Analogical Reasoning of Elderly Adults Using Three Modalities: Words, Pictures, and Figures

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ANALOGICAL REASONING OF ELDERLY ADULTS USING THREE MODALITIES: WORDS, PICTURES, AND FIGURES

by

Judy L. Rau

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
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and Audiology

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This study examined the analogical processing skills of elderly adults. Forty-seven subjects (ages 65-90) completed analogy tasks presented in three modalities: words, pictures, and geometric figures (90 total). The subjects for this study were elderly adults living independently in a federally subsidized apartment building. The subjects used in this study possessed characteristics similar to the "typical" American adult. Results indicated that performance does not vary significantly with age in the word and picture modalities. Significant ($p < .05$) negative relationships were found between performance on the geometric figure analogies and increased age and between overall performance and increased age. Significant ($p < .05$) positive relationships were found between education and performance on each of the three modalities as well as between education and overall performance.
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Judy L. Rau
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Analogical reasoning of elderly adults using three modalities: Words, pictures, and figures

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Western Michigan University, 1990
TABLE OF CONTENTS

ACKNOWLEDGEMENTS .....................................................  ii

LIST OF TABLES ............................................................... vii

CHAPTER

I. INTRODUCTION .................................................................  1

   Aging and Intelligence ......................................................  1

   The Changing Definition of Aging ......................................  1

   The Changing Conception of the Nature of Intelligence .......  2

   Sampling Techniques and Aging Research Methods ..........  4

   Types of Tests Used to Measure Intelligence ....................  4

   Analogical Reasoning .....................................................  5

   Intelligence and Analogical Reasoning .............................  5

   Analogical Reasoning and Problem Solving in Aging ..........  6

   Purpose of the Study .....................................................  7

II. REVIEW OF THE LITERATURE ............................................  9

   Cognitive Functioning in Adult Life ...............................  9

   Early Concepts of Aging and Cognition ............................  9

   Present Concepts of Aging and Cognition .......................... 10

   Research in Cognitive Aging .......................................... 13
Table of Contents--Continued

CHAPTER

Issues Concerning Tests Used in Cognitive Aging ............... 13

Differences Between Young and Old Subjects’
Behavior in Cognitive Research ............................................. 14

Subjects Used in Aging Research ................................................. 15

Longitudinal Design ................................................................. 15

Cross Sectional Design ............................................................. 16

Longitudinal Sequential Strategies .......................................... 18

Education and Health Variables ............................................. 19

Reversal of Age Related Declines ........................................ 20

Analogical Reasoning and Cognition ........................................ 23

Types of Analogies ................................................................. 24

Verbal Analogies ................................................................. 24

Pictorial Analogies ............................................................... 25

Figural Analogies ................................................................. 25

Components of Analogical Reasoning ....................................... 26

Statement of Rationale for the Present Study ........................... 28

III. METHODOLOGY ................................................................. 30

Subjects ................................................................. 30

Stimuli ................................................................. 31
# Table of Contents--Continued

## CHAPTER

Procedures ................................................................. 35

### IV. RESULTS ............................................................... 37

Age Group Performance Analysis ................................. 37
  Differences in Modality Performance Within Age Groups ................................................. 38
  Modality Effects and Overall Performance Across Age Groups ........................................ 40

Analysis of Individual Data ............................................ 42
  Age and Performance .................................................. 42
  Educational Level and Performance .................................. 43

Summary ........................................................................... 44

Analysis of Age Group Data ........................................... 45

Analysis of Individual Data .............................................. 45

## V. DISCUSSION .............................................................. 46

Issues Concerning Modalities ......................................... 46

Order of Presentation .................................................... 46

Modalities and Measurement of Cognitive Functions .......... 47

Analysis of Age Group Data and Analysis of Individual Performance Data ..................... 52

Educational Level and Performance ............................... 53
LIST OF TABLES

1. Mean Scores and Standard Deviations of Five Age Groups ............... 39
2. Mean Scores and Standard Deviations of Two Age Groups ............... 40
3. Pearson r Values of Regression Analysis ........................................... 43
CHAPTER I

INTRODUCTION

Aging and Intelligence

One of the most frequently studied issues in research on human aging is intelligence (Botwinick, 1977). The available research on intelligence and aging argues against a general decline in intelligence with normal aging. Current research has indicated that declines start later in life, are less dramatic, and affect fewer aspects of cognitive functioning than previously thought (Botwinick, 1977; Labouvie-Vief, 1985). Although it is generally agreed by researchers that there is some decline in intellectual ability with age, a controversy exists over the concept of decline in intelligence with aging. This controversy centers around several associated issues, including: (a) the definition of aging, (b) the nature of intelligence itself, (c) sampling techniques and aging research methods, and (d) the types of tests used to measure intelligence (Botwinick, 1977).

The Changing Definition of Aging

The concept of aging has been redefined within the 20th century as the age structure of our society has shifted upward. Both the number of people in the over-65-year age group and the quality of later adult life have affected the
The Changing Conception of the Nature of Intelligence

Spearman (1927) characterized intelligence as a relatively unitary phenomenon when he described his g factor as an index of general ability. Recently, Gardner (1983) distinguished seven kinds of intelligence. These were (1) musical, (2) bodily, (3) kinesthetic, (4) logical-mathematical, (5) linguistic, (6) spatial, and (7) interpersonal and intra-personal. These "intelligences" were viewed as being relatively autonomous and of equal stature. Each individual was seen as possessing some degree of each of the seven intelligences. Gardner viewed individual profiles of intelligence as determined by innate endowment as well as by history of training. Another view of intelligence as consisting of multiple components is that of Horn and Cattell (1966), who proposed a theory of two types of intelligence, fluid and crystallized. Fluid intelligence (Gf) skills (of which analogical reasoning is one) represent a basic capacity, similar to Spearman's (1927) "g" factor or traditional general factor of intelligence. Crystallized intelligence (Gc) represents abilities that are acquired through the
effects of learning, practice, and education on basic capacity.

Research on aging has suggested that different abilities change in different ways with age. Multidirectional changes have now been identified as characterizing a classical pattern of intellectual aging (Cornelius, 1984). These changes include decrement and evolution as well as stability. For example, verbal (or linguistic) intelligence has been hypothesized as one skill that is not affected by age-related decline and is preserved with age (Eysenck, 1975; Jarvik & Falek, 1963; Lovelace & Cooley, 1982). Sward (1945) found that word knowledge or general vocabulary was superior in his older subjects. The concept of multi-directional change in intellectual abilities with age suggests the need to determine further which abilities are affected, and which are not.

Concepts such as the multifactorial nature of intelligence (Guilford, 1967) have been useful in explaining multidirectional changes in intelligence components with age (Cornelius, 1984). For example, the ideas of Horn and Cattell (1966) have been useful for this purpose. Although these two types of intelligence are interrelated (Gc is said to develop initially as a function of Gf), they are said to follow different paths of growth and decline. Fluid intelligence declines at an increasing rate with advanced age, due to its relation with neurophysiological status of the individual. Crystallized abilities show increasing growth, with a slight decline prior to death (Hayslip & Sterns, 1979).
Sampling Techniques and Aging Research Methods

Sampling techniques used in research on aging have been discussed by most authors reviewing the literature (Labouvie-Vief, 1985). Findings from studies using cross sectional and longitudinal methods require careful interpretation by readers of the literature, in terms of the limitations inherent in both methods.

Bayles and Kaszniak (1987) challenged researchers to conduct cross sectional studies of abilities exhibited by normal aging individuals wherein the methodology accounts for cohort variables. Examples of cohort variable controls include matching for education and health of subjects within a cross sectional design.

Types of Tests Used to Measure Intelligence

The types of instruments employed in research on cognitive aging reflect the researcher's conception of intelligence. Too often, the tests utilized have been those designed for younger populations, such as students. The frequent use of these ubiquitous tests reflects the history of cognitive research, which has typically centered on developmental stages in children and young adults. Analogy problems have been utilized in different ways by researchers to investigate changes in intellectual functioning with age. In some cases, analogy problems have been components of the tests designed for younger populations; however,
researchers investigating cognitive aging have also developed tests involving analogies specifically for their research purposes. Hayslip and Sterns (1979), for example, used common word analogies as one of several tests measuring fluid intelligence and abstruse word analogies as one of several measures of crystallized intelligence in their investigation of the relationship between age and crystallized and fluid intelligences.

**Analogical Reasoning**

**Intelligence and Analogical Reasoning**

Many theorists have used analogies as an index of intelligence. For example, Spearman (1927) stated that skills measured by analogical reasoning tests show correlations with all operations known to be involved in his "g" factor of general intelligence. Sternberg (1977b) also noted the close association recognized within psychological theory between analogical reasoning ability and intelligence. Psychometric tests (i.e., intelligence tests) and academic potential tests (e.g., college entrance exams) include analogy items. Oppenheimer (1956) noted that analogical reasoning is an indispensable tool in scientific progress and is intrinsically linked to human thought.

People use analogical reasoning every day, whenever a new decision is made based on previous experience or knowledge, and a parallel is being drawn between old and new (Sternberg 1977b). For example, when people decide to go...
to a movie made by a particular director because they enjoyed his last film, or when one turns left in the lines at Walt Disney World, Orlando, Florida, because that strategy has worked in the past to shorten the wait, they are reasoning analogically. Goodnow (1986) described practical or everyday intelligence as the process that occurs when people use their past knowledge to solve current real-life problems.

It is interesting to note that experiential knowledge is inherent in analogical reasoning. If learned experiences were the only factor involved, then age would only bring a wider base of knowledge on which to draw when making decisions. However, more factors are involved in analogical reasoning than past experiences, such as the ability to learn and to remember new information. Older adults often have excellent long term memory skills but experience difficulty with short term memory skills (Labouvie-Vief, 1985). Research has shown that the ability to solve novel problems involving learning and remembering of new information and rapid performance (as measured by some analogy tests) can be expected to decrease with aging (Bayles & Kaszniak, 1987).

**Analogical Reasoning and Problem Solving in Aging**

Neurophysiological changes associated with age, such as sensory and physical decrements, necessitate adaptations by elderly individuals in relation to their environment. These adaptations involve problem solving and decision making, which have been defined as cognitive links between the individual and the
environment by Reese and Rodeheaver (1985). Older adults utilize analogical reasoning to adapt to their changing relationship with the environment. Effectiveness in dealing with the problems and opportunities of one's environment is defined by North and Ulatowska (1981) as the essence of competence in independently living older adults. The analogical reasoning inherent in problem solving in everyday life is related to successful adaptation to changes with age.

Problem solving ability has been a favorite target of training programs designed to facilitate higher mental functioning in elderly adults. Kausler (1988) calls for research to develop improved means of training that will transfer to everyday problem solving.

Purpose of the Study

This study was designed to investigate the performance of a group of elderly adults on analogy tasks in three modalities: (1) words, (2) pictures, and (3) geometric figures. The subjects used in this study demonstrated characteristics similar to those of a "typical" elderly adult, as described by Bayles and Kaszniak (1987). It was expected that the results of this study would provide information concerning the relationship between the modalities in which the analogies were presented and the performances of the elderly adults. In accordance with the description of intelligence as a multiple component entity, it was hypothesized that the performances would differ across the modalities. It was further hypothesized that the results would confirm the findings of previous investigations (e.g., Hayslip
\& Sterns, 1979) that analogical reasoning skills do decline with age and are influenced by educational levels.

The following experimental questions were of interest:

1. Does the modality in which analogies are presented affect the performance of elderly adults on analogy tasks?

2. Does a negative relationship exist between increased age and performance on analogy tasks? If so, is the negative relationship evident in each of the three modalities tested?

3. Does a positive relationship exist between level of education of elderly adults and their performance on analogy tasks? If so, is the positive relationship evident in each of the three modalities tested?
CHAPTER II

REVIEW OF THE LITERATURE

Cognitive Functioning in Adult Life

**Early Concepts of Aging and Cognition**

Early theories regarding intellectual functioning over the adult life span, reviewed by Labouvie-Vief (1985), predicted a pattern of pronounced and universal decrement beginning in the early twenties. Cognitive growth was linked with the progression of neurophysiological development, defined as a pattern of growth followed by each individual. It was hypothesized that as neurological structures degenerated with age, a parallel degeneration of all cognitive abilities occurred. Furthermore, deterioration was thought to affect all cognitive functions. Functions such as semantic memory, lexical access, and executive reasoning were thought to compose a unitary system which reached an optimal peak in functioning by the end of neurophysiological development and then deteriorated throughout the rest of the adult life span. However, as research continued to investigate the nature of intelligence and the nature of decrement in cognition with age, it soon became apparent that neither the structure of intelligence nor the patterns of change in intelligence could be satisfactorily depicted as
unifactorial concepts (Labouvie-Vief, 1985).

Present Concepts of Aging and Cognition

More recent conceptions of the nature of intelligence and life-course change patterns have provided a better framework in which to view cognitive aging. Intelligence has come to be conceptualized as a multi-dimensional entity, composed of multiple mental abilities. Each of these abilities has distinct structural, functional, and developmental properties, each having distinct and multiple patterns of change (Labouvie-Vief, 1985). Changes in life-course patterns are now described in terms of interindividual variability. These concepts account for observed differences in individual life-course patterns of mental functioning. Intelligence and life-course patterns are no longer conceived of as one-factor totalities but multi-factorial entities, each encompassing somewhat independent elements (Labouvie-Vief, 1985). These concepts have provided a more practical structure in which to study life-span intellectual functioning in terms of interindividual variability in cognitive functioning and life-course pattern.

Subsequent to the development of theories of intelligence as a non-unitary entity, research on cognition and aging has focused on component changes in mental functioning with age. Changes in cognitive functions with age have been found to evidence decrement, stability and even evolution over the adult life (Horn & Cattell, 1966; Labouvie-Vief, 1985). Further, cognitive declines have been discovered to be smaller in magnitude and to include fewer functions than
previously thought, and their onset and rate have been found to vary according to original potential levels (Schaie, 1983).

One function that researchers have investigated in cognitive aging research that has been shown to decrease with age is speed of response. Slowing in operations, as reflected in response latencies, has been found in elderly subjects in many studies (Bowles & Poon, 1985; Charness, 1981; Eysenck, 1975; Hogaboam & Pellegrino, 1978; Petros, Zehr, & Chabot, 1983; Rabbitt, 1977). However, the slower responses were not necessarily incorrect. When factors such as educational level of subjects were controlled, age had the effect of impairing the rate far more than the quality or the accuracy of the mental operations (Sward, 1945). Speed of response is not necessarily related to intellectual abilities, although commonly used tests of intelligence measure response latencies. Decreases found by researchers in abilities such as abstract reasoning and perceptual motor functioning may also be related to speeded response conditions in the testing of these abilities. These findings may also be related to sensory acuity deficits common in aging.

On the other hand, although investigations of age-related changes in various cognitive functions have reported cognitive deficits in later life, a core of spared functions has also been noted. For example, Cerella and Fozard (1984) found that one spared function in aging was lexical access ability, as measured by the time required to recover the meaning of a word.

Research has even shown that there exists an advancement in certain skills
with aging, especially in well practiced abilities (Dixon & Baltes, 1986). For example, word-knowledge or general vocabulary, an attribute in which continued practice or learning operates in favor of the old, was uniformly superior in elderly subjects in an early study by Sward (1945).

Horn and Cattell's (1966) theory of two intelligences, fluid (Gf) and crystallized (Gc) has been used to explain multidirectional changes in intelligence with age and to suggest some of the reasons why component changes vary with age. The optimal level of fluid intelligence (Gf), attained by early adulthood, is assumed to be determined by heredity. Inductive reasoning, a component of fluid intelligence, is assumed to be unaffected by education and acculturation (Kausler, 1988). Crystallized intelligence, on the other hand, is seen as largely the product of both education and acculturation. Fluid intelligence, as measured by inductive reasoning, is said to decline progressively with neurological degeneration beyond early adulthood. Crystallized intelligence, as measured by tests of vocabulary and general information, is said to increase moderately from early to late adulthood (Hayslip & Sterns, 1979).

Individual performance data in research on cognitive aging support the notion of interindividual patterns of change with age. In light of the wide range of interindividual differences found, Willis (1985) questioned the relevance of research focusing on normative patterns of intellectual aging. Willis discussed cohort (generational) effects as one critical source of individual differences in change and further suggested that unique lifestyles and non-normative life events...
experienced by older people encourage increasing variation in their cognitive abilities.

Research in Cognitive Aging

Issues Concerning Tests Used in Cognitive Aging

Many research findings which have indicated "deficits" associated with age are strictly relative to youth-centered standards adopted by researchers. For example, intelligence tests commonly used in cognitive aging research were developed to measure academic potential of children and youth in educational settings rather than cognitive abilities of adults (Baltes & Willis, 1971). These ability tests have been less familiar to and more difficult for older than for younger adults. Furthermore, cognitive functioning of elderly adults, who are less likely to have had recent experience in taking ability tests, has been judged with instruments which are not relevant to cognitive demands experienced in their daily lives. Labouvie-Vief (1985) suggested that the ability to engage in abstract reasoning outside of contextual and pragmatic considerations may be an adaptive trait of youth, who are daily involved with exercising newly acquired skills. Mature older adults, Labouvie-Vief argued, reason in a way reflecting cognitive maturity, which she defined as working within ambiguity creatively. Therefore, behaviors of older adults in testing situations are different from the behavior of younger adults.
Differences Between Young and Old Subjects' Behavior in Cognitive Research

Older subjects demonstrate what in one context may be conceived of as high levels of flexibility but in another may be characterized as maladaptive and rigid behaviors. For example, researchers are accustomed to young Western adults who often show a certain submissive compliance, refusing to question the validity of test items or the researcher's underlying conception of cognition. However, older adults often are highly interested in such issues (Labouvie, 1985).

College students' behavior on problem-solving tasks seems to indicate that their perceptions of logical relationships in test problems are based solely on the information and surface relationships provided by the examiners. Older subjects may perceive different logical relationships in a problem in terms of their world knowledge and in terms of factors not provided by examiners (Labouvie-Vief, 1985).

Older adults have been observed to leave more items unanswered on cognitive research tests, puzzling researchers (Reese & Rodeheaver, 1985). This phenomenon may be due to the fact that older adults understand that deliberately choosing not to solve a problem (by withdrawing from the situation or withholding a response) is a viable option in the real world. Not solving a problem indicates possible choice of this as a solution strategy (Willis, 1985). College students, on the other hand, drawing on recent and frequent experience, may believe that choosing a best guess rather than leaving an item blank is a more appropriate
strategy for standardized test taking. Reese and Rodeheaver (1985) suggest that as the current population of younger adults grows older, the cohort effect of experience with psychometric testing may become evident in research on cognitive functioning in future elderly generations.

Another consideration in examination of past research on aging is the attitude of the older adults toward testing situations. Fear of volunteering as subjects in scientific studies is common among the elderly. This fear may be due to limited experience with standardized testing, among other factors, and the influence of the fear factor raises questions about the generalizability of results (Reese & Rodeheaver, 1985). Adults that do participate in studies may not be representative of their age cohorts (Bayles & Kaszniak, 1987).

Subjects Used in Aging Research

Other issues related to subject selection in aging research also influence the generalizability of results. An important issue to consider, especially when interpreting results reporting declines in intellectual functioning with age, is the manner in which subjects are selected for the studies. Longitudinal, cross-sectional, and sequential designs have all been utilized in the investigation of intellectual functioning with age. Each has its own advantages and disadvantages.

**Longitudinal Design**

One method of subject selection is represented in longitudinal research
designs, in which the same individuals are tested repeatedly over time. These designs have the advantage of using subjects as their own controls. However, they also have many disadvantages, such as practice effects of repeated testing, confounding effects of generational, cultural, and social factors on age, expense, time consumption, and potential obsolescence of measurements. In addition, the participants may not be representative of a broad population due to the difficulty of obtaining volunteers willing to participate in a long term project. Furthermore, even when it can be assumed that the original group of subjects was representative, some may drop out of the study (by various means, including death), leaving a group that is not representative (Bayles & Kaszniak, 1987).

Cross Sectional Design

In cross sectional designs, in which individuals across generations are tested using the same instrument, there is difficulty in obtaining equally representative samples of all age groups (Bayles & Kaszniak, 1987). The divergent histories of generations represented by the subjects in cross sectional design studies may confound results.

To illustrate, consider a hypothetical project in which the problem-solving ability of adults from 21 to 80 years of age was measured by having subjects decide which type of car would be the best buy, based on various features of performance, price and make. Next, suppose that the car that had the most features for the lowest price, which the investigators had decided was the "correct"
response choice, was a German car. Suppose further most of the subjects between 21 and 69 chose the correct answer. However, all subjects over 70 indicated that a different model was the best buy. The researchers might conclude that the ability to solve everyday problems declines with age. Unfortunately, they would have failed to take into account that these particular subjects over 70 years of age were young adults during World War II. The older people might have felt that no German car should ever be chosen as a best buy, due to their shared experience of regarding Germany as an enemy in wartime. This outcome would be an example of a generational sociocultural effect on the performance of subjects over 70 years of age.

Furthermore, researchers using cross sectional designs have often failed to account for the multitude of ways in which individuals are influenced by sociocultural factors (Labouvie-Vief, 1985). For example, in addition to the generational effect in the hypothetical study discussed above, individuals might have been influenced by their personal sociocultural histories in choosing their answer. It could be, for example, that one person in the 50 to 60 year-old age group chose the American Chevrolet car because his teenage friends had all had an affinity for the Chevrolet Biscayne. Someone else from the same age group might have chosen the American car because he had suffered financially from the recession in the early 1980s and had subsequently resolved to buy American products. Perhaps a woman in the 60-years-and-older group might have never driven a car, in which case, certain features desirable to those familiar with driving
would not be important to her. She might simply pick the car with the lowest price. In any case, the results of this study could be affected by the subjects’ individual sociocultural experiences and the researchers would be measuring attitudes, not problem-solving abilities.

Studies investigating the same phenomena using cross sectional and longitudinal designs can produce different results. Cross sectional studies have reported earlier and more dramatic cognitive losses with aging than longitudinal studies (Labouvie-Vief, 1985). Such dissimilarities may be a consequence of uncontrolled variables inherent in cohort, or generational membership of the subjects across the age groups (Kausler, 1988). It is further possible that participation in a longitudinal study on cognition may even produce cohort effects in the subjects. Participation may tend to affect the subjects’ attitudes towards continued learning.

**Longitudinal Sequential Strategies**

Cross sectional and longitudinal designs are not the only types of design utilized in aging research. There is also a sequential strategy, in which longitudinal studies are augmented by concurrent cross sectional research. These designs reduce the limitations inherent in both cross sectional and longitudinal designs, by resisting historical (social and cultural) effects. For example, Schaie (1983) describes the Seattle study, a longitudinal sequential research program that has at present been underway for more than three decades. So far, the results
indicate widespread differences in the onset of cognitive decline, with many subjects exhibiting stable levels until their 70s and some not evidencing decline until their early 80s (Schaie & Willis, 1986). This finding again supports the notion discussed earlier concerning the variability of interindividual abilities with aging.

**Education and Health Variables**

Age related differences observed in problem-solving performances between elderly and young adults may be to a large extent reflections of cohort differences in educational level (Kausler, 1988; Reese & Rodeheaver, 1985). In cross sectional studies where subjects have been matched for education levels, results have shown that increased age was not related to the quality or accuracy of various mental operations (Reese & Rodeheaver, 1985; Sward, 1945). When research designs are constructed in this manner, with matched education levels, however, the performance of the older sample may not be generalizable to the population from which it was drawn (Charness, 1981). Therefore, although the results of these studies reflect the effect of educational level on cognitive functioning in old age, their findings cannot be generalized to the entire population of elderly adults.

Two methods of modifying statistical interpretation of the data from cross sectional research, in order to compensate for the problem of confounding factors such as educational level, are discussed by Kausler (1988). The first method is
that the factor of differences in educational level is partialled out in order to statistically examine the interaction between age and performance. The second method of modification is the use of age groups that are balanced in terms of educational level.

Another variable in research on aging is health. In longitudinal studies, data showing continuing decline with age may only be an artifact of the correlation of age and morbidity. Cognitive performances of elderly subjects may be affected by pathological changes associated with and eventually leading to natural death (Labouvie-Vief, 1985). Researchers investigating intellectual ability and survival in the aged have noted an approaching death-related decline (Jarvik & Falek, 1963). That is, the subjects who performed the most poorly in some longitudinal research tests have tended to die within the next five years. Labouvie-Vief (1985) views such results as an indication that individuals maintain a more or less stable level throughout most of their life, with dramatic changes occurring primarily in the five years preceding death.

Reversal of Age Related Declines

Elderly adults possess a degree of resilience in their higher mental processes, and appropriate training programs have been shown to facilitate mental performance in areas in which it has begun to decline. Theorists have suggested that training of cognitive functions may only involve a regeneration of abilities still present in the individual but seldom utilized in adult life (Reese &
Rodeheaver, 1985).

The disuse theory of intellectual aging suggests that findings of cognitive decline with aging actually reflect changes in how older adults use their abilities (Reese and Rodeheaver, 1985). Proponents of this theory argue that cognitive "declines" merely reflect the disuse of functions needed in youth as one grows older, such as those required in formal learning. On the other hand, practice of a specific skill that is relevant in an older adult's everyday life facilitates cognitive functioning (Reese and Rodeheaver, 1985). For example, an adult who has played the piano in church for many years can play well, because the ability has been put to practical and frequent use, while adults who played the piano well during youth may no longer play well if they are not called upon to play in everyday life. Reese and Rodeheaver (1985) have suggested that stimulating environments and frequent mental challenges positively affect elderly adults' overall cognitive functioning. Higher levels of competence in independently living older adults have been found to be related to operating in more demanding environments, engaging in more activities, and belonging to more organizations (North & Ulatowska, 1981). Older women have been targeted as candidates for intellectual stimulation through educational activities by Willis (1985), who based her judgment on evidence of dramatic drops in cognitive functioning experienced by women who reported having inactive life styles, experiencing loss of a spouse, and living in inaccessible environments. Given the longer life expectancy for women, and the likelihood of a lengthy period of widowhood, Willis suggested
elderly women benefit not only from social interaction within the context of educational activities but also from the intellectual stimulation necessarily provided.

Research has discovered the existence of facilitative cognitive training techniques. Reversal of documented age related declines in certain figural relations (e.g., induction composites, identical picture identification tasks) was facilitated both by formal instruction and self-instructed group interactions in a study by Blackburn, Papalia-Finlay, Foye, and Serlin (1988). They found that gains made from self-generated strategies for task solution were more durable over time than gains resulting from specific rule training. Similarly, cognitive training techniques were found to reverse a reliably documented decline over a 14-year period in a substantial number of older adults in a study by Schaie and Willis (1986). In this longitudinal study subjects were classified into two groups: (1) those whose abilities of inductive reasoning and spatial orientation had declined, and (2) those whose inductive reasoning and spatial orientation abilities had remained stable. The improvement from training on spatial orientation was found to be greater for those who had experienced decline than for those who had remained stable.

Kausler (1988) suggested that training methods be designed that can: (a) transfer to fluid intellectual abilities other than those specifically trained, (b) transfer to everyday problem-solving and reasoning, and (c) facilitate the retention of effects of training long after the training program itself has been completed.
Willis (1985) suggested that it may be more advantageous for researchers concerned with intervention to identify which components of intellectual functioning show earliest decline within longitudinal and cohort-sequential data sets. The differential pattern of developmental change elucidated by the theory of fluid and crystallized intelligence (Horn & Cattell, 1966) suggests a focus on fluid abilities as the target for intervention.

**Analogical Reasoning and Cognition**

As mentioned earlier in this discussion, analogies and analogical reasoning have played an important part in cognitive research (Whitely & Barnes, 1979). Many well known psychometric tests utilize analogical reasoning because of its prominent role in theories of intelligence and information processing (Sternberg, 1977a, 1977b). Components of analogical reasoning have been closely associated with those of intelligence (Sternberg, 1982). Spearman (1927) proposed that properly constructed and utilized analogy test items measure abilities which have correlations with all the components known to contain "g" (his general factor of intelligence). Researchers investigating cognitive aging have also developed tests involving analogies specifically for their research purposes. Hayslip and Sterns (1979) used common word analogies as one of the tests measuring fluid intelligence and abstruse word analogies as part of the problem-solving measures of crystallized intelligence in their investigation of the relationship between age and crystallized and fluid intelligences.
Types of Analogies

An analogy is a complex comparison between two things, usually involving formal or structural similarities as well as qualitative ones (Beardsley, 1975). Formal analogy test items are most commonly presented in the form A is to B as C is to ? (A: B::C: ?). There are a number of response formats in which analogy problems may be presented (multiple choice, true-false, or fill-in-the-blank). Analogies can also be constructed in a number of different modalities such as words, geometric figures, or schematic pictures. Although the last term in an analogy problem is usually the one a subject must induce, analogies may be presented in forms where a different term is missing, or even several terms are missing (Sternberg, 1982).

Verbal Analogies

Research on solving verbal analogies is important because the processes involved in their solution are often used to explain frequently occurring processes in thinking (Whitely & Barnes, 1979). The verbal analogy is the most common type presented in test items. Typical varieties of semantic relationships between terms in verbal analogies are: (a) synonymy (e.g., go: leave::come: arrive), (b) antonymy (e.g., good: bad::better: worse), (c) function (e.g., shoes: feet::hat: head), (d) linear ordering (e.g., yesterday: today::before: now), and (e) category membership (e.g., noon: time::west: direction). Test designers have attempted to
vary difficulty levels of verbal analogy problems in terms of these semantic relationships as well as in terms of the vocabulary used in items (Sternberg, 1982).

**Pictorial Analogies**

Pictorial analogy problems utilize the same types of relationships as do verbal analogies, but are presented as pictures instead of words. They have been employed for testing children who are too young to read or who have reading deficits (Nippold, Erskine, & Freed, 1988). Pictorial analogy test items may be useful, then, when working with a population such as elderly stroke victims with reading deficits.

**Figural Analogies**

Geometric figural analogies are unique in that the process utilized in their solution is spatial in nature (involving internal representations) and is not thought to necessarily involve linguistic processing (Mulholland, Peligrino, & Glaser, 1980). Common elements found in geometric analogy test items include lines, triangles, circles, crosses, rectangles, and pentagons. The figures are transformed and altered in a number of ways to constitute the terms of the analogy problem. Transformations employed include removal or addition of elements, rotation, reflection, displacement of elements, changes in size, and variations in element shading. Difficulty seems to be related both to the number of elements and the number of transformations present in an item. Transformations tax working
memory, increasing the occurrence of error as the number of transformations increases (Mulholland et al., 1980).

Components of Analogical Reasoning

In an attempt to explain how inductive reasoning is used to solve analogy problems, Sternberg (1977a; 1977b) proposed a componential theory of information processing. He described six processing events involved in solution of analogies. These six processing events include: (1) encoding the individual terms of the analogy; (2) inferring the relationship between the first two terms (A and B); (3) mapping the relationship between the first and third terms (A and C); (4) applying the results of the inference and mapping processes to the third term to generate an ideal fourth term which is then used to evaluate the several alternative answers presented; (5) an optional justification process which is used to select among alternative answers when none of them precisely matches the ideal answer; and, (6) a response process for indicating the choice of an answer. Gick and Holyoak (1980) have noted a relationship between Sternberg's component processes and general cognitive functions.

Whitely and Barnes (1979) suggested that the application event (step four) is better described by two component processes, image construction and response evaluation. Further, they suggested that a new component event, confirmation, might be added. That is, in analogy formats where answer options are presented, the subject compares each of the answer options to the ideal solution.
Four alternative procedural models for solution of analogies were presented by Sternberg and Rifkin (1979). These four procedural models differ in whether the component processes are applied in an exhaustive manner (where all possible relations between terms are considered) or in a self-terminating manner (where only as many attribute values are considered as are necessary to choose an appropriate answer). In all models the processes are ordered into the same general sequence; however, the way which the processing events are executed (self-terminating or exhaustive mode) varies. To illustrate, in the third model, inference is exhaustive, but mapping and application are self-terminating. The authors investigated the processes of children and college-age adults in solving analogies and found that the self-terminating strategy, which the children used more often, was less effective (in terms of higher error rates) than the exhaustive mode.

One important element in performance on an analogy task is that of strategic expertise. For example, in geometric analogies, memory problems can arise when items are made more difficult (by increasing the number of elements and/or transformations), and success then depends on applying effective strategies to combat memory overloading. Therefore, an adaptive strategy of processing of transformations, involving procedural knowledge, is needed. Individuals who have these adaptive strategies decompose patterns in an ordered manner to discover elements that need to be isolated. Likewise, an ordered method is used to identify which transformations need to be considered and which are extraneous.
Mulholland et al. (1980) argued that these adaptive cognitive strategies are important sources of individual differences in solving geometric analogies.

Statement of Rationale for the Present Study

The foregoing review of the literature reveals several clear elements of current theoretical views of cognitive aging. The elements include: (a) the multidimensional nature of intelligence and the multidirectional nature of change in cognitive abilities with age; (b) the high degree of interindividual variation in cognitive abilities among same age subjects; (c) the need to examine cohort variables in cross sectional studies, and; (d) the intrinsic relationship between analogical reasoning and the nature of intelligence. The literature implies that performance on analogies in different modalities may vary in individuals and may be associated with age and education. However, no published research study has investigated the manner in which a population of elderly people performs on multiple modality analogies as a way of exploring their cognitive functions.

The present study was designed to provide information on elderly subjects’ performance on multiple modality analogies. Because only independently living elderly adults were selected as subjects, variability in general health and socioeconomic status was controlled to some degree. Characteristics of the subjects used in this study were similar to those of the "typical elderly adult" described by Båyles and Kaszniak (1987). Although the design of this study was cross sectional, subjects were drawn from an over-65-years-of-age population,
reducing the effect of the generational cohort affects inherent in studies that compare current young adults and elderly adults.
CHAPTER III

METHODOLOGY

Subjects

The subjects for this study were 47 elderly adults between the ages of 65 and 90 (mean age of 77 years, with a Standard Deviation of 6.25 years) who were living in a federally subsidized (low income - Section 8 housing for the elderly) apartment building in Grand Rapids, Michigan, at the time of the study. All tenants were asked to volunteer to participate during an annual group meeting. Tenants were given the opportunity to register for any of several testing sessions conducted on various days of the week over a two-month period. Forty-seven of the 150 tenants participated.

The subjects had a mean of 11 years of education (range of 7 - 16 years). All were living independently, a requirement for tenancy. All subjects’ incomes were at low or very low levels as defined by federal guidelines, with their main source of funds coming from social security benefits. With the exception of one woman who had a part-time job, the subjects were unemployed. Thirty-one percent (15) reported hearing losses. Twelve (25% of total subjects) reported wearing hearing aids.

These subjects exhibited characteristics similar to the typical elderly adult
as described by Bayles & Kaszniak (1987). Characteristics of this typical senior include having completed 12 years of education, being self-sufficient yet unemployed, living on a modest income, and probably having hearing loss.

Although Bayles and Kaszniak (1987) also noted that the typical elder is likely to be coping with at least one chronic disease, the existence of chronic disease in these subjects was not investigated. The subjects were asked to rate their general health on a scale from poor to excellent. Twelve did not report their health status, none reported their health status as poor, 9 reported their health status as fair, 20 reported their health status as good, and 6 reported excellent health status.

Subjects were asked to read and sign a consent form (See Appendix A) which outlined the purpose of the investigation, their right to withdraw from participation at any time, and the approximate amount of time their participation would involve. In addition, the consent form advised the participants that all information obtained would be kept strictly confidential and that their names would not be used at any time. These methods were approved by the Western Michigan University Human Subjects Institutional Review Board (See Appendix B).

Stimuli

Stimuli consisted of 90 analogy problems produced in three modalities: words, pictures and geometric figures. These were provided by Dr. Nickola
Nelson of Western Michigan University, Kalamazoo, and Letitia Gillespie of Case Western Reserve University, Cleveland, Ohio, who are currently working with Communication Skill Builders, Inc. to develop an intervention program employing analogies constructed in these three modalities. The analogy problems utilized in this study were developed from those used in a master's thesis by Gillespie (1987) on the effects of unilateral brain damage on analogical reasoning skills.

There were thirty analogies of each type, and each set contained items at three levels of difficulty: (1) easy, (2) medium, and (3) difficult. These classifications were based on complexity of vocabulary, complexity of analogical relationships, and the number and complexity of geometric transformations. Nelson and Gillespie (in press) evaluated the difficulty of the words used for the vocabulary analogies using data compiled by Stemach and Williams (1988). These data contained the first 2500 words of spoken English from spontaneous language samples from over 500 first graders. These words were divided, according to frequency of use, into 10 levels of 250 words each. According to Stemach and Williams, the words in Levels 1 and 2 accounted for approximately 85% of all of the words used by first grade children. Nelson and Gillespie (in press) selected vocabulary for both the word and picture analogies by drawing from Stemach and Williams' Levels 1, 2, and 3 for Level A (easy), Levels 4, 5, and 6 for Level B (medium), and Levels 7, 8, 9, and 10 for Level C (difficult).

In addition to vocabulary, the types of relationships represented were used to assign difficulty levels to the word and picture analogies. Some researchers
have suggested that it is possible to identify some types of analogical relationships that are easier or more difficult to understand than others (Nelson & Gillespie, in press). For example, antonymous and functional relationships are easier to process than synonymous, category membership, and linear ordering relationships (Sternberg & Nigro, 1980). The following eight analogical relationships were represented in the word and picture relationships (Nelson & Gillespie, in press):

1. antonymy (slow: fast::up: down)
2. synonymy (easy: simple::hard: difficult)
3. functional (knife: cut::pencil: write)
4. part-whole (page: book::teeth: mouth)
5. member-class (red: color::square: shape)
6. cause-effect (match: fire::refrigerator: chill)
7. degree (good: better::bad: worse)
8. characteristic property (wheel: round::arrow: straight)

Some distinctions between the two modalities resulted from the ability to represent relationships pictorially. These distinctions tended to generate pictorial analogies that were more concrete in nature. For example, a Level A word analogy representing the relationship of part to whole was state is to country as city is to ?. A Level A picture analogy representing the same relationship was hand is to arm as foot is to ?.

In developing the figure analogies, Nelson and Gillespie (in press) used six structural relationships based on those used in constructing analogy problems for
the Test of Nonverbal Intelligence (TONI; Brown, Sherbenou, & Johnson, 1982). These relationships include:

(1) matching (no difference between figures A and B is matched in the identical relationship between figures C and D);

(2) addition (figures A and C are changed into figures B and D, respectively, by adding attributes or parts);

(3) subtraction (figures A and C are changed into figures B and D, respectively, by subtracting attributes or parts);

(4) alteration or rotation (figures or attributes are moved in some systematic way to change figures A and C into B and D);

(5) progression (a continuum of change appears among or between figures);

(6) combinations (multiple changes, involving more than one of the previous five types, appear from A to B and C to D).

All analogies were presented as two relationships within a four-frame box format (see example of analogies from each modality in Appendix C). This format is closely aligned with the proportional A: B::C: D arrangement. In the four-frame box arrangement, a completed relationship is represented in the upper two boxes (A:B) and a comparable stimulus (C) appears in the lower left box. Three choices for completing the fourth member of the analogy are presented at the bottom of the page in boxes labeled "1," "2," and "3." Subjects are required to indicate the number of their choice for completing the analogy item on their
Procedures

Information concerning level of education, general health, handedness, vision and hearing status, native language, and familiarity with analogy tests was gathered on information sheets at the time of testing (see Appendix D). Each subject was asked to indicate his or her sex and date of birth on the answer sheets. The ages of the subjects are presented along with raw scores and educational levels in Appendix E.

Subjects were tested in groups of two to twenty at sessions held either in the library or in the community room of their apartment building. They sat at tables in groups of three to eight.

The analogies were presented in three-part test booklets. Each part of the test booklet contained 30 analogies in one modality, for a total of 90 drawn from all three modalities. The analogies were presented in order of difficulty (Level A first, then Level B, followed by Level C). Verbal analogies were presented first, then pictorial, and finally figural. Each of the three parts of the test booklet began with a practice item, in order to familiarize the subjects with the task.

The examiner began by asking the entire test group to look at the practice verbal analogy and find the answer, saying "This (A) is to this (B) as this (C) is to which one of these, one, two, or three?" The subjects responded by answering in chorus. If a subject expressed confusion regarding the task, the examiner
would explain that they were required to find the relationship between the first
two items (A and B) and then decide which one of the three practice answers (D
one, two, or three) would best duplicate that relationship when combined with C.

The time allotted to complete all three parts of the test booklet was
approximately 50 minutes. The subjects were instructed not to take a long time
to decide on one particular answer, and instead to make their "best choice" and
move on. The examiner informed the subjects of the time at 15 minute intervals
and then suggested that they finish the part of the test booklet they were working
on and begin the next. All subjects completed the entire test within the allotted
time.

At the start of the testing session, each subject was given three computer
answer sheets and two number 2 pencils and asked to label one sheet for words,
one for pictures, and one for figures. Subjects were advised that on the answer
sheet each circle corresponding to their answer choice needed to be filled in
completely and no marks were to be made outside of the circle. Subjects were
cautioned that although the answer sheets contained blank circles for five possible
responses, there would only be three possible choices on the test items and the
fourth and fifth circles should be ignored. Each subject was shown an answer
sheet with only choices 1, 2, and 3 filled in as this was explained.
CHAPTER IV

RESULTS

In this study, analogical reasoning abilities of elderly adults were measured by asking subjects to complete 30 analogy tasks in each of the three modalities, words, pictures and figures. Each correct response was awarded one point, for a maximum individual score of 90 overall, 30 in each modality. Statistical procedures utilized during the investigation of age group performances include contingency tables, Friedman-$F$ statistics, and non-parametric median tests (see Appendix F). Linear regression analysis was performed to obtain Pearson $r$ values for correlations between individual age and performance and between educational level and performance.

Age Group Performance Analysis

Initial analysis was conducted subsequent to dividing the subjects into age groups. One method used was to group subjects according to age in five-year increments. This division produced the following 5 age groups:

1. Group I - Age range: 85 - 90 years ($n = 5$)
2. Group II - Age range: 80 - 84 years ($n = 13$)
3. Group III - Age range: 75 - 79 years ($n = 11$)
(4) Group IV - Age range: 70 - 74 years \((n = 13)\)

(5) Group V - Age range: 65 - 69 years \((n = 5)\)

A summary of the five groups' raw scores for the three modalities and overall performance is presented in Appendix E. Means and standard deviations for the five groups' performances on the three modalities and overall scores are presented in Table 1.

Additional group performance analysis was conducted using the method of dividing the subjects into two groups. These groups were composed of "older" elders (those whose ages were greater than or equal to 80 years, \(n = 18\)) and "younger" elders (those persons under 80 years of age, \(n = 29\)). A summary of the means and standard deviations of the two groups' performances on modalities and overall is presented in Table 2.

Differences in Modality Scores Within Age Groups

The investigation of whether there was a significant difference in performance across the modalities (e.g., did the 65-69 year-old group perform better on the word task than on the picture task?) began by constructing contingency tables to compare performances within age groups on the three modalities. The observed scores within each age group were ranked. The rank sum for each modality score was then computed. A Friedman \(F\) statistic (i.e., the mean square error divided by the mean square regression) was then computed for each age group based on the rank sums for the modalities. See Appendix F for
Table 1

Mean Scores and Standard Deviations of Five Age Groups

<table>
<thead>
<tr>
<th>Group Number (Age Range)</th>
<th>Modality</th>
<th>Mean Score</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I (85-90)</td>
<td>Words</td>
<td>20.00</td>
<td>5.57</td>
</tr>
<tr>
<td>(n = 5)</td>
<td>Figures</td>
<td>16.00</td>
<td>4.64</td>
</tr>
<tr>
<td></td>
<td>Pictures</td>
<td>17.60</td>
<td>4.28</td>
</tr>
<tr>
<td></td>
<td>All Modalities</td>
<td>53.60</td>
<td>13.39</td>
</tr>
<tr>
<td>Group II (80-84)</td>
<td>Words</td>
<td>19.92</td>
<td>6.09</td>
</tr>
<tr>
<td>(n = 13)</td>
<td>Figures</td>
<td>20.31</td>
<td>5.11</td>
</tr>
<tr>
<td></td>
<td>Pictures</td>
<td>19.54</td>
<td>6.29</td>
</tr>
<tr>
<td></td>
<td>All Modalities</td>
<td>59.77</td>
<td>14.64</td>
</tr>
<tr>
<td>Group III (75-79)</td>
<td>Words</td>
<td>19.91</td>
<td>2.91</td>
</tr>
<tr>
<td>(n = 11)</td>
<td>Figures</td>
<td>19.18</td>
<td>4.75</td>
</tr>
<tr>
<td></td>
<td>Pictures</td>
<td>19.00</td>
<td>5.97</td>
</tr>
<tr>
<td></td>
<td>All Modalities</td>
<td>61.00</td>
<td>12.94</td>
</tr>
<tr>
<td>Group IV (70-74)</td>
<td>Words</td>
<td>21.08</td>
<td>4.91</td>
</tr>
<tr>
<td>(n = 13)</td>
<td>Figures</td>
<td>21.08</td>
<td>4.27</td>
</tr>
<tr>
<td></td>
<td>Pictures</td>
<td>19.92</td>
<td>5.98</td>
</tr>
<tr>
<td></td>
<td>All Modalities</td>
<td>62.08</td>
<td>13.52</td>
</tr>
<tr>
<td>Group V (65-69)</td>
<td>Words</td>
<td>22.40</td>
<td>2.70</td>
</tr>
<tr>
<td>(n = 5)</td>
<td>Figures</td>
<td>23.20</td>
<td>3.11</td>
</tr>
<tr>
<td></td>
<td>Pictures</td>
<td>22.40</td>
<td>4.16</td>
</tr>
<tr>
<td></td>
<td>All Modalities</td>
<td>68.00</td>
<td>9.77</td>
</tr>
</tbody>
</table>
an example of a rank sum table and brief explanation of the Friedman $F$ test. All five tests revealed no significant differences in performances across the three modalities within the age groups. All $p$ values were greater than .100.

Analysis was then done using the two sets of older and younger elders. The same procedure was used, and results again indicated no significant differences ($p$ was greater than .100) across modalities within each of the two age groups.

Table 2

<table>
<thead>
<tr>
<th>Group Number (Age Range)</th>
<th>Modality</th>
<th>Mean Score</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I (80-90) (n = 18)</td>
<td>Words</td>
<td>19.94</td>
<td>5.79</td>
</tr>
<tr>
<td></td>
<td>Figures</td>
<td>15.00</td>
<td>5.23</td>
</tr>
<tr>
<td></td>
<td>Pictures</td>
<td>19.00</td>
<td>5.75</td>
</tr>
<tr>
<td></td>
<td>All Modalities</td>
<td>58.06</td>
<td>14.20</td>
</tr>
<tr>
<td>Group II (65-79) (n = 29)</td>
<td>Words</td>
<td>20.86</td>
<td>3.90</td>
</tr>
<tr>
<td></td>
<td>Figures</td>
<td>20.72</td>
<td>4.40</td>
</tr>
<tr>
<td></td>
<td>Pictures</td>
<td>20.00</td>
<td>5.65</td>
</tr>
<tr>
<td></td>
<td>All Modalities</td>
<td>62.69</td>
<td>12.57</td>
</tr>
</tbody>
</table>

Modality Effects and Overall Performance Across Age Groups

A second research question was whether performance on the modalities or on overall performance differed with age (e.g., did subjects of different ages
differ significantly in their performances on the picture modality?). Investigation of this question began using age group data. Contingency tables were constructed for each modality and for overall score showing the number of scores within each age group greater than and the number within each age group less than or equal to the grand median (the score that was exceeded by half of all the observed scores). All of the data appeared to fall evenly on both sides of the median, suggesting no significant difference.

To investigate this question further, four non-parametric median tests were performed using the contingency tables, one for the total scores and one for each modality subtest. On these tables, as noted above (See Appendix F for an example of these tables and brief explanation of the median test), the number of scores in each age group falling above or equal to and less than the respective grand medians were entered. The data on the tables were then used to perform the median tests. All four median tests revealed no significant difference of performance across the five age groups, in any modality or in total score. All \( p \) values observed were greater than .100.

The subjects were then regrouped into the two sets of older and younger elderly (above or equal to 80 years of age and below 80 years of age) and the same procedures were performed. The results again were not significant at the .05 level for words, pictures, figures, or overall score. However, it was noted that the \( p \) value for pictures and age was between .05 and .100, whereas the other \( p \) values were all greater than .100.
Analysis of Individual Data

Subsequent to age group performance analysis, further investigation proceeded by examining individual ages and levels of education in relation to performances, since the actual age and level of education of each of the subjects were known. The relationship between age and scores and the relationship between education and scores were investigated using linear regression analysis. Pearson $r$ values were obtained for the correlations between these variables (See Appendix G for all scatter plots). The Pearson $r$ values resulting from these analyses are presented in Table 3.

Age and Performance

Examination of Table 3 shows a negative relationship between increased age and all modality scores as well as between increased age and overall score. However, of these the only correlations found to be significant were between age and total score and between age and figures score. The coefficient of age was relatively small. Interpretation would suggest that a one year increase in age would produce a .25 point reduction in score on the figure modality, and a 1.4 point reduction in overall score.
Table 3

Pearson r Values of Regression Analysis

<table>
<thead>
<tr>
<th>Correlation Variable</th>
<th>Modality</th>
<th>Overall Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Words</td>
<td>Figures</td>
</tr>
<tr>
<td>Age</td>
<td>-.19</td>
<td>*-.33</td>
</tr>
<tr>
<td>Educational Level</td>
<td>*.25</td>
<td>*.34</td>
</tr>
</tbody>
</table>

Critical r value = .243

* Indicates correlation as significant

A nonsignificant (p < .05) relationship was found between age and word modality score and between age and picture modality score. However, the Pearson r values (-.19 for words, -.21 for pictures) were close enough to the critical level (.243), to suggest that this finding might have been due to sampling error.

Educational Level and Performance

Another research question was whether there was a significant difference in performance of subjects in relation to educational level. The relationships between level of education and performance on each of the modalities as well as the relationship between level of education and overall performance were explored, again using linear regression. Examination of Table 3 shows significant
positive relationships between educational level and scores on all three modalities
as well as between educational level and overall score. However, the low Pearson
$r$ values suggest that the correlations are relatively weak. Although the
relationships are positive as was expected, the predictive value of knowing
educational level is quite small. Interpretation would suggest that a one year
increase in level of education would add .49 points to word modality score, .68
points to figure modality score, .78 points to picture modality score, and 1.7 points
to total overall score.

Summary

The three experimental questions were:

1. Does the modality in which the analogies are presented affect the
   performance of elderly adults on analogy tasks?

2. Does a negative relationship exist between increased age and
   performance on analogy tasks? If so, is the negative relationship evident in each
   of the three modalities tested?

3. Does a positive relationship exist between level of education of elderly
   adults and their performance on analogy tasks? If so, is the positive relationship
   evident in each of the modalities tested?

These questions were investigated using analysis of age group data and
analysis on individual data.
Analysis of Age Group Data

The data indicate that no difference across modality scores existed within age groups, and similarly no difference in overall score or modality scores existed across age groups. Whether elderly subjects were grouped according to five year intervals, or in two groups of older and younger elderly, age was shown to have no apparent effect on overall test performances nor on word, figure, or picture modality performances.

Analysis of Individual Data

When individual ages and performances were investigated, relatively weak but significant relationships were found between age and figure modality score and between age and overall score. The relationships between word modality score and age and between picture modality score and age were found to be nonsignificant.

A significant positive relationship was found between level of education and all modality scores as well as between level of education and overall score. Although these correlations were positive, as was expected, again, the relationships were relatively weak.
CHAPTER V

DISCUSSION

The first major finding of this study was the lack of significant differences across modalities within age groups. The modalities in which the analogies were presented did not appear to affect the subjects’ performance. The statistical nature of this finding is straightforward. However, a fuller understanding of its implications concerning cognitive functioning in old age rests upon exploration of several issues concerning the modalities.

Issues Concerning Modalities

Order of Presentation

All 30 verbal analogy tasks were presented first, followed by pictorial, and finally figural analogies. The results of the within age group performances across the modalities suggested no significant difference between modality performances. This finding may not reflect the actual situation because of effect of the order of presentation. The possibility of a practice effect causing the performance to improve as the testing progressed must be considered. It would seem reasonable to suspect a practice effect if the word modality scores (the first modality
presented) had been significantly lower, or if modality scores increased from words to pictures to figures. In fact, the results showed that, of all the modalities, the mean score was highest for words (20.511), and, on the surface, this result would indicate that no practice effect was present. Even so, it is possible that the experimental data were influenced by a practice effect. Conceivably, the true distribution of the word modality scores was even higher than the observed scores indicated. If lexical access and semantic processing are spared functions in aging, word modality scores might have been expected to have been higher simply due to the use of vocabulary in the construction of the word analogy problems. In that case a practice effect would have lowered the word modality scores to similar levels to the other modality scores.

Another problem with the order of presentation used in this study is the possibility that a fatigue effect was occurring. That is, the figure modality scores may have been depressed below their true distribution if the subjects' were tiring during the last part of the test.

An implication for future research design is that modalities should be presented in a counterbalanced order, perhaps in sets of words, pictures, and figures repeated several times. Such a design would be better able to show a clearer picture of the effects of the modalities.

Modalities and Measurement of Cognitive Functions

Two issues must be considered when examining the lack of performance
differences across the modalities within age groups. One is that the modality sets used in this investigation may not have been measuring the same cognitive functions. The various modalities require different types of processing for solution of analogies. Semantic processing of verbal stimuli accesses different codes in long term memory than semantic processing of non-verbal stimuli (Hogaboam & Pellegrino, 1978). Picture stimuli may be easier to process than word stimuli, because fewer transformations need to occur before semantic processing can begin (Pellegrino, Rosinski, Chiesi, & Siegal, 1977). Sternberg (1977a; 1977b) found that geometric analogies were harder (in terms of length of time required to find solutions) than verbal analogies, while Mulholland et al. (1980) suggested that difficulty in geometric analogies appears to be related to the number of transformations and elements within an item. All these considerations relate to the findings of this study in their relation to semantic processing and the concept of the sparing of this cognitive function in elderly adults (Cerella & Fozard, 1984; Eysenck, 1975; Jarvik & Falek, 1963; Lovelace & Cooley, 1982; Sward, 1945). These differences in the processes required for solution of analogies in the different modalities increase the difficulty in designing tests which have items of similar difficulty across modalities, especially for this population.

The second issue concerns whether the difficulty of each modality subtest was equitable in relation to the others. It is difficult to judge whether equitable levels of difficulty exist between the three subtests. Consequently each subtest's value as a measurement in level of cognitive functioning may be dissimilar from

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the others. In other words, the word, picture and figure modality subtests may not have been equally difficult, regardless of their differences in modality. Different concepts are used for increasing difficulty within the various modalities. For example, increasing the number of transformations within a figural analogy has been found to increase solution time (Mulholland et al., 1980). In this study, difficulty of verbal and pictorial analogies was determined in part by the vocabulary used in their construction.

In this study, decline in performance in relation to increased age was found for the figure analogies but not for the word or picture analogies. If vocabulary knowledge and lexical access skills do not decline with age, as previously suggested, perhaps the lack of decline in the word and picture modalities suggested by these data is misleading. It may be that decline in the figure analogies with increased age reflects declines in sensory perception associated with age, specifically in figure/ground conceptualization (which is a separate issue related to cognition). However, the lack of decline in picture modality performance complicates this hypothesis.

It may be that the fact that vocabulary was used to increase difficulty of word and picture analogy items may have been instrumental to the observed lack of decline found in word and picture modality scores with increasing age. Sternberg (1982) claimed that inductive reasoning is not necessarily being measured by analogical tasks that derive their complexity from the terms used in the items (vocabulary). Making the terms difficult to encode (semantically),
Sternberg (1982) argues, only arbitrarily makes the analogy more difficult. For example, consider the analogy walk is to bailiwick as profession is to metier. The terms presented in both relationships of this analogy are synonymous. The words walk and bailiwick may be used to define a limited area of knowledge to which pursuits or endeavors are confined (such as medicine as a walk in life). Similarly both profession and metier may be used to define a pursuit followed as an occupation or a means of livelihood, requiring technical knowledge and skill. Even though the relationship (i.e., synonymy) is a simple one that requires only minimal reasoning ability, the analogy is difficult because few people know the meanings of the words bailiwick and metier. Increasing demands on vocabulary knowledge indeed tests mental skill, but it is the skill of semantic or linguistic processing, not inductive reasoning. Sternberg (1982) considered the complexity of the relationships represented in an analogy task as an authentic measure of difficulty.

Nelson and Gillespie (in press), in explaining their rationale for basing increased difficulty levels in verbal and pictorial analogies in part on vocabulary level, reasoned that the types of relationships represented in analogies not only have to do with the level of abstraction and commonality of concepts but also with the vocabulary represented. They compare the following two analogies involving antonyms, which have been reported to be the easiest kind to solve: (1) big is to little as tall is to short and (2) accelerate is to retard as initiate is to conclude. Although the two analogies involve the same type of relationship, the
latter is hardly comparable to the former in terms of vocabulary difficulty. Nelson and Gillespie attempted to incorporate some of this distinction of vocabulary difficulty, because, they argued, vocabulary level interacts with the level of abstraction and commonality of concepts represented.

Implications for future research on cognitive aging (in terms of analogical reasoning within modalities) include the use of verbal and pictorial analogies involving only the factor of complexity in relationships rather than vocabulary for increases in difficulty levels. This might be accomplished if the vocabulary utilized in construction were drawn from a base of words similar in difficulty and appropriate to subject populations. If stimuli of this kind were used, the results could give a clearer indication of modality effects.

The results here appear to support the literature regarding the diminishing of certain functions with aging. It may be that memory loading problems inherent in solution of the difficult geometric analogies confounded the resulting data. However, these data may reflect some difficulty with executive functions (such as adaptive strategies) in later old age. Age decrements have been found when memory tasks call for spontaneous organizational and elaborative learning processes. It is interesting to note that these decrements are not evident in verbal memory tasks (Salthouse, 1985).

Problem-solving ability has been a favorite target of training programs designed to facilitate higher mental functioning in elderly adults. Kausler (1988) calls for research to develop improved means of training that will transfer to
everyday problem-solving. A clinical implication of the findings from the present study is that training to improve elderly adults' ability to adapt to their environment might be facilitated with stimuli and strategies that utilize semantic processing skills to improve these cognitive links (Reese & Rodeheaver, 1985) between the individual and the environment.

Analysis of Age Group Data and Analysis of Individual Performance Data

No significant relationships between age and scores were found when subjects were divided into age groups. This was true for both methods of division used. Significant relationships were found only after analysis was performed on individual age and performance data. This difference in findings suggests that when researchers group subjects by age some information may become lost. Any division of adult human subjects by age may be argued to be arbitrary. This study's disparate findings between the analysis performed using age group data and the analysis using individual data also lend support to the notion of a differential pattern of aging (Cornelius, 1984).

Suggestions for future research include analysis of individual performances on cognitive tasks in relation to age rather than analysis performed on data arbitrarily arranged into age groups. Due to the relatively weak relationship found between performance and age, another suggestion is that other variables associated with change in cognitive functions alluded to in the literature might be examined (e.g., decrements in sensory perception with age).
This study found that performance was negatively related to increased age, but not in a uniform way for individuals of the same age. Informal examination of individual scores showed distinct patterns of differences across modalities for some individuals. A suggestion for future research would be to examine characteristics of individuals who display such disparate performances across modalities and statistically compare these characteristics in relation to performance.

Educational Level and Performance in this Study

In this study, relationships were found to exist between educational level and modality scores as well as between educational level and overall score. Although these relationships were relatively weak, they were stronger than those found for age. This finding supports past research, which has suggested that performance on cognitive tasks is often more highly correlated with education than with age (Kausler, 1988; Reese & Rodeheaver, 1985; Sward, 1945).

Gonda, Quayhagen, and Schaie (1981) argued that generalizing results in aging research is difficult because of the indistinct way in which education levels are grouped by researchers addressing the cohort effects of education. For example, high and low education levels are often used, but the terms are not congruous between studies. The present study related individual scores and individual educational levels. The results more precisely defined the relationship between scores and educational level which was significant but again relatively
Suggestions for future research on cognitive functions in old age include analysis of individual scores in relation to various other factors suggested by the literature, rather than analysis of group data. A further suggestion for research might be to utilize Kausler’s (1988) notion of the use of cross sectional groups of subjects matched according to level of education.

Educational Level and Cognitive Functioning in Old Age

Educational level attained (at least in terms of formal educational instruction pertaining to specific professions) has been associated with a general maintenance of cognitive function in old age (Dixon & Baltes, 1986). Dixon and Baltes discuss cognitive complexity and demand in work environments as being related to level and rate of intellectual development during adulthood. Life-styles that include the pursuit of high levels of environmental stimulation, particularly those that include continuing formal and informal education, tend to be related to the maintenance of high level intellectual functioning (Reese & Rodeheaver, 1985). These types of life-styles are associated with, among other factors, professions requiring continued learning.

This notion has interesting implications for further research. Subjects might be grouped according to profession and then studied using a cross sectional design to investigate cognitive functions in relation to age. This might be done by recruiting subjects from professional organizations. It might be interesting to
compare life-styles associated with differing professions. Information obtained could suggest rehabilitative or facilitative cognitive therapy techniques for elderly clients.

Other Factors and Individual Performances

The findings of this study suggest that relationships exist both between age and performance and between educational level and performance, but that these relationships are relatively weak. This finding raises the question of what other factors may be related to performance. Informal examination of particular subjects' performances and characteristics suggests some possible answers mentioned in the literature, such as profession.

Another research implication regards the need to explore the effects of individual factors such as profession, environments, life histories, original capacity levels and career histories in relation to cognitive functioning. A clinical implication is related to establishing goals for the training or retraining of cognitive functions of elderly clients (Schaie & Schaie, 1977).

Conclusions

This study was designed to investigate analogical reasoning abilities in independently living elderly adults. The tasks used to measure reasoning abilities were analogy problems in three modalities. The conclusions that can be drawn from this study are as follows:
1. The modalities in which the analogy problems were presented in this study did not affect the performances of similarly aged individuals.

2. A negative relationship was found between increased age and scores on the figure analogies as well as between increased age and overall scores. However, nonsignificant relationships were found between age and scores on the word modality as well as between age and scores on the picture modality.

3. A positive relationship was found between educational level and scores on each of the modalities and between educational level and overall scores.
Appendix A

Subject Consent Form
SUBJECT CONSENT FORM

Thank you for volunteering to participate in this study!

Please read the following carefully, sign, and return to:

Judy Rau
In care of Greentree Apartments
Office 4320 Kalamazoo Ave.
Grand Rapids, Michigan 49508

I understand that I am under no obligation to participate in this study and that I have the right to withdraw from the study at any time without penalty of any nature, real or implied, of any kind.

I understand that the purpose of this study is to determine the reasoning abilities of normal elderly adults and that the results will be used to aid in the treatment of elderly adults that have language disorders due to conditions such as strokes or traumatic brain injuries.

I understand that my participation will be in the form of taking a test in solving analogies. I understand that analogies involve comparing the relationship between two given items, and choosing an item that "matches" the test item in the same way, for example:

QUESTION: fire to hot, ice to ______

CHOICES: (1) cold (2) warm (3) cool

I am aware that the test will take about one hour of my time.

I understand that I will be asked to participate in the gathering of a language sample (a recording of my voice and speech), lasting approximately 20 minutes.

I understand and expect that information about myself will be kept strictly confidential.

Signed __________________________

Date __________________________

Contact Person at Western Michigan University:
Dr. Michael Clark
Department of Speech Pathology and Audiology
Western Michigan University
387-8045
Appendix B

Confirmation Letter from HSIRB Stating Approval of Research Protocol
Date: October 30, 1989
To: Judy Reu
From: Mary Anne Bunda, Chair

This letter will serve as confirmation that your research protocol, "Analogical Processing in Multiple Modalities of an Elderly Population", has been approved as expedited by the HSIRB. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the approval application. You must seek reapproval for any change in this design.

The Board wishes you success in the pursuit of your research goals.

cc: M. Clark, Speech Pathology and Audiology

HSIRB Project Number 89-08-18
Appendix C

Examples of the Three Analogy Sets
Example of a Verbal Analogy

name  person

title

page  book  author

1  2  3
Example of a Pictorial Analogy

1

2

3

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Example of Figural Analogy
Appendix D

Subject Information Sheet
INFORMATION SHEET

PLEASE ANSWER THE FOLLOWING QUESTIONS AS COMPLETELY AS POSSIBLE

1. DATE OF BIRTH   MONTH ____ DATE ____ YEAR ____

2. CIRCLE THE LAST YEAR OF EDUCATION YOU COMPLETED
   1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 OVER ____

3. HEALTH DESCRIBE YOUR GENERAL HEALTH   EXCELLENT  GOOD  FAIR  POOR
   DO YOU WEAR A HEARING AID?     YES  NO
   HAVE YOU EVER EXPERIENCED A HEARING LOSS?     YES  NO
   IF YES, PLEASE EXPLAIN ____________________________

   DO YOU WEAR EYE GLASSES?     YES  NO
   HAVE YOU EVER EXPERIENCED A VISION LOSS?     YES  NO
   IF YES, PLEASE EXPLAIN ____________________________

   HAVE YOU EVER HAD A STROKE OR BRAIN INJURY/DAMAGE OF ANY KIND?     YES  NO
   IF YES, EXPLAIN ____________________________

4. IS ENGLISH YOUR NATIVE LANGUAGE?     YES  NO
   IF NOT, WHAT IS YOUR NATIVE LANGUAGE? ____________________________

5. ARE YOU RIGHT OR LEFT HANDED?              RIGHT  LEFT

6. OCCUPATION (BEFORE RETIREMENT) ____________________________

7. HAVE YOU EVER TAKEN A TEST INVOLVING ANALOGIES BEFORE?     YES  NO
   IF YES, DO YOU REMEMBER WHAT TEST OR WHEN YOU TOOK IT? ____________________________

PLEASE SAVE THIS SHEET TO TURN IN WITH YOUR ANSWER SHEETS
Appendix E

Age, Education Level, Raw Scores, and Group Means and Standard Deviations from Individuals Within Five Age Groups
RAW SCORES, TOTAL SCORE, STANDARD DEVIATIONS AND MEANS FOR FIVE AGE GROUPS

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MEAN: 20.511 20.106 19.617 60.914
SD: 4.671 4.747 5.647 5.18

Note: SD = Standard Deviation
Appendix F

Examples of Contingency Table
Explanation of Statistical Procedures
Examples of Contingency Tables

Explanation of Statistical Procedures

The contingency table

In general, an $r \times c$ contingency table is an array of natural numbers arranged into $r$ rows and $c$ columns and thus has $rc$ cells or places for the numbers (McClave & Dietrich, 1985). This table may be used to present a tabulation of data contained in several samples to test the hypothesis that the probabilities do not differ from sample to sample.

Friedman F-test

To compare the three modalities the observations within each age group (or block) were first ranked. Secondly, the rank sum for each modality was computed. These rank sums were used to obtain a Friedman F statistic.

Rank Scores of Group I

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<th>Word Score</th>
<th>Picture Score</th>
<th>Figure Score</th>
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<td>R1 = 6.5</td>
<td>R2 = 11.0</td>
<td>R3 = 12.5</td>
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</table>
The Friedman F statistic, which is based on the rank sums for each treatment is:

\[ F = \frac{12}{bk(k + 1)} \times \text{the sum of } (R_j \text{ squared}) - 3b(k + 1) \]

where \( b \) is the number of blocks (or subjects), \( k \) is the number of treatments (or modalities), and \( R_j \) is the \( j \)th rank sum.

The Friedman F statistic has a \( X^2 \)sampling distribution with \((k - 1)\) degrees of freedom. A table is used to compare the statistic obtained with the chosen beta level at \((k - 1)\) degrees of freedom.

The null and alternative hypothesis are:
Null: The populations' performances are identically distributed for all three modalities.
Alternative: At least two of the modalities have probability distributions of scores that differ in location. The rejection region is:
\[ F > X_{\beta}^2 \text{ with } (k - 1) \text{ degrees of freedom}. \]

(McClave and Dietrich, 1985)

The Median Test:
The group scores were compared using median tests. Forty seven subjects were used, which resulted in 141 obtained scores on modalities. These scores were then used to obtain a grand median for each modality and for overall score.
Contingency Table for Word Modality

<table>
<thead>
<tr>
<th>Group</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater than Grand Median</td>
<td>3</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>a = 23</td>
</tr>
<tr>
<td>Less than or equal to</td>
<td>2</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>2</td>
<td>b = 24</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total in Group</td>
<td>5</td>
<td>13</td>
<td>11</td>
<td>13</td>
<td>5</td>
<td>N = 47</td>
</tr>
</tbody>
</table>

The grand median is the number that is exceeded by about half of the observations in the entire array of scores for a given modality. The within modality scores of each age of the five age groups are then arranged on a 2 x 5 (2 x c) contingency table where:

- the 2 rows represent the number of scores that are: (1) greater than and (2) less than or equal to the median
- c is the number of persons within the age group
- a = the total of observations that exceed the median
- b = the total of values that are less than or equal to the median
- a + b = N the total number of observations.

An example of the contingency table used is shown above.

The test statistic is as follows:
T = N squared/ab x The sum of (difference between the observed scores above the median and below the median from each column) squared/the total score for each column or,
T = the sum of the square of (O sub 1i - O sub 2i)/n sub i
where O sub 1i is equal to the number of observations in the ith sample that exceed the grand median and O sub 2i is equal to the number in the ith sample that are less than or equal to the grand median; n sub i is equal to the total of O sub 1i plus O sub 2i.

The critical region for rejection of the Null hypothesis (that all the modalities have the same median) of a chosen alpha value is corresponds to T greater than x (sub 1 - alpha), the (1 - alpha) quantile of the chi square random variable with c - 1 degrees of freedom, obtained from a chi-square distribution table.

(Conover, 1980)
Appendix G

Scatter Plots
Pearson r = 0.34

FIGURE

SCORE

EDUCATION LEVEL (years)
Pearson $r = -0.21$

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Pearson $r = -0.28$
Pearson $r = 0.25$

![Graph showing a scatter plot with Pearson correlation coefficient]

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Pearson r = 0.34
Pearson $r = 0.33$

- X-axis: Education Level (years)
- Y-axis: Picture Score

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BIBLIOGRAPHY


Language-Hearing Association (ASHA), 31, 67-69.
