
MEAN	43.88	45.80	43.50	14.90	19.46	19.90	23.20	25.70	27.80

EXPERIMENTAL GROUP

	MODIFIED SET TEST			WORD FLUENCY WITH CONSONANT CUES			SYMBOL DIGIT CODING		
SUBJECT	PRE TEST	POST TEST 1	POST TEST 2	PRE TEST	POST TEST 1	POST TEST 2	PRE TEST	POST TEST 1	POST TEST 2
1	52.00	73.00	70.00	18.00	30.00	31.00	7.00	20.00	21.00
2	21.00	27.00	24.00	6.00	1.00	10.00	7.00	19.00	15.00
3	25.00	32.00	32.00	7.00	7.00	10.00	13.00	13.00	14.00
4	61.00	63.00	62.00	22.00	31.00	32.00	24.00	26.00	20.00
5	46.00	63.00	58.00	16.00	18.00	16.00	22.00	29.00	29.00
6	55.00	69.00	60.00	20.00	24.00	22.00	10.00	10.00	12.00
7	35.00	40.00	37.00	17.00	27.00	31.00	6.00	10.00	10.00
8	33.00	36.00	33.00	1.00	6.00	6.00	8.00	8.00	6.00
9	40.00	46.00	43.00	26.00	27.00	32.00	25.00	24.00	22.00
10	33.00	45.00	47.00	12.00	25.00	23.00	35.00	44.00	50.00
MEAN	40.10	49.40	46.60	14.50	19.60	21.30	15.70	20.30	19.90