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# Reaction Time in Elderly Subjects: The Effects of Practice on Two Different Reaction Time Tasks

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# REACTION TIME IN ELDERLY SUBJECTS: THE EFFECTS OF PRACTICE ON TWO DIFFERENT REACTION TIME TASKS

by

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Dawn Marie Birk

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# ABSTRACT

Reaction Time in Elderly Subjects: The Effects of Practice on Two Different Reaction Time Tasks

by

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The reaction time of four groups of elderly human subjects were examined to determine the effects of stimulus presentation and task practice. Each group practiced different tasks, each requiring a response when more than one alternative was available. Two tasks involved making responses based on either visually or auditorily presented stimuli only. One task required decisions to be made on the basis of both auditory and visual stimuli. The fourth group acted as a comparison group and did not practice a reaction-time task; although they did perform a task on the computer and their reaction times were measured. Before and after practicing these tasks, each group was given a single trial involving a completely different decision-making task, and reaction time was measured. Results show that practice led to decreased reaction times on the practiced task in all treatment groups. The comparison group did not improve. Practicing any of the three reaction time tasks also led to decreased reaction time on the unpracticed task. These findings indicate that elderly individuals can decrease their reaction time with practice and that after practicing one task, changes will generalize to a different task. If the older population can alter performance on this task, then they may also be capable of altering performance on other tasks.

(181 pages)

# CHAPTER I

# INTRODUCTION

Behavior analysts have recently become involved in the field of gerontology. As a result, a new area of research has evolved under the name behavioral gerontology. Although limited literature exists in this area compared with other topics (Burgio & Burgio, 1986), an increasing number of behavior analytic studies have recently appeared.

Biology has always played an important role in any theory pertaining to gerontology (Burgio & Burgio, 1986). While it is true that certain biological alterations will affect behavior as humans age, behavior is still governed, to a large degree, by environmental factors (Skinner & Vaughan, 1983). Behavioral gerontology is the study of the way the interactions of environmental events and the aging, biologically changing organism produce behavior (Burgio & Burgio,1986).

The majority of psychological research involving the elderly is concerned with reteaching lost skills, such as walking or eating independently (Hussian, 1981). Such skills are often lost through to physical or intellectual impairments. Few gerontological investigations attempt to improve elderly individuals' existing skills that may have declined during the physiological process of aging.

Most of the literature pertaining to decision making by the elderly has examined situations in which the elderly individual has lost the ability to make decisions, so others must make decisions for them (e.g., Murrell, Schulte, Hutchins, & Brockwal, 1983; Levkoff & Wetle, 1982). However, decision making in the nonclinical elderly population has, for the most part, been ignored. It may well be the case that decision-making skill deteriorates from lack of use and that guided practice would retard impairment.

Behaviorally, a decision-making task requires an individual to make a response when two or more alternatives are available (Poon, 1980). The individual's overt response (e.g., pressing a key or saying a word) is considered to be the decision, since it can be objectively measured. Cognitive or physiological structures involved in making the decision need not be specified because they are unobserved. Experimentally, decision making has often been examined in terms of the time required for an individual to make a response and the number of errors made (Birren & Schaie, 1977). In this way, the length of time it takes an individual to make a decision (an overt response) and the actual decision (the specific response alternative) can be studied.

The biological decision-making processes that occur between the time of stimulus presentation and the response are currently not easily observable and can only be inferred. The period of time that elapses between the presentation of a stimulus and the individual's response is called reaction time (Welford, 1980). Reaction time is assumed to be a measurement of the speed of the biological processes involved in making decisions. Reaction time is therefore considered by some experimenters to be a measure of the time used by the sensory, peripheral, central nervous, and motor systems to process and respond to the stimulus (Birren & Schaie, 1977).

The relation between decision making and reaction time can be formally stated by the equation RT = a + bx; where RT = reaction time, a = time taken by peripheral processes (depends on deficit present in the sensory modalities), b = properties of the stimulus (i.e., complexity, similarity, etc.), and x = the number of response choices available to the subject (Welford, 1961). Reaction time is affected by the condition of the sensory modalities, the stimulus used, and the number of responses available. All of these variables presumably affect the biological processes leading to a particular decision and therefore affect the amount of time required for a decision to be made.

Reaction time changes with age (Denney & List, 1979; Nebes, 1978), and, since it at least partially reflects nervous system functioning, it is extremely important to examine how reaction time changes with age and whether its reduction can be retarded or even reversed. It has been suggested that reaction time reflects perceptual and cognitive ability, for example IQ (Jensen & Munro, 1979; Nettlebeck, 1986; Poon, Yu, & Chan, 1986; Sacuzzo, 1986; Guilford, 1969; Welford & Birren, 1969). If this is true, it would be particularly useful to determine whether certain interventions might alter reaction time. Such interventions might affect central nervous system processes and cognitive operations and, hence, functional behavior.

An increase in time required to make decisions leads to a delay in responding,increased reaction time, and may result in serious consequences. Birren (1964) suggested that the increased reaction time of elderly persons may be a cause of the high rate of accidents occurring in the elderly population (e.g., broken hips from falling). Elderly individuals may be unable to integrate incoming stimuli fast enough to make a response before an accident occurs. The increased time required to make a response may also cause problems for the elderly in certain occupations (Murell & Griew, 1965). Aged individuals would have an increasingly difficult time in those jobs that require quick decisions, as in business deals. Amato and Bradshaw (1985) verified that elderly people require a longer period of time to make decisions requiring help (e.g., obtaining a doctor, calling a plumber, etc.). In some cases, this extended period of time required to respond to the environment may be fatal, as in the case of hesitating to call a doctor for illness or injury. Clearly, in such situations many decisions need to be made, a wide variety of responses are available, and input comes from many different sources in the environment. These sources may involve auditory, tactual, visual or other types of sensory input from the environment. No research studies were located that involve decision making in the elderly based on information coming from more than one sensory modality simultaneously.

The purpose of the present research was to determine whether practicing a decision-making reaction-time task would lead to a decrease in reaction time. In addition, this study was designed to determine if a cross-modal (two sensory modes) reaction time task is more effective in reducing reaction time than a single modality task. Utilizing multiple-choice pretests and posttests allowed examination of the effects of the treatments on completely different reaction-time tasks. In effect, this research deals with areas that have been neglected in reaction-time research with the elderly.

# CHAPTER II

# REVIEW OF LITERATURE

## Definitions of Decision Making

Decision-making tasks that involve choosing between two or more available response alternatives have typically been examined in terms of reaction time and numbers of errors (Birren & Schaie, 1977). Reaction time is the time required for unobserved stages of information processing to occur (Ford, Pfefferbaum, Tinklenberg, & Kopell, 1982). The actual process of making a decision is biological, governed by the peripheral and central nervous systems, and psychological, determined by maturation and understanding. Because the biological processes cannot be readily observed, overt reaction time is typically assumed to be an indirect measure of the time it takes the biological mechanisms to process and respond to decision-making tasks.

Behaviorally, since a decision is an unobserved event, the subject's overt response (i.e., pressing a key) can be considered to be the actual decision. Since one does not observe what a subject decides until the subject does or says something, then doing it is in fact the decision, rather than a manifestation of the decision. Therefore, decision making, as measured by reaction time, is the amount of time required for a subject to make a response. As such, the length of time taken to respond and the overt response can be measured directly.

The cognitive processes underlying reaction time and/or the decision-making process are not necessary information for this study.

## History of Reaction Time

According to Brebner and Welford (1973), the length of time taken to respond to a given stimulus was first examined by F. W. Bessel, an astronomer. Bessel invented the "personal equation," which describes an individual's slowness to respond. This equation was the result of Bessel's finding that there is low interobserver agreement between his and his assistants' recordings of stellar movements. These discrepancies led Bessel to investigate differences in individual's response times, and the personal equation became an important way of examining individual differences.

Although this equation was eventually abandoned, Bessel's discovery led to the further investigation of individual reaction times. Differences among age groups became of interest. Koga and Morant (1923) performed an in-depth analysis of reaction times of groups of individuals from 16 to over 80 years old. He also examined differences in reaction time due to the sensory modality stimulated.

Welford (1980) reviewed 10 reaction-time studies that involved subjects from 6 to over 80 years of age. He concluded, based on these studies, that reaction times become progressively shorter from childhood to adolescence to the late twenties. However, after the twenties, reaction times begin to gradually lengthen through the fifties and sixties. Reaction time increases sharply when individuals reach their seventies and eighties.

Several variables should be considered when noting any relation between increase in reaction time and age. First, to what extent can changes be attributed to the subject's sensory organs (physical) and to what extent are they due to central nervous system (cognitive) changes? Are the increases part of the natural aging process or due to changes in the environment, such as lack of opportunity to perform (practice) reaction-time tasks? If the latter is true, then it may be possible that the decrements are reversible, and, therefore, elderly individuals could benefit from practicing such tasks.

## Decision Making and Reaction Time

In the 1850s , Helmholtz attempted to measure the speed of neural transmission in a reaction-time task. He found that the speed of the nerve conduction took up only a small portion of the total reaction time. Other investigators attempted to determine the amount of time taken by various processes in reaction times. These studies were inconclusive, although several relationships became clear (Welford, 1980). It was obvious, for example, that the salience of a stimulus affected reaction time. As the stimulus was made more salient, reaction time decreased up to a point and then reached a plateau. After this point, the salience of the stimulus no longer affected reaction time. Sensory modalities were also found to effect reaction time. This has been described at length by Davis (1957). Generally, reaction time is shorter when the stimulus is presented auditorily rather than visually. The complexity of the stimulus also affects reaction time. As the complexity of the stimulus increases, so does reaction time. Finally, the response requirement is related to reaction time. Reaction time will increase or decrease depending on whether the response to the stimulus is a key press, foot press, jaw movement or other response (Birren & Botwinick, 1955).

Donders (1868) was one of the first individuals to examine both simple and choice reactions in an attempt to measure the mental processes involved in reaction time. He subtracted the time required to perform a simple reaction time task from the time required for a reaction with two alternatives and concluded that the resulting amount of time is the time spent making a decision. Although this approach seems appropriate, it is clear that many processes overlap and that mental processing time cannot be measured in this way. Wundt, in 1874, and Cattell, in 1886, attempted to use variations of Donders' equation to measure mental processing, but these were later abandoned. Not until 1957, when Davis attempted to calculate peripheral versus central nervous system processing time in a reaction-time experiment, did a seemingly accurate estimate of mental processing become available.

In the 1950s, the relation between decision making and reaction time was first formulated in the equation: $RT = a + bx$ (Birren & Schaie, 1977). This statement implied that reaction time is affected by the condition of peripheral processes (a), properties of the stimulus (b), and the number of choices available (x). Davis (1957) utilized this equation in his experiments on human reaction time. However, at that point it was still not known how much the peripheral and the central nervous systems affect reaction time.

## Biological Influences on Reaction Time--
## Peripheral Processes

Davis (1957) calculated, using human subjects' reaction time as a measure, that a response to a visual stimulus takes a minimum of 150 msec, while responding to an auditory stimulus takes only about 138 msec. Davis estimated the time it takes for an auditory stimulus to reach the brain to be approximately 8-9 msec, for a visual stimulus 20-40 msec, and the time spent in motor nerve conduction and translation into an actual movement to be 40-55 msec. Davis logically concluded that the central nervous system (brain) processes the signal for 90-100 msec in a healthy adult.

Davis' calculations, while only approximate, have been supported by other experimenters who have examined the roles that the peripheral and central mechanisms play. Evidence now indicates that reaction time and therefore, decision making is controlled only minimally by peripheral processes, while the central nervous system appears to play a major role. Experimenters have concluded that peripheral processes do not have a large effect on the changes that occur in reaction time in the elderly (Ford & Pfefferbaum, 1980; Surwillow, 1968; Hugen, Norris, & Shock, 1960; Birren & Wall, 1956; Norris, Shock, & Wagman, 1953). Birren and Botwinick (1955) examined reaction time using finger, jaw, and foot responses to auditory stimuli. They found that their elderly human subjects always had longer reaction times than their college-age subjects, no matter what response was measured. However, the length of the reaction times did not vary with the type of response. Reaction times were always approximately the same number of milliseconds longer for the elderly subjects than for the college subjects. Birren and Botwinick concluded that this finding indicates that central nervous system pathways must also affect reaction time. If only the peripheral pathways affect reaction time, the foot response would be the slowest. Hugen et al. (1960) found that although reflex latencies do not change with age, voluntary responses, such as depressing a key, do significantly differ between elderly and young subjects. These experimenters concluded that because a voluntary response involves higher levels of the central nervous system, the slowing of reaction time with age is primarily due to alterations in the central nervous system (i.e., brain processing).

Motor time, measured from the time electrical activity reaches the muscle until an overt response is made, appears to have little effect on reaction time. Wagman and Lesse (1979) examined conduction velocity in human motor nerves by means of electromyograms. They found that the speed of transmission of the nervous impulse is only fractionally slowed by old age. The maximum conduction velocity of the motor fibers occurs at approximately 10 years of age and declines at about 50 years, according to their results. These investigators calculated that the small change in conduction velocity in the elderly only accounts for approximately 4% of the reductions in speed of voluntary actions.

Wayner and Emmers (1958) obtained similar results when they examined rat motor-conduction velocity.

## Biological Influences on Reaction Time--
## Central Nervous System

The central nervous system appears to play a large role in the changes that occur in elderly individuals' reaction times. The involvement of the central nervous system in reaction time is typically studied by electroencephalography (EEG). In these studies the basic tenet is that oscillations in the EEG, particularly in the alpha rhythm, correlate with events occurring in the central nervous system, called event-related potentials (ERPs) (Surwillow, 1968). According to Welford (1980), Hans Kornhuber and Luder Deeck were the first to record event-related potentials. In 1963, they were examining changes in brain signal voltage. Kornhuber and Deeck asked their subjects to flex certain muscles during specific intervals. They found that bursts or spikes in the voltage caused by neurological activity, occurred prior to any physical movements by their subjects. This activity occurred approximately 800 msec before any overt movement. Presently, these ERPs are assumed to reflect the relative times required by the brain to evaluate different stimuli involved in decision-making tasks (Ford et al., 1982). When reaction time, the time between presentation of a stimulus and the overt response, is compared with timing of peaks in the alpha rhythm, evoked, or event-related potentials, the occurrence of the potentials and the response are practically simultaneous. The response appears to occur 1-2 msec before the evoked potential. By comparing reaction times with evoked potentials in elderly and younger subjects, reasons for differences in reaction times have been formulated. The EEGs of people 65 years and over have lower evoked potentials and longer periods of time between them, suggesting longer reaction times, than younger subjects. While individuals under 65 have peaks occurring at an average of 12 cps, those over 65 have an average of 8 cps (see Figure 1.) These slower alpha rhythms are associated with increased reaction time. Ford and Pfefferbaum (1980) found that the evoked potentials typically occurred 80 msec later in people over 70 than in individuals 20-30 years of age. It has been postulated that transmission in the central nervous system is reduced or slowed by cell death and age changes in the physiological properties of nerve cells and fibers (Poon, 1980). The specific nature of these changes has yet to be discovered and can only be inferred. Although the occurrence of ERPs correlates with the response, this does not demonstrate a causal relation between the two.

## Types of Reaction Time Experiments

The physiological studies previously mentioned involved all types of reaction time data and no distinction was made between the two different types of reaction time procedures. This is because any physiological differences that may exist between these two types are not clear as yet. There are, however, two separate types of reaction time experiments existing in the psychological and sociological literature. They can be described in terms of their different response requirements

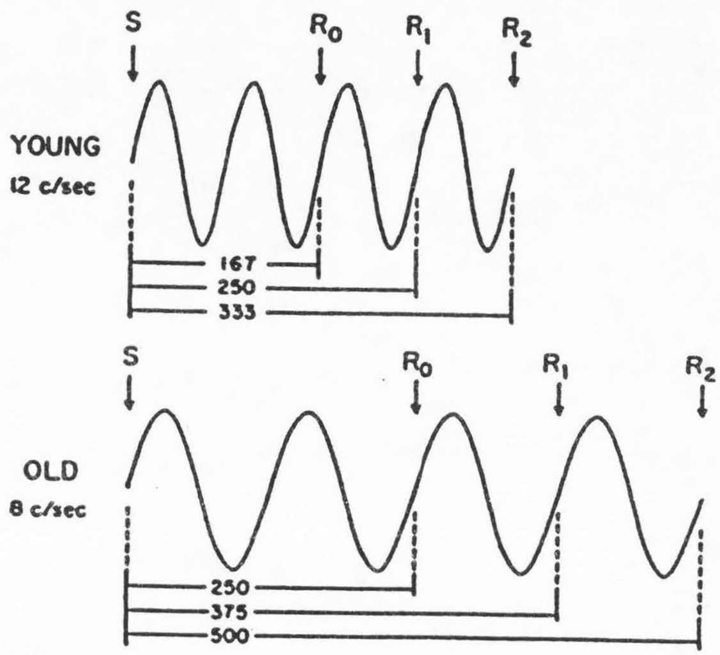



Figure 1. Comparison of EEGs and reaction times of two hypothetical Ss, one a young adult with an alpha rhythm of 12 cps and the other an elderly person with an alpha rhythm of 8 cps. S indicates the time of presentation of a stimulus; R0 is the response in a simple RT experiment; R1 and R2 are the responses under the conditions of 1.00 and 2.00 bits of stimulus information, respectively. Numbers below the waves are hypothetical RTs in millisecond (Surwillow, 1968).

as either simple or disjunctive. Simple reaction time experiments involve the presentation of only one stimulus and there is one response possible. In these studies, subjects are asked to respond as fast as they can after a stimulus is presented. For example, subjects are told to press the key when a light appears. No choice is involved because there is only one response alternative that is valid, and they must respond to every stimulus. Disjunctive reaction time, on the other hand, involves a choice between two or more response alternatives. This type of experiment may be designed in one of two ways. A "disjunctive type one" experiment involves two or more different stimuli and each stimulus or stimulus pair requires a particular response. For example, subjects are told to press the white key when a circle appears and press the green key when a triangle appears. Only circles and triangles are presented. Therefore, there is more than one response alternative and a response must be made to every stimulus presentation. A "no response" response is invalid.

In a "disjunctive type two" experiment, several different stimuli are used but the subject must respond only to certain target stimuli and not to the rest. The subject can choose to respond or not respond to each stimulus presentation. These are the only two choices available to the subject. For example, subjects are told that many different stimuli will appear but only press the key when a square appears. The disjunctive reaction time studies are therefore differentiated from the simple reaction time studies by the fact that a choice must be made between response alternatives. In disjunctive reaction time studies, not only is the subject required to detect a certain stimulus, but must also choose a certain response and then respond. In simple reaction time studies, only perception of the occurrence of a stimulus is required, followed by a response. No choice, as such, needs to be made between response alternatives (Birren & Schaie, 1977).

## Reaction Time and Response Errors

In conjunction with absolute reaction time, the number of response errors is also typically monitored when studying decision making. Number of errors is examined in order to determine if subjects simply "guessed" at responses so as to have a shorter reaction time, or, in fact, attempted to make the correct response. This question allows for the investigation of the presence of any relationship between reaction time and error frequency. According to some research, the number of errors typically decreases as reaction time decreases (Vickers, 1980; Birren & Schaie, 1977). However, Welford (1980) found that the number of errors actually increased as a function of decreasing reaction time. Welford suggested that the increase in errors was due to the subjects' attempts to respond more rapidly. Subjects may not pause long enough prior to responding to determine whether a decision is correct.

## Reaction Time in the Elderly

The time required to react in a situation in which many different stimuli are presented and several response alternatives are available, involves four processes. These include: a) stimulus reception by a sensory organ and transmission of the signal to the central nervous system, b) "translation" of the signal in the central nervous system, c) processing of the input and response alternatives, d) initiating the overt response (Welford, 1980). In the elderly population it appears that the reduction of reaction time with age is involved with the first two stages of this process.

It is now widely accepted that changes in reaction time across the life span are due to central, rather than peripheral mechanisms (Welford, 1980). Changes in the sensory organs, muscle activation, and slowing of speed of nerve conduction account for only a small portion of the total reaction time (Ford & Pfefferbaum, 1980). Also, changes in reaction time with age do not seem to be motivational as Botwinick, Brinley, and Robbins (1959) demonstrated. These investigators gave electric shocks for slow reactions in order to punish subjects who responded slowly. Older subjects did shorten their reaction times but their times were still longer than those of younger subjects. Finally, it has been hypothesized that older people sacrifice speed for accuracy (Salthouse & Somberg, 1982), however, the slowing is too great to be explained entirely in terms of accuracy.

Welford (1980) has suggested that slowing of reaction time with age may be attributed to a reduction in signal-to-noise ratio in the central nervous system. The deficits seen in elderly individuals' sensory modalities lead to weaker signals sent to the brain upon stimulus presentation. These weaker signals, combined with the death of brain cells that naturally occurs with aging (Kandel & Schwartz, 1985), and other factors such as decreased cerebral blood flow, lead to difficulty in transmitting the sensory signals. Cell death and decreased cerebral blood flow also lead to increased noise, as Welford terms it, such that once the signals are transmitted, the aged individual's central nervous system has more difficulty processing them. Thus, the lowering of the signal-to-noise ratio results in an increase in reaction time in elderly individuals. It has also been suggested by Birren and Schaie (1977), that the subject may continue processing a response even after the overt response has been made, a sort of aftereffect. This continued processing may act as noise that blurs any further decision making that might be required. Therefore, it appears that processing of sensory signals in the central nervous system might be the cause of the lengthening of reaction time with age.

Several factors appear to be involved with the increase in reaction time occurring in elderly subjects including: the duration of the stimulus (O'Conner, 1980a; Welford & Birren, 1965), the complexity of the stimulus (Salthouse & Somberg, 1982; Spencer, Williams, & Oldfield-Box, 1974; Birren, 1964), the salience of the stimulus (Poon & Fozard, 1978), the response required (Nebes, 1978; Birren & Botwinick, 1955), and the number of response alternatives available (Birren & Schaie, 1977). As the period of time that the stimulus is presented or the salience of the stimulus (i.e. color, pitch, etc.) decreases, reaction time increases in the elderly. Reaction time will also increase as the complexity of the stimulus, or the number of available responses increases. The type of response required (i.e., vocal, manual, etc.) may increase or decrease reaction time depending on the response. Thus, it may be inferred that changes in reaction time and due to the alterations in the central nervous system of elderly individuals. This, however, is speculative.

Intelligence and Reaction Time

Welford and Birren (1969) have suggested that most intellectual functioning requires decision making and that since reaction time is presumed to indirectly measure decision making, then it must also be a measure of some aspects of intelligence. Increased reaction time, according to these experimenters, is negatively correlated with intellectual functioning as measured by the intelligence quotient (IQ). This is demonstrated in Jensen's work (e.g., Carlsen, Jensen, & Widman, 1983; Jensen & Munro, 1979). Jensen (1980) found reaction time to be highly correlated with IQ in school age children.

Since it has been found that elderly individuals have increasingly longer reaction times, it is assumed that mental abilities, defined as IQ, decrease with age. In fact, elderly individuals often do have lower IQ scores on assessment instruments such as the WAIS-R (Birren, Woods, & Williams, 1980; Hendrickson, Levy, & Post, 1979; Hoyer, Labouvie, & Baltes, 1973). However, the WAIS-R, which is the most frequently used evaluation tool for measuring IQ in the elderly, requires a great deal of speed and manual dexterity on 50% of its subtests. Sprott (1980) found that the changes occurring in aging individuals' IQ scores were on those subtests requiring speed and dexterity. Changes in IQ are, therefore, apparently due to the poorer performance of older individuals on the speed/dexterity scales. Sprott did not include data on subjects over 65 years of age but it is suspected that further decrements occur. Only slight decreases occur on two of the verbal scales, and they are not as marked as the differences occurring on the performance scales. Elderly individuals typically exhibit decreased reaction time and dexterity, due to arthritis, Parkinson's disease, and other clearly diagnosed physiological problems. These are obvious reasons for elderly individuals' poor performance on timed tests requiring fine motor movements.

An intervention that decreases reaction time would do one of two things. It would either improve motor performance, or it would improve central nervous system processing. At this point, it is of no consequence whether peripheral or central skills would be improved because such an inference cannot yet be proven. Higher IQ scores should result from improved performance on tasks requiring either motor skills or cognitive skills (e.g., verbal skills, etc.) where speed of central processing is required. If cognitive or motor skills are improved by decreasing reaction time, then IQ scores should increase for those elderly who decrease their times. All that can be stated, at this point, is that a negative correlation exists between reaction time and IQ. The correlation between the two does not, however, indicate causation.

## Practice and Reaction Time

There is some evidence that reaction time will decrease with practice (Hoyer et al., 1973; Murrell & Griew, 1965; Nobel, Baker, &

Jones, 1964). Murrell and Griew (1965) found that their elderly subjects decreased reaction time significantly after practicing for 300 trials. Ford and Pfefferbaum (1980) found that not only did reaction time decrease with practice, but the differences between the evoked potentials of the elderly and the college students disappeared. Potash and Jones (1977) allowed their subjects a total of 40 trials in which to practice in their signal detection experiment. They found no differences in reaction times between the elderly subjects and college students. This finding may have resulted from practice. This task, however, was a type two disjunctive reaction time experiment. It did not require a response for each stimulus, only a response to certain target stimuli. Practice on a task like this may yield different results than a type one disjunctive reaction time task because of the different response requirements of the tasks. While not responding is an alternative available in the disjunctive type two task, a disjunctive type one task requires that a response be made to every stimulus presented. Such a response requirement may facilitate changes in reaction time. The one group of investigators that examined the effects of practice on a "same-different" decision-making task of a disjunctive type one design, did not examine reaction time. However, the results of the study indicated that a decrease in errors occurred for both college students and elderly individuals (Ball & Sekuler, 1986).

Overall, there is little research using disjunctive type one procedures in reaction time experiments. The single experiment that was similar to a type one disjunctive experiment did not examine reaction time. This particular type of research is important because a situation in which a response is required for each problem (or stimulus presentation), more closely approximates actual daily decision making where several choices are available and some response is required. Also, few investigators have examined the effects of practice on reaction time. Those that examined reaction time (e.g., Hoyer et al, 1973; Murrell & Griew, 1965) found decreases with practice. It is useful to verify whether reaction time decreases with practice because this would indicate that deficits in the aged can be reversed. This may mean that other aspects (e.g., motor skills), previously thought irreversible, can also be altered. It has been shown that a correlation exists between physical exercise and improved performance on cognitive tasks in the elderly (Jones, 1959). It is suggested here that practicing reaction time tasks might, as in the case of performing physical tasks, effect other skills of elderly individuals. For example, this type of practice may effect the reaction time of elderly when responding to a dangerous situation such as falling (Birren, 1964), or in terms of obtaining necessary aid (Amato & Bradshaw, 1985; Calhoun & Hutchison, 1981). Also, since many portions of intelligence tests are timed (i.e., Wechsler Adult Intelligence Scales - Revised, 1974), practicing reaction time tasks may lead to better performance, as demonstrated by higher IQs, on these tests.

## Sensory Modalities and Reaction Time

An important factor in decision making is the modality or modalities through which stimuli are received. As previously mentioned, Davis (1957) computed that auditory stimuli are processed more rapidly than visual stimuli. It was also stated that elderly people take a longer period of time to process incoming stimuli. Therefore, if stimuli are simultaneously presented across sensory modalities (i.e., both visually and auditorily), it may take more trials for elderly individuals to decrease their reaction times than on a task in which stimuli are presented in only one modality. Reaction times may increase with the number of modalities being stimulated simultaneously. Such a multimodality possibility has not been examined as far as this author can determine. Some experimenters have compared reaction times involving a particular sensory modality with tasks involving a different modality (e.g., Craik, 1969; Murdock & Walker, 1969). However, a task involving more than one sensory modality simultaneously has not been reported. It is important to determine whether additional sensory stimuli increase reaction time and whether there is some way of teaching elderly individuals to cope with multiple stimuli. As Birren (1964) has suggested, the number of accidents involving the elderly may be due to their inability to process incoming multisensory stimuli quickly enough. Therefore, they fail to make a response before an accident occurs. It may be possible to demonstrate that some intervention (i.e., practicing a cross-modality task) can reduce reaction time, thereby improving the ability of the elderly to cope with a variety of incoming stimuli.

## Practicing Reaction Time and the Effects on Other Tasks

Finally, the generalization of the effects of practicing one reaction time task on another task has received little attention. While some experimenters have compared reaction time from one modality to another (Craik, 1969; Murdock & Walker, 1969), or reaction times using various responses (Birren & Botwinick, 1955; Nebes, 1978), there is a lack of data on whether decreased reaction time on one type of task will result in a decrease in reaction time on other tasks. This absence of data in the literature leaves unresearched the question of whether an intervention, such as practicing with one decision-making task, will effect reaction time on a different type of decision-making task. This is important because such a study would show the generalization of the effects of a rather simplistic intervention, such as practicing decision-making tasks, on other reaction-time tasks. If practicing one task reduces reaction time not only on that task, but on other decision-making tasks as well, then each separate type of task need not be practiced. A decrease in the time required to respond to incoming stimuli could occur by practicing one task. Reducing reaction time is of particular importance because of its relation to job performance, and to responding in dangerous situations. Murrell and Forsaith (1960) found that industrial workers aged 50 and over were slower than younger workers, not due to the speed of the movements, but (apparently) because of the time required to plan and decide what actions to take. King

(1955) found that agricultural accidents increase in frequency with age. Such increases in accidents can be explained in terms of slowness to respond in dangerous environments. McFarland, Tune, and Welford (1964) also found that older individuals' slowness, or lack of responding, led to an increase in traffic accidents and violations with age.

## Further Research

Overall, few investigators have used a disjunctive type one procedure to examine reaction time in the elderly. Disjunctive type one studies that have investigated the effects of practice on reaction time in the elderly are virtually nonexistent. This is of interest because it may indicate that skills previously believed to be irreversibly lost in the elderly due to the aging process, can in fact be altered. Researchers have found that practicing certain types of tasks, for example, simple reaction time tasks, lead to decrements in reaction time (e.g., Potash & Jones, 1977). However, a cross modality study has not been completed with elderly subjects and there is an absence of literature on whether decreased reaction times on one task will lead to decreased reaction times on other tasks. This indicates a need for research involving practice and/or a cross-modality task. The reaction times on these tasks could then be compared to reaction times on a different type of task so as to examine generalization of reaction time performance. Finally, clear and measurable definitions of decision making are infrequent in the literature. Clearly-defined and measurable events (e.g., length of time, response) are necessary in decision-making research. Finally, the performance of research that does not utilize inferences regarding biological or cognitive processes is necessary.

If it can be demonstrated that a cross-modal task leads to a reduction in reaction time significantly better than a single modality task, then any intervention attempting to lower reaction time in the elderly should involve a cross-modal task. If it can also be shown that practicing one reaction time task does significantly effect performance on a completely different type of task, then practicing a reaction time task daily may effect the rapidity with which a decision is made in areas other than the one practiced. This would be extremely useful information for those individuals interested in creating interventions for the elderly population.

## Purpose of this Research

The preceding review of the literature indicates that while reaction time in the elderly has been examined previously to some extent, it has not been explored in a cross-modality experiment. Furthermore, few researchers have reported the effects of practice on elderly individuals' reaction times. The generalization of one decision-making task to another is a third area that has not been researched with elderly subjects. The term "elderly", which often is not clearly defined in the literature, was defined in this research as subjects 70-80 years old that have no gross physical or mental disabilities (e.g., Alzheimer's). Also, definitions that describe decision making in measurable and observable terms were used in this study, something that many previous studies lack. The goal of this research was to investigate some of those areas presently missing from the literature.

Therefore, one purpose of this research was to determine if reaction times and error rates could be changed in elderly individuals after they practiced a visual, auditory, or cross-modality disjunctive type one reaction time procedure (decision-making task). Furthermore, this study also investigated whether the type of task practiced (i.e., visual, auditory, or cross modal) would significantly affect reaction time or error rate on the practiced task. This study was designed to determine if any changes occurring in reaction times due to practicing one task would lead to changes in reaction time on another type of decision-making task. The type of task practiced was examined in terms of whether it would significantly affect reaction time and error rate on the unpracticed task (a multiple-choice test).

It was predicted that mean reaction time and error rate for each of the groups would decrease (even slightly) across sessions (Ball & Sekuler, 1986; Murrell, & Griew, 1965; Welford & Birren, 1969). It was also predicted that reaction times would differ between groups, based on the type of stimuli presented, but that error rate would be approximately equal across groups. It was assumed that all groups, other than comparison, would have a significantly lower mean reaction time and error rate on the posttest, than they did on the pretest (Hoyer et al., 1973; Murrell & Griew, 1965; Nobel et al., 1964). It was predicted that the cross-modality group would show a greater change in mean reaction time from pretest to posttest than any of the other groups. This was assumed because the multiple-choice test required subjects to choose from four different response alternatives, which was a more complex task than the practiced task that involved only two response alternatives. The cross-modality group was required to practice a task involving a decision that had to be made on the basis of stimuli presented to two separate sense modalities (visual and auditory). One word of a simultaneously presented word pair was presented auditorily while the other word of the pair was presented visually. The other groups' responses were based on stimuli presented to only one sense modality, either visual or auditory. Therefore, the cross-modality task appeared to be more complex than the other, visual or auditory stimuli-only tasks, because it required a response to be made based on two different types of sensory stimuli. This suggested that practicing the cross-modality task would lead to decreased reaction times on this task and possibly other complex tasks (i.e., multiple-choice test). The simpler practice tasks (i.e., all visual or auditory) were not expected to affect reaction times on the complex task (i.e., the multiple-choice test). The visual group, it was expected, would have the second greatest change in mean reaction time from pretest to posttest compared to the auditory or the comparison groups. This was assumed only because the visual group practiced with all visual stimuli, and the multiple-choice test was all visual. Therefore, their reaction time performance was expected to generalize better than the auditory group's because the tasks were somewhat similar (Potash & Jones, 1977; Cooper & Shepard, 1973). The comparison group, it was assumed, would not have practiced decreasing their reaction time and therefore, any pretest to posttest changes that occurred would be attributed to spending time using the computer. It was presumed that all groups would have approximately the same error rates on their posttests. However, all groups' error rates on their posttests were expected to be lower than error rates on their pretests (Surwillow, 1968).

# CHAPTER III

# EXPERIMENT

## Introduction to the Research

In this research, subjects without gross physical or mental disabilities (e.g., blindness, Alzheimer's) were asked to volunteer. The subjects were given an informal visual and auditory screening to determine that they could read stimuli presented on a computer screen and repeat stimuli played on a tape player. Subjects completed a 20-question multiple-choice pretest in which questions were presented visually on a computer monitor. The subjects were asked to select the correct answer, by pressing a key, as quickly as possible. Next, the subjects were randomly assigned to one of four treatment groups. This random assignment reduced the probability that intergroup differences would significantly affect the results, thus increasing the internal validity of the study (Welkowitz, Ewen & Cohen, 1982).

The treatment conditions consisted of one of four tasks, depending on the treatment group, each requiring 10, 15 min sessions (see Table 1). Subjects in treatment Group 1 performed a practice task involving the presentation of both auditory and visual stimuli simultaneously (Cross Modality); Group 2 received only auditory stimuli; Group 3 visual stimuli only; and Group 4, the comparison group, received visual stimuli but were not required or instructed to practice decreasing reaction time. Subjects in each group, except the comparison, were asked to respond as quickly as possible to the stimuli presented.

Table 1

Conditions in the Four Treatment Groups

| | PRETEST | INTERVENTION | POSTTEST |
|---|---|---|---|
| GROUP 1 | MULT CHOICE | CROSS-MODAL STIMULI | MULT CHOICE |
| GROUP 2 | MULT CHOICE | AUDITORY STIMULI | MULT CHOICE |
| GROUP 3 | MULT CHOICE | VISUAL STIMULI | MULT CHOICE |
| GROUP 4 | MULT CHOICE | COMPARISON | MULT CHOICE |

Stimuli consisted of words presented in pairs. Subjects pressed one key if the two words were the same, and the other key if the two words were different. After the 10 treatment (practice) sessions, subjects were administered a multiple-choice posttest. In all phases (i.e.,the pretest, treatment, and posttest), for each stimulus presentation (trial), the reaction time and response (error rate) were recorded for each subject.

The data of particular interest included the mean intergroup differences in change between pretest and posttest scores on the multiple-choice test, the change in reaction time, and error rate, across sessions in each group. These data were used to determine if there were significant differences between treatment groups, and which treatment was most effective in decreasing reaction times and errors. The data were also used to indicate which treatment decreased reaction time and errors not only on the practiced task but on the different task (the multiple-choice test) as well.

In the cross-modality group, stimuli were presented via two separate sensory modalities, auditory and visual, because this has not been previously reported, and because stimuli encountered in the environment typically involve more than one modality. Visual and auditory stimuli were used because they are the types of stimuli most frequently used in reaction time experiments and those most often encountered in the environment (e.g., Proctor, 1978; Warren, Wagener, & Herman, 1978; Waugh, 1985). A multiple-choice test, the unpracticed task, was used to determine generalization of the effects of practicing a reaction time task on an unpracticed reaction time task where several choices were available to the subject. The multiple-choice test was used because typically, in most life decisions several choices are available.

## Method

### Subjects

Subjects between the ages of 70 and 80 were recruited from a local senior citizens' center and retirement housing complex. Subjects were recruited after the experimenter made a short presentation in the seniors' center and in a classroom at the local university. The presentation covered the potential benefits of performing this research, and a short explanation of what the study entailed. Subjects were asked to participate on a voluntary basis. Money was not offered; however, at the end of 10 sessions a drawing was held and the subject whose ID number was chosen won dinner for two at a local restaurant. Participation in the drawing was contingent upon the subject finishing 10 sessions. Subjects signed a consent form and completed a health questionnaire prior to participating in the study (see Appendix A).

Twenty male and twenty female subjects ranging in age from 70 years 1 month to 80 years 4 months were used. Subjects, by self report, had not been diagnosed as having any type of debilitating disease (e.g., AIDS, Alzheimer's disease, Parkinson's disease), nor did they have severe auditory or visual deficits (e.g., legally blind with eyeglasses, or profoundly deaf with hearing aids) as noted in the health questionnaire (see Appendix A). Any mild to moderate auditory or vision deficiencies were corrected by glasses or hearing aids that were worn during all screening/testing sessions. During the screening procedure, subjects were observed to determine whether they appeared to have difficulties in meeting the demands of this study. For example, severe tremors in the arms and hands were observed to determine whether the subject would have difficulty in pressing the operandum. Subjects were excused from participation if they did not meet any of the requirements (complete demographics are shown in Table 2). Subjects who did not qualify were told that no other subjects were required.

The 40 selected subjects were randomly assigned to one of four groups such that there were 5 men, and 5 women (10 individuals) in each group. The groups consisted of: 1) a cross-modality (auditory and visual stimuli) group; 2) an all auditory stimuli group; 3) an all visual stimuli group; and 4) a comparison group.

Table 2

Demographics of Subjects at the Time of Research Participation

| AGE | NUMBER OF SUBJECTS | NUMBER OF SUBJECTS WITH: ARTHRITIS | HEARING AIDS | GLASSES |
|---|---|---|---|---|
| 70-71 | 9 | 5 | 3 | 8 |
| 72-73 | 6 | 4 | 2 | 6 |
| 74-75 | 10 | 7 | 5 | 9 |
| 76-77 | 7 | 6 | 5 | 6 |
| 78-79 | 7 | 6 | 4 | 7 |
| 80 | 1 | 1 | 0 | 1 |

| LEVEL OF EDUCATION | NUMBER OF SUBJECTS |
|---|---|
| DOCTORATE | 4 |
| MASTERS | 3 |
| B.A. / B.S. | 12 |
| 1-3 YEARS COLLEGE | 5 |
| HIGH SCHOOL DIPLOMA | 9 |
| LESS THAN 12TH GRADE | 5 |
| OTHER DEGREE (E.G., TECHNICAL SCHOOL) | 2 |

Apparatus

The apparatus consisted of a Commodore 64 computer keyboard with a 9" black and white Samsung television monitor, a cassette tape player with a monaural speaker, 5 prerecorded cassette tapes for the auditory group and 5 for the cross-modal group, one for each day of the week (Monday through Friday) for each group. A wooden mask was placed over the computer keyboard so that only four keys were available for the multiple-choice test, and only two keys for the same-different practice task. On the multiple-choice task of the study, the four keys were evenly spaced across the keyboard mask and labelled "one", "two", "three", and "four" so that they could be easily identified. On the same-different task, the keys were on opposite ends of the keyboard, one on the extreme left and one on the extreme right. These keys were labelled "same" and "different". Data were recorded on 5 1/4" floppy discs with a 1541C disk drive. The resolution of the computer utilized, the Commodore 64, was .0166 seconds. Data were computer analyzed for each individual, trial by trial, following each session.

The apparatus was kept at a convenient central, but quiet, meeting area. These areas consisted of a room on the main floor of the senior citizens' center, a room at the local university, and in a centrally located apartment of one of the subjects in a housing complex. The rooms were typically free of distractions.

Procedure

Screening. Initially, each volunteer was evaluated in order to determine that s/he could rapidly and easily read stimuli presented on the television monitor screen. Twenty words were presented on the screen and the subject was asked to read each word aloud as soon as it appeared. Subjects were similarly tested with the tape player in order to determine hearing ability. Subjects were asked to repeat each of the 20 words as they were presented. If subjects did not pass this screening, they were excused from further participation. In this particular study, only one subject was excused from participation because she experienced great difficulty reading the words on the computer screen. She stated that the words on the screen made her dizzy and that they were too blurred to read. Participating subjects were then randomly assigned to one of four groups. Random assignment was performed by assigning numbers to each of the four groups as follows: 1=cross-modal, 2=auditory, 3=visual, and 4=comparison. Each subject that met the criteria for participation was placed into group 1, 2, 3, or 4 based on the number appearing on a random digits table (Glass & Hopkins, 1984). For example, if John Doe met the participation criteria, the first number appearing on the random digit table that was a 1, 2, 3, or 4 resulted in Mr. Doe being placed in that group. Therefore, if a 3 appeared on the table, Mr. Doe would be placed in the visual stimuli group. The subject participating after Mr. Doe would be placed in one of the four treatment groups based on the next number in the random digit table.

Pretest. The 40 subjects utilized in the study were given a 20 item multiple-choice test that was presented one item at a time on the computer. This was done in order to determine pre-training reaction time and error rate. Reaction time on the multiple choice-test was measured from the time the multiple-choice answers were presented on the television screen to the time an answer key selection was depressed. Answers were brought up by the subject pressing a key on the computer after the question had been presented. The times and choices were saved to disk by the computer. Each group's and individual's mean reaction times and error rates were calculated and compared with post-treatment measures on the posttest multiple-choice test, given at the end of 10 sessions (12 calendar days because subjects had weekends off), to determine the effects of the treatment. The 20 questions for the pretests and posttests were randomly drawn, by computer, from a pool of 40 possible questions taken from the Wechsler Adult Intelligence Test-Revised (WAIS-R), and the Wechsler Intelligence Test for Children-Revised (WISC-R). It was highly unlikely that the subjects would receive the same 20 questions for their posttest as for their pretest. Appendix B contains a complete list of the 40 questions. These questions were chosen because, based on Wechsler's (1974a,b) normative data, most English-speaking people who are approximately 16 years old or older, with average intelligence, can answer these questions. It should be noted, however, that the questions taken from the WAIS-R and the WISC-R were those found to be the "easiest" questions by the developers of these IQ tests (the first 16 questions). Questions taken from the WISC-R were drawn from the information, similarities, vocabulary, and arithmetic subtests. WAIS-R questions used in this research were from the information and vocabulary subtests. Prior to beginning the actual multiple-choice test, subjects received four "warm-up" questions so that it could be determined that the task was clearly understood by the subject.

Treatment. At the beginning of the treatment phase, subjects were given instructions. A complete verbatim protocol of these instructions is presented in Appendix C. At the beginning of a session, subjects were seated before the console and instructed to put one index finger near each of the response keys. This was stated so that subjects would likely continue to use the same strategy, that of keeping their hands near the response apparatus.

Stimuli consisted of the words for the Arabic numerals one through ten (e.g., one, two, etc.) presented in pairs at the rate of one pair every 5 seconds (Strauss, Wagman, & Quaid, 1980). These number names were used as stimuli because they are relatively short, one to two syllable words, and are familiar to most English-speaking individuals. Stimuli with these characteristics have typically been used in reaction time experiments (e.g., Elliott, Busse, & Bailet, 1985; Gilmore, Tobin, & Royer, 1985; Kline, & Orme-Rogers, 1978). It was also useful to have a restricted number of stimulus words so that reaction times to specific word pairs could be analyzed. Reaction times in the presence of certain word pairs were examined to determine whether some word pairs had significantly shorter (or longer) reaction times than other word pairs.

The way in which the words were presented, auditorily or visually, depended upon the treatment group. Subjects had to respond to each stimulus word pair by pressing one of two response keys. If the two presented words were the same, the subject was instructed to press as quickly as possible the key labeled "same", if the words presented were different, the "different" key should have been pressed. One half (50%) of the word pairs presented each day consisted of two of the same word (e.g., "one"-"one") so that no less than .50 of the responses in a day were "same". One half of the word pairs were "different" each day such that the word pair consisted of two different words (e.g., "two"-"six"). The order in which the "same" and "different" pairs were presented was random, although each day had a pre-specified order. For example, Monday always had the first two pairs as "same", the third as "different", and so on, while on Tuesday, the first pair were "different", the second "same", etc. This procedure minimized the possibility of the subject receiving a better than chance amount of correct responses simply by consistently pressing one key or by other forms of guessing.

Key assignments were alternated so that "same" was on the right-hand key for one half of the sessions and on the left-hand key for the other one half. This procedure partially controlled for hand dominance which some researchers have suggested may effect the data (Dimond, 1970). Keys were clearly labelled "same" or "different" by printing these words in black ink and taping them above the appropriate key.

Each session consisted of three blocks of trials, 60 trials per block, for a total of 180 trials per session. The computer recorded the total correct responses on disk as well as the response "same" or "different" that the subject made, reaction time to the ninth decimal place (.000000000) for each word pair, and incorrect responses. Sessions lasted for approximately the same amount of time each day for each subject and occurred five days per week for 10 sessions. Based on previous research, 10 days of practice was expected to allow subjects enough opportunity to decrease their reaction times to a level at which little variation occurred. Murrell and Griew (1965) found that their elderly subjects decreased reaction time significantly after practicing for 300 trials in a single session. It was assumed in the present research that 180 trials per day for 10 days would lead to significant reductions in reaction time for all or most subjects.

Cross-modality group. In the cross-modality group the cassette player presented one word of the word pair at a rate of 1 word every 5 sec. The tape for the auditory presentation of the stimuli was made using a male's voice since this is generally easier for elderly individuals to perceive (Kandel & Schwartz, 1985). This is due to the fact that, as humans age, they lose the ability to hear higher frequencies, such as those of female voices (Warren et al., 1978). The computer also presented one word of the word pair visually on the monitor for approximately 1 sec., which is the approximate time it takes to say the same word, at the rate of 1 word every 5 sec. Five seconds was reported to be the optimal preparatory interval for elderly subjects in at least one previous study (O'Conner, 1980a). The auditory and visual stimuli were presented simultaneously so that one word of each pair was presented visually and the other word was presented auditorily. This was difficult to coordinate, particularly due to the wild and flutter of the tape recorder. However, the auditory and visual presentations were coordinated such that words did not occur sequentially and the auditory stimulus never proceeded or followed the visual or vice-versa. Therefore, the auditory stimulus occurred in the presence of the visual, and the visual occurred in the auditory stimulus' presence. Reaction time was measured from the time the visual-auditory pair was presented until the time the response was made on the keyboard. The word pairs were randomly drawn by the computer so that words were paired differently each session but specific word pairings existed for each day of the week such that a Monday routine existed, a Tuesday routine, etc. This should have controlled for accidental paired associate learning (Heaps, Greene, & Cheney, 1968). All groups received the same word pairs so that no group had an advantage over another group due to the number of times words were paired in a particular routine.

Auditory stimuli group. In the auditory stimuli group, the same procedures were followed as those in the cross-modality group, except that all words were presented auditorily and the television monitor screen remained blank. Five cassette tapes existed, one for each day of the week (Monday through Friday), with both words of the word pairs recorded on these tapes so that all words were presented auditorily.

Word pairs were presented at a rate of one pair every 5 seconds. The tape for the auditory presentation of the stimuli used a male's voice also (Kandel & Schwartz, 1985). If the word pair consisted of the same word repeated twice (e.g., the pair "one"-"one"), the subject should have pressed the "same" key on the computer. If the word pair consisted of two different words (e.g., "four"-"six"), then the subject should have depressed the "different" key. Reaction time was measured from the time the auditory word pair was presented (every 5 seconds) until the response was made on the keyboard.

Visual stimuli group. The procedure for the visual stimuli group was the same as that for the auditory group, however, all word pairs were presented on the computer screen. The tape player was not used. Five routines existed, one for each day of the week (Monday through Friday), so that both words in each word pair were presented visually on the television computer screen, one word above the other.

Subjects had to depress a computer key, either the "same" key or the "different" key after each word pair was presented. Word pairs were presented at a rate of one pair every 5 seconds. If the word pair consisted of two of the same word (e.g., the pair "one"-"one"), the subject was expected to press the "same" key on the computer. If the word pair consisted of two different words (e.g., "four"-"six"), then the subject was expected to depress the "different" key. Reaction time was measured from the time the visual word pair was presented until the response was made on the keyboard.

Comparison group. The comparison group was presented with the same word pairs as all other groups, however, these subjects were not allowed to respond until approximately 2 sec after the word pair was presented. The computer would not accept responses prior to printing a message on the screen stating that subjects could respond. Therefore, the subjects were forced to delay their responses for 2 sec. This procedure was not expected to provide any advantage from practicing. This was done so that all subjects in the study had an equal amount of exposure to the computer, but only three groups actually practiced lowering their reaction times. Therefore, any significant changes that may have occurred in multiple-choice test reaction times should be attributed to the various types of treatments used, not to exposure to the computer.

Subjects had to depress a computer key, either the "same" key or the "different" key, after each word pair was presented. Word pairs were presented at a rate of one pair every 5 seconds. If the word pair consisted of two of the same word (e.g., the pair "one"-"one"), the subject had to press the "same" key on the computer. If the word pair consisted of two different words (e.g., "four"-"six"), then the subject was expected to depress the "different" key. Reaction time was measured as the time from the message appearing on the screen stating that subjects may respond until the time a key was pressed on the keyboard.

Posttest. Immediately following the 10th session, all subjects took another computer-presented multiple-choice test. Again, they received four warm-up questions. Any changes in reaction times and error rates from pretest to posttest were used to determine whether practicing the decision-making task led to changes in reaction times or error rates on the multiple-choice decision-making task. Each group's changes in the means of their pretest to posttest reaction times were compared to the other groups' mean changes to determine whether significant changes occurred in the mean reaction times or error rates of any of the groups.

## Data Analysis

After each session a printout of the trial number, reaction time by trial, the words "right" or "wrong" for each trial, the cumulative number of errors, average reaction time (excluding the first ten "warm-up" trials), date, subject number, key assignment ("same" - right or left), and condition for each subject, was obtained. The average reaction time and number of errors were plotted daily in order to examine changes in error rate and reaction time.

The data of interest in this study included the mean reaction times on the pretest and the posttest multiple-choice tests and the number of errors on this test for each group. The groups were statistically compared by means of analysis of covariance (ANCOVA) in order to determine whether significant changes occurred in mean reaction time and/or mean error rate. This analysis was performed so that any differences between groups prior to the interventions could be held constant. Therefore, the treatment group was analyzed as the independent variable while pretest reaction times or errors were treated as covariates. Posttest reaction times or errors served as the dependent variables (Glass & Hopkins, 1984).

Reaction times and number of errors were obtained by the computer calculating the mean reaction time for the entire session for each individual. These individual session reaction times were then averaged to find the mean reaction time for each group. This was performed for each session. These group means were plotted daily to illustrate changes in error rate and reaction time. The mean reaction time for each group's last session was compared by a t test for correlated means to its first session to determine whether practice significantly decreased reaction time within each group (Welkowitz et al., 1982). The mean reaction time of each group for the last session was subtracted from the group's mean from the first session to determine whether a change in reaction time occurred. Any changes in reaction time were then compared using an analysis of covariance to determine whether one group's change significantly differed from any other group (Glass & Hopkins, 1984). In this way, the interventions were compared to examine effectiveness. An analysis of covariance was used because this should have statistically controlled for any differences existing between groups prior to the intervention. Therefore, the treatment group was used as the independent variable while session one reaction times and errors were treated as covariates, with session ten reaction times and errors as the dependent variables (Glass & Hopkins, 1984).

The analysis of covariance assumes a normal distribution of the data. However, since there was a possibility that the data were not normally distributed, a log (x) transformation (Glass & Hopkins, 1984) of the data was performed after the raw data had been analyzed. Each t test for correlated means and each ANCOVA was repeated on the transformed data. This analysis was performed so that even if the data were skewed, it could still be determined whether any statistically significant differences occurred.

Effect sizes (Glass & Hopkins, 1984) were also calculated for each group in order to determine any effect of the intervention even if statistical analysis was not obtained. The effect sizes would at least give an indication of the differences in the means between the groups so as to indicate whether this might be a useful line of research to pursue.

In addition, word pairs and reaction times were analyzed in a series of analyses of variance (ANOVAs) to determine any particular word pairs that may have had consistently lower or higher reaction times for each group. In making these comparisons, the longest reaction times to particular word pairs within a group were compared to the shortest reaction times to word pairs.

## Results and Discussion

Hoyer et al. (1973) and Nobel et al. (1964) have found that reaction time decreases when the subject is given a chance to practice the task. However, these studies did not involve "disjunctive type one" procedures in which a response is required for each stimulus presentation, and a choice, other than to respond or not respond, is required. Also, these studies did not use a cross-modality task group, nor did they examine the effect of practicing one task on reaction times of a different task. Furthermore, the population typically studied consists of physically and mentally impaired elderly. Therefore, many studies have only examined decision making in terms of those who make decisions for the elderly (e.g., Levkoff & Wetle, 1982). Few studies have used a nonclinical elderly population. Ball and Sekular (1986) examined the effects of practice on a "same-different" decision-making task in a nonclinical elderly population and found a decrease in errors but did not examine reaction time.

## Effects of Practice

It was anticipated that since reaction time was used as a measure of decision making that reaction time would decrease with practice, as demonstrated by others (Hoyer et al., 1973; Nobel et al., 1964). As shown in Appendix D, reaction time decreased for 33 (83%) subjects in terms of mean reaction time in session 1 compared to mean reaction time in session 10 (see Figures 2-41). There were fluctuations over the ten sessions but the trend was toward a decrease for all but 7 subjects. Figure 42 shows the mean reaction time and error rate for all 40 subjects across the 10 sessions. It is important to note that for some subjects the two day weekend break between session 5 and session 6 affected reaction time and error rate in the sixth session. This was obvious in the overall mean for 40 subjects and in individual data. Subjects 014 and 023, for example, showed an increase in both reaction time and error rate in session 6. This indicates that the daily practice was apparently necessary for maintaining low reaction times and error rates. Also, it appears that some subjects, 013 for example, attempted a different response strategy after the first few days of practice. However, the strategy utilized to respond may have led to a sudden increase in errors. The error rate again dropped off when the previously, more successful strategy was reinstituted. Figures 43-46 show the changes in mean reaction time for the ten subjects in each of the four different treatment groups across the 10 sessions.

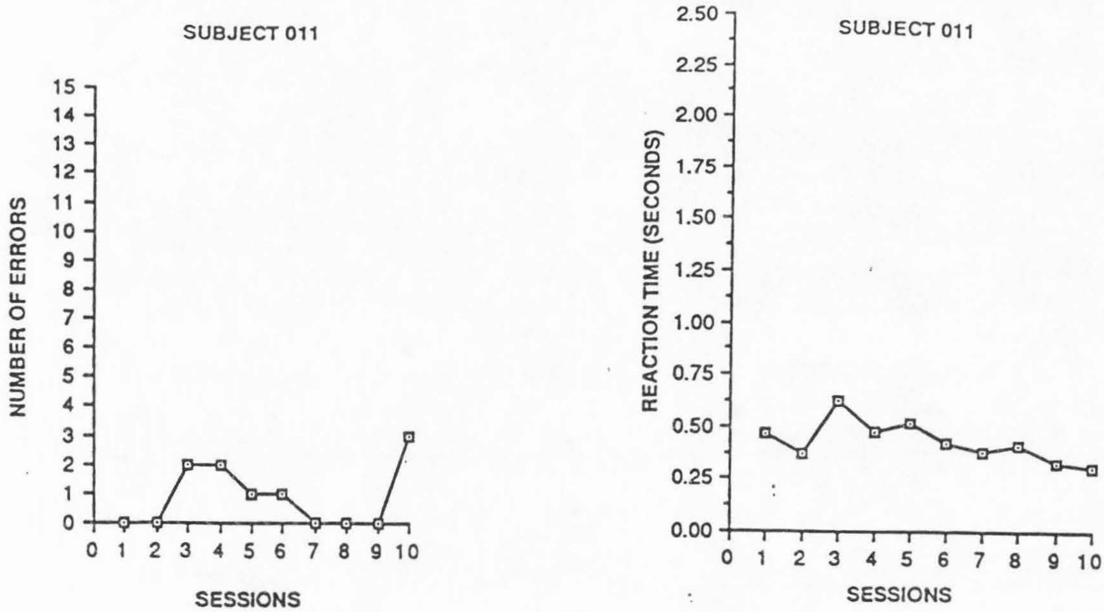



Figure 2. Subject 011: Mean reaction times and number of errors for all 10 sessions.

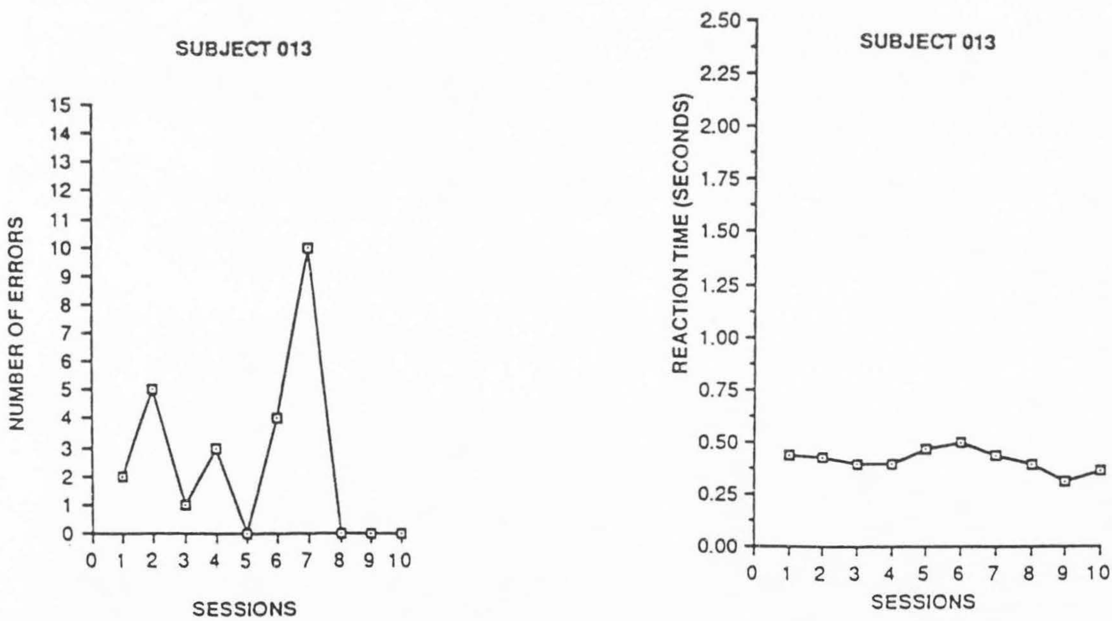



Figure 3. Subject 013: Mean reaction times and number of errors for all 10 sessions.

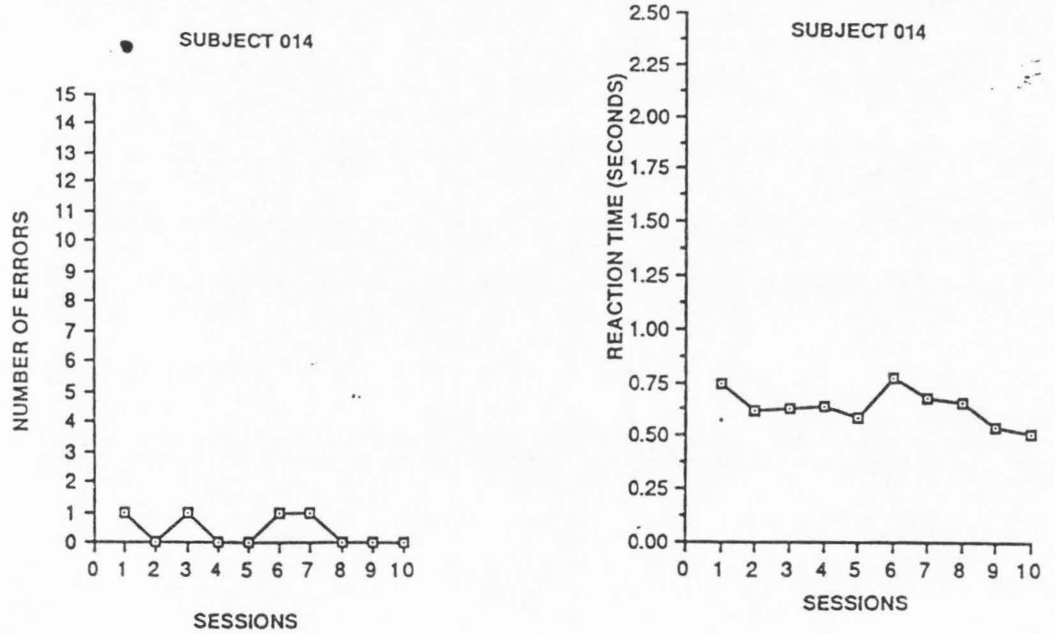



Figure 4. Subject 014: Mean reaction times and number of errors for all 10 sessions.

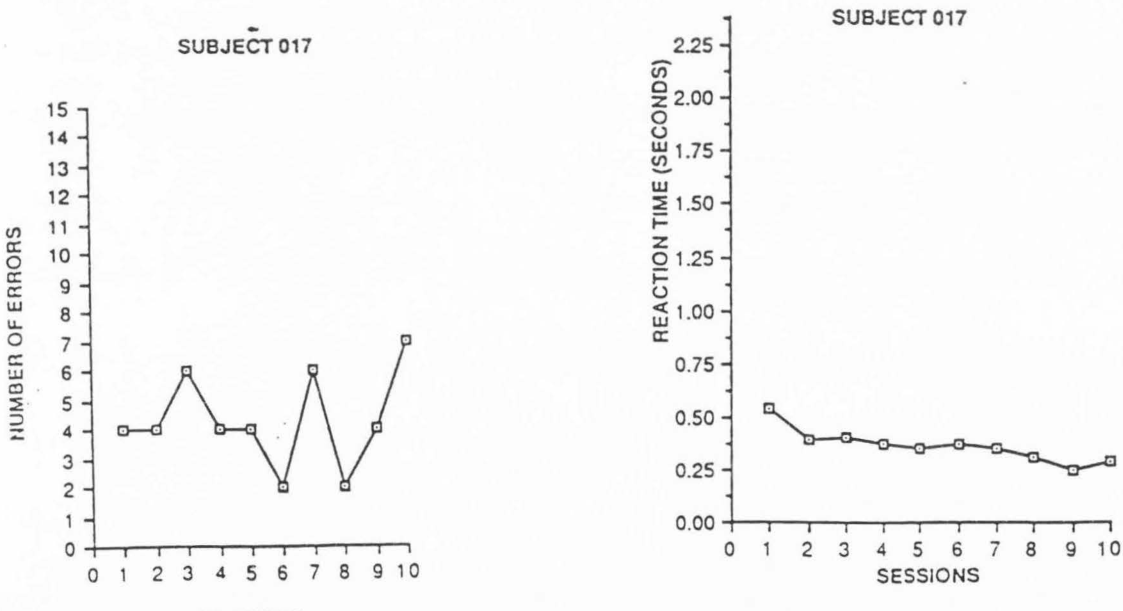



Figure 5. Subject 017: Mean reaction times and number of errors for all 10 sessions.

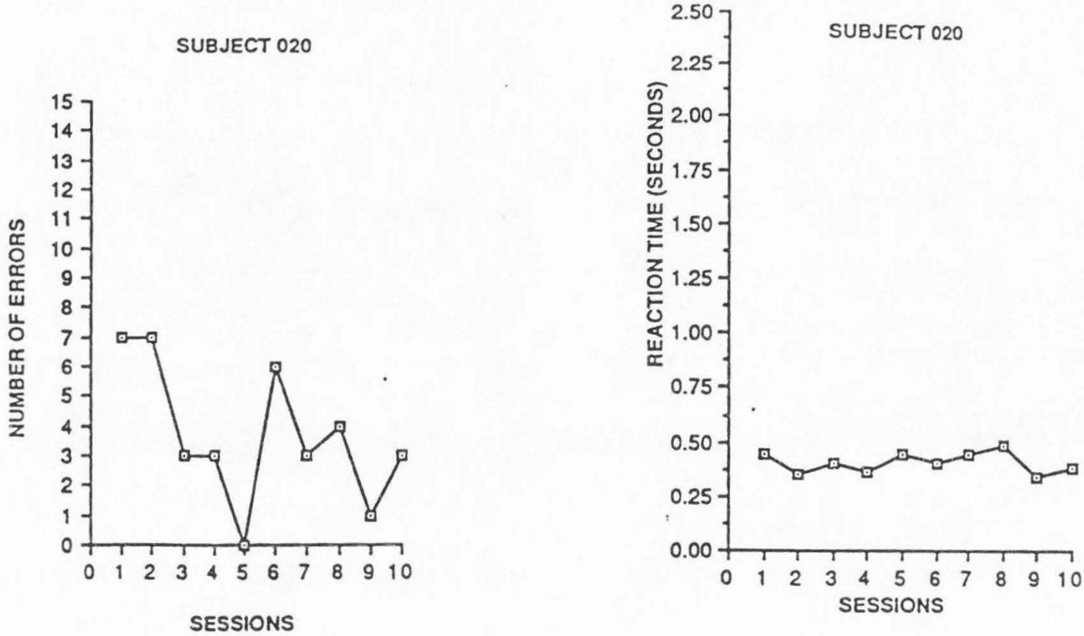



Figure 6. Subject 020: Mean reaction times and number of errors for all 10 sessions.

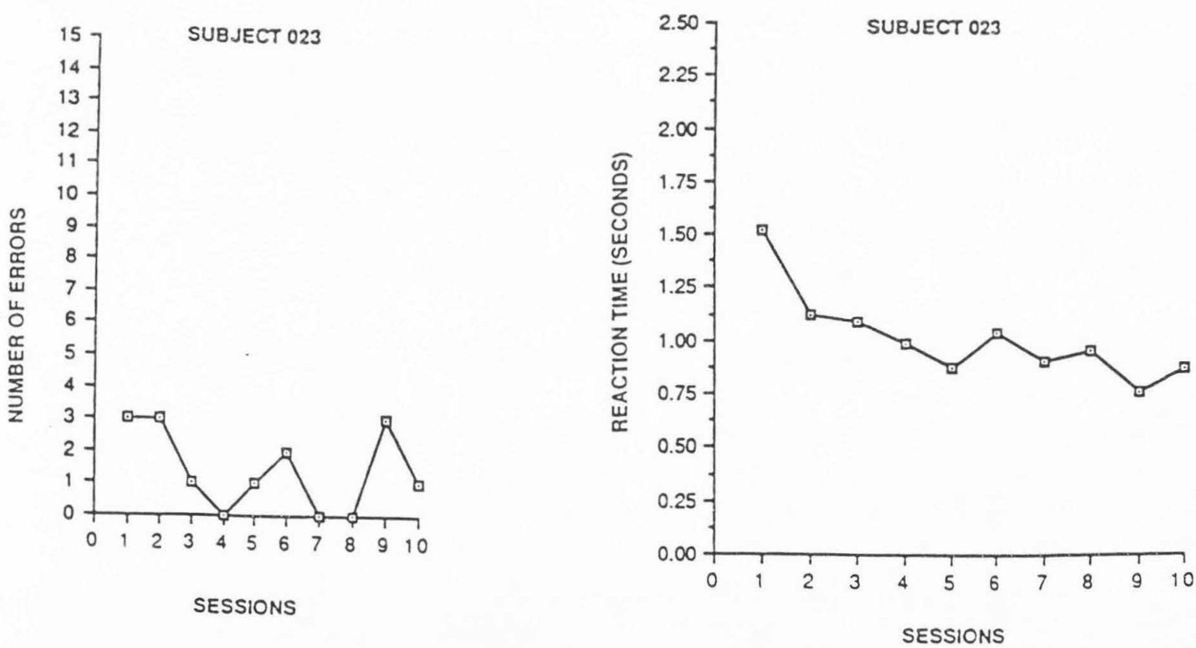



Figure 7. Subject 023: Mean reaction times and number of errors for all 10 sessions.

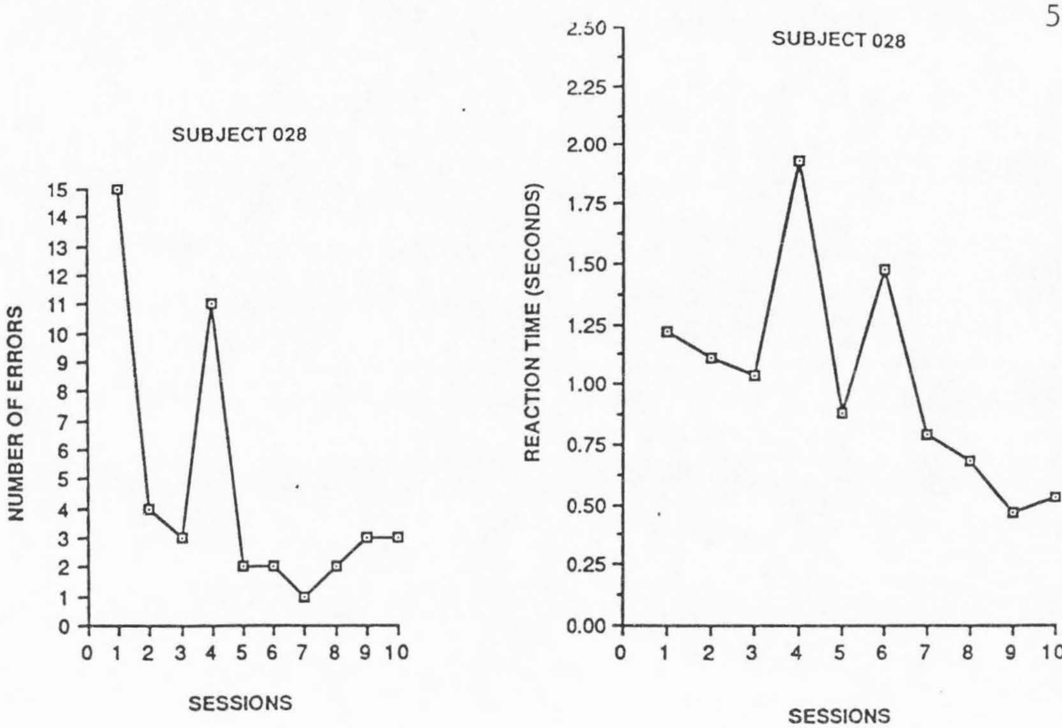



Figure 8. Subject 028: Mean reaction times and number of errors for all 10 sessions.

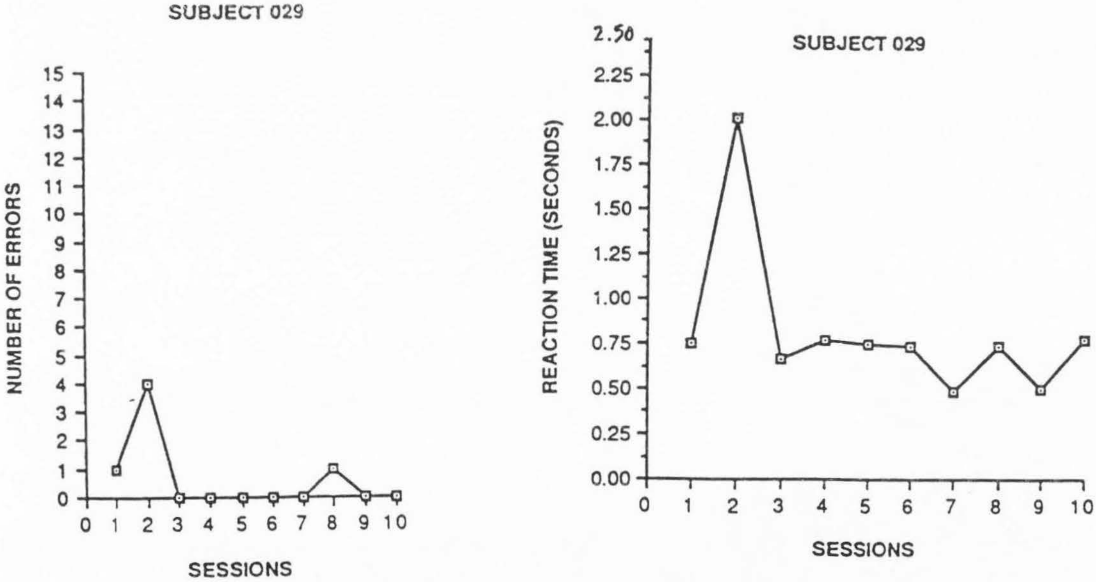



Figure 9. Subject 029: Mean reaction times and number of errors for all 10 sessions.

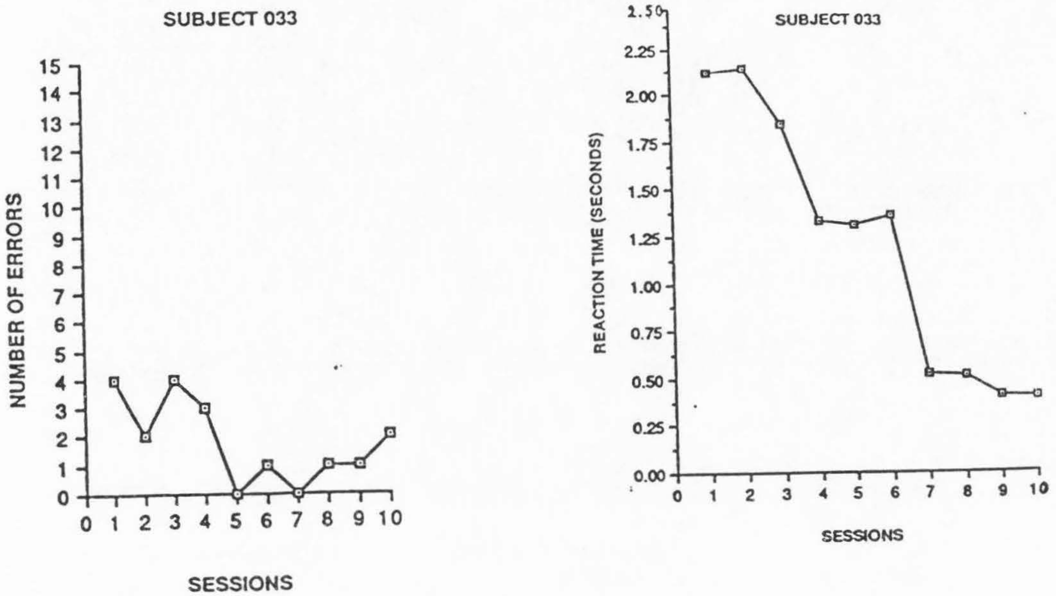



Figure 10. Subject 033: Mean reaction times and number of errors for all 10 sessions.

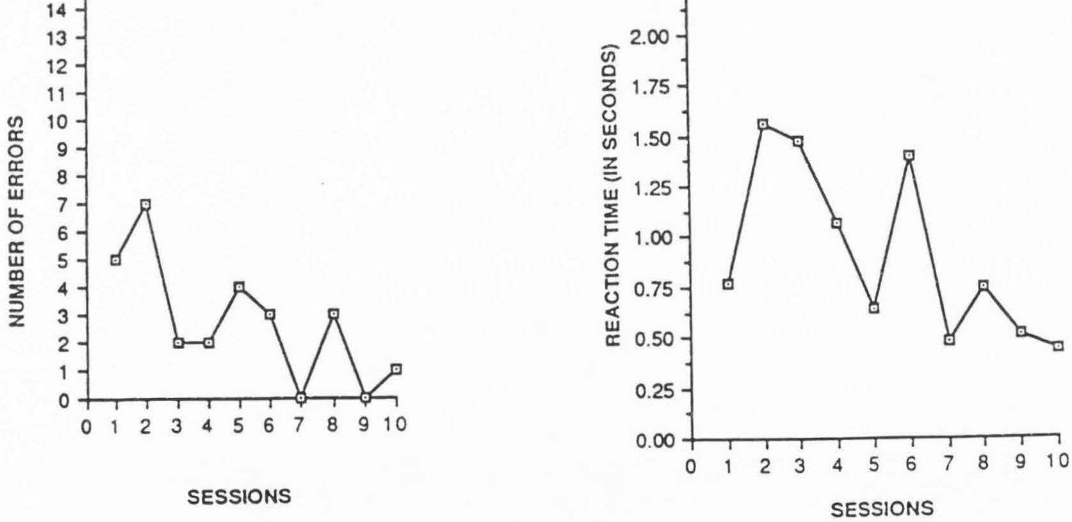



Figure 11. Subject 036: Mean reaction times and number of errors for all 10 sessions.

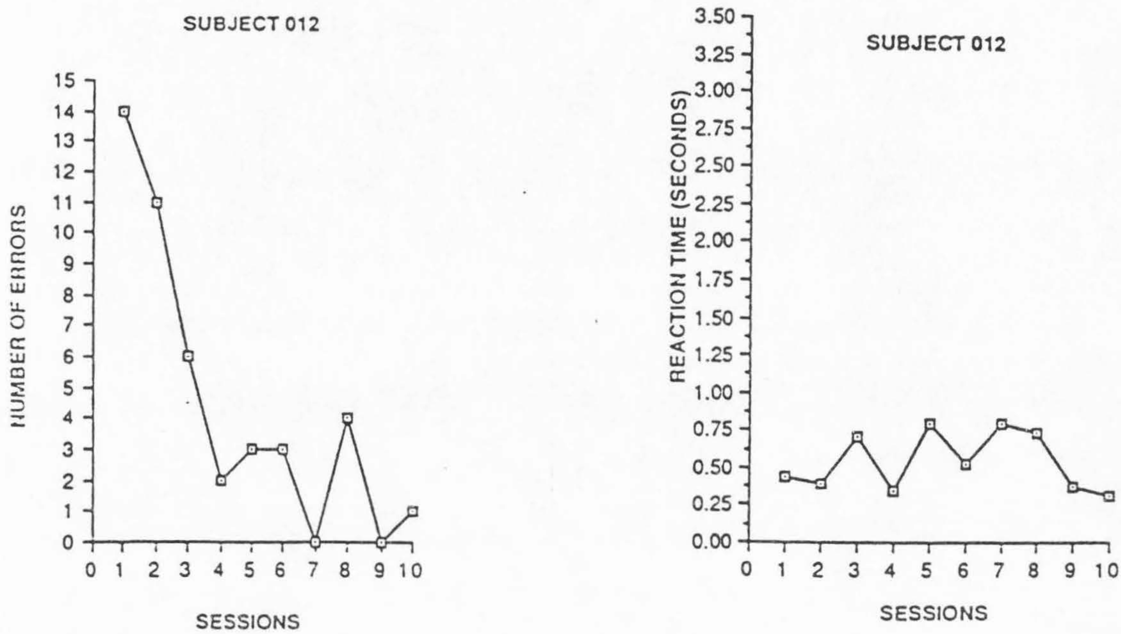



Figure 12. Subject 010: Mean reaction times and number of errors for all 10 sessions.

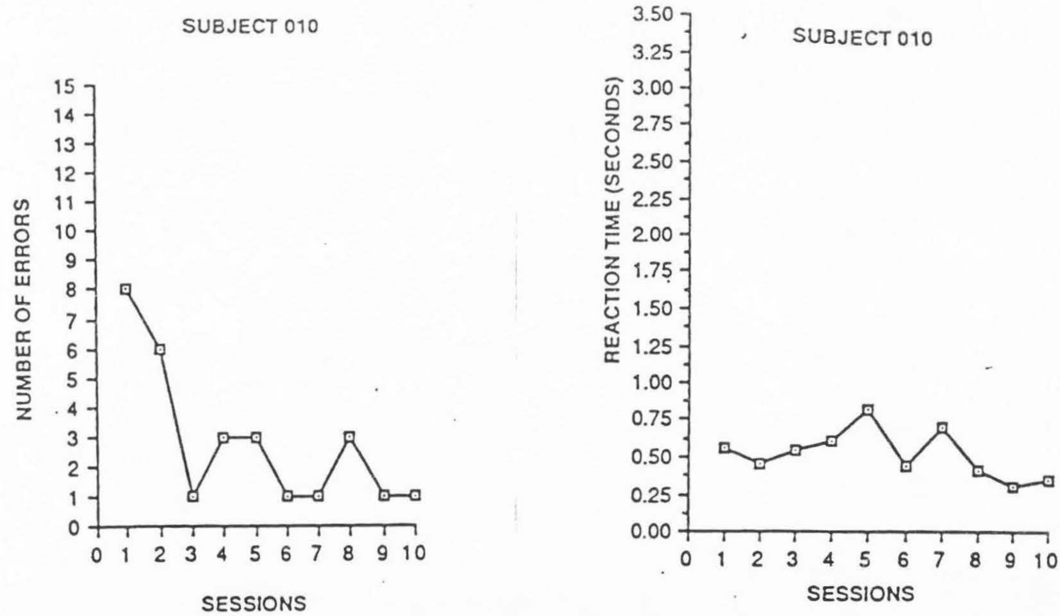



Figure 13. Subject 012: Mean reaction times and number of errors for all 10 sessions.

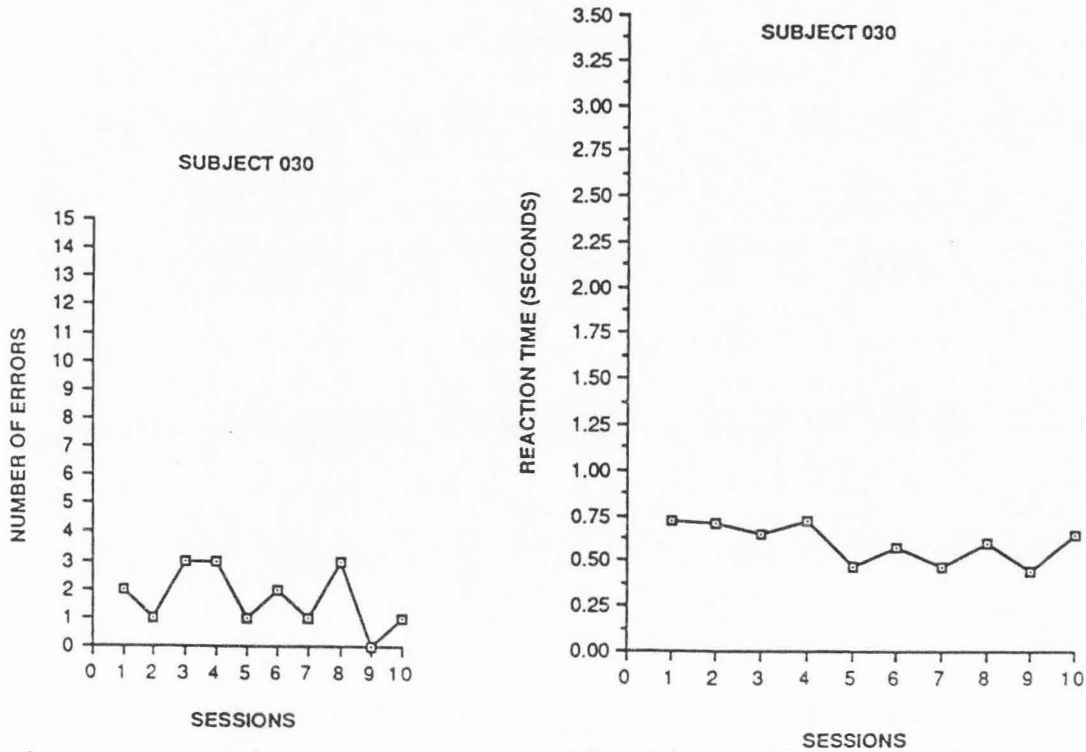



Figure 14. Subject 024: Mean reaction times and number of errors for all 10 sessions.

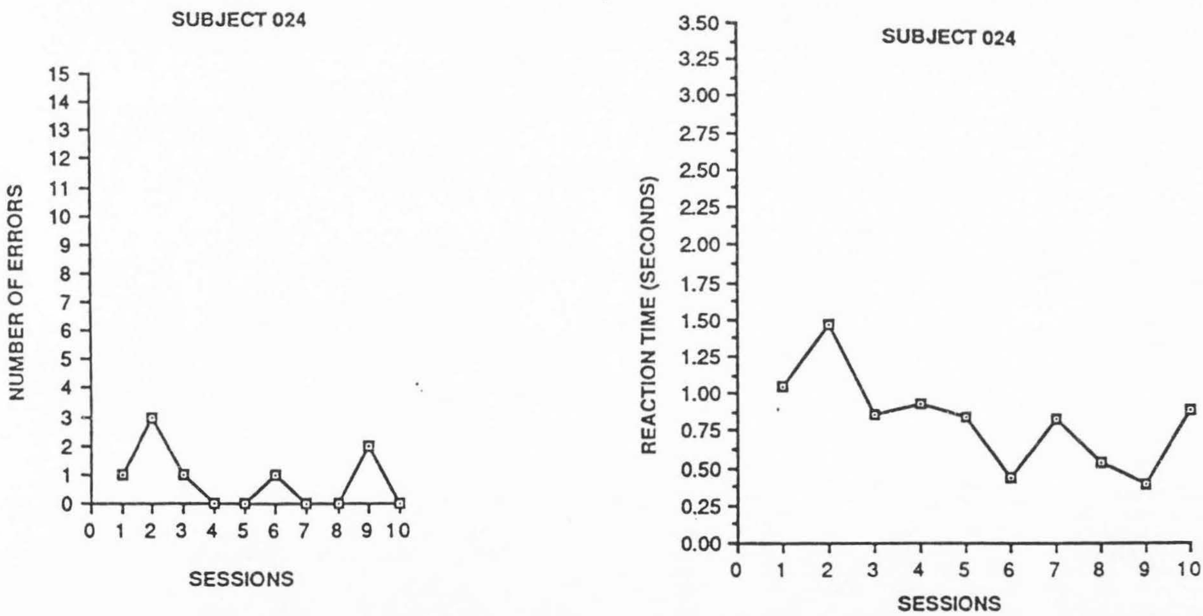



Figure 15. Subject 030: Mean reaction times and number of errors for all 10 sessions.

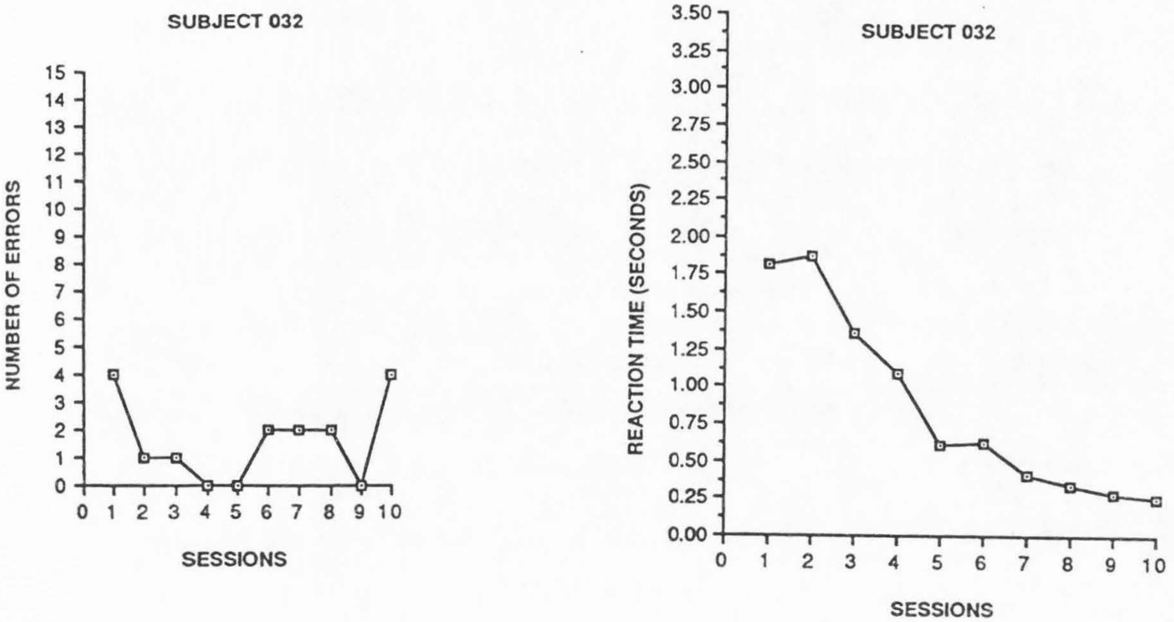



Figure 16. Subject 032: Mean reaction times and number of errors for all 10 sessions.

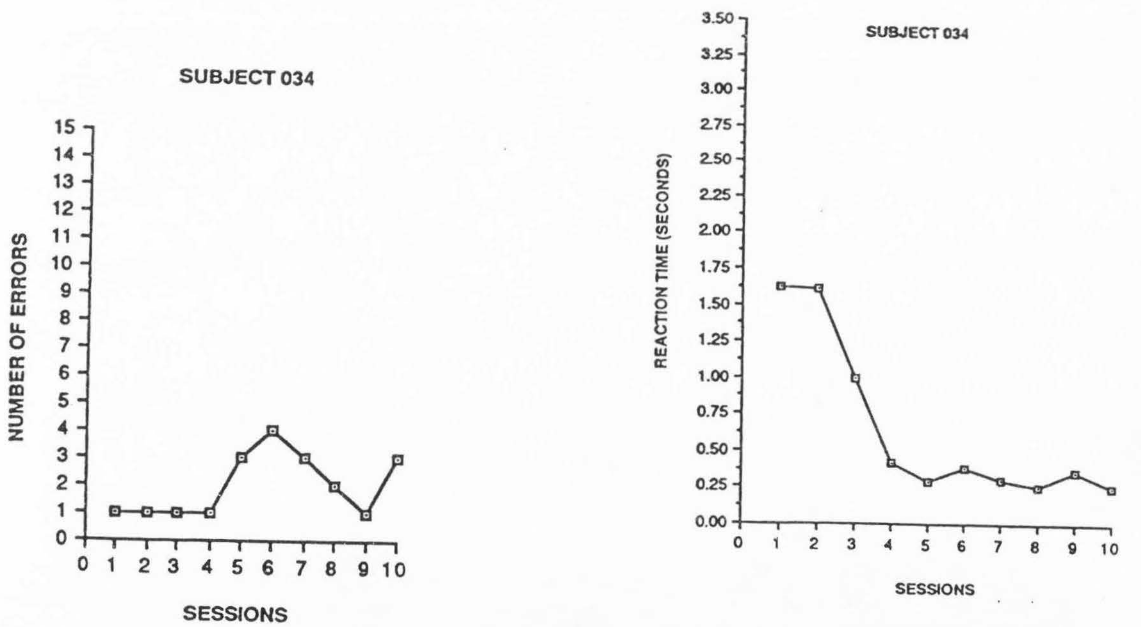



Figure 17. Subject 034: Mean reaction times and number of errors for all 10 sessions.

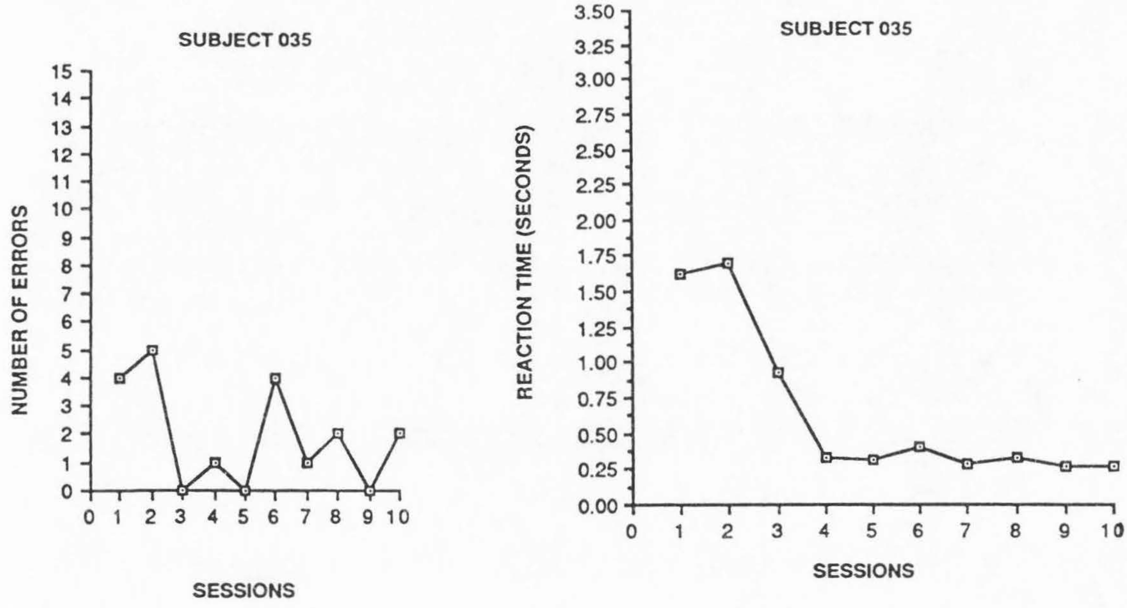



Figure 18. Subject 035: Mean reaction times and number of errors for all 10 sessions.

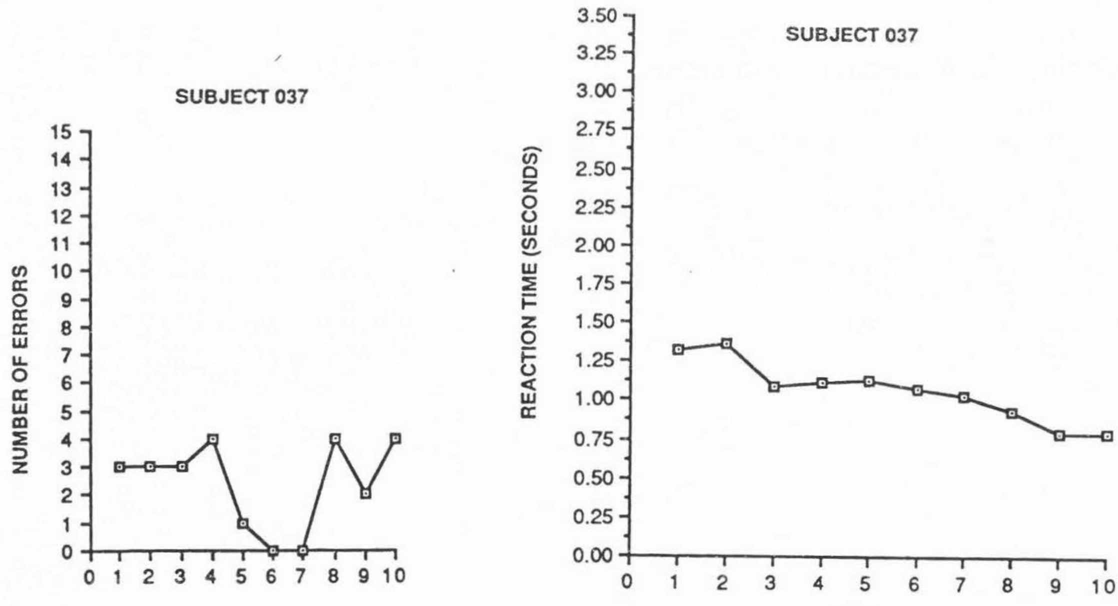



Figure 19. Subject 037: Mean reaction times and number of errors for all 10 sessions.

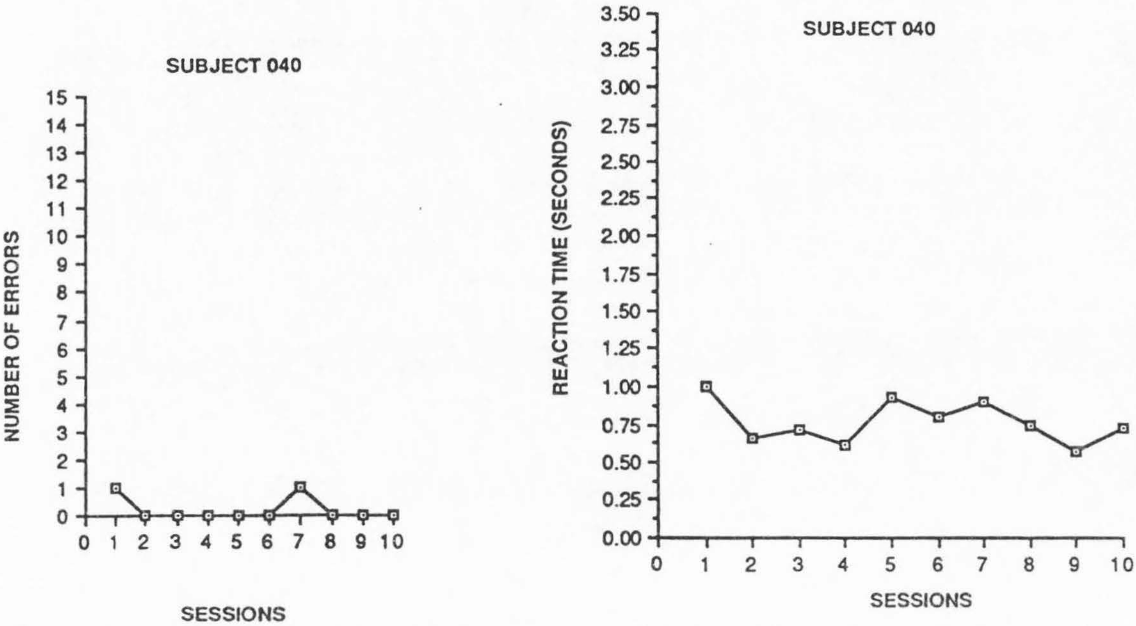



Figure 20. Subject 039: Mean reaction times and number of errors for all 10 sessions.

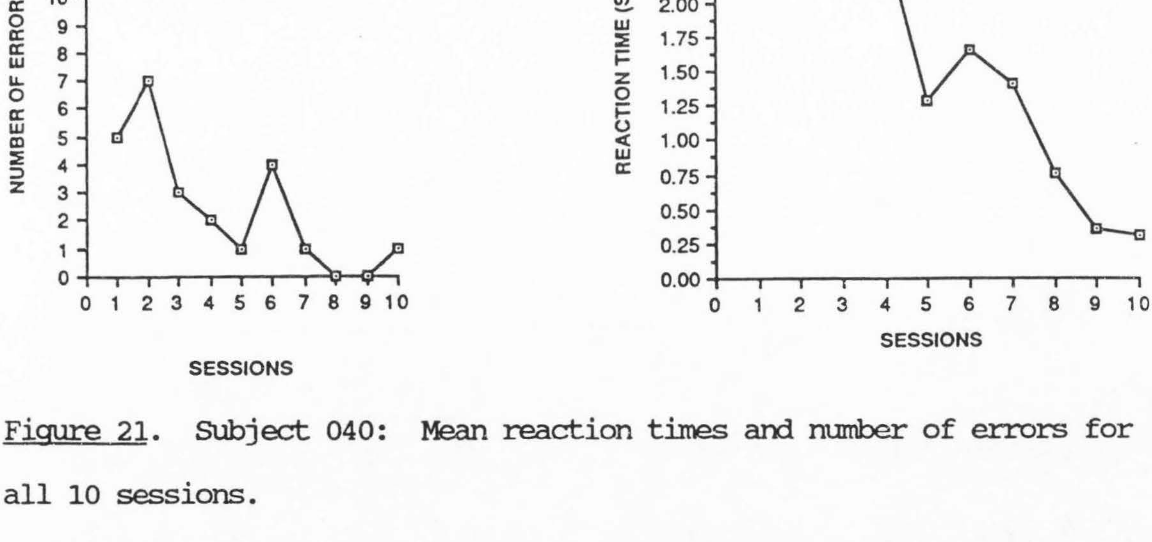



Figure 21. Subject 040: Mean reaction times and number of errors for all 10 sessions.

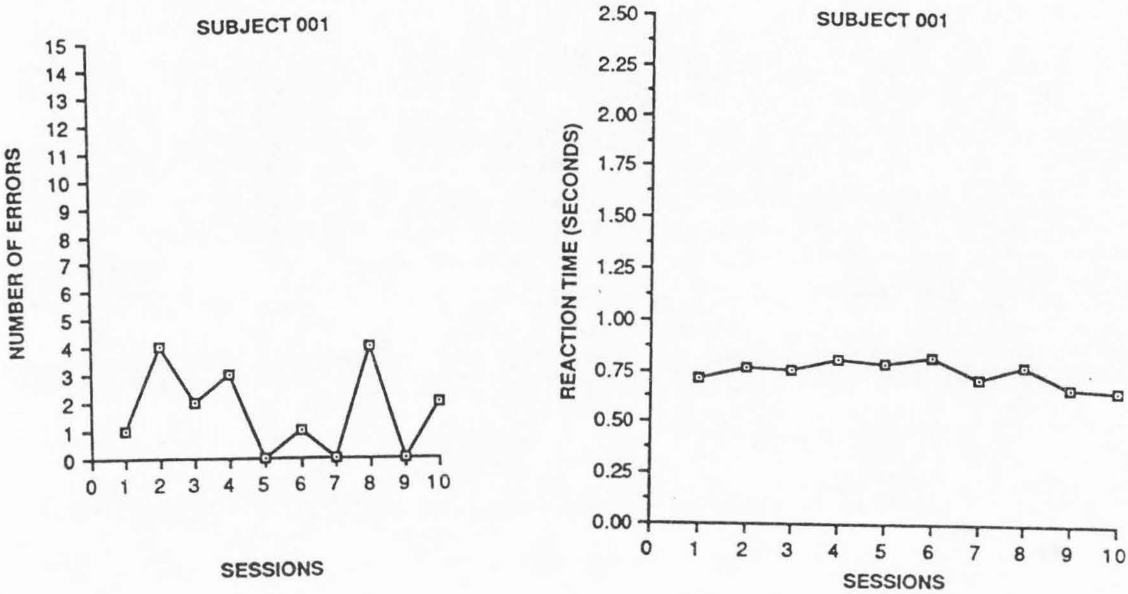



Figure 22. Subject 001: Mean reactions times and number of errors for all 10 sessions.

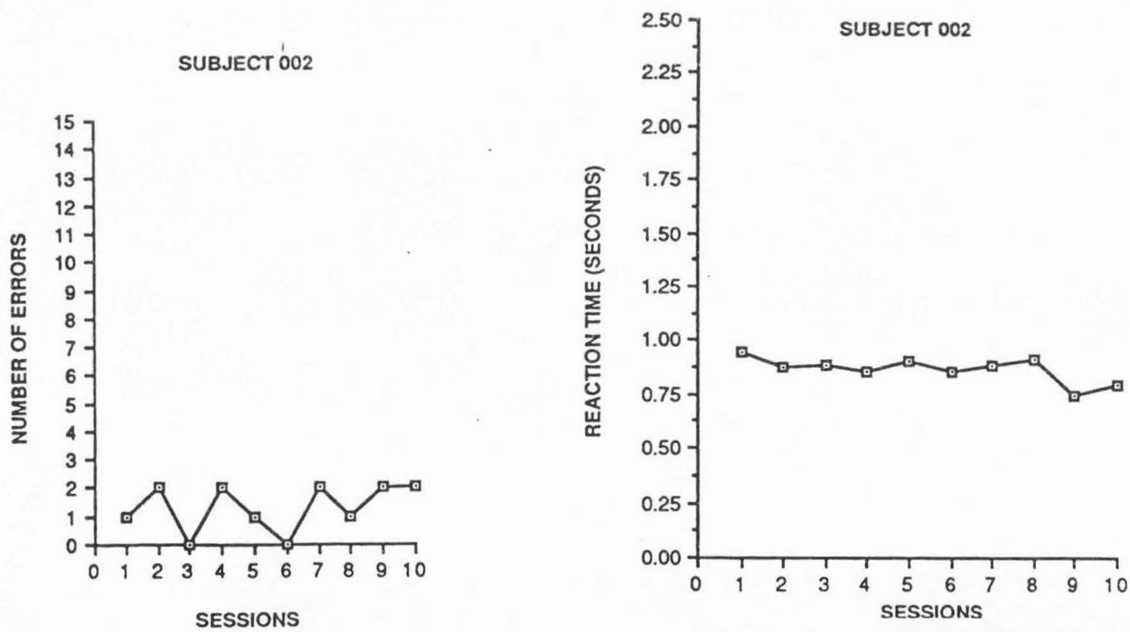



Figure 23. Subject 002: Mean reaction times and number of errors for all 10 sessions.

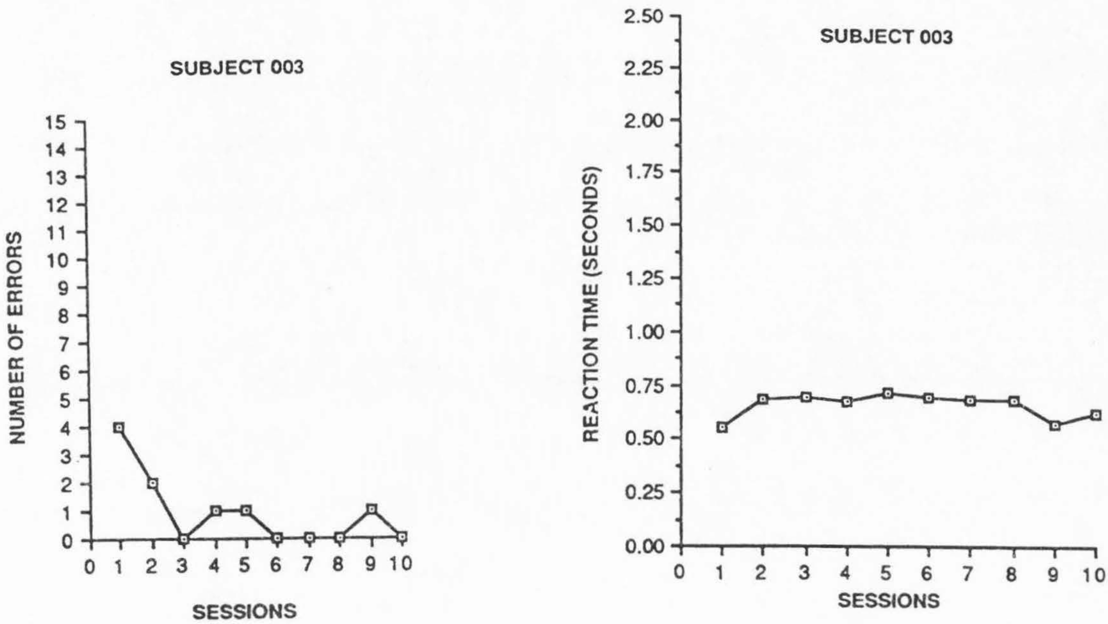



Figure 24. Subject 003: Mean reaction times and number of errors for all 10 sessions.

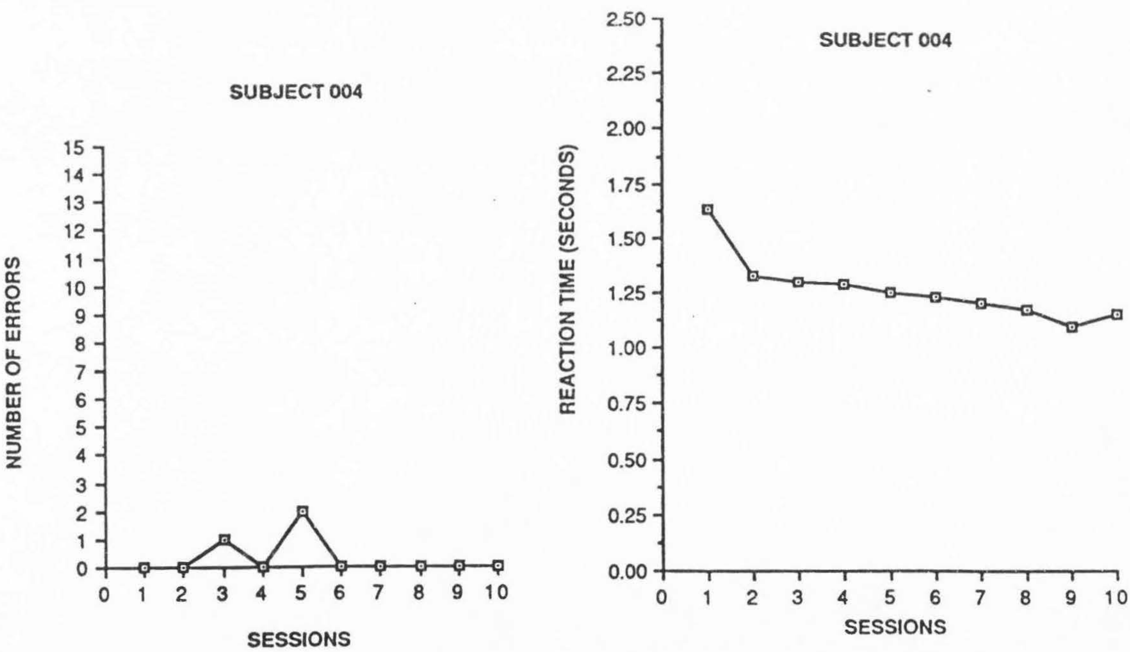



Figure 25. Subject 004: Mean reaction times and number of errors for all 10 sessions.

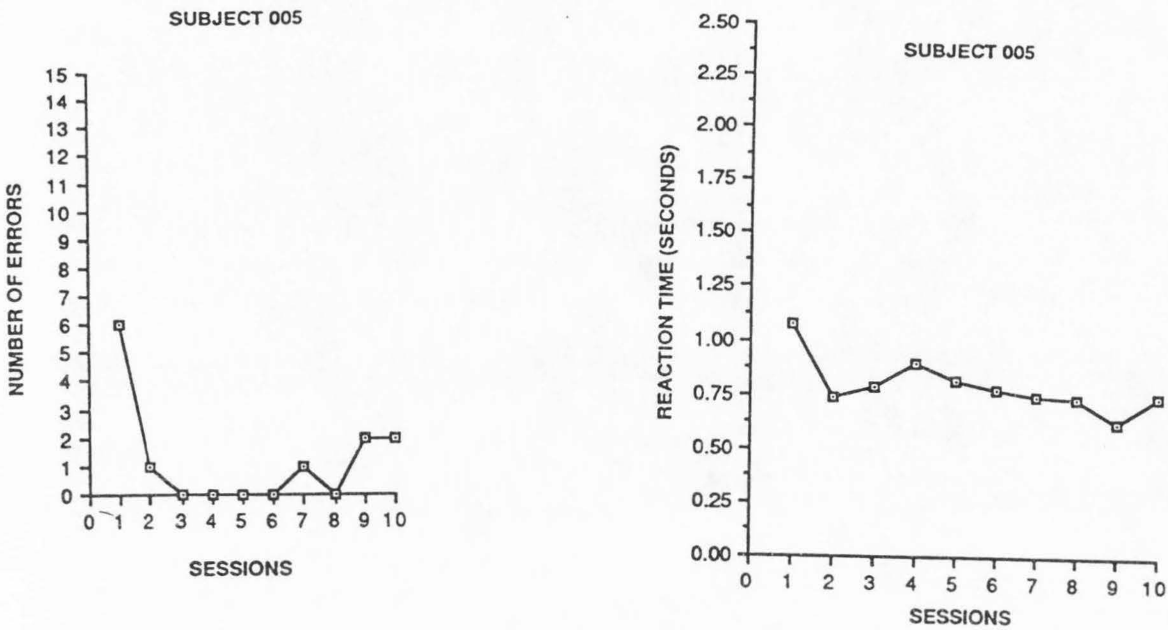



Figure 26. Subject 005: Mean reaction times and number of errors for all 10 sessions.

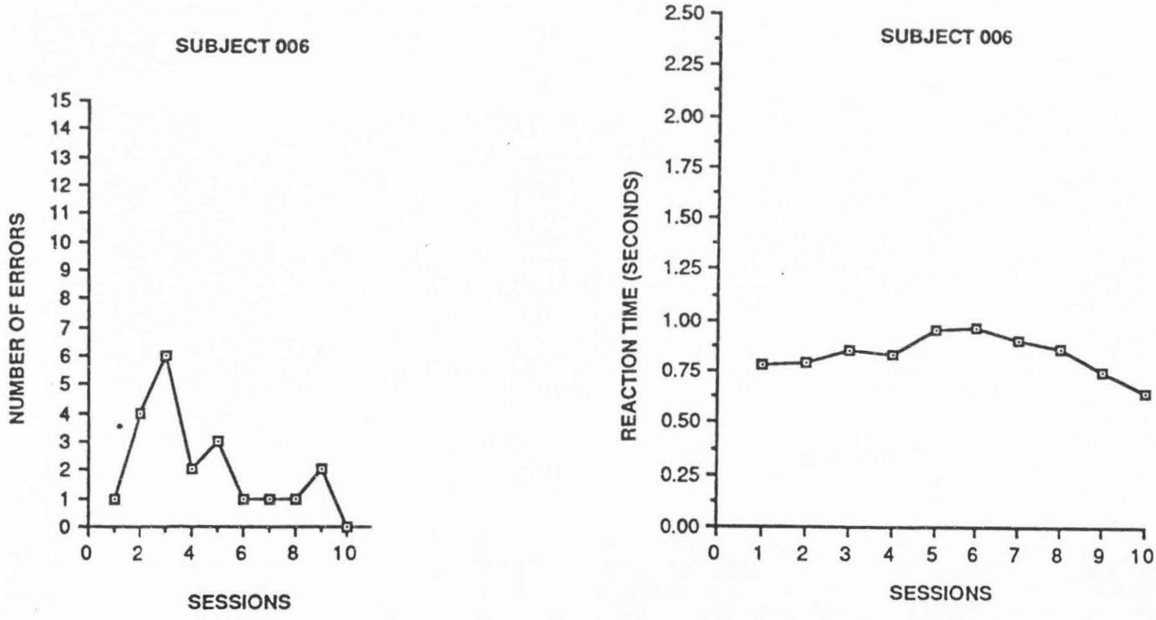



Figure 27. Subject 006: Mean reaction times and number of errors for all 10 sessions.

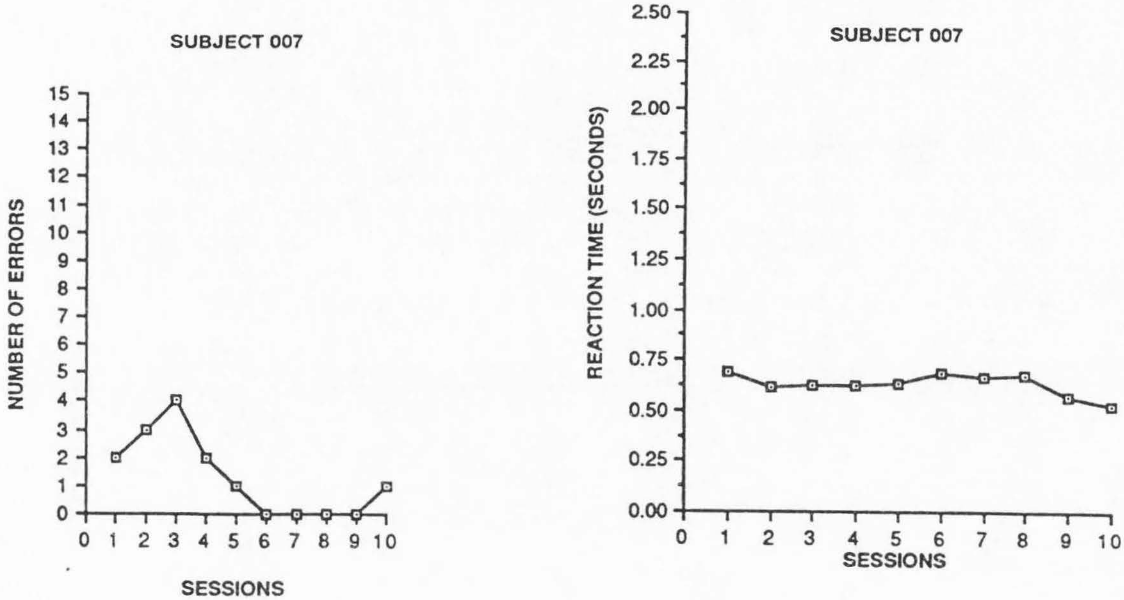



Figure 28. Subject 007: Mean reactions times and number of errors for all 10 sessions.

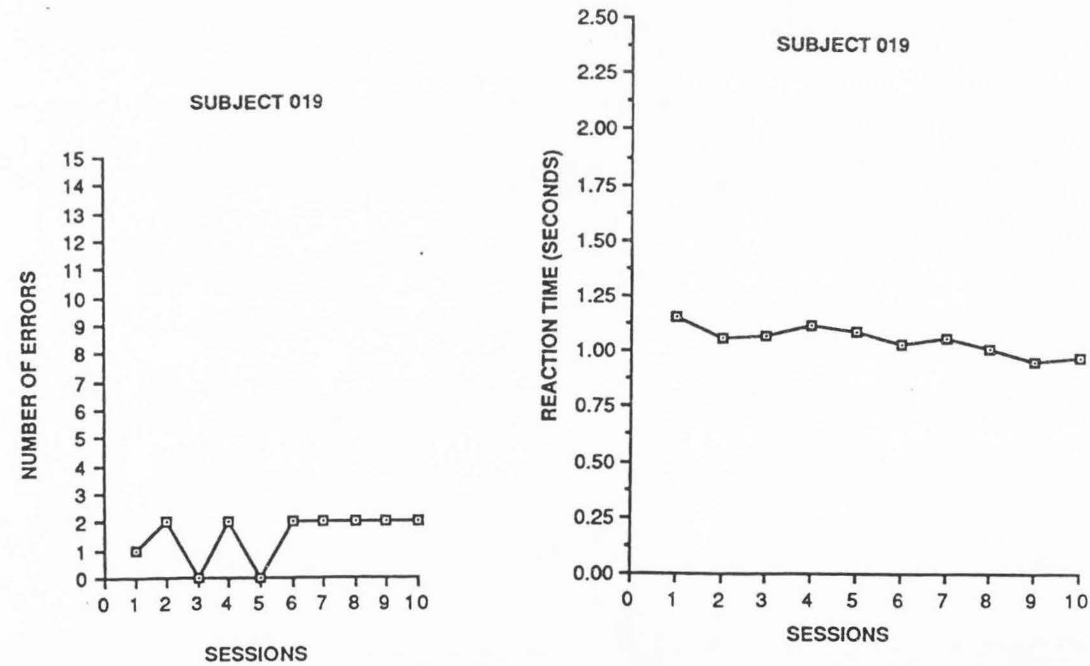



Figure 29. Subject 019: Mean reaction times and number of errors for all 10 sessions.

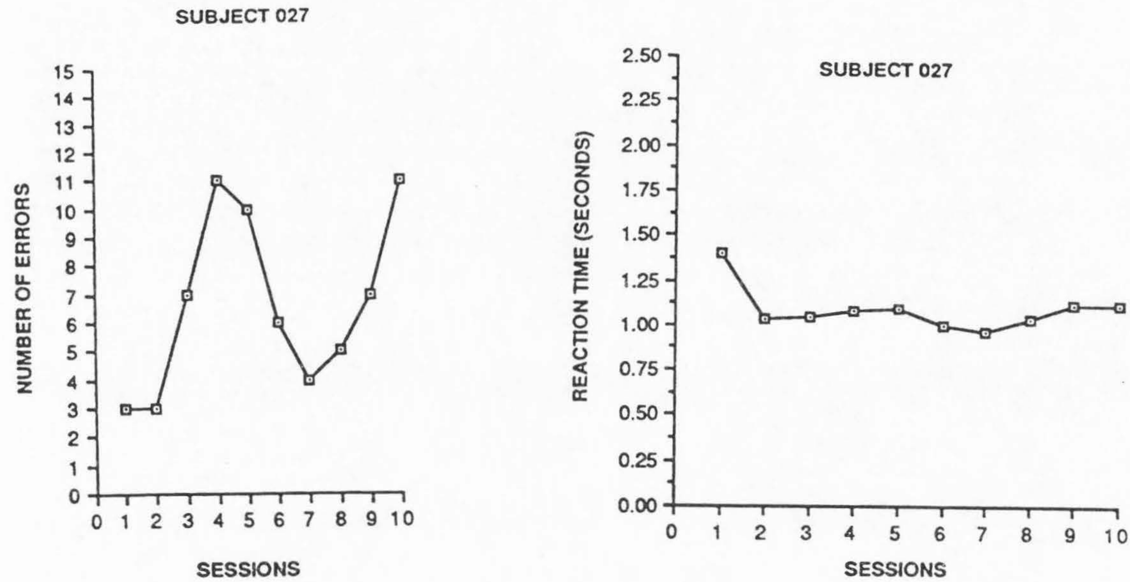



Figure 30. Subject 027: Mean reaction times and number of errors for all 10 sessions.

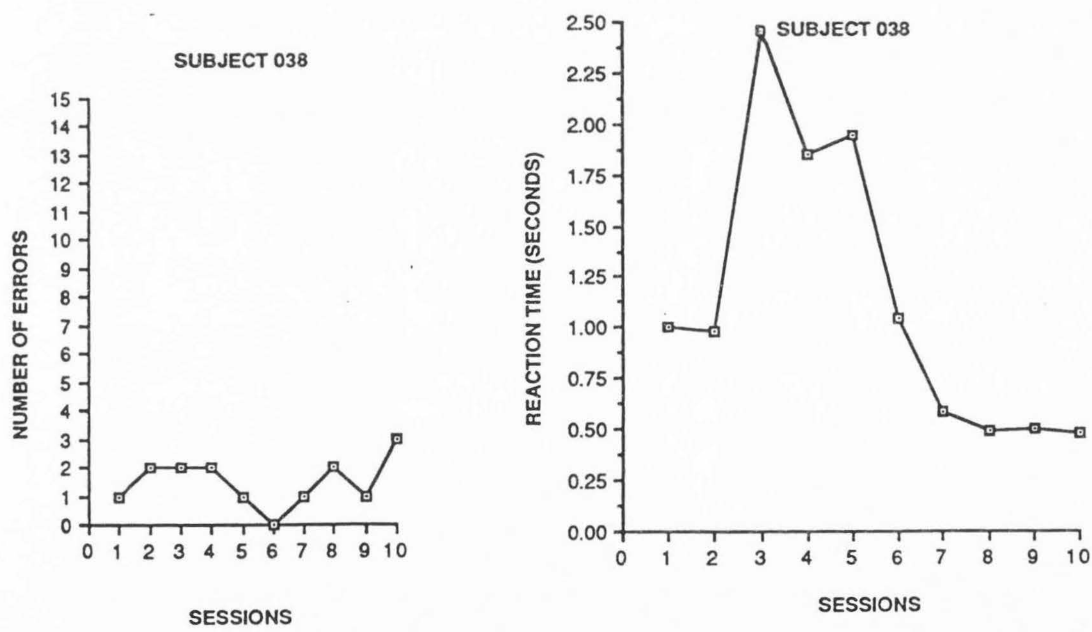
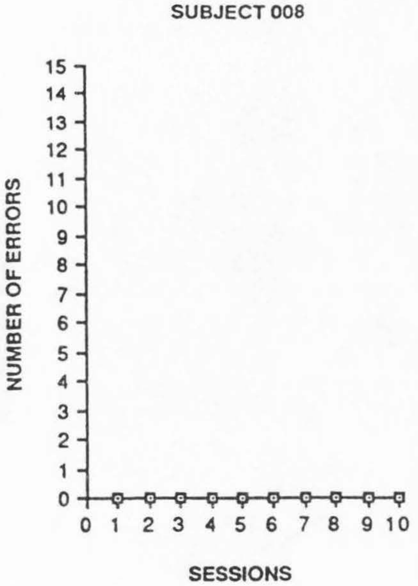



Figure 31. Subject 038: Mean reaction times and number of errors for all 10 sessions.



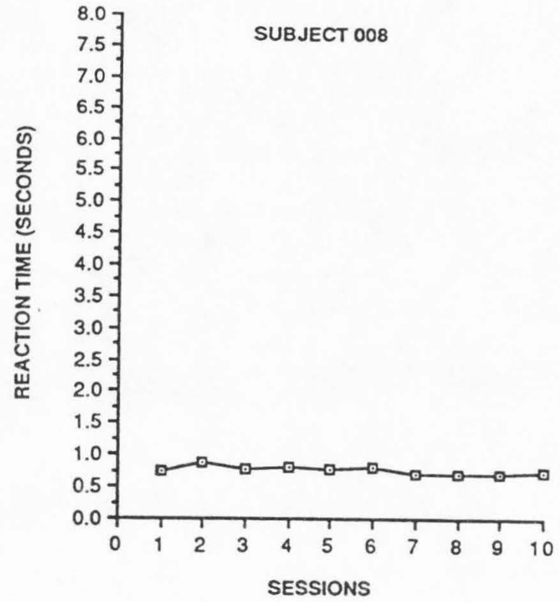
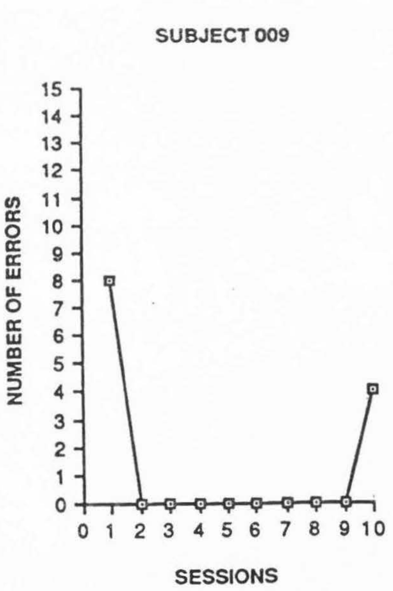




Figure 32. Subject 008: Mean reaction times and number of errors for all 10 sessions.



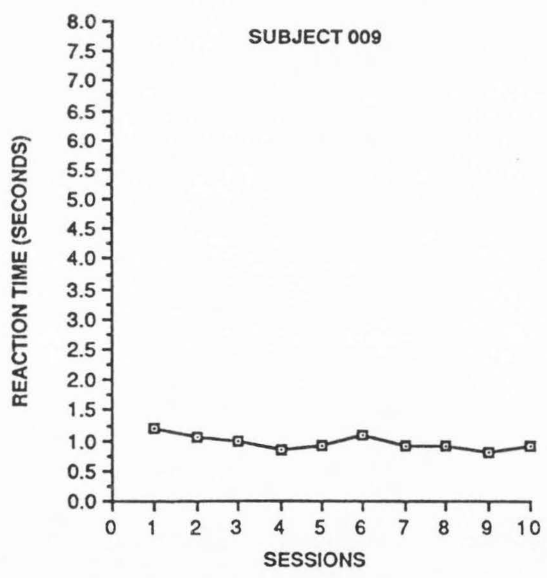




Figure 33. Subject 009: Mean reaction times and number of errors for all 10 sessions.

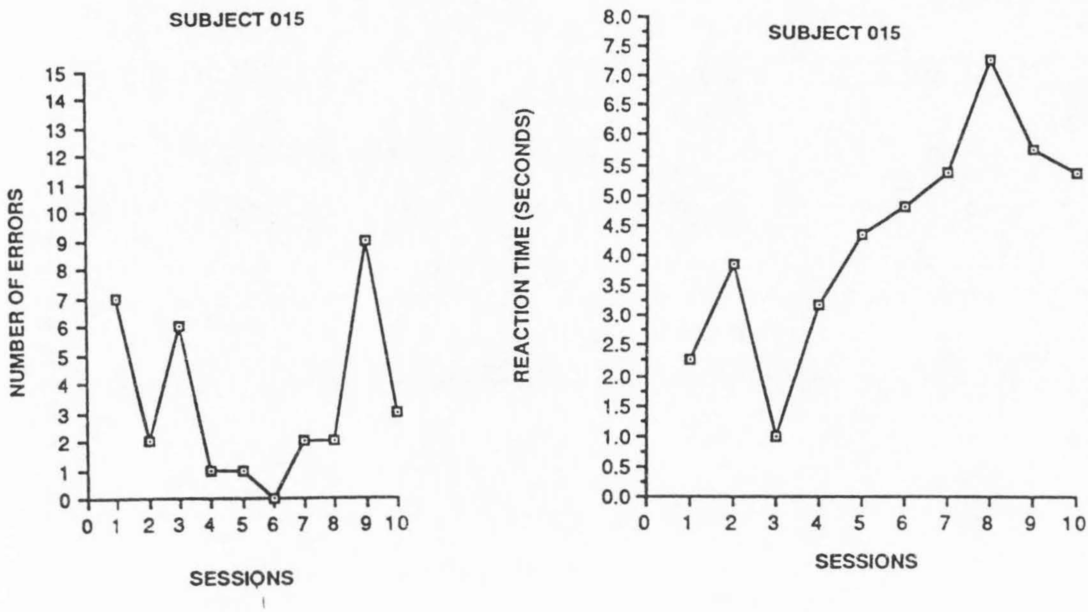



Figure 34. Subject 015: Mean reaction times and number of errors for all 10 sessions.

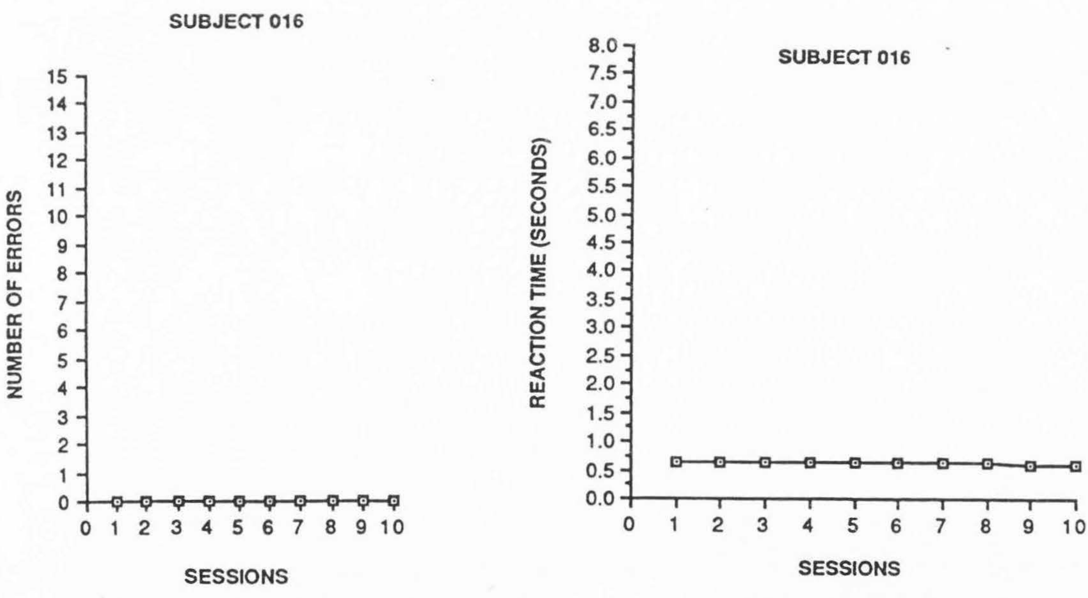



Figure 35. Subject 016: Mean reaction times and number of errors for all 10 sessions.

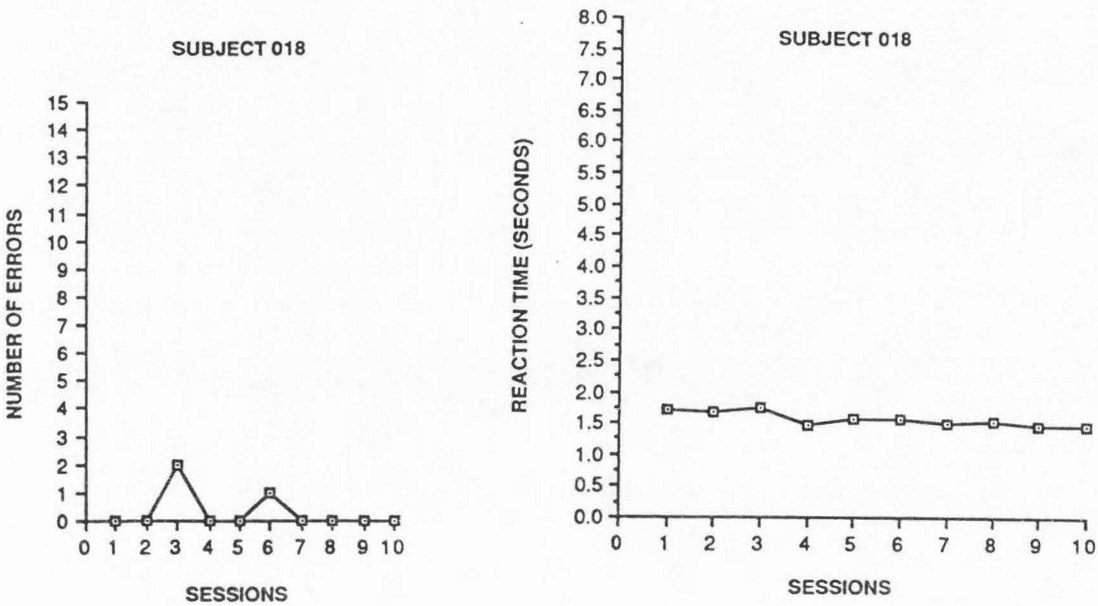



Figure 36. Subject 018: Mean reaction times and number of errors for all 10 sessions.

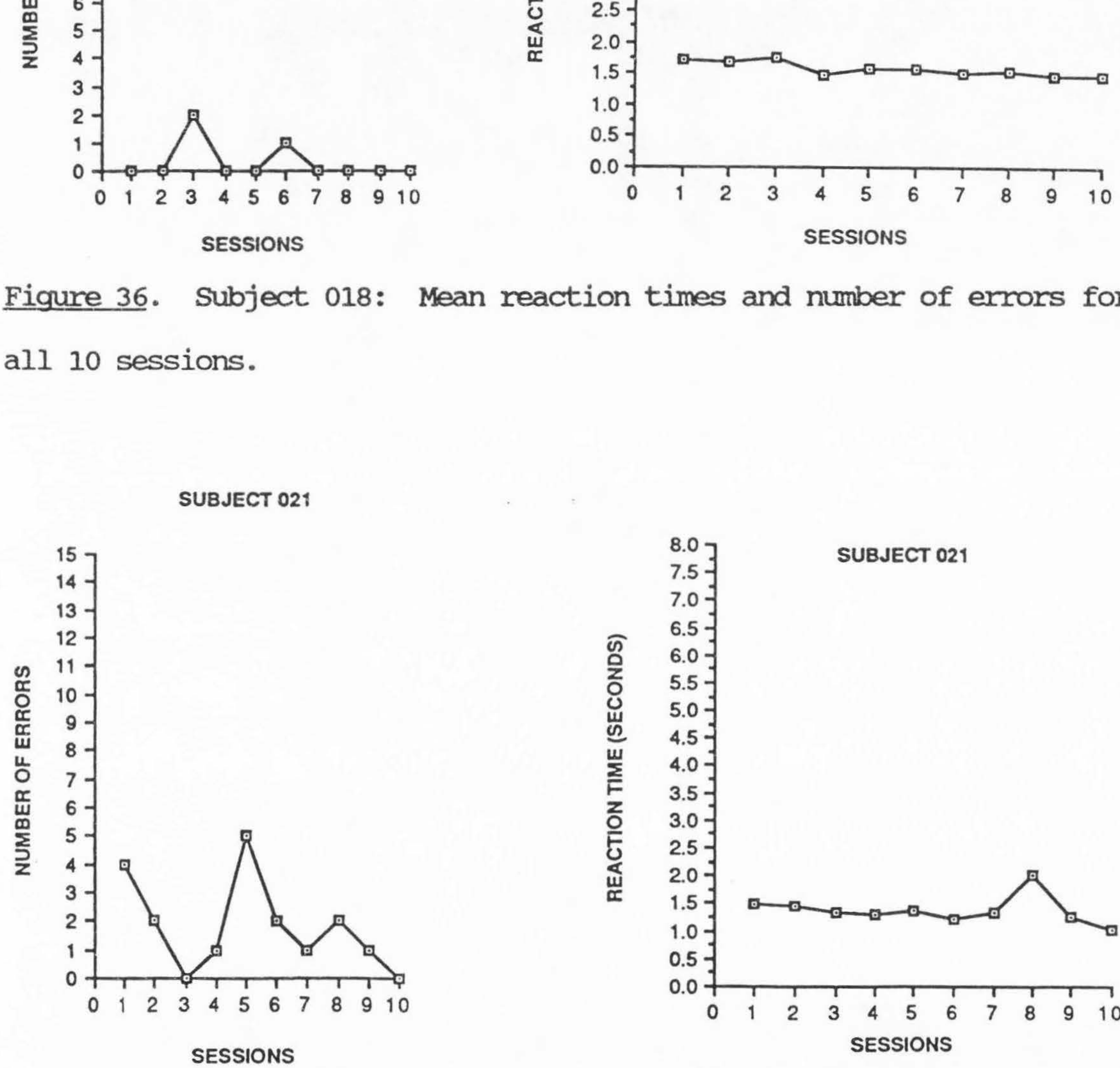



Figure 37. Subject 021: Mean reaction times and number of errors for all 10 sessions.

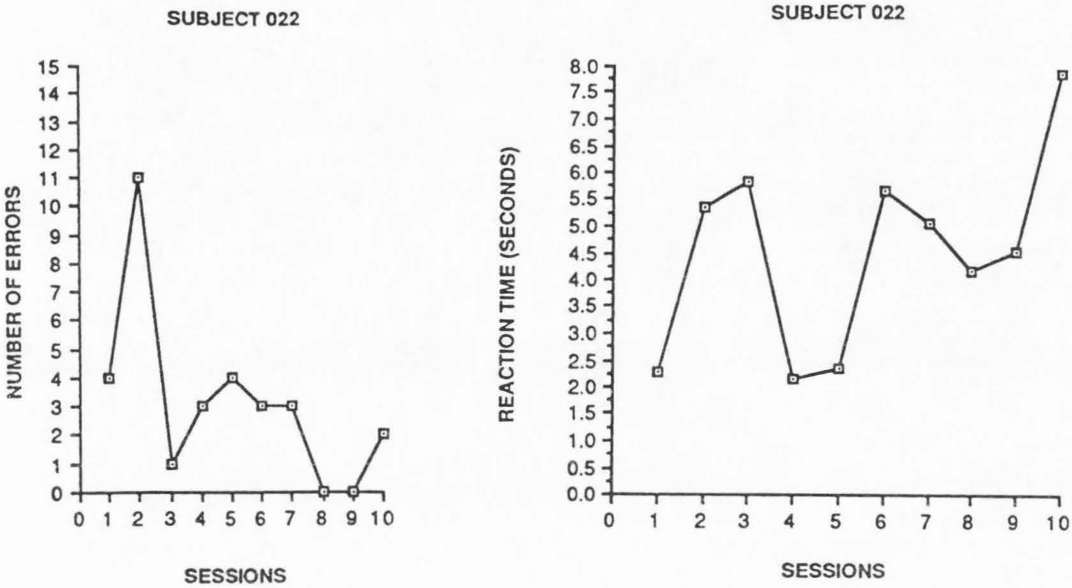



Figure 38. Subject 022: Mean reaction times and number of errors for all 10 sessions.

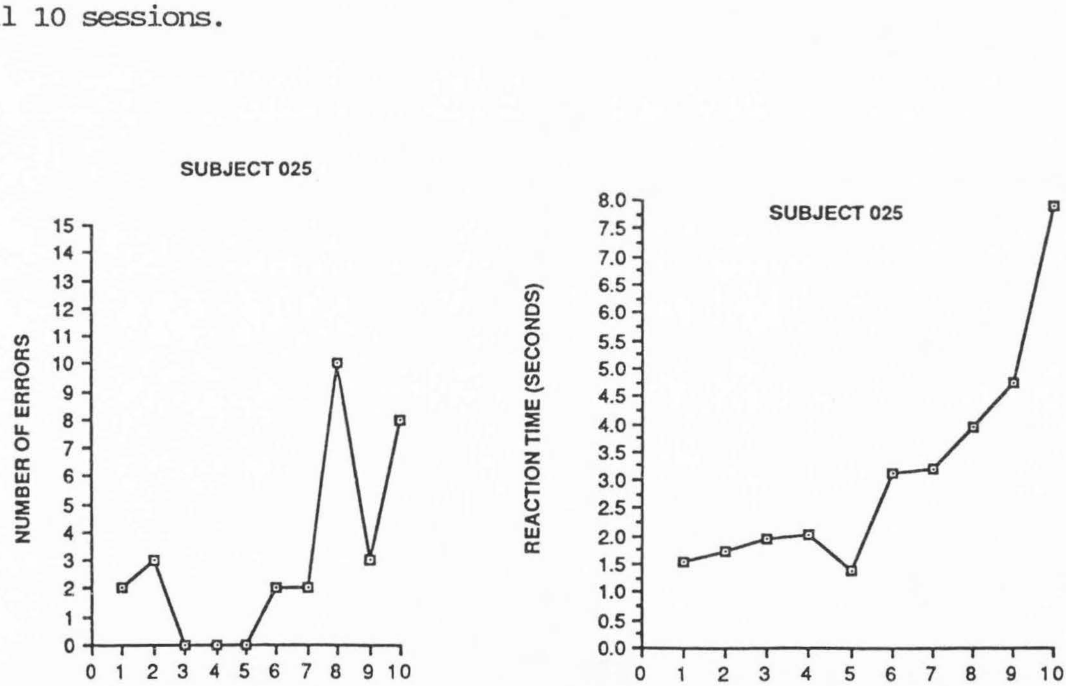



Figure 39. Subject 025: Mean reaction times and number of errors for all 10 sessions.

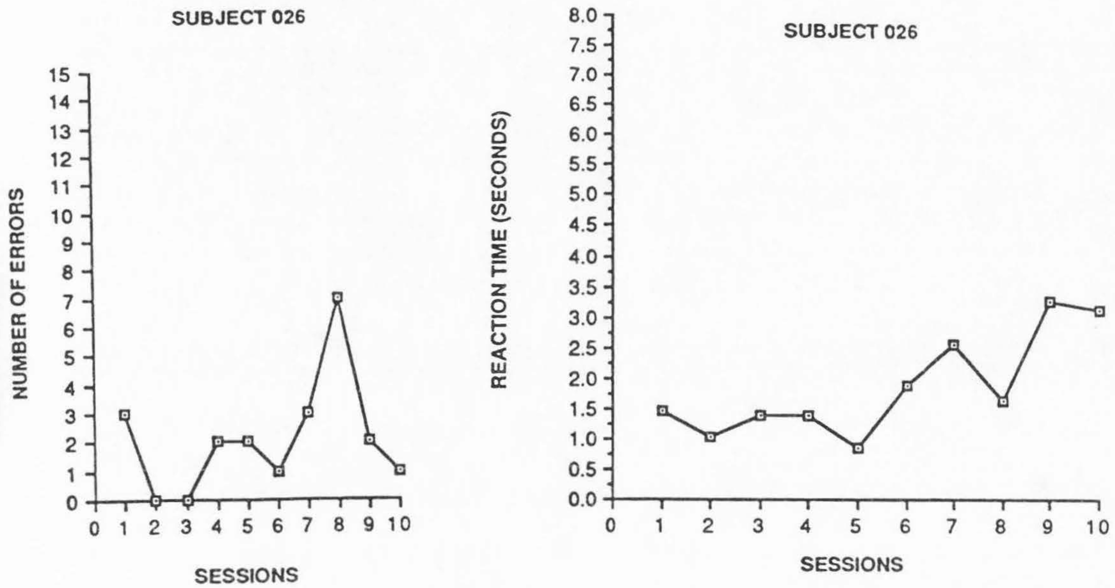



Figure 40. Subject 026: Mean reaction times and number of errors for all 10 sessions.

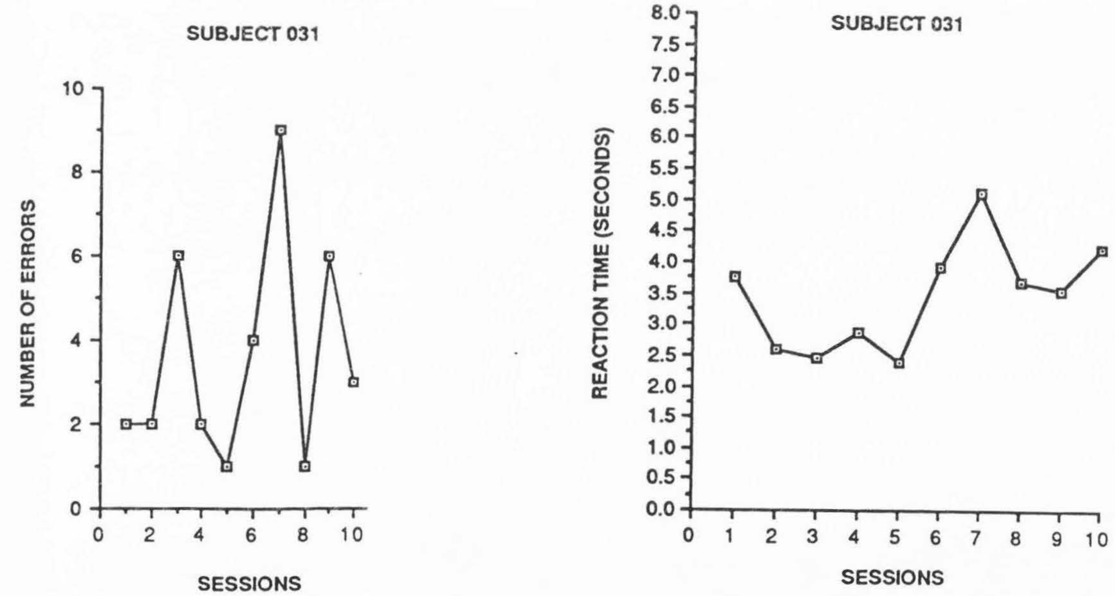
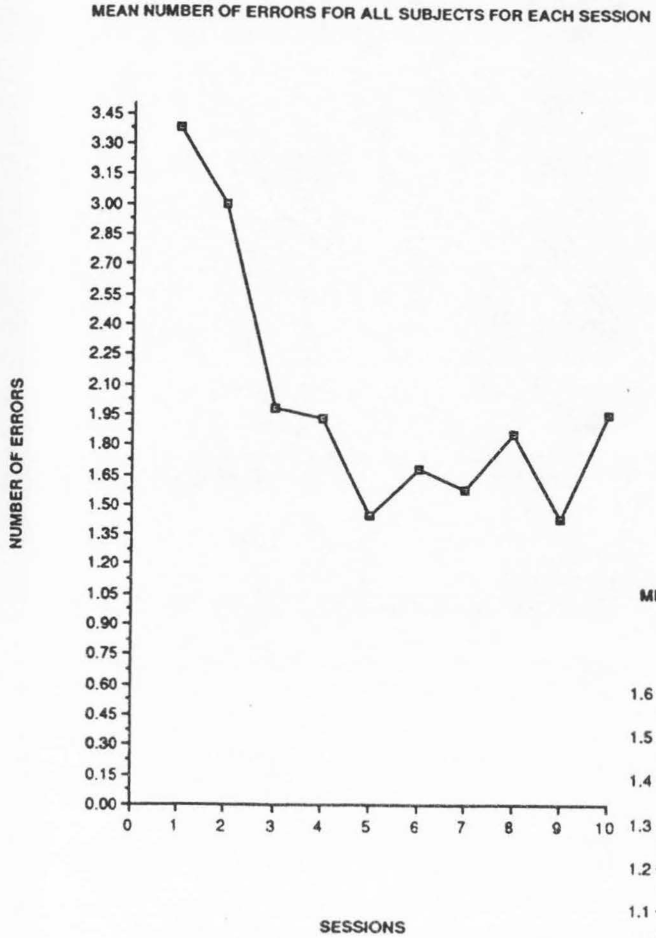



Figure 41. Subject 031: Mean reaction times and number of errors for all 10 sessions.



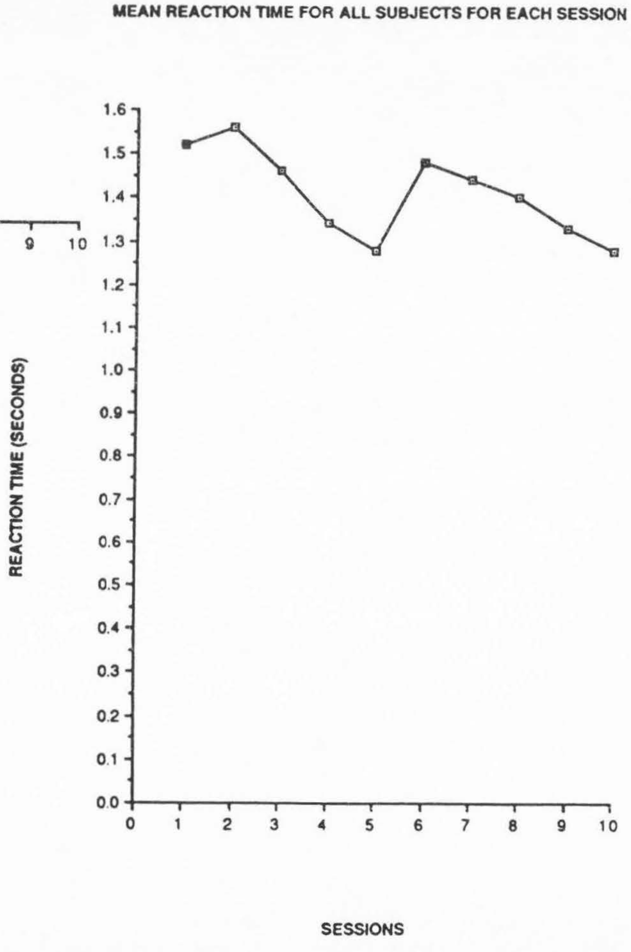




Figure 42. Mean reaction time for all subjects across the 10 sessions.

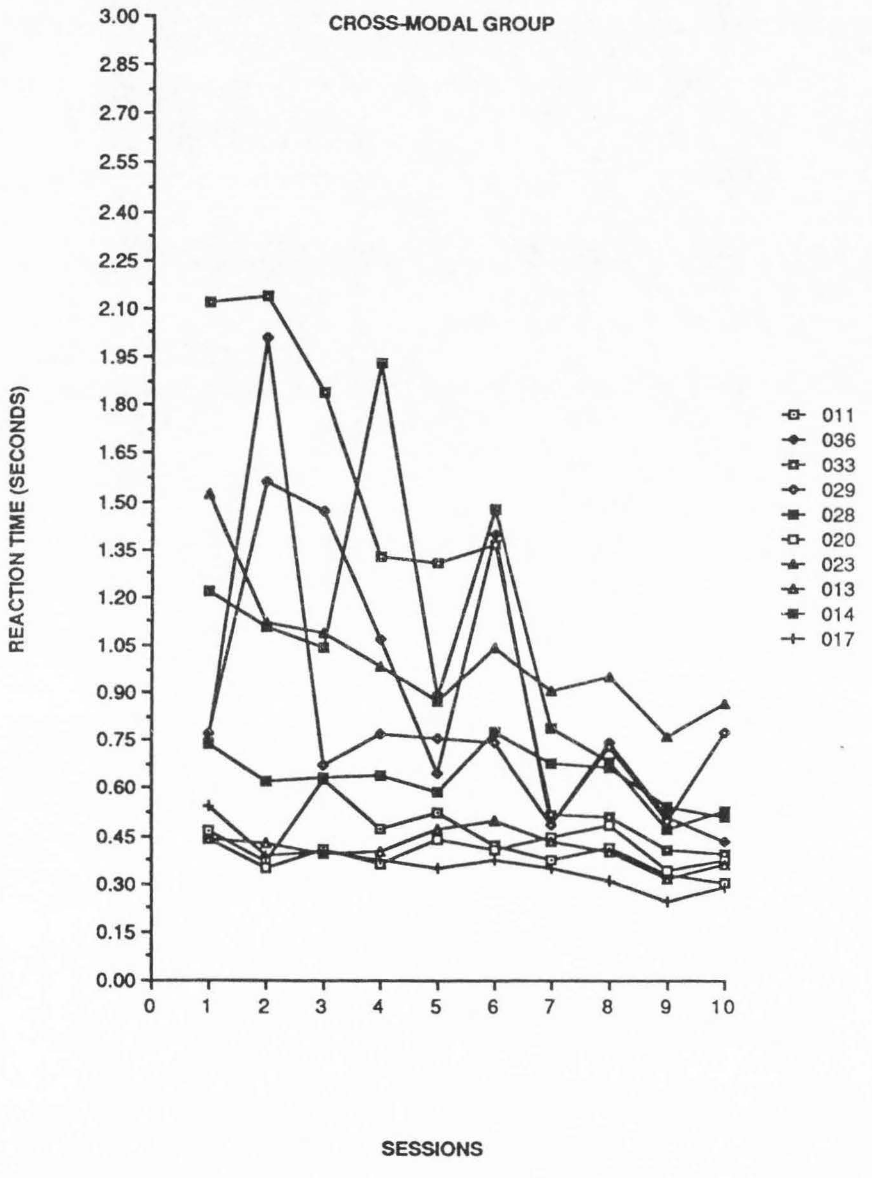



Figure 43. Mean reaction time for each of the ten subjects in the cross-modal group.

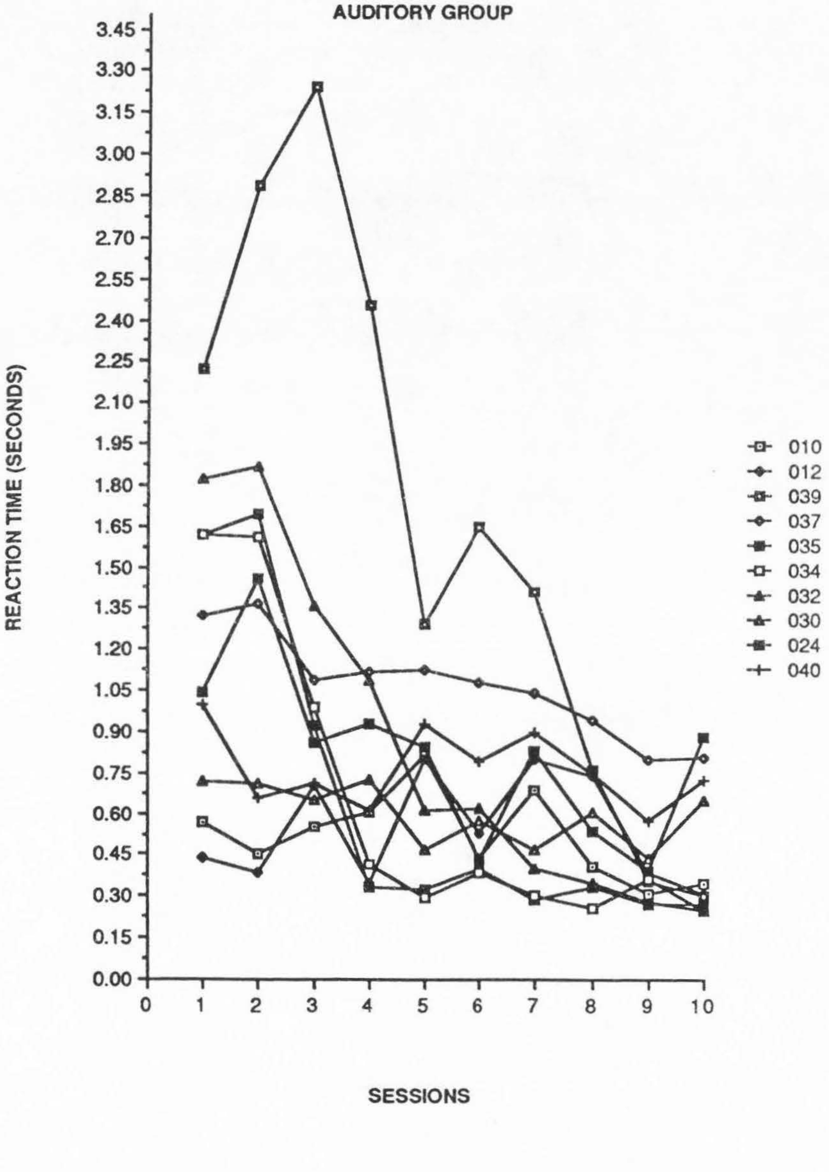



Figure 44. Mean reaction time for each of the ten subjects in the auditory group.

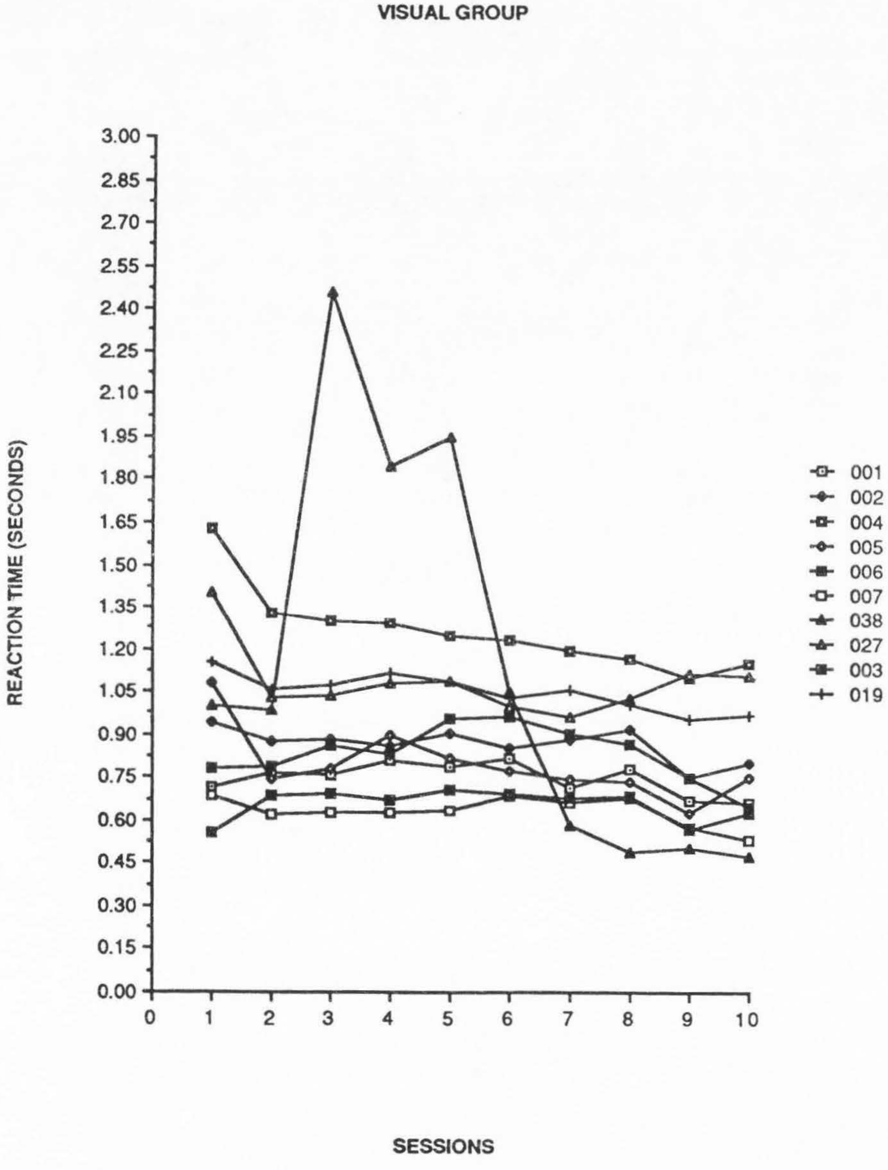



Figure 45. Mean reaction time for each of the ten subjects in the visual group.

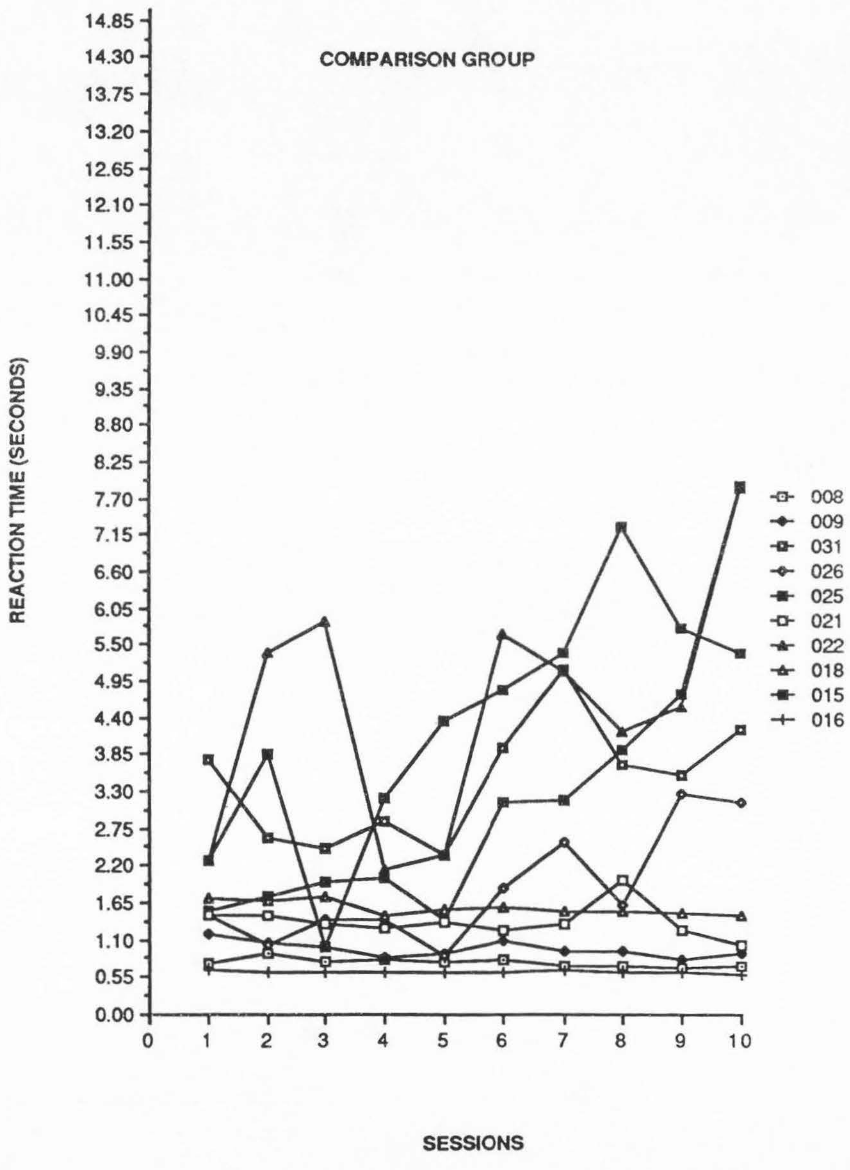



Figure 46. Mean reaction time for each of the ten subjects in the comparison group.

The comparison group (Figure 46) demonstrated the most unusual pattern. In this group, a 2-sec delay was required before subjects were allowed to respond. If they responded before this 2-sec delay, the computer would simply ignore this response and wait until the delay was completed. Therefore, the reaction time in this group was measured from the time the message was printed on the screen telling subjects that they could respond, until a response was made. While exactly half of this group's reaction times remained approximately the same for all 10 sessions, or showed a slight decrease, the others showed an increase in reaction time. There appeared to be no demographical differences between the subjects whose reaction times increased and those whose decreased, such as age, sex, health or education. Since all ten subjects in this group passed the vision and hearing screening, it was assumed that all had the capability to perform the task equally well. There were three males and two females in the long reaction time group and three females and two males in the low reaction time group. Some experimenters (Gridley, Mack, & Gilmore, 1986; Birren et al., 1980; Birren & Schaie, 1977) have reported that the length of time spent on-task in any situation seems to decrease with age in the majority of individuals. This may or may not account for the slow responding in some of the comparison group individuals. This type of phenomenon would be most likely to appear in the comparison group, rather than the other groups, since these subjects are forced to wait to respond (2 sec.) and, therefore, may become distracted by other environmental stimuli. This distractibility may have then led to a lengthy delay in responding by some. Also, many elderly individuals seem more concerned with whether they are performing a task correctly, rather than quickly (Nettlebeck, 1986; Birren, 1964, 1969). Therefore, these longer delay subjects may have paused for a longer period of time before responding in order to be certain that they were correct. However, this doesn't seem to be the universal case because these individuals still made errors. Another cause for the different types of responding may have been due to the fact that the comparison group's task was divided into components. Subjects were forced to pause for 2 sec. before responding in this group. Once the subjects were given the opportunity to respond, they may have had to reconsider the response alternatives again. Birren and Schaie (1977) discuss the finding that by simply dividing a task into components, one in which the subject must wait and one in which the subject is required to respond, such as in the comparison group task, increases in reaction time may result. It has also been repeatedly demonstrated that humans often respond differently even though given the same task (Hunt, 1983; Nallan, Brown, Edmonds, Gillham, Kowàlewski, & Miller, 1981; Buskist, Miller, & Bennett, 1980; Lowe, Harzem, & Bagshaw, 1978; Lowe, Harzem, & Hughes, 1978). Hunt's work is particularly pertinent to this research because he examined human responding on reaction time "disjunctive type one" tasks. Hunt reported that differences in reaction time occurred as a result of the various ways in which his subjects responded to incoming stimuli. Their different ways of responding were hypothesized to be a result of previous experiences with similar tasks in which they successfully utilized a particular strategy. Some strategies required more time than others before a response was made.

Buskist, Miller, and Bennett (1980) and Lowe, Harzem, and Bagshaw (1978) found that even with simple schedules of reinforcement (i.e., fixed interval and fixed time), human subjects did not respond as nonhumans did, and individuals responded differently from each other on the same task. While some of the subjects in these experiments exhibited a high rate of responding, other subjects showed an extremely low rate. This is similar to the case with the comparison group of this research. While some of the subjects demonstrated short reaction times that changed very little over the 10 sessions, others in the same group, performing the same task, showed long and variable reaction times. When examining the individual figures in the comparison group (Figures 32-41), it becomes clear that approximately half of the subjects had low reaction times (less than 4 sec), two had moderate reaction times (about 4 sec), and three had long reaction times (greater than 4 sec) and also showed gradual increases across the 10 sessions.

## Changes in Reaction Time Across Sessions

Tables 3-10 show the mean reaction times and the results of correlated t tests for each group. Tables 4, 6, and 10 show that the auditory, visual, and cross-modal groups demonstrated statistically significant decreases in reaction time from session 1 to session 10. Figure 47 shows the mean reaction time for each session, over 10 sessions, for the cross-modal group. Table 4 contains the mean reaction time for all 10 subjects in the cross-modal group for the first and last sessions. In Table 5, the results of a t test for correlated means indicates that the change in reaction time is significant for the cross modality group at the .0312 level. It should be noted that a two-tail, rather than a one-tail test was utilized in order to decrease the likelihood of falsely rejecting the null hypothesis.

Table 3

Mean Reaction Time (in Seconds) for all 10 Subjects in the Cross-Modal Group for the First and Final Sessions

| SUBJECTS | MEAN REACTION TIME IN THE FIRST | MEAN REACTION TIME IN THE FINAL | CHANGE (+/-) |
|---|---|---|---|
| 1 | .476 | .302 | -.174 |
| 2 | .438 | .360 | -.078 |
| 3 | .542 | .294 | -.248 |
| 4 | .442 | .378 | -.064 |
| 5 | 1.519 | .870 | -.649 |
| 6 | 1.218 | .533 | -.685 |
| 7 | .754 | .775 | +.021 |
| 8 | 2.124 | .398 | -1.726 |
| 9 | .771 | .436 | -.335 |
| 10 | .741 | .515 | -.226 |
| | | | $\bar{X}$ = -.416 |

Table 4

Results of a T Test for Correlated Means Comparing the Means of the First and the Final Sessions' Reaction Times for the Cross-Modal Group

| DF | MEAN X-Y | PAIRED T-VALUE | PROB (2-TAIL) |
|---|---|---|---|
| 9 | .416 | 2.549 | .0312 |

Table 5

Mean Reaction Time (in Seconds) for all 10 Subjects in the Auditory Group for the First and Final Sessions

| SUBJECTS | MEAN REACTION TIME IN THE FIRST | MEAN REACTION TIME IN THE FINAL | CHANGE (+/-) |
|---|---|---|---|
| 1 | .738 | .400 | -.338 |
| 2 | .437 | .311 | -.126 |
| 3 | 1.044 | .887 | -.157 |
| 4 | .717 | .651 | -.066 |
| 5 | 1.822 | .253 | -1.569 |
| 6 | 1.618 | .250 | -1.368 |
| 7 | 1.621 | .272 | -1.349 |
| 8 | 1.321 | .806 | -.515 |
| 9 | 2.218 | .306 | -1.912 |
| 10 | 1.000 | .725 | -.275 |
| | | | $\overline{X}$ = -.767 |

Table 6

Results of a T Test for Correlated Means Comparing the Means of the First and the Final Sessions' Reaction Times for the Auditory Group

| DF | MEAN X-Y | PAIRED T-VALUE | PROB (2-TAIL) |
|---|---|---|---|
| 9 | .767 | 3.464 | .0071 |

Table 7

Mean Reaction Time (in Seconds) for all 10 Subjects in the Comparison Group for the First and Final Sessions

| SUBJECTS | MEAN REACTION TIME IN THE FIRST | MEAN REACTION TIME IN THE FINAL | CHANGE (+/-) |
|---|---|---|---|
| 1 | .750 | .730 | -.020 |
| 2 | 1.190 | .910 | -.280 |
| 3 | 2.269 | 5.379 | +3.110 |
| 4 | .649 | .592 | -.057 |
| 5 | 1.723 | 1.472 | -.251 |
| 6 | 2.471 | 1.031 | -1.440 |
| 7 | 2.267 | 7.861 | +5.594 |
| 8 | 1.540 | 7.890 | +6.350 |
| 9 | 1.462 | 3.135 | +1.673 |
| 10 | 3.756 | 4.242 | +.486 |
| | | | $\bar{X}$ = +1.617 |

Table 8

Results of a T Test for Correlated Means Comparing the Means of the First and the Final Sessions' Reaction Times for the Comparison Group

| DF | MEAN X-Y | PAIRED T-VALUE | PROB (2-TAIL) |
|---|---|---|---|
| 9 | -1.617 | -2.006 | .0758 |

Table 9

Mean Reaction Time (in Seconds) for all 10 Subjects in the Visual Group for the First and Final Sessions

| SUBJECTS | MEAN REACTION TIME IN THE FIRST | MEAN REACTION TIME IN THE FINAL | CHANGE (+/-) |
|---|---|---|---|
| 1 | .717 | .661 | -.056 |
| 2 | .941 | .800 | -.141 |
| 3 | 1.630 | 1.150 | -.480 |
| 4 | 1.080 | .749 | -.331 |
| 5 | .782 | .647 | -.135 |
| 6 | .687 | .530 | -.157 |
| 7 | .552 | .629 | +.140 |
| 8 | 1.000 | .477 | -.523 |
| 9 | 1.400 | 1.110 | -.290 |
| 10 | 1.150 | .973 | -.177 |
| | | | X = -.215 |

Table 10

Results of a T Test for Correlated Means Comparing the Means of the First and Final Sessions' Reaction Times for the Visual Group

| DF | MEAN X-Y | PAIRED T-VALUE | PROB (2-TAIL) |
|---|---|---|---|
| 9 | .221 | 3.765 | .0045 |

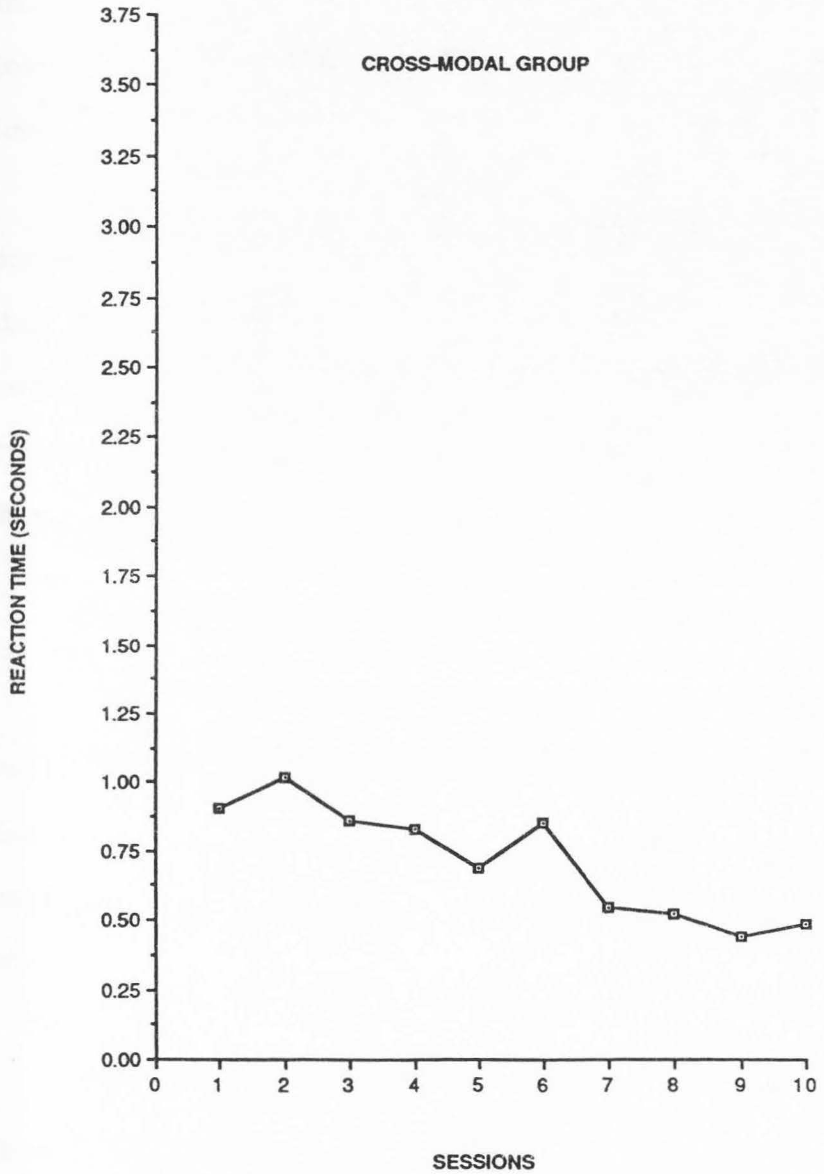



Figure 47. Group data: Mean reaction time for 10 sessions for the cross-modal group.

Figure 48 shows the mean reaction time for each session, over 10 sessions, for the auditory group and Table 6 contains the mean reaction time for all 10 subjects in the auditory group for the first and last sessions. Table 7 is a t test for correlated means. This indicates that the change in reaction time is significant at the .0071 level.

Figure 49 shows the mean reaction time for each session, over 10 sessions, for the comparison group. Table 8 contains the mean reaction time for all 10 subjects in the comparison group for the first and last sessions. In Table 9, the results of a t test for correlated means is shown. This indicates that the change in reaction time is not significant at the .05 level. Although the mean reaction time for the comparison group did increase from session 1 to session 10, the change was not significant.

Figure 50 shows the mean reaction time for each session, over 10 sessions, for the visual group. Table 10 contains the mean reaction time for all 10 subjects in the visual group for the first and last sessions. In Table 11, the results of a t test for correlated means is shown. This indicates that the change in reaction time is significant at the .0045 level.

It was expected that a plateau would be reached by all or most subjects such that their reaction times would remain stable over several sessions. Table 12 shows that there were differences of only hundredths of seconds over the last two sessions for all groups except the comparison group which showed a nonsignificant one second increase in mean reaction time, according to the t test for correlated means. However, individual data show (see Figures 2-41.) that there were

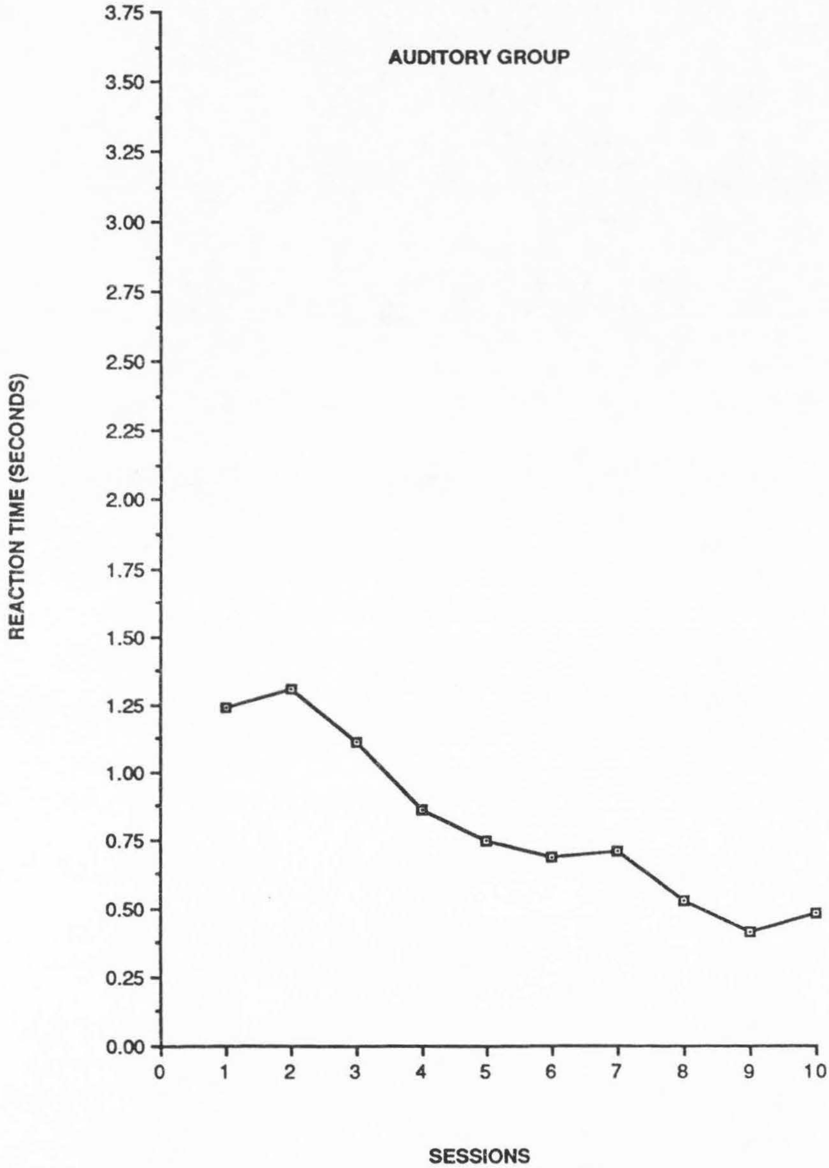



Figure 48. Group data: Mean reaction time for 10 sessions for the auditory group.

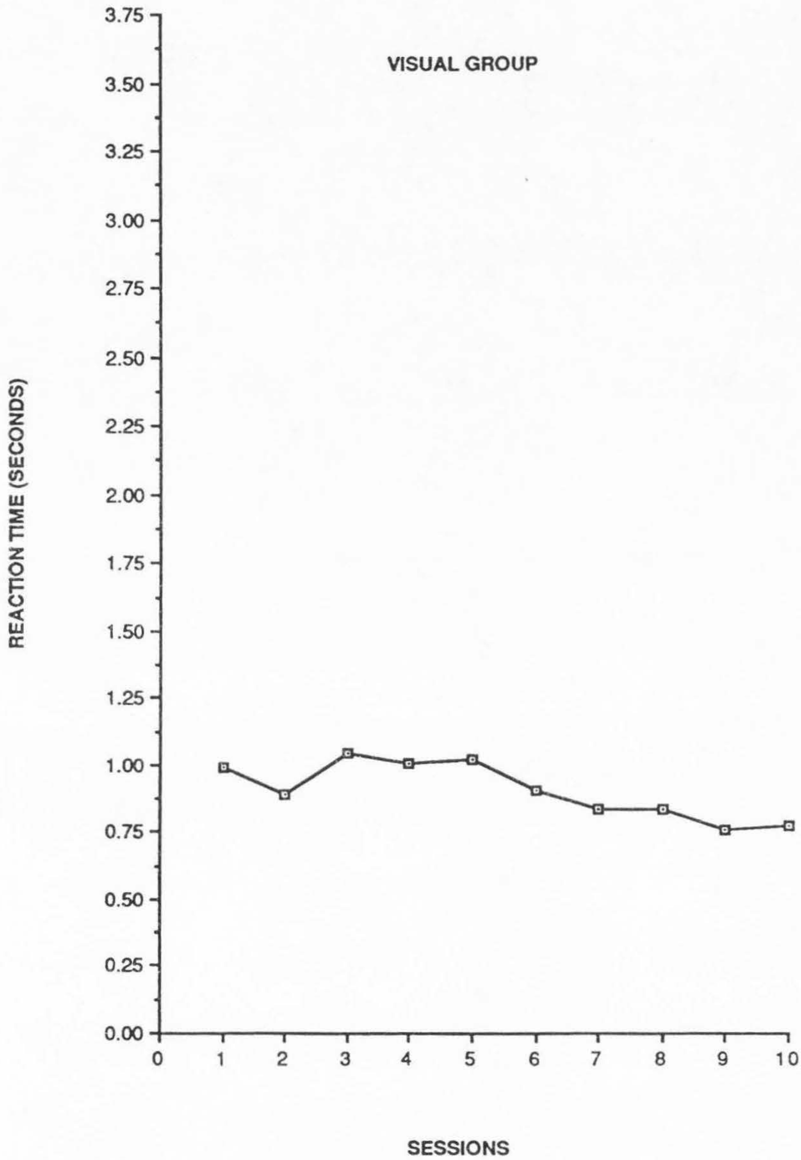



Figure 49. Group data: Mean reaction time for 10 sessions for the visual group.

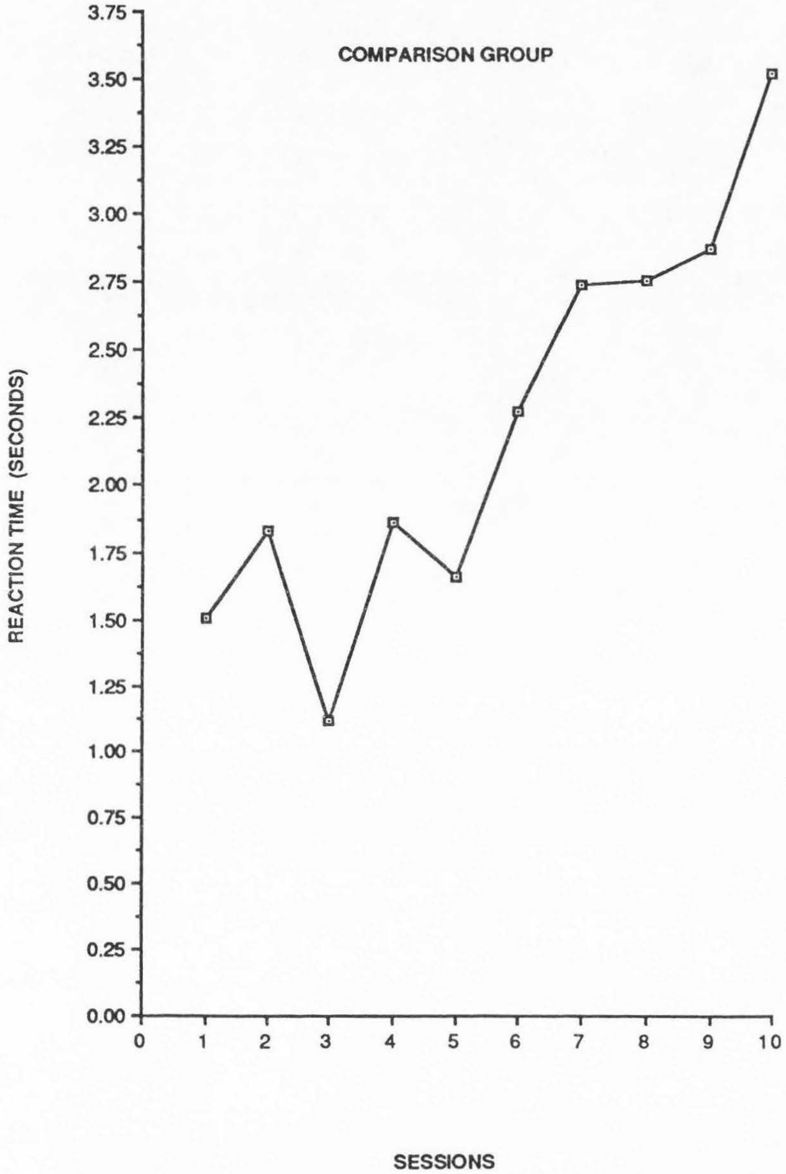



Figure 50. Group data: Mean reaction time for 10 sessions for the comparison group.

fluctuations in reaction times even over the last two sessions for some individuals.

A visual stimulus usually results in a longer reaction time than auditory stimuli (Hoyer et al., 1973; Murrell, & Griew, 1965; Nobel et al., 1964). Therefore, it was expected that the auditory group would have the shortest reaction time. The comparison group, which did not have the opportunity to practice decreasing their reaction time, was expected to have the longest mean reaction times. The visual group was hypothesized to have the second shortest reaction time. Finally, the cross-modal group, which required a response based on both auditory and visual stimuli, was expected to result in the second longest mean reaction times because of the complexity of the task (making a decision based on two different sensory modalities). However, this ordering was not the case (see Figure 51).

Table 11 shows that visual group had the second longest mean reaction times (x=.908) after the comparison group (x=.2.22). The auditory group had a lower reaction time (x=.870) than either the visual or the comparison group. However, the cross-modal group had a mean reaction time (x=.715) that was lower than all other groups. This was not expected because a visual stimulus typically requires a longer reaction time than an auditory stimulus and since the cross-modal group utilized both visual and auditory stimuli, it was expected that the reaction time would be at least as long, or longer than, the visual group's reaction times. Therefore, the auditory group was expected to have the shortest reaction time, as suggested by the literature. As seen in Table 12, the difference between the auditory and cross-modal groups' reaction times was not significant.

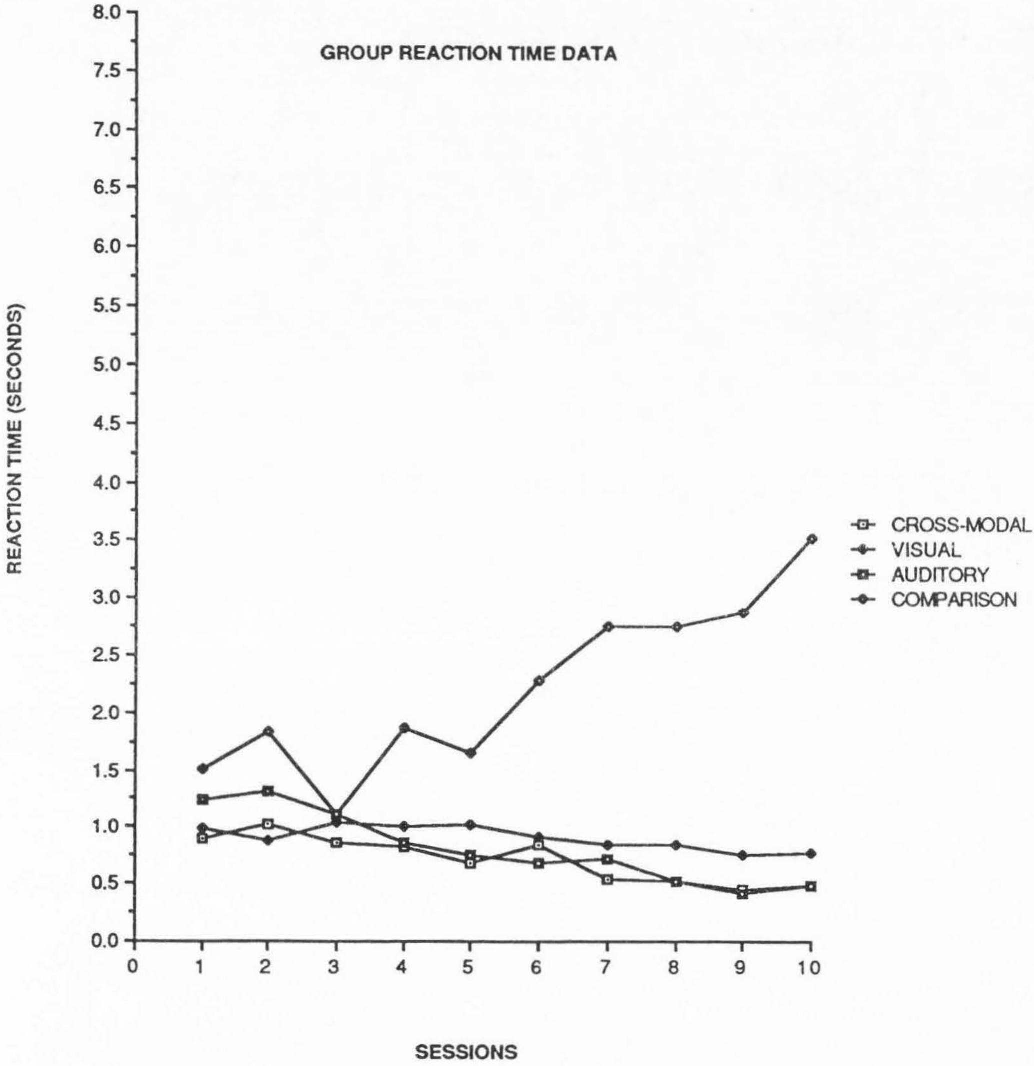



Figure 51. Mean reaction time for each of the four groups for 10 sessions.

Table 11

The Mean Reaction Times (in Seconds) and Error Rates for Each Group for all 10 Sessions

RT = REACTION TIME

| SESSIONS | CROSS-MODAL | | AUDITORY | | VISUAL | | COMPARISON | |
|---|---|---|---|---|---|---|---|---|
| | RT | ERRORS | RT | ERRORS | RT | ERRORS | RT | ERRORS |
| 1 | .903 | 4.2 | 1.237 | 4.3 | .994 | 2.0 | 1.508 | 3.0 |
| 2 | 1.021 | 3.6 | 1.310 | 3.8 | .888 | 2.3 | 1.829 | 2.0 |
| 3 | .857 | 2.3 | 1.108 | 1.9 | 1.047 | 2.2 | 1.114 | 1.5 |
| 4 | .834 | 2.8 | .865 | 1.6 | 1.004 | 2.5 | 1.863 | .90 |
| 5 | .685 | 1.2 | .752 | 1.2 | 1.018 | 1.9 | 1.661 | 1.3 |
| 6 | .851 | 2.2 | .691 | 2.1 | .910 | 1.0 | 2.276 | 1.3 |
| 7 | .547 | 2.1 | .712 | 1.0 | .840 | 1.1 | 2.747 | 2.0 |
| 8 | .525 | 1.3 | .529 | 2.0 | .838 | 1.5 | 2.756 | 2.2 |
| 9 | .444 | 1.2 | .415 | .60 | .763 | 1.7 | 2.875 | 2.1 |
| 10 | .486 | 2.0 | .481 | 1.7 | .773 | 2.3 | 3.527 | 2.1 |
| $\bar{X}$ = | .7153 | 2.29 | .810 | 2.02 | .908 | 1.85 | 2.22 | 1.84 |

Table 12

Results of ANCOVAs Comparing the Mean Reaction Times of the First and Final Sessions of the Four Groups

| EFFECT | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| COVARIATE - 1ST SESSION | 11.0702 | 1 | 11.0702 | 5.911 | .0192 |
| IV - GROUPS | 30.5922 | 3 | 10.1974 | 5.445 | .0038 |
| WITHIN | 65.5496 | 35 | 1.8728 | | |

| GROUPS | MEANS | SD | ADJUSTED MEANS |
|---|---|---|---|
| 1 | .9017 | .5553 | .758696 |
| 2 | 1.2359 | .5834 | .458079 |
| 3 | 1.7080 | .9003 | 2.884380 |
| 4 | .9939 | .3359 | .963641 |

PLANNED COMPARISONS

| GROUPS COMPARED | MEAN RT OF THE LAST SESSION | S.D. | VARIANCE ESTIMATE | DF | P |
|---|---|---|---|---|---|
| CROSS-MODAL & | .486 | .195 | | | |
| AUDITORY | .481 | .255 | .049 | 18 | .914 |
| CROSS-MODAL & | .486 | .195 | | | |
| COMPARISON | 3.325 | 2.891 | -3.099 | 18 | .006 |
| CROSS-MODAL & | .486 | .195 | | | |
| VISUAL | .773 | .234 | -2.974 | 18 | .008 |
| AUDITORY & | .481 | .255 | | | |
| COMPARISON | 3.325 | 2.891 | -3.099 | 18 | .006 |
| AUDITORY & | .481 | .255 | | | |
| VISUAL | .773 | .234 | -2.664 | 18 | .015 |
| VISUAL & | .773 | .234 | | | |
| COMPARISON | 3.325 | 2.891 | -2.783 | 18 | .012 |

The reason for this unexpected ordering of reaction times may be due to the way in which the stimuli were presented. While the cross-modal group received each word of every word pair simultaneously, one word presented visually and one auditorily, the visual group was presented with both words on the computer screen as simultaneously as was possible for the computer. Therefore, it is conceivable that the computer's presentation lagged such that the subjects had to read the words sequentially rather than simultaneously. However, this should have made no more than perhaps thousandths of seconds difference. Another potential reason for the ordering of groups may have been the time taken by the visual subjects to read each word of the pair before responding. This is in contrast to the cross-modal subjects who only needed to read one word, while simultaneously listening to the other word of the pair, before responding. Finally, the mean reaction time for the comparison group was expected to remain approximately the same since they were not afforded the opportunity to practice. Although the changes in reaction time that occurred in the comparison group were not significant, based on a two-tailed test, there were increases, rather than decreases in the group's mean reaction times. As mentioned above, this may have been due to "distractability" or different types of responding to the same task, particularly since the comparison group's task was broken up into components. Or it may have been that since they were not prompted to be fast and there was no feedback the reason for speed was not apparent.

There were significant differences between groups in the amount of change occurring between Session 1 and Session 10. It is important, however, to remember that the mean reaction times themselves are not the data of major importance. Reaction times differ simply on the basis of the type of stimulus presented (i.e., auditory or visual). The data that are compared, and that are of most importance, are the changes occurring within each group's reaction times on the practiced and the unpracticed tasks (multiple-choice test). In order to determine the effectiveness of each intervention, it is most important to examine which of the four groups demonstrated the greatest amount of change in reaction time and error rate, and whether these changes were significant. Table 12, which shows the results of an ANCOVA, indicates that the mean reaction time on the first day, was significantly related to the reaction time on the last day. This was expected since the type of stimulus used may affect reaction times. Therefore, it was expected that the various reaction times seen in the first session would correlate with or significantly impact the times in the final session. Here, the four treatment groups were used as the independent variable with the first session reaction times as the covariate and the last session reaction times as the dependent variable. When the first session is utilized as a covariate, the differences between groups' adjusted mean reaction times are not statistically significant indicating that the differences in reaction time are due to the task requirement. Planned comparisons between groups resulted in significant differences between the auditory, visual, and cross-modal groups when compared to the comparison group. There were also significant differences between the cross-modal, and the visual groups, and between the auditory and visual groups as shown in Table 12. There were no significant differences between the auditory and cross-modal groups however. This demonstrates that the cross-modal and auditory groups were most similar in length of reaction time and that both differed from the visual group. All treatment groups differed significantly from the comparison group.

### Changes in Error Rates Across Sessions

Surwillow (1968) reported that, as the amount of time taken to make a response decreases, the number of errors on the decision-making task should also decrease. This was the case for all except the visual group which had a slight increase in errors in session 10 compared to session 1 (see Appendix D and Figures 52, 53, 54, & 55). However, based on the results of four t tests for correlated means, the differences in the number of errors in the first session, compared to the number in the last session, are not statistically significant (see Tables 13, 14, 15, and 16).

It was anticipated that the mean number of errors per session for each group would reach a plateau. However, Figures 54 and 56 indicate that the only group that appeared to achieve a plateau lasting over sessions 7-10 was the comparison group. All other groups showed a great deal of fluctuation in mean number of errors each session. The comparison group may have maintained a more stable mean rate of errors, while the other groups did not, because these subjects were forced to wait before responding. Therefore, they may have made approximately the same number of errors per day, without fluctuation, because they were not required to respond as quickly as possible to the stimuli presentations.

Since all groups practiced an equal number of trials and sessions, it was expected that any changes occurring in error rates would not be

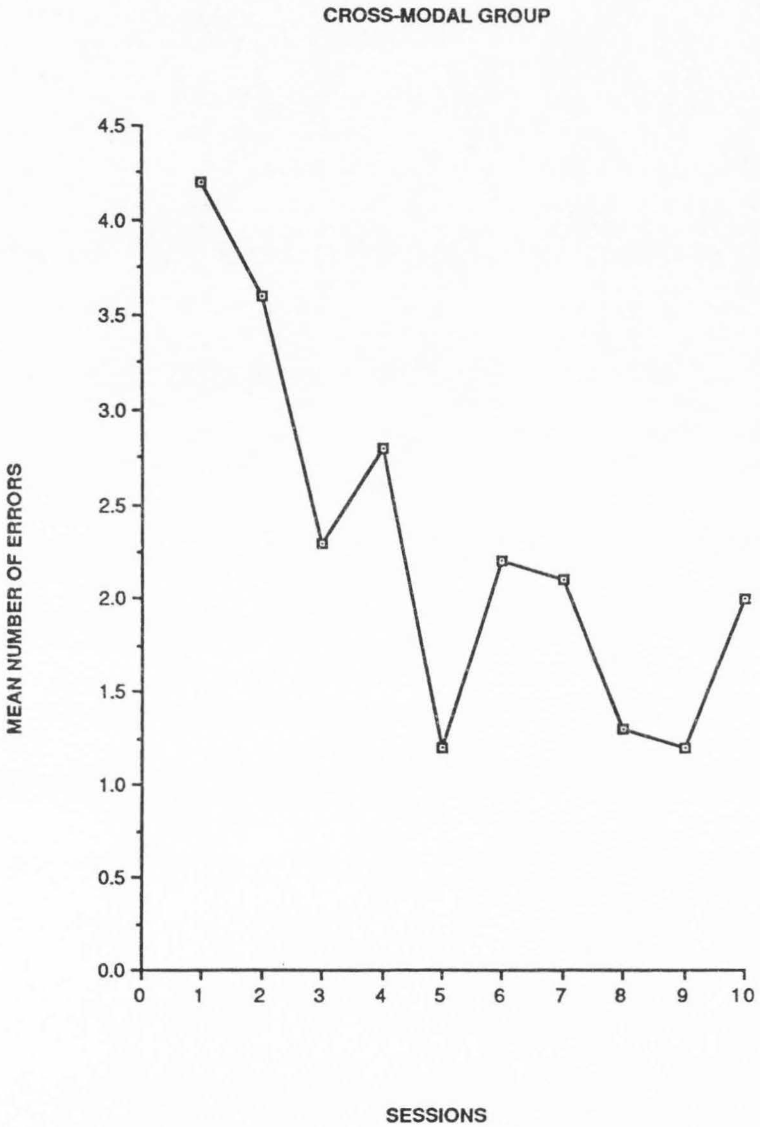



Figure 52. Mean error rate for the 10 sessions for the cross-modal group.

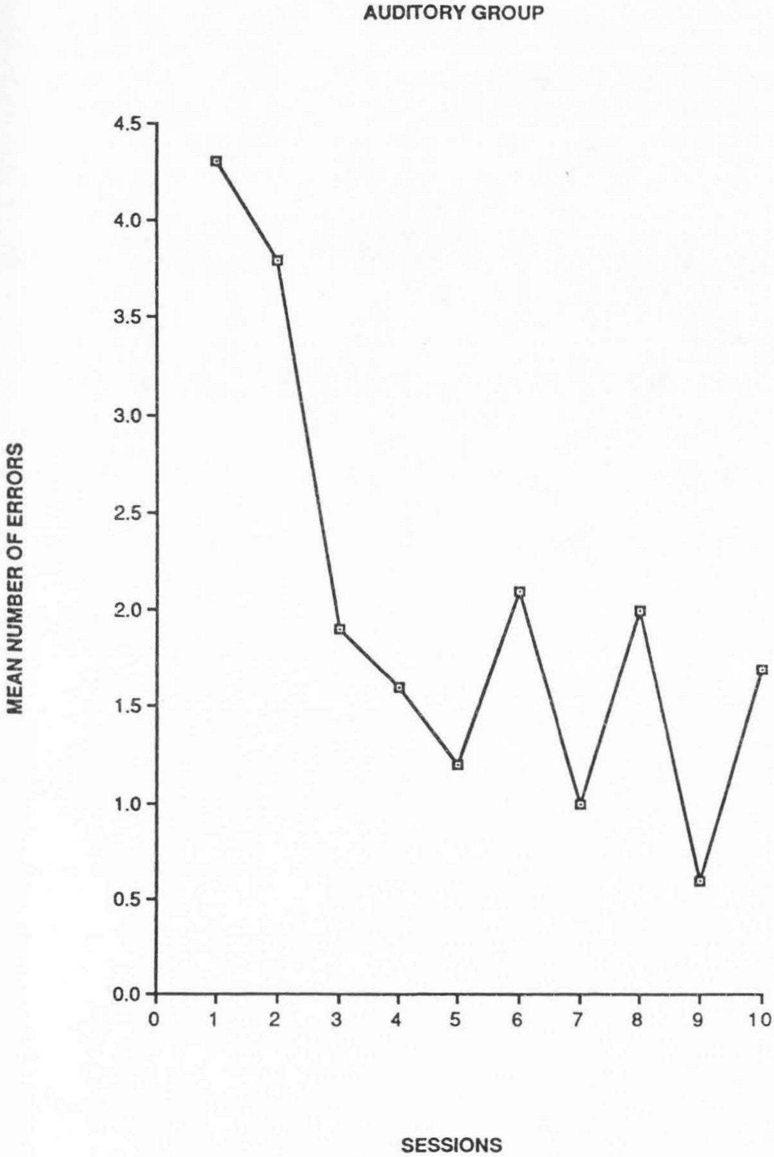



Figure 53. Mean error rate for the 10 sessions for the auditory group.

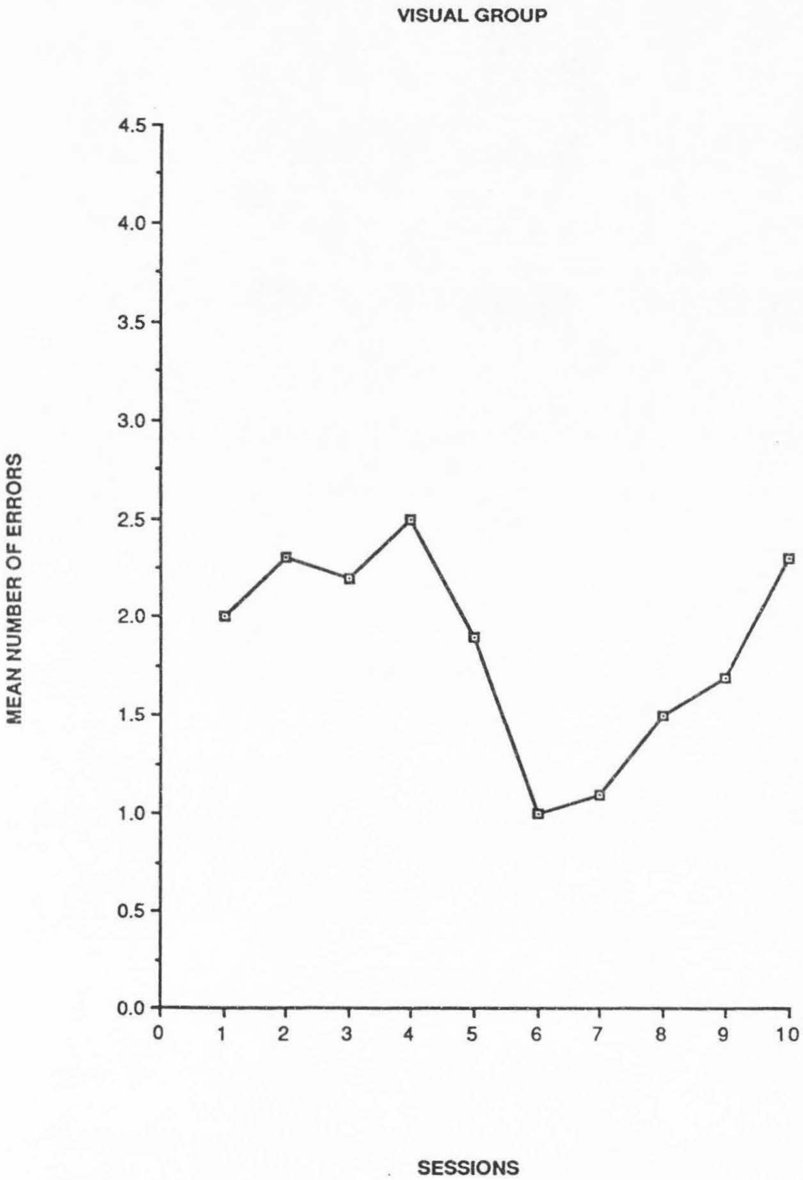



Figure 54. Mean error rate for the 10 sessions for the visual group.

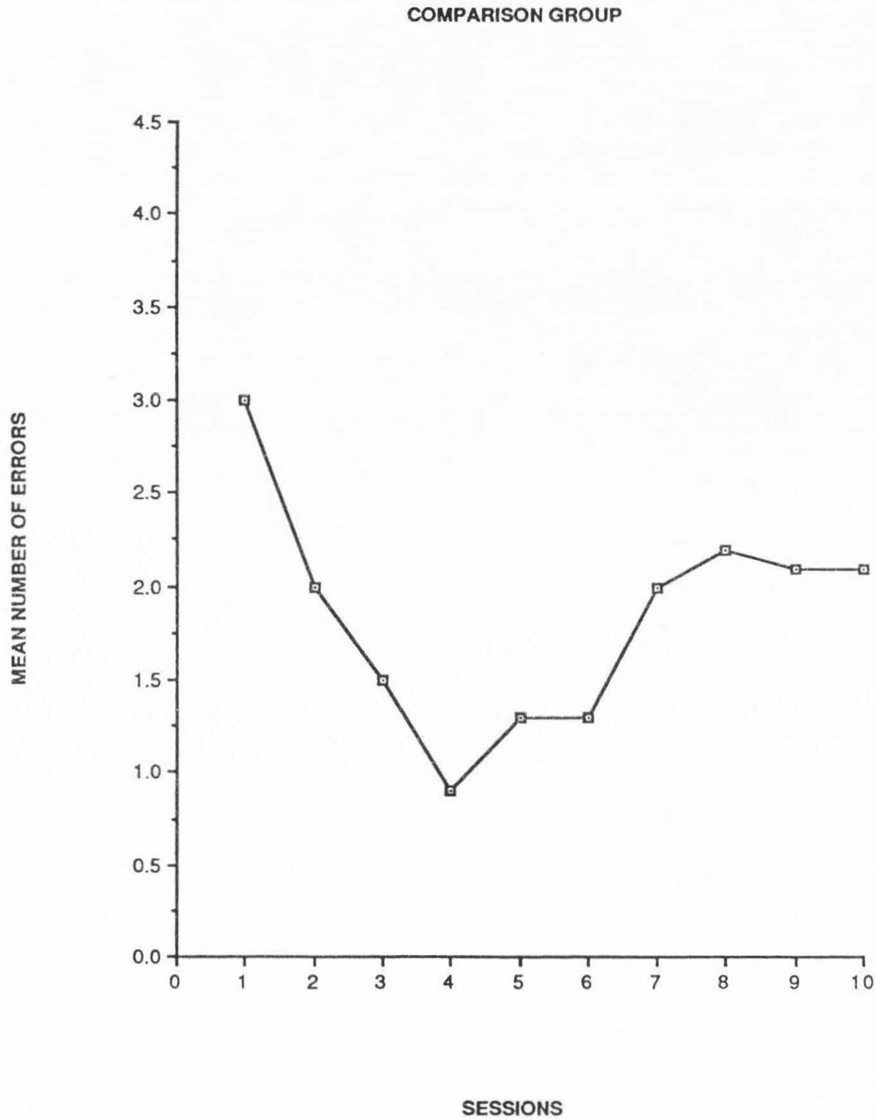



Figure 55. Mean error rate for the 10 sessions for the comparison group.

Table 13

Results of a T Test for Correlated Means Comparing Error Rates from the First and the Last Session in the Cross-Modal Group

| DF | MEAN X-Y | PAIRED T VALUE | PROB (2-TAIL) |
|---|---|---|---|
| 9 | 2.2 | 1.652 | .1329 |

Table 14

Results of a T Test for Correlated Means Comparing Error Rates from the First and the Last Session in the Auditory Group

| DF | MEAN X-Y | PAIRED T VALUE | PROB (2-TAIL) |
|---|---|---|---|
| 9 | 2.6 | 1.847 | .0979 |

Table 15

Results of a T Test for Correlated Means Comparing Error Rates from the First and the Last Session in the Comparison Group

| DF | MEAN X-Y | PAIRED T VALUE | PROB (2-TAIL) |
|---|---|---|---|
| 9 | .9 | .927 | .3783 |

Table 16

Results of a T Test for Correlated Means Comparing Error Rates from the First and the Last Session in the Visual Group

| DF | MEAN X-Y | PAIRED T VALUE | PROB (2-TAIL) |
|---|---|---|---|
| 9 | -.3 | -.279 | .7866 |

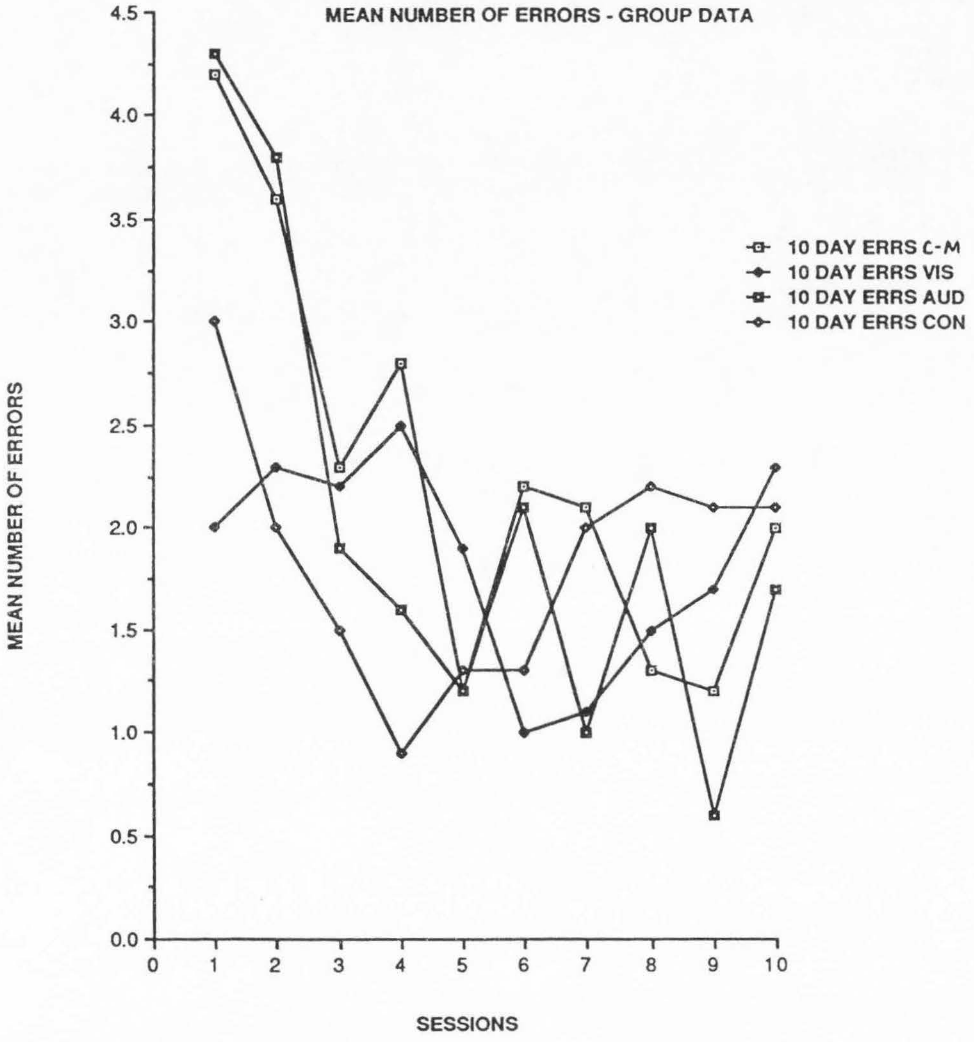



Figure 56. Group data: Mean error rate for each of the four groups for all 10 sessions.

significantly different between groups. This has been reported by Cooper and Shepard (1973), Davis (1957), and Koga and Morant (1923). Table 17 reveals that there were no statistically significant differences in error rates between groups using an analysis of covariance.

### Changes in Pretest to Posttest Multiple-Choice Test Reaction Times

Hoyer et al. (1973), Murrell and Griew (1965), and Nobel et al. (1964) found that reaction time and error rates decrease after practicing a reaction time task. It might then be hypothesized that posttest reaction time and error rates might decrease after treatment when compared to pretreatment scores. This might occur even if the practiced reaction time task differed from the task requirement of the pre and posttests. Figure 57 shows the mean pretest to posttest reaction times and error rates for all 40 subjects combined. It is clear that both the mean reaction time and error rate decreased from the pretest to the posttest. This change in reaction time was significant at the .001 level but was not statistically significant for the change in errors. Figures 58, 59, 60 and 61 show pretest to posttest reaction times for each subject and each group. The reaction times were lower on the posttest compared to the pretest for all subjects except one in the visual group (#19), one in the cross-modal group (#23), and six in the comparison group. Reaction times were longer on the posttest for these eight subjects (Appendix D). Table 18 contains the mean reaction times for all ten subjects in the cross-modal group for the pretest and posttest. In Table 19, the results of a t test for correlated means for

Table 17

Results of ANCOVAs Comparing the Mean Error Rates of the Four Groups

| EFFECT | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| COVARIATE - 1ST SESSION | 7.9061 | 1 | 7.906 | 1.339 | .2539 |
| IV - GROUPS | 3.0879 | 3 | 1.0293 | .174 | .9106 |
| WITHIN | 206.6939 | 35 | 5.9055 | | |

| GROUPS | ADJUSTED MEANS |
|---|---|
| 1 | 1.86730 |
| 2 | 1.72317 |
| 3 | 2.13492 |
| 4 | 2.47461 |

PLANNED COMPARISONS

| GROUPS COMPARED | MEANS | S.D. | VARIANCE ESTIMATE | DF | P |
|---|---|---|---|---|---|
| CROSS-MODAL & | 2.0 | 2.160 | | | |
| AUDITORY | 1.8 | 1.476 | .242 | 18 | .798 |
| CROSS-MODAL & | 2.0 | 2.160 | | | |
| COMPARISON | 2.1 | 2.558 | -.094 | 18 | .887 |
| CROSS-MODAL & | 2.0 | 2.160 | | | |
| VISUAL | 2.3 | 3.234 | -.244 | 18 | .796 |
| AUDITORY & | 1.8 | 1.476 | | | |
| COMPARISON | 2.1 | 2.558 | -.321 | 18 | .747 |
| AUDITORY & | 1.8 | 1.476 | | | |
| VISUAL | 2.3 | 3.234 | -.445 | 18 | .665 |
| COMPARISON & | 2.1 | 2.558 | | | |
| VISUAL | 2.3 | 3.234 | -.153 | 18 | .852 |

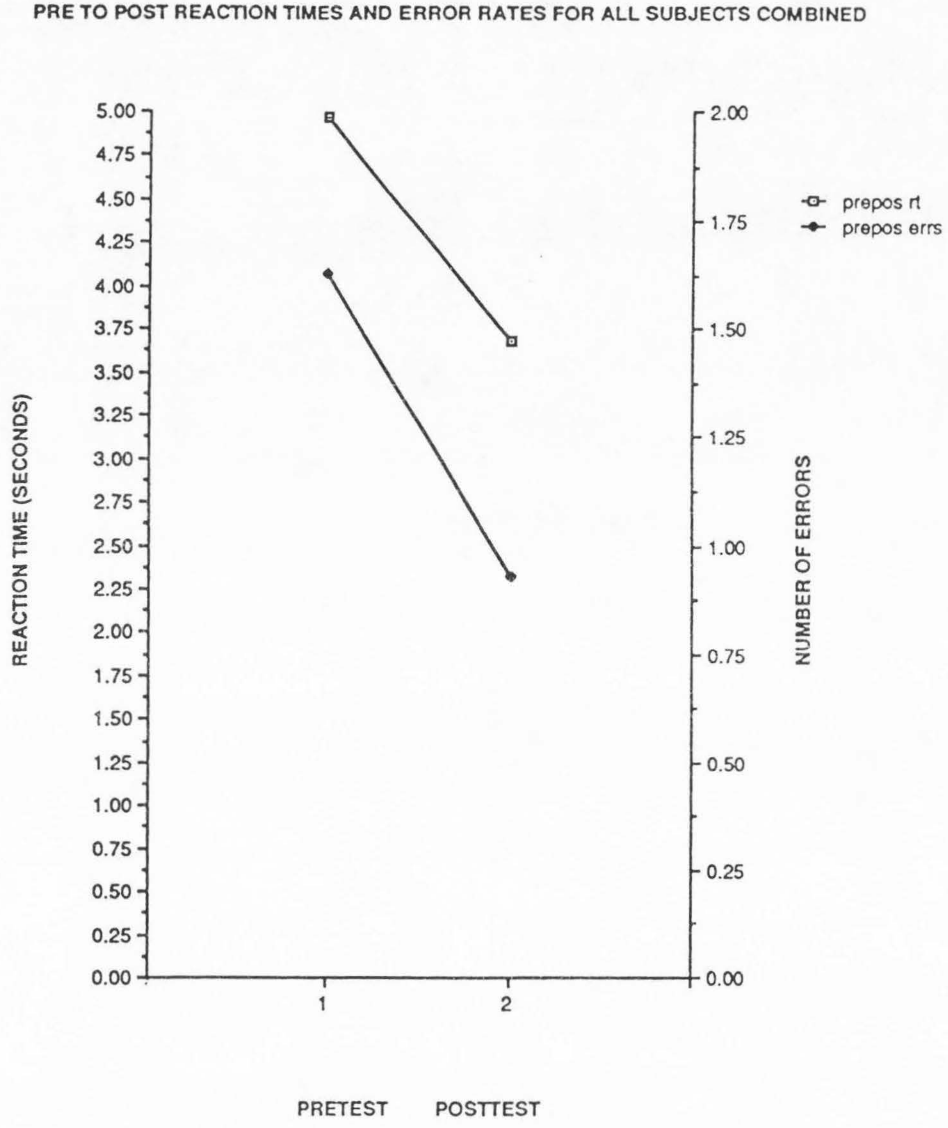



Figure 57. Mean pretest and posttest reaction times and error rates for all 40 subjects.

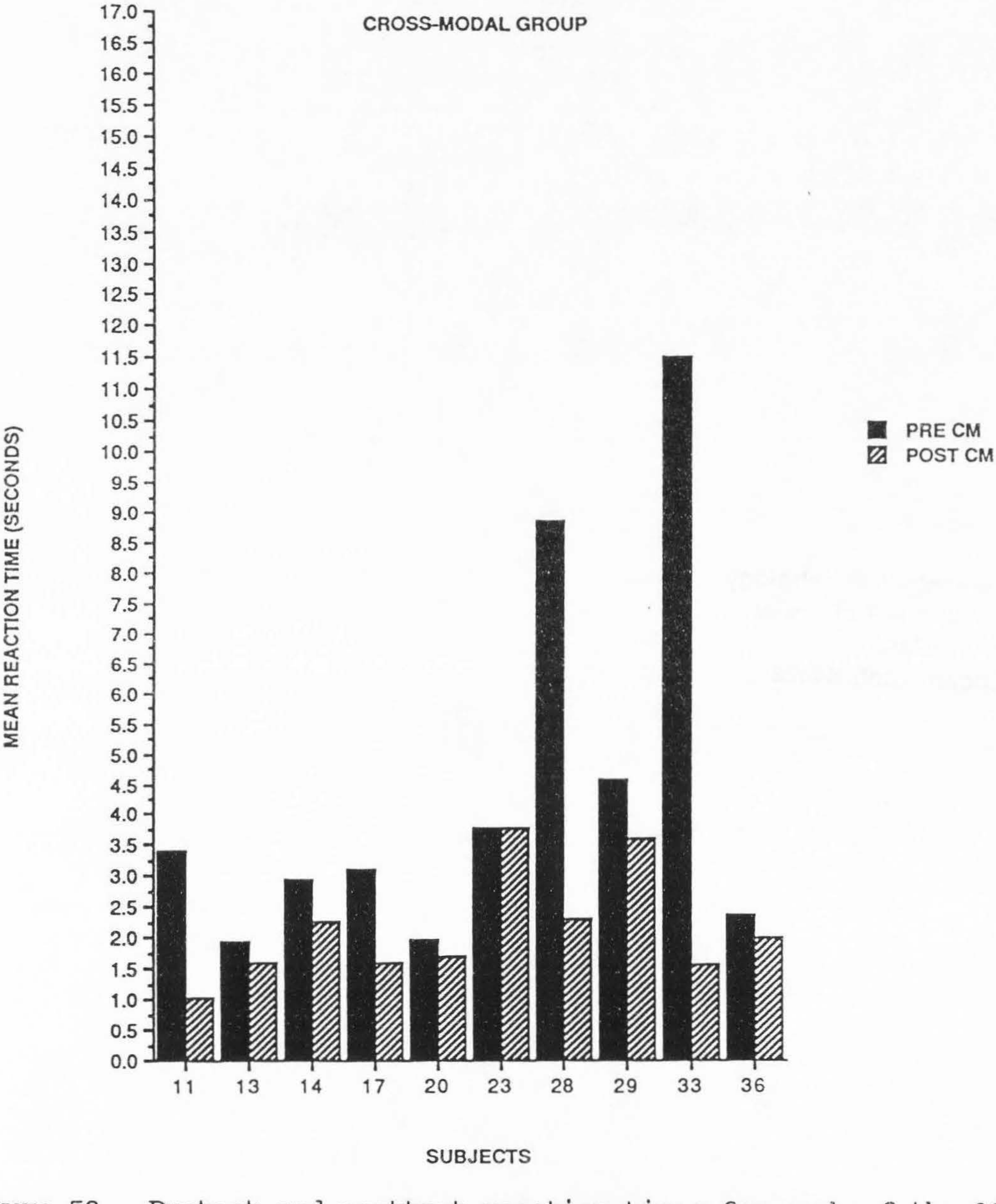



Figure 58. Pretest and posttest reaction times for each of the 10 subjects in the cross-modal group.

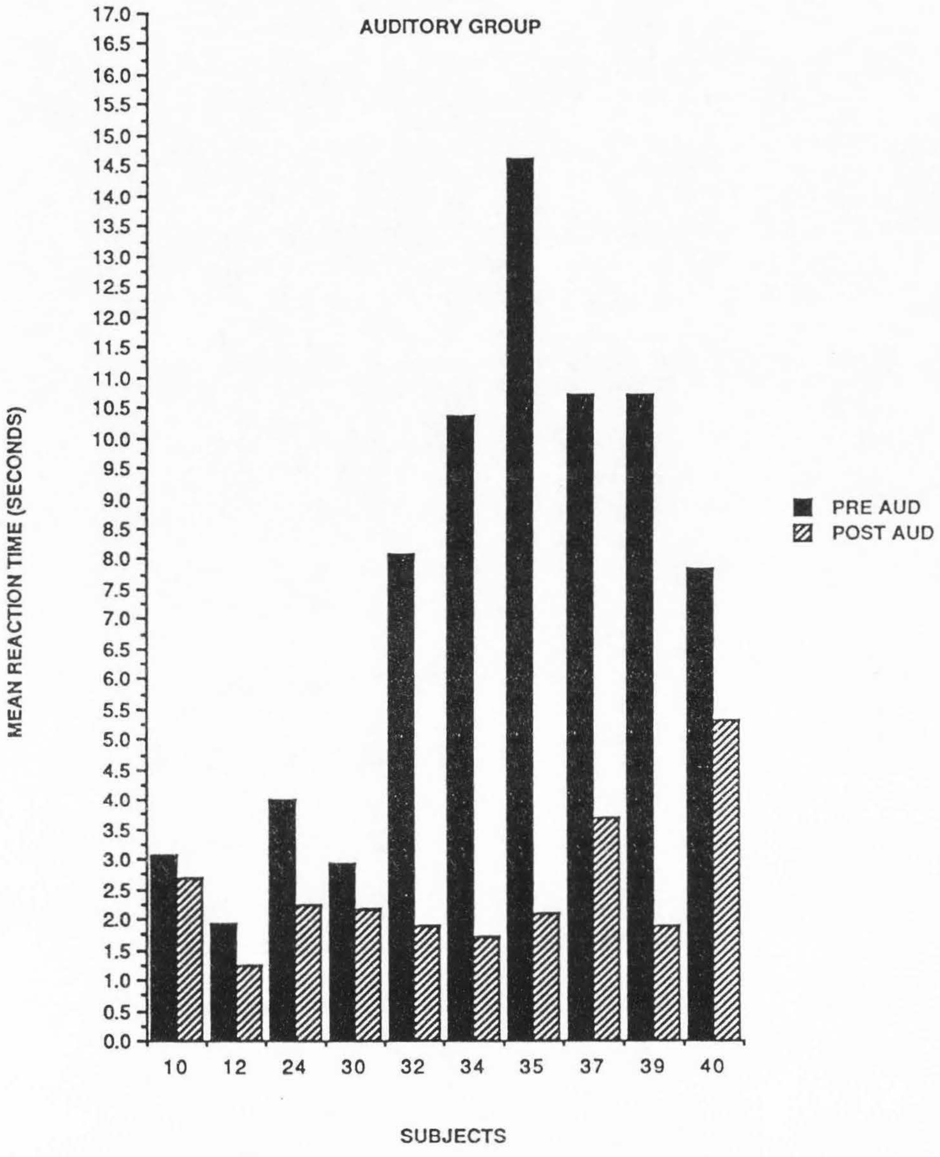



Figure 59. Pretest and posttest reaction times for each of the 10 subjects in the auditory group.

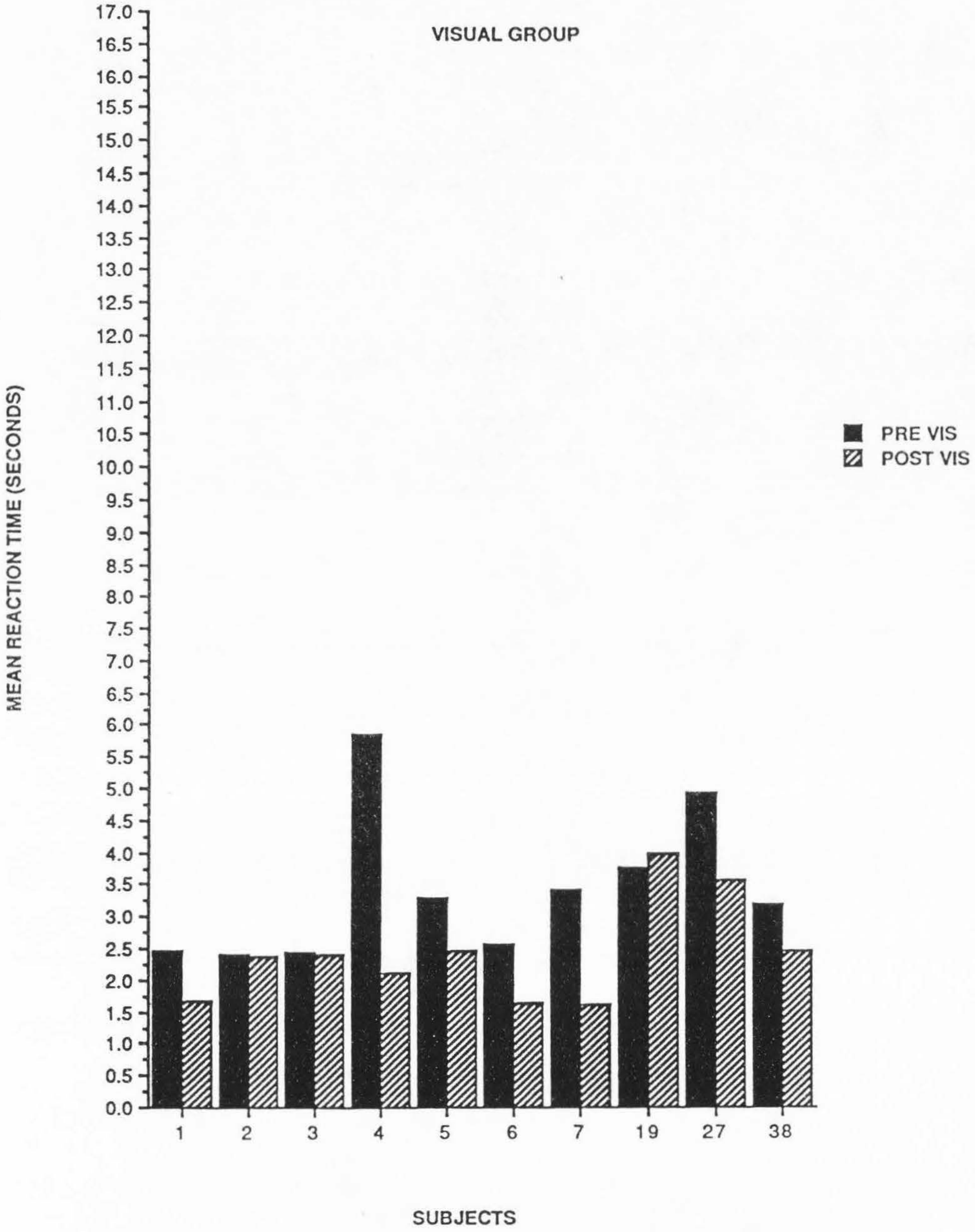



Figure 60. Pretest and posttest reaction times for each of the 10 subjects in the visual group.

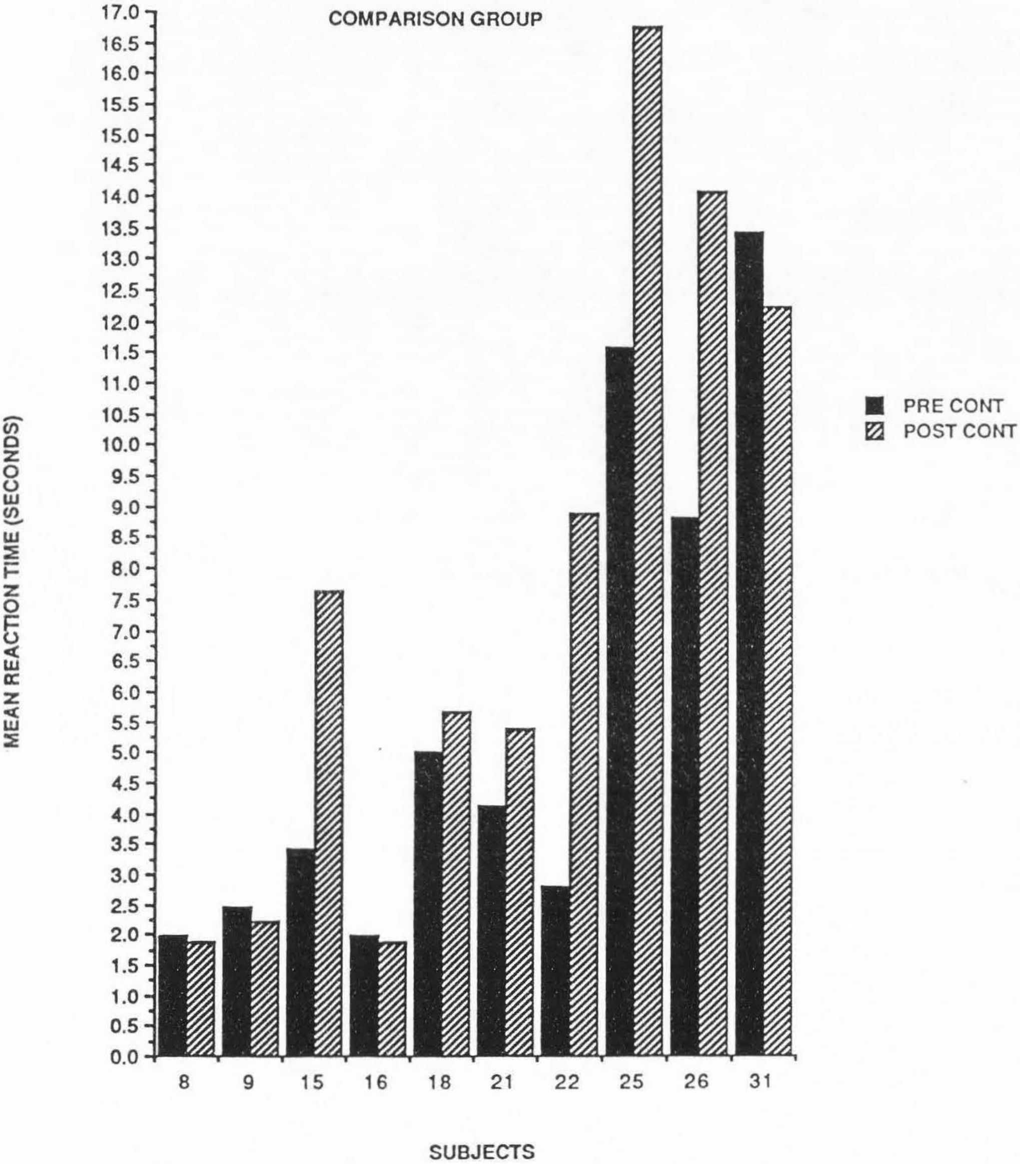



Figure 61. Pretest and posttest reaction times for each of the 10 subjects in the comparison group.

Table 18

Mean Reaction Time (in Seconds) for all 10 Subjects on the Pre and Posttests for the Cross-Modal Group

| SUBJECTS | MEAN REACTION TIME ON THE PRETEST | MEAN REACTION TIME ON THE POSTTEST | CHANGE (+/-) |
|---|---|---|---|
| 1 | 3.410 | 1.041 | -2.369 |
| 2 | 1.927 | 1.593 | -.334 |
| 3 | 2.938 | 2.238 | -.700 |
| 4 | 3.098 | 1.600 | -1.498 |
| 5 | 1.976 | 1.708 | -.268 |
| 6 | 3.770 | 3.775 | +.005 |
| 7 | 8.873 | 2.295 | -6.578 |
| 8 | 4.582 | 3.623 | -.959 |
| 9 | 11.522 | 1.574 | -9.948 |
| 10 | 2.383 | 2.018 | -.365 |
| | | | $\overline{X}$ = -2.297 |

Table 19

Results of a T Test for Correlated Means Comparing the Means of the Pre and the Posttest Reaction Times for the Cross-Modal Group

| DF | MEAN X-Y | PAIRED T-VALUE | PROB (2-TAIL) |
|---|---|---|---|
| 9 | 2.297 | 2.19 | .0562 |

the cross-modal group shows that the change in reaction time is not significant, although only slightly over the acceptable .05 level at .0562. This lack of statistical significance may have been due to the fact that this group had practiced a task in which they received stimuli simultaneously. The requirement to read each of the multiple-choice questions and answers before responding may have led to long response times for this group due to the difference between the practiced and the multiple-choice tasks. The visual and comparison groups were accustomed to reading words on the screen, while the auditory group received stimuli sequentially. The simultaneous practiced task for the cross-modal group may have simply been too different from the multiple-choice task. Although it was assumed that a cross-modal task would be more complex, and therefore more similar to the multiple-choice task, this apparently was not the case. In fact, it appears that the cross-modal task may have been less complex than the other tasks because the subjects in this group were required to only read one stimulus, rather than two, as in the visual group. The cross-modal group only had to listen for one stimulus word, rather than two, as in the auditory group. This suggests that receiving stimuli in two different modalities simultaneously requires less time to make a decision than when basing a decision on two stimuli presented sequentially even when the two are different and both are required. Tables 20, 22, and 24 show the mean reaction times for the pretest and posttests for each of the 10 subjects in auditory, control, and visual groups, respectively. In Table 21, the results of a t test for correlated means for the auditory group is shown. This indicates that the change in reaction time was significant, at the .0053 level. In Table 23, the results of a t test for correlated

Table 20

Mean Reaction Time (in Seconds) for all 10 Subjects on the Pre and Posttests for the Auditory Group

| SUBJECTS | MEAN REACTION TIME ON THE PRETEST | MEAN REACTION TIME ON THE POSTTEST | CHANGE (+/-) |
|---|---|---|---|
| 1 | 3.07 | 2.70 | -.370 |
| 2 | 1.949 | 1.252 | -.697 |
| 3 | 3.989 | 2.231 | -1.758 |
| 4 | 2.941 | 2.168 | -.773 |
| 5 | 8.091 | 1.902 | -6.189 |
| 6 | 10.374 | 1.715 | -8.659 |
| 7 | 14.632 | 2.098 | -12.534 |
| 8 | 10.716 | 3.714 | -7.002 |
| 9 | 10.313 | 1.903 | -8.410 |
| 10 | 7.856 | 5.308 | -2.548 |
|  |  |  | $\overline{X}$ = -4.894 |

Table 21

Results of a T Test for Correlated Means Comparing the Means of the Pre and the Posttest Reaction Times for the Auditory Group

| DF | MEAN X-Y | PAIRED T-VALUE | PROB (2-TAIL) |
|---|---|---|---|
| 9 | 4.894 | 3.654 | .0053 |

Table 22

Mean Reaction Time (in Seconds) for all 10 Subjects on the Pre and Posttests for the Comparison Group

| SUBJECTS | MEAN REACTION TIME ON THE PRETEST | MEAN REACTION TIME ON THE POSTTEST | CHANGE (+/-) |
|---|---|---|---|
| 1 | 3.920 | 3.110 | -.810 |
| 2 | 2.460 | 2.220 | -.240 |
| 3 | 3.413 | 7.625 | +4.212 |
| 4 | 1.978 | 1.885 | -.093 |
| 5 | 5.019 | 5.672 | +.653 |
| 6 | 4.110 | 5.392 | +1.282 |
| 7 | 2.792 | 8.892 | +6.100 |
| 8 | 11.580 | 16.750 | +5.170 |
| 9 | 8.830 | 14.070 | +5.240 |
| 10 | 13.430 | 12.230 | -1.200 |
| | | | $\overline{X}$ = +2.031 |

Table 23

Results of a T Test for Correlated Means Comparing the Means of the Pre and the Posttests Reaction Times for the Comparison Group

| DF | MEAN X-Y | PAIRED T-VALUE | PROB (2-TAIL) |
|---|---|---|---|
| 9 | -2.031 | -2.27 | .0494 |

Table 24

Mean Reaction Time (in Seconds) for all 10 Subjects on the Pre and Posttests for the Visual Group

| SUBJECTS | MEAN REACTION TIME ON THE PRETEST | MEAN REACTION TIME ON THE POSTTEST | CHANGE (+/-) |
|---|---|---|---|
| 1 | 2.480 | 1.670 | -.810 |
| 2 | 2.400 | 2.390 | -.010 |
| 3 | 5.870 | 2.110 | -3.760 |
| 4 | 3.300 | 2.480 | -.820 |
| 5 | 2.580 | 1.640 | -.940 |
| 6 | 3.420 | 1.630 | -1.790 |
| 7 | 3.769 | 3.989 | +.220 |
| 8 | 4.953 | 3.586 | -1.367 |
| 9 | 3.198 | 2.458 | -.740 |
| 10 | 2.130 | 2.123 | -.007 |
| | | $\overline{X}$ = | -1.002 |

Table 25

Results of a T Test for Correlated Means Comparing the Means of the Pre and the Posttest Reaction Times for the Visual Group

| DF | MEAN X-Y | PAIRED T-VALUE | PROB (2-TAIL) |
|---|---|---|---|
| 9 | 1.002 | 2.749 | .0225 |

means for the control group is shown. This indicates that the change in reaction time was significant, at the .0494 level. Finally, Table 25 indicates that the change in reaction time in the visual group from pre to posttest was significant at the .0225 level.

The greatest change from pretest to posttest reaction times occurred in the auditory group. This was surprising because the task that this group practiced seemed most different from the multiple-choice task than the other groups' tasks. In the auditory group's practice sessions, they received only auditory stimuli, while the pretest and posttests consisted of only visual stimuli. It was therefore expected that the visual group would experience a greater change from pretest to posttest scores than the auditory group because the visual group's practice task was more similar to the visually presented posttest than the auditory group's task. Had the multiple-choice test been presented auditorily, then the auditory group would have been expected to show the greatest change. Also, it was hypothesized that the cross-modal group had received a more complex type of practice, requiring decisions to be made on the basis of stimuli presented auditorily and visually. The complexity of this task was assumed to be similar to the complexity of the multiple-choice task, which required making a decision based on several alternatives. Therefore, it was assumed that the cross-modal group would exhibit the greatest decrease from pre to posttest reaction time, the visual group next, and then the auditory group followed by the comparison. The auditory group had the greatest decrease in reaction time on this task. Therefore, this decreased reaction time may have generalized to the multiple-choice posttest. The auditory group responded quickly during their practice task, significantly reduced their reaction times, and perhaps then could respond faster on the posttest.

It was hypothesized that the cross-modality group would exhibit the greatest change in mean reaction time from pretest to posttest. This assumption was made because the multiple-choice task requires subjects to choose from four different responses, which seems to be a complex task. The cross-modality group practiced what might be considered a relatively complex task because they were not only required to choose between two response alternatives on their practice task, but to utilize two different sensory modalities in order to make this choice. Potash and Jones (1977) and Cooper and Shepard (1973) suggested that reaction time performance might generalize from one task to another if the tasks were similar. Therefore, it seemed likely that the visual group should have the next most change in mean reaction time from pretest to posttest and auditory and comparison group last. This is because the visual group received all visual stimuli and the multiple-choice task was also all visual stimuli. The comparison group should have shown the least changes between pretest and posttest because these subjects did not practice decreasing their reaction time. Any changes that occurred in this group's reaction time were assumed to be due only to using the computer.

Table 26 shows the results of an ANCOVA in which the independent variable was the treatment group, the pretest was used as a covariate in order to statistically minimize differences between groups, and the posttest served as the dependent variable (Glass & Hopkins, 1984). The main effect (see Table 26), demonstrates that there is a significant

Table 26

Results of ANCOVAs Comparing the Mean Reaction Times on the Pre and Posttests of the Four Groups

| EFFECT | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| COVARIATE - PRETEST | 75.9993 | 1 | 84.0603 | 14.266 | .0009 |
| IV - GROUPS | 208.5628 | 3 | 69.5209 | 12.097 | .0001 |
| WITHIN | 201.1371 | 35 | 5.7468 | | |

| GROUPS | POSTTEST MEAN | SD | N | ADJUSTED MEAN |
|---|---|---|---|---|
| 1 | 2.1510 | .8977 | 10 | 2.47685 |
| 2 | 2.4990 | 1.1848 | 10 | 1.56449 |
| 3 | 7.6620 | 5.2865 | 10 | 7.51933 |
| 4 | 2.4370 | .7978 | 10 | 3.18832 |

PLANNED COMPARISONS

| GROUPS COMPARED | MEANS | SD | VARIANCE ESTIMATE | DF | P |
|---|---|---|---|---|---|
| CROSS-MODAL & AUDITORY | 2.151<br>2.499 | .898<br>1.185 | -.740 | 18 | .475 |
| CROSS-MODAL & COMPARISON | 2.151<br>7.662 | .898<br>5.286 | -3.25 | 18 | .005 |
| CROSS-MODAL & VISUAL | 2.151<br>2.437 | .898<br>.798 | -.753 | 18 | .467 |
| AUDITORY & COMPARISON | 2.499<br>7.662 | 1.185<br>5.286 | -3.014 | 18 | .007 |
| AUDITORY & VISUAL | 2.499<br>2.437 | 1.185<br>.798 | .137 | 18 | .862 |
| VISUAL & COMPARISON | 2.437<br>7.662 | .798<br>5.286 | 3.091 | 18 | .006 |

difference between groups. All groups showed significant differences compared to the comparison group in their changes in reaction time from pretest to posttest. This clearly demonstrates that the interventions were effective in reducing the reaction times on the posttest as indicated by the significant changes seen in the treatment groups but not in the comparison group. However, the visual, auditory, and cross-modal groups did not differ significantly, indicating that they were equally effective interventions for reducing reaction time on the posttest.

Changes in Pretest to Posttest Error Rate

Cooper and Shepard (1973), and Surwillow (1968) found that number of errors decreased with practice. This also occurred in the pretest experiment. Figures 62, 63, 64, and 65 show the number of errors made on the pretest and posttest by each subject according to group. Two auditory subjects had more errors on the posttest, one visual subject, three control subjects, and two cross-modal subjects also showed increases.

The t tests for correlated means are shown in Tables 27, 28, 29, and 30. These results indicate that the changes in errors are statistically nonsignificant for all groups. The average number of errors decreased for all groups, except the comparison group, where the number of errors remained unchanged. However, these changes were not statistically significant. Improvement was not expected here since this group did not have the chance to practice a task requiring speed.

Figures 62-65 show the changes in groups in the error rates on the pretest and posttests. The results of an ANCOVA indicated

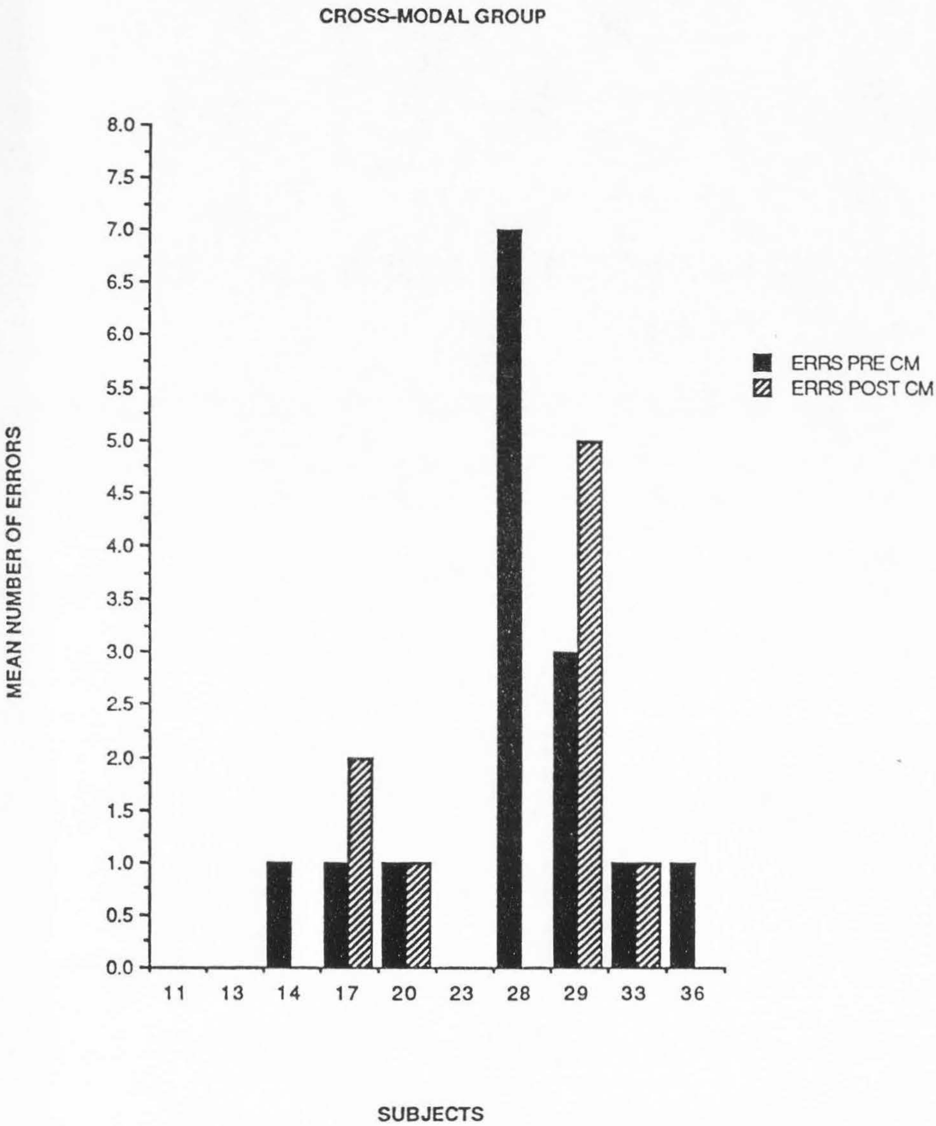



Figure 62. Pretest and posttest error rates for each of the 10 subjects in the cross-modal group.

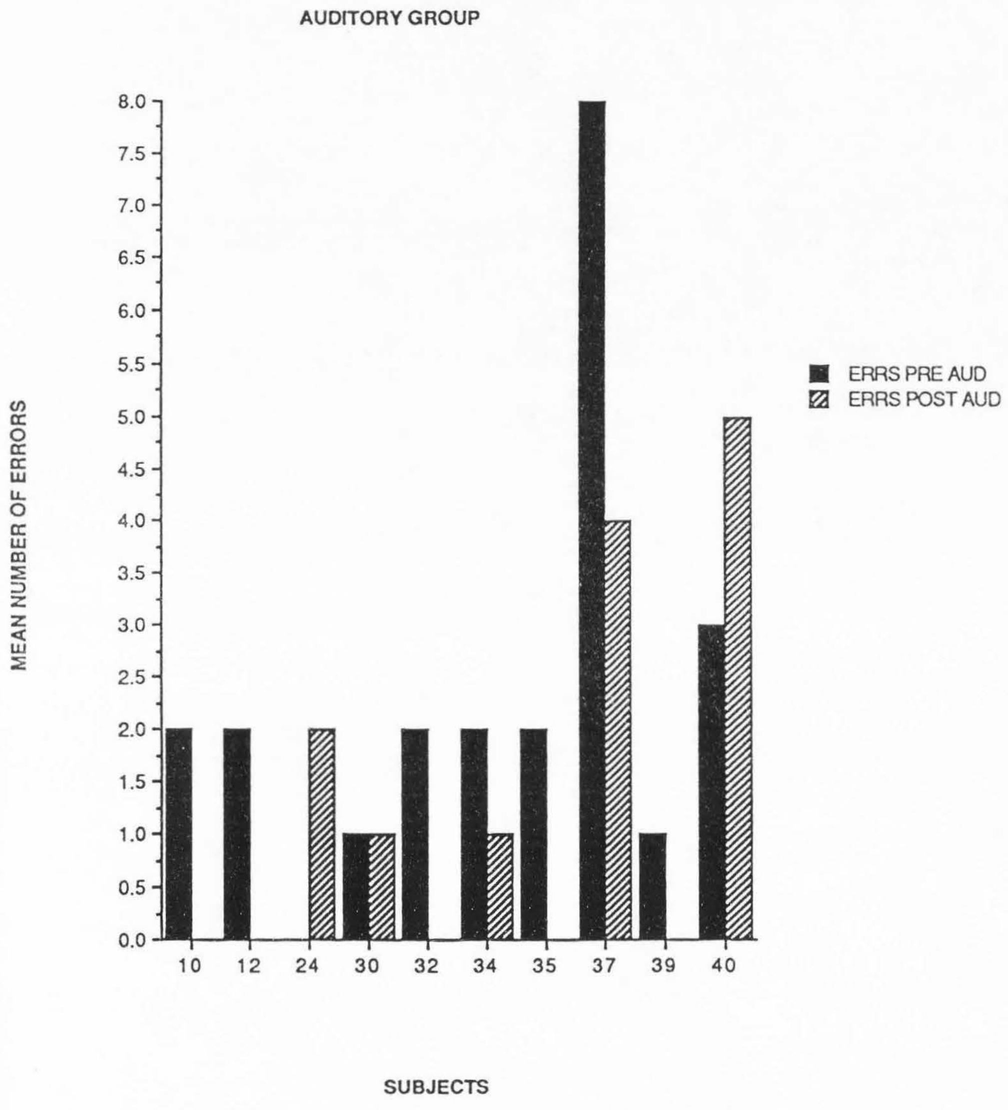



_Figure 63_. Pretest and posttest error rates for each of the 10 subjects in the auditory group.

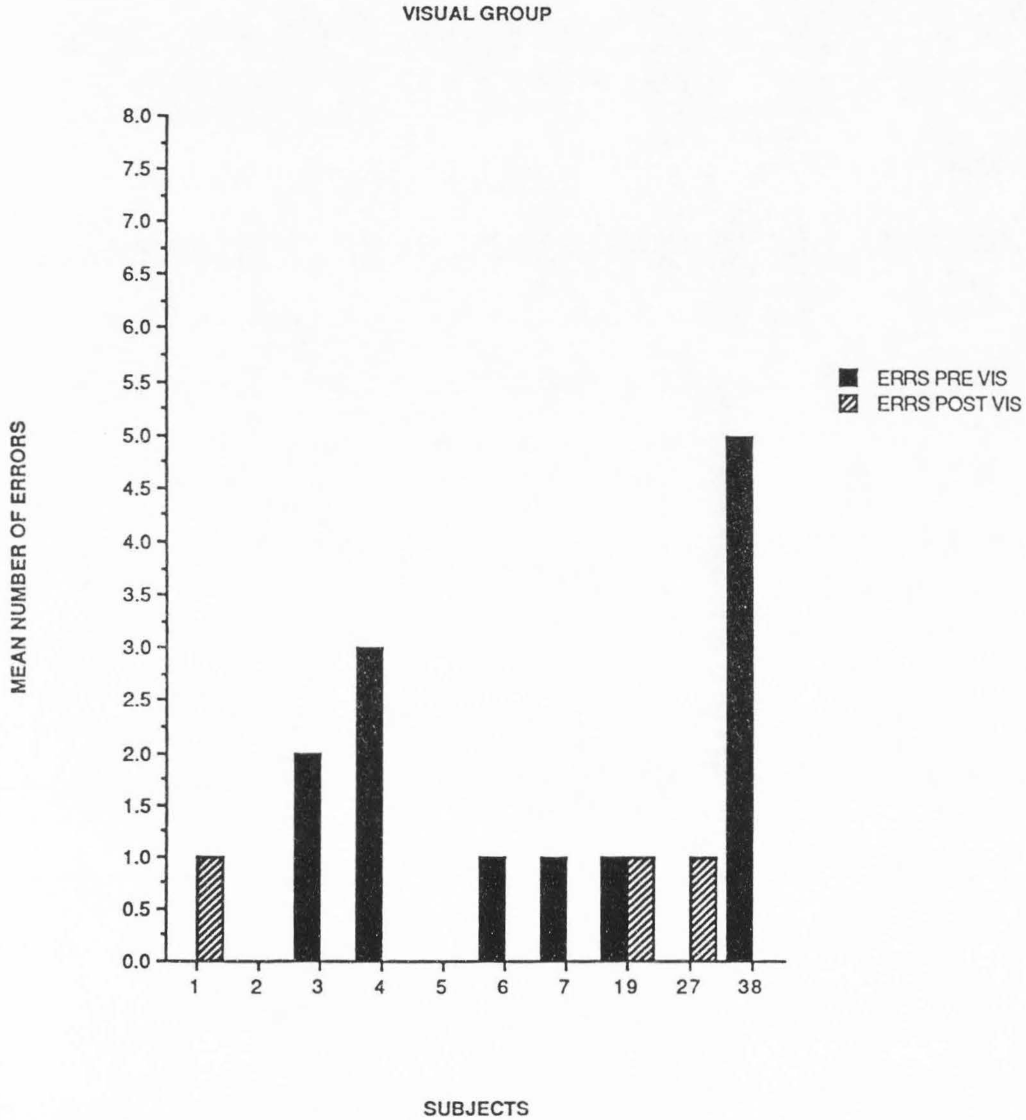



Figure 64. Pretest and posttest error rates for each of the 10 subjects in the visual group.

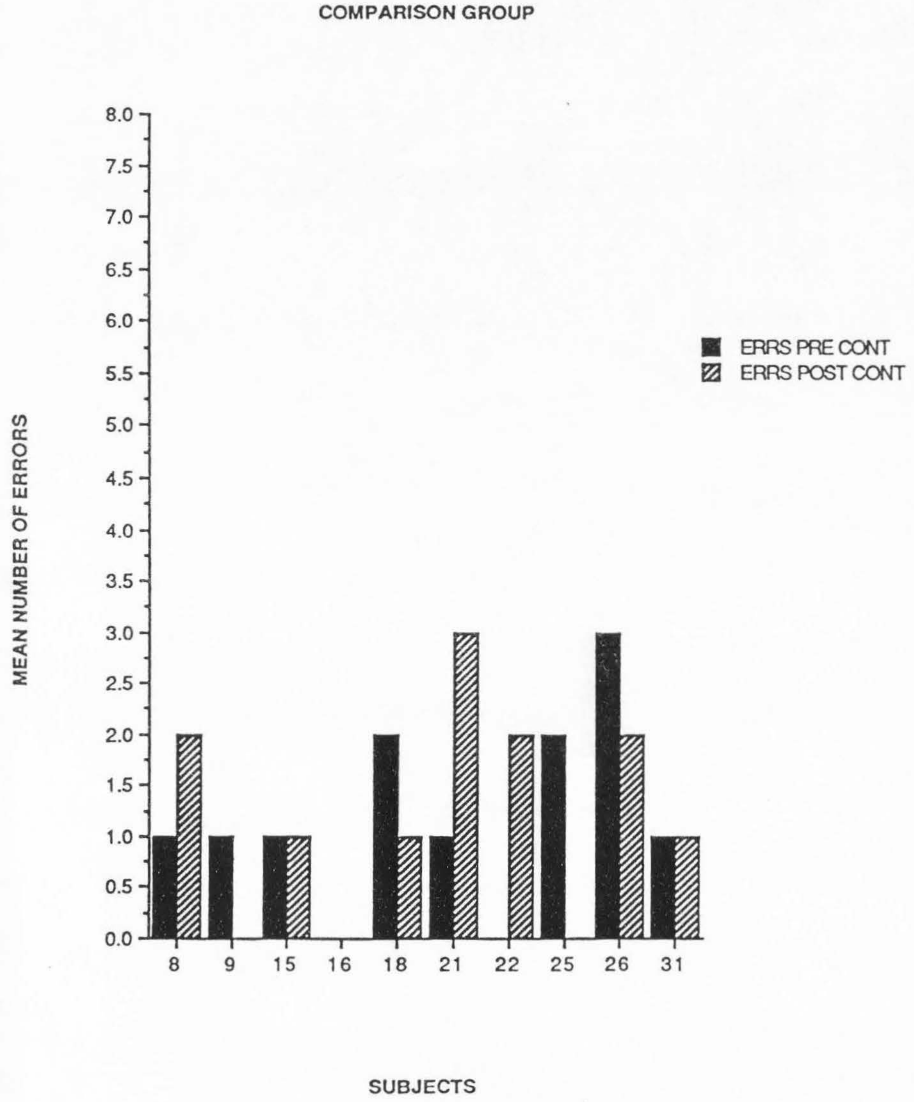



Figure 65. Pretest and posttest error rates for each of the 10 subjects in the comparison group.

Table 27

Results of a T Test for Correlated Means Comparing Error Rates on the Pre and Posttests in the Cross-Modal Group

| DF | MEAN X-Y | PAIRED T VALUE | PROB (2-TAIL) |
|---|---|---|---|
| 9 | .6 | .786 | .4519 |

Table 28

Results of a T Test for Correlated Means Comparing Error Rates on the Pre and the Posttests in the Auditory Group

| DF | MEAN X-Y | PAIRED T VALUE | PROB (2-TAIL) |
|---|---|---|---|
| 9 | 1.0 | 1.677 | .1278 |

Table 29

Results of a T Test for Correlated Means Comparing Error Rates on the Pre and Posttests in the Comparison Group

| DF | MEAN X-Y | PAIRED T VALUE | PROB (2-TAIL) |
|---|---|---|---|
| 9 | 0 | 0 | 0 |

(NO DIFFERENCES IN THE NUMBER OF PRE TO POSTTEST ERRORS.)

Table 30

Results of a T Test for Correlated Means Comparing Error Rates on the Pre and Posttests in the Visual Group

| DF | MEAN X-Y | PAIRED T VALUE | PROB (2-TAIL) |
|---|---|---|---|
| 9 | 1.0 | 1.667 | .1278 |

significant differences in errors between the comparison group and the visual group. Comparisons between all other groups were nonsignificant (see Table 31). One of the reasons why the changes in error rates were probably statistically nonsignificant was because of a ceiling effect. This would mean that the number of errors were so low on the pretest that there was no room for improvement on the posttest. For example, some subjects had 0 errors on the pretest and could not be expected to decrease the number of errors on the posttest (Appendix D).

Word Pair Differences

Word pairs were analyzed by a series of ANOVAs for repeated measures for each of the four treatment groups. Table 32 shows that there was a significant difference between reaction times for certain word pairs in the cross-modal group. Table 33 shows the results of ANOVAs for word pairs in the cross-modal group. Based on these analyses, the following word pairs had the statistically significant shortest reactions times in the cross-modal group: 4-1, 1-4, 1-5, 4-5, 3-2, 5-4, 1-2, 2-1, 8-3, and 9-4. There was no trend or obvious reason why these particular word pairs had shorter reaction times. However, either a 4 or a 1 was involved in most (8 out of 10) of these pairs. Table 34 shows the results of an ANOVA for the word pairs in the auditory group and none of the word pairs were statistically significant. None of the word pairs had statistically significant shorter reaction times in the comparison group (see Table 35). Table 36 shows the results of several ANOVAs for word pairs in the visual group and again, none were significantly short.

Table 31

Results of ANCOVAs Comparing the Number of Errors on the Pre and Posttests of the Four Groups

| SOURCE | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Between | 1.439984 | 48 | .029999658465 | 2787852 | 0.00001 |
| Within | .00000053 | 490 | .000000001076 | | |

Table 32

Results of a Repeated Measures ANOVA Used to Determine Whether the Mean Reaction Times of the Word Pairs Significantly Differed from each Other in the Cross-Modal Group

| EFFECT | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| COVARIATE - PRETEST ERRORS | 4.7497 | 1 | 4.7497 | 2.773 | .1011 |
| IV - GROUPS | 4.9596 | 3 | 1.6532 | .965 | .4217 |
| WITHIN | 59.9503 | 35 | 1.7129 | | |

| GROUPS | POSTTEST MEAN | SD | N | ADJUSTED MEAN |
|---|---|---|---|---|
| 1 | .9 | 1.5951 | 10 | .915289 |
| 2 | 1.3 | 1.8288 | 10 | 1.15221 |
| 3 | 1.2 | 1.0328 | 10 | 1.27644 |
| 4 | .3 | .4830 | 10 | .356059 |

PLANNED COMPARISONS

| GROUPS COMPARED | MEANS | SD | VARIANCE ESTIMATE | DF | P |
|---|---|---|---|---|---|
| CROSS-MODAL & | .9 | 1.595 | | | |
| AUDITORY | 1.3 | 1.829 | -.521 | 18 | .614 |
| CROSS-MODAL & | .9 | 1.595 | | | |
| COMPARISON | 1.2 | 1.033 | -.499 | 18 | .629 |
| CROSS-MODAL & | .9 | 1.595 | | | |
| VISUAL | .3 | .483 | 1.138 | 18 | .269 |
| AUDITORY & | 1.3 | 1.829 | | | |
| COMPARISON | 1.2 | 1.033 | .151 | 18 | .854 |
| AUDITORY & | 1.3 | 1.829 | | | |
| VISUAL | .3 | .483 | 1.672 | 18 | .109 |
| VISUAL & | 1.2 | 1.033 | | | |
| COMPARISON | .3 | .483 | 2.496 | 18 | .021 |

Table 33

One-Way ANOVA for Repeated Measures Comparisons Between Word Pairs for the Cross-Modal Group. The Results of the Comparisons Reveal the Word Pairs That Were Statistically Significant for Having the Shortest Reaction Times

| WORD PAIR | SOURCE | SS | DF | MS | F | p |
|---|---|---|---|---|---|---|
| 4-1 | BETWEEN | .207025 | 1 | .207025 | 7.075186 | .0102 |
| | WITHIN | 14.337800 | 490 | .029261 | | |
| 1-4 | BETWEEN | .207025 | 1 | .207025 | 7.079138 | .0102 |
| | WITHIN | 14.329800 | 490 | .029244 | | |
| 1-5 | BETWEEN | .145161 | 1 | .145161 | 4.963723 | .0287 |
| | WITHIN | 14.329800 | 490 | .029244 | | |
| 4-5 | BETWEEN | .233289 | 1 | .233289 | 7.977225 | .0069 |
| | WITHIN | 14.329800 | 490 | .029244 | | |
| 3-2 | BETWEEN | .198470 | 1 | .198470 | 6.788612 | .0117 |
| | WITHIN | 14.329750 | 490 | .029244 | | |
| 5-4 | BETWEEN | .253512 | 1 | .253512 | 8.668752 | .0051 |
| | WITHIN | 14.329750 | 490 | .029244 | | |
| 1-2 | BETWEEN | .230880 | 1 | .230880 | 7.894859 | .0071 |
| | WITHIN | 14.329750 | 490 | .029244 | | |
| 2-1 | BETWEEN | .233772 | 1 | .233772 | 7.993750 | .0068 |
| | WITHIN | 14.329750 | 490 | .029244 | | |
| 8-3 | BETWEEN | .136161 | 1 | .136161 | 4.655972 | .0338 |
| | WITHIN | 14.329750 | 490 | .029244 | | |
| 9-4 | BETWEEN | .132132 | 1 | .132132 | 4.518210 | .0363 |
| | WITHIN | 14.329750 | 490 | .029244 | | |

Table 34

Results of a Repeated Measures ANOVA Used to Determine Whether the Mean Reaction Times of the Word Pairs Significantly Differed from each Other in the Auditory Group

| SOURCE | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| BETWEEN | 4.65745 | 48 | .09636968 | .5029024 | .9906 |
| WITHIN | 93.8972 | 490 | .19162700 | | |

Table 35

Results of a Repeated Measures ANOVA Used to Determine Whether the Mean Reaction Times of the Word Pairs Significantly Differed from each Other in the Comparison Group

| SOURCE | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| BETWEEN | 12.11754 | 48 | .25244879 | .9579529 | .5586 |
| WITHIN | 129.1294 | 490 | .2635294 | | |

Table 36

Results of a Repeated Measures ANOVA Used to Determine Whether the Mean Reaction Times of the Word Pairs Significantly Differed from each Other in the Visual Group

| SOURCE | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| BETWEEN | .6588933 | 48 | .01372694 | .9394175 | .5851 |
| WITHIN | 7.159210 | 490 | .01461063 | | |

# CHAPTER IV

## GENERAL DISCUSSION

It is now widely accepted that changes in motoric reaction time across the life span are due to central, rather than peripheral mechanisms (Welford, 1980). Changes in sensory organs, muscle activation, and speed of nerve conduction account for only a small portion of the total reaction time (Ford & Pfefferbaum, 1980). Also, changes in reaction time with age do not seem to be motivational as Botwinick et al. (1959) demonstrated with electric shocks given for slow reactions. Older subjects shortened their reaction times but their times were still significantly longer than those of younger subjects. Finally, it has been hypothesized that older people sacrifice speed for accuracy (Salthouse & Somberg, 1982), however, the slowing is too great to be explained entirely in terms of improved accuracy.

Welford (1980) suggested that slower reaction times with age may be due to a reduction in signal-to-noise ratio in the central nervous system. That is, the deficits in elderly individuals' sensory transducers lead to weaker signals sent to the brain upon stimulus presentation. These weaker signals, are a result of the death of brain cells that naturally occurs with aging (Kandel & Schwartz, 1985), and other factors such as decreased cerebral blood flow, lead to difficulty in transducing and transmitting the sensory signals. Central cell death and decreased cerebral blood flow also lead to increased "noise", as

Welford termed it, such that once the signals are transmitted, the individual's central nervous system has difficulty processing. The reduction of signal-to-noise ratio therefore results in an increase in reaction time in elderly individuals. It has also been suggested by Birren and Schaie (1977), that the subject may continue processing a response even after the overt response is made, a type of aftereffect. This continued processing may act as noise that blurs further decision-making that might be required. Therefore, it appears that processing of sensory signals in the central nervous system is the cause of the lengthening of reaction time with age.

The general finding in reaction time studies is that reaction time increases with age (Poon, 1980; Birren & Schaie, 1977; Surwillow, 1968). Several overt factors are also clearly involved with the increase in reaction time, including the duration of the stimulus (O'Conner, 1980b; Welford & Birren, 1965), the complexity of the stimulus (Salthouse & Somberg, 1982; Birren, 1964), the salience of the stimulus (Poon & Fozard, 1978), the response required (Nebes, 1978; Birren & Botwinick, 1955), and the number of response alternatives available (Birren & Schaie, 1977). As the period of time that the stimulus is presented or the salience of the stimulus (i.e., color, pitch, etc.) decreases, reaction time increases in the elderly. Reaction time will also increase as the complexity of the stimulus, or the number of available responses increases (Jensen & Munro, 1979). The type of response required (i.e., vocal, manual, etc.) may increase or decrease reaction time depending on the response.

Birren (1964) suggested that increased reaction time may lead to the high rate of accidents occurring in the elderly population (e.g., broken hips). Elderly individuals may be unable to "integrate" incoming stimuli fast enough to make a response before an accident occurs. The increased time required to make a response may also cause problems for the elderly in certain occupations (Murell & Griew, 1965). Aged individuals have an increasingly difficult time in those jobs that require quick decisions, as in working with machinery, if decision-making takes too long. Amato and Bradshaw (1985) discovered that elderly people require a longer period of time to make a decision regarding help (e.g., obtaining a doctor, calling a plumber,etc.). In some cases, this delay may be fatal, as in the case of hesitating to call a doctor when ill or injured. Clearly in such a situation many decisions need to be made, a wide variety of responses are available, and input comes from many different sources in the environment. These sources may involve auditory, tactual, visual or other types of input from the environment. Currently, no studies have been located that involve decision making which is based on information from incoming visual and auditory stimuli simultaneously.

## Subjects

One of the main problems in performing research with the elderly population is obtaining subjects. Few subjects wish to volunteer, and those that do presumably offer a biased sample (Birren, 1964). Elderly individuals that volunteer are most likely those subjects who are healthy. In the present study, three individuals dropped out. Two simply did not appear for the second session, while the third did not return after the first three sessions. Many more refused to participate despite the fact that all seemed healthy, resided in the community, and lived independently. Of those who declined to volunteer, several stated that they were ill or did not believe that they could perform the task. Obviously then, the sample used in this research was biased by the types of individuals who participated. Therefore, this study cannot be representative of the elderly population in general since the sample of elderly was biased toward healthy volunteers. It would be useful to perform a similar study utilizing a different sample of elderly, such as those residing in a nursing home. Data obtained with a nursing home sample could then be compared to this research data to determine what types of differences exist due to the sample used.

## Effects of Practice on Reaction Time

Reaction time decreased across sessions for 33 out of the 40 subjects in this study. There were fluctuations over the ten sessions in reaction time, as seen in the individual data, but there was a significant overall trend of decreasing reaction time across sessions. While the group data for the visual, auditory, and cross-modal groups revealed decreases in mean reaction times from session 1 to session 10, the comparison group exhibited an unusual pattern of responding. This may have been due to the type of task that they were given to practice, or personal characteristics of the subjects, such as different responding strategies. There was only a short (2 sec) delay between the stimulus presentation and the opportunity to respond in the comparison group and this might have confused some of the subjects and caused them to delay their responses. All groups, except the comparison, exhibited significant decreases in their reaction times from session 1 to session 10. This indicates that subjects of this age can improve with practice and suggests that practicing such tasks can lead to better performance in this area. The auditory group demonstrated the greatest amount of change from session 1 to session 10. The large decrease might be attributed to the type of stimulus used in this group since Birren and Schaie (1977) noted that auditory stimuli appear to be easier to process than visual stimuli. Therefore, the auditory group may have been able to process and master this task more quickly than the other groups.

## Effects of Practice on Error Rates

There was not a statistically significant decrease in errors from session 1 to 10. Also, when error rates were compared between groups, no significant differences in number of errors made between sessions 1 and 10 were found. Since all groups practiced an equal number of trials and sessions, it was expected that no differences would occur between groups in error rate. This may mean that, while practice enables elderly individuals to decrease their reaction times, their error rates are not decreased by this same method.

## Effect on Unpracticed Task--Reaction Time on the Multiple-Choice Test

Hoyer et al. (1973), Murrell and Griew (1965), and Nobel et al. (1964) found that reaction time decreased after practicing a reaction time task. Reaction times decreased on the posttest compared to the pretest for 32 out of 40 subjects. For the 8 who did not, 6 were comparison, and their reaction time increased. The increased reaction time was not expected on the posttest however, but the fact that it did suggests that the practice task for the comparison group actually resulted in subjects pausing for longer periods on the multiple-choice test, as they did on the practiced task. The change in reaction time from pretest to posttest was significant for all groups except the cross-modal group. This was unexpected for this group because it had been hypothesized that the complexity of the cross-modal task would be more likely to carry over into the multiple-choice task.

This study indicated that rather than requiring a complex task, which was defined as a task involving more than one sensory modality, the task leading to the greatest reduction in reaction time might be the most useful task to practice. Although auditory tasks will typically have shorter reaction times simply due to the speed with which auditory information is processed (Davis, 1957), it was practicing the auditory task that also led to the greatest change in that task and in the subsequent multiple-choice task. Therefore, the necessary condition for changing reaction time in various areas of an individual's life may be simply to practice an auditory, rather than a visual or cross-modal task. It appears from this work that the complexity, as defined by utilizing more than one sensory modality, of the task is not the key issue. Instead, the major component for reducing reaction time in all areas is to practice a task that can be performed more quickly than others (i.e., auditory rather than others). Part of the reason why the cross-modal group's reaction time did not change significantly may relate to the word pairs. Although all groups received the same word pairs on a given day (i.e., all groups received the same 180 word pairs on a given day of the week), only the cross-modal group demonstrated significant differences in reaction time to word pairs. The visual-auditory task may have been too confusing for subjects, particularly with certain word pairs as demonstrated by the statistical analysis in Tables 35 and 36.

## Effects on Unpracticed Task--Error Rate on Multiple-Choice Task

Cooper and Shepard (1973) and Surwillow (1968) found that error rate decreased with practice in a reaction time task. This occurred in the pre-sent experiment as well. The number of errors decreased on the posttest for all groups except the comparison, where the number of errors remained unchanged from the pretest. However, this decrease was not significant when session 1 was compared with session 10. Based on previous literature, little or no change in the error rate was expected. If error rates are to be decreased, it seems apparent that another type of task, other than a reaction time task should be utilized.

## Implications

The purpose of this research was to determine whether practicing a cross-modality decision-making task, versus a single modality task, would lead to more of a decrease in reaction time. This research was also performed to determine whether this particular method supports, and extends previous literature indicating that practice will reduce reaction time. This study was also designed to determine if a cross-modal reaction time task would be more effective in reducing reaction time than a single modality task. Utilizing a pretest/posttest multiple-choice test allowed for examination of the effect of the various treatments on a completely different type of reaction time task. In this way, it could be determined whether the effects of the interventions might generalize into other aspects of the subjects' lives and into other decision-making tasks.

The results of this experiment did support previous studies indicating that practicing reaction time tasks leads to decreases in both reaction time and error rate. A plateau was reached wherein reaction time remained stable even when practice was continued; although a plateau was not found in error rate. The decreased reaction time appeared to effect the multiple-choice task best in the auditory group. These results demonstrated that practicing one task could not only decrease response latency on that task, but on another type of task as well.

Additionally, the results suggest an alternative way of regarding the elderly. These results indicate that the elderly (70-80 year olds) can increase their speed and skill at making decisions. Often it is assumed that reaction time increases with age and is unchangeable. Some studies (Stern, Oster, & Newport, 1980; Welford, 1977; Griew, 1958) have reported that the elderly typically hesitate longer before making a response than do college students. The current research showed that reaction time can be changed if the person is given sufficient time to practice, even if only 15 min. per day. Also, practice not only decreases reaction time on the practiced task, but this research showed that it can also lead to decreased reaction times on other tasks requiring decisions. Clearly, this is useful information for those working with aged individuals, particularly those interested in rehabilitation. It indicates that there may be more plasticity in performance than is usually attributed to the elderly.

According to some, decision making has a biological component involving peripheral and central processes (Sacuzzo, 1986; Nebes, 1978; Welford, 1961; Davis, 1957). Reaction time can be considered a measure of the time it takes these biological processes to occur (Poon, 1980; Birren & Schaie, 1977; Welford, 1961). Because the changes that occur in reaction time with aging have been found to be a function of a slowing of central nervous processes (Ford & Pfefferbaum, 1980; Hugen et al., 1960), a decrease in reaction time with practice may indicate some biological improvements. Of course, such changes are not directly observable and therefore can only be inferred by examining measurable variables such as reaction time, and error rate. Until the time arrives when the biological processes can be observed, all that can be stated, without inference, is that certain interventions lead to decreased reaction time in the elderly. The present study demonstrates that changes in reaction time are possible, no matter what the subject's age.

Finally, these changes in performance indicate that other tasks containing time limits might be explored in terms of practice for all age groups. Perhaps scores on certain timed tests (e.g., sub tests of the WAIS-R) would improve if subjects were given an opportunity to practice timed tasks more frequently, and not necessarily the same tasks. People typically show declining WAIS-R scores as they age (Poon, 1980; Birren & Schaie, 1977; Birren, 1964). However, this may be due, in part, to the fact that younger, college-aged students, often work outside of the test setting on timed tasks and so have more recent practice at performing under temporal constraints. On average, the elderly probably do not have as much practice. If given practice, however, their scores might improve. If decreasing reaction time can occur with practice, perhaps improvements may occur on other tasks with practice, despite the aging process.

## Future Research

While the present study indicates that the effects of practicing one reaction time task may generalize to an unpracticed task involving reaction time, further research in this area is required. Several variables should be manipulated including the population used in the research, the complexity of the task practiced (i.e., utilizing many different types of stimuli simultaneously), as well as feedback provided to the subjects. In this research, a statistically significant decrease in the number of errors made was not found. Perhaps a task that included feedback after each trial or session could be utilized to reduce the number of errors made in the practice task. This might then generalize to the unpracticed task as the reaction time did in this experiment. Other types of tasks, such as utilizing driving simulators, should be practiced in order to determine into what areas the effects of practicing such a task would generalize.

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# APPENDICES

## Appendix A

### Consent Form

This certifies that I have been informed of the purpose and procedures of this research study and that I agree with the requirements. I understand that all information is confidential and that I may request to receive results of the study when it is completed. I will be expected to sit in front of a computer screen. Word pairs may be presented auditorily (from a tape recorder) and/or visually (on the computer screen) at approximately the same time. I will have to decide whether the words in each pair presented were the same or different and press the button on the computer corresponding to that choice. I understand that I will be asked to make my responses as quickly as possible in order for the experimenter to record my reaction time and that the number of errors will also be counted. These responses will be recorded by the computer, however, my name will not be associated with these responses, only a number. (I will be assigned a number by the experimenter prior to beginning the experiment.) My services will be needed 15 minutes per day, Monday through Friday for 10 sessions.

____________________ ________________

Printed Name Date

____________________ ________________

Signature Witness

Appendix A (continued)

PLEASE ANSWER THE FOLLOWING QUESTIONS.

CIRCLE YES OR NO AFTER EACH QUESTION.

1. Do you have deafness in one or both ears?

YES NO

2. Do you have any trouble hearing with one or both ears?

YES NO

3. Do you use a hearing aid?

YES NO

4. With your hearing aid, can you hear MOST things people say?

YES NO

5. With you hearing aid, can you hear only a FEW words people say?

YES NO

6. Have you ever been diagnosed with Alzheimer's, AIDS, or any other debilitating disease?

YES NO

7. During the past 12 months have you had arthritis or rheumatism in your hands,wrists, or fingers?

YES NO

8. If you answered YES to question #7, does your arthritis/rheumatism typically interfere in activities such as pressing buttons, or typewriter keys?

YES NO

9.Please check the appropriate response. What is the highest degree or level of education you have obtained?

| | |
|---|---|
| ____ Grades 1st - 3rd | ____ 3rd year college |
| ____ Grades 4th - 6th | ____ Over 3 years college |
| ____ Grades 7th - 9th | ____ B.A. or B.S. |
| ____ Grades 10th - 12th | ____ Master's |
| ____ 1st year college | ____ Doctorate |
| ____ 2nd year college | ____ Other |

## Appendix B

Multiple-Choice Questions Used for the Pretest and Posttest

(Adapted from Wechsler, 1974a,b, and from Mental Status Exams)

1. What is the name of the state you are in right now?
2. Who is currently the president of the United States?
3. Who was president of the United States before Reagan?
4. What is the year?
5. How many ears do you have?
6. How many legs does a dog have?
7. What must you do to make water boil?
8. How many pennies make a nickel?
9. What do we call a baby cow?
10. How many days make a week?
11. Name the month that comes next after March?
12. From what animal do we get bacon?
13. How many things make a dozen?
14. What are the four seasons of the year?
15. Who discovered America?
16. What does the stomach do?
17. In what direction does the sun set?
18. Which month has one extra day during leap year?
19. Who invented the electric light bulb?
20. In what way are a wheel and a ball alike?
21. In what way are a candle and a lamp alike?
22. In what way are a shirt and a hat alike?

23. In what way are a piano and a guitar alike?

24. What are the colors in the American flag?

25. What is the shape of a ball?

26. How many months are in a year?

27. In which direction does the sun rise?

28. How many weeks are there in a year?

29. What is a thermometer used for?

30. Who is Louie Armstrong?

31. What is a knife?

32. What is an umbrella?

33. What is a clock?

34. What is a hat?

35. What is a bicycle?

36. What is a bed?

37. What is a ship?

38. What is a penny?

39. What is winter?

40. If I cut an apple in half, how many pieces will I have?

## Appendix C

Instructions to subjects in each group.

### Cross-Modality

A word will appear on the television screen and a word will be spoken on the tape. If the word on the screen and the spoken word are the exact same word, then press the button marked "same". If the word presented on the screen is different from the spoken word, press the button marked "different". Please press the button that you choose as quickly as possible. You have four seconds to respond after the word is presented on the screen and after it is spoken. You may still respond by pressing a button even after the word has disappeared from the screen. If you accidently press a button before a word appears, you should still press a button after the word appears on the screen.

### Visual Stimuli

The instructions are the same as above but it will be explained that two words will appear on the screen.

### Auditory Stimuli

The instructions are the same as above but it will be explained that two words will be spoken on the tape.

### Control

The instructions are the same as those for the visual stimuli group but they will be told that they must wait until the computer screen prints a message stating that they can respond, before responding.

Appendix D

Table 37

The Mean Reaction Times and Number of Errors on the Pretest, Intervention and on the Posttest for Each Subject

RT = Mean Reaction Time
E = Errors

A = Age
S = Sex

| SUBJECT # | | | PRETEST | | SESSIONS 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | | 10 | | POSTTEST | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | S | RT | E | RT | E | RT | E | RT | E | RT | E | RT | E | RT | E | RT | E | RT | E | RT | E | RT | E | RT | E |
| 1 | 71 | F | 2.48 | 0 | .717 | 1 | .764 | 4 | .758 | 2 | .808 | 3 | .786 | 0 | .817 | 1 | .714 | 0 | .782 | 4 | .671 | 0 | .661 | 2 | 1.67 | 1 |
| 2 | 74 | F | 2.48 | 0 | .941 | 1 | .878 | 2 | .881 | 0 | .861 | 2 | .902 | 1 | .857 | 0 | .884 | 2 | .919 | 1 | .750 | 2 | .800 | 2 | 2.39 | 0 |
| 3 | 73 | F | 2.43 | 2 | .552 | 4 | .686 | 2 | .696 | 0 | .672 | 1 | .711 | 1 | .693 | 0 | .681 | 0 | .689 | 0 | .570 | 1 | .629 | 0 | 2.41 | 0 |
| 4 | 76 | M | 5.87 | 3 | 1.63 | 0 | 1.33 | 0 | 1.30 | 1 | 1.29 | 0 | 1.25 | 2 | 1.23 | 0 | 1.20 | 0 | 1.17 | 0 | 1.10 | 0 | 1.15 | 0 | 2.11 | 0 |
| 5 | 71 | M | 3.30 | 0 | 1.08 | 6 | .742 | 1 | .782 | 0 | .900 | 0 | .814 | 0 | .774 | 0 | .745 | 1 | .740 | 0 | .630 | 2 | .749 | 2 | 2.48 | 0 |
| 6 | 79 | F | 2.58 | 1 | .782 | 1 | .790 | 4 | .858 | 6 | .834 | 2 | .953 | 3 | .966 | 1 | .905 | 1 | .869 | 1 | .751 | 2 | .647 | 0 | 1.63 | 0 |
| 7 | 80 | F | 3.42 | 1 | .687 | 2 | .619 | 3 | .629 | 4 | .627 | 2 | .637 | 3 | .685 | 0 | .664 | 0 | .682 | 0 | .577 | 0 | .530 | 1 | 1.63 | 0 |
| 8 | 71 | M | 1.98 | 1 | 2.75 | 0 | 2.89 | 0 | 2.77 | 0 | 2.80 | 0 | 2.77 | 0 | 2.81 | 0 | 2.72 | 0 | 2.72 | 0 | 2.70 | 0 | 2.73 | 0 | 1.89 | 2 |
| 9 | 72 | F | 2.48 | 1 | 3.19 | 8 | 3.06 | 0 | 3.00 | 0 | 2.84 | 0 | 2.90 | 0 | 3.09 | 1 | 2.92 | 1 | 2.92 | 3 | 2.82 | 1 | 2.91 | 1 | 2.22 | 0 |
| 10 | 74 | M | 3.07 | 2 | .565 | 8 | .452 | 6 | .550 | 1 | .608 | 3 | .820 | 3 | .441 | 1 | .690 | 1 | .410 | 3 | .310 | 1 | .350 | 1 | 2.70 | 0 |
| 11 | 71 | M | 3.41 | 0 | .469 | 0 | .370 | 0 | .626 | 2 | .475 | 2 | .524 | 1 | .424 | 1 | .377 | 0 | .415 | 0 | .330 | 0 | .302 | 3 | 1.04 | 0 |
| 12 | 75 | M | 1.95 | 2 | .437 | 14 | .386 | 11 | .704 | 6 | .344 | 2 | .806 | 3 | .527 | 3 | .788 | 0 | .362 | 4 | .347 | 0 | .311 | 1 | 1.25 | 0 |
| 13 | 77 | F | 1.93 | 0 | .438 | 2 | .425 | 5 | .395 | 1 | .399 | 3 | .471 | 0 | .497 | 4 | .433 | 10 | .400 | 0 | .315 | 0 | .360 | 0 | 1.59 | 0 |
| 14 | 71 | F | 2.94 | 1 | .741 | 1 | .623 | 0 | .635 | 1 | .639 | 0 | .590 | 0 | .776 | 1 | .681 | 1 | .667 | 0 | .547 | 0 | .515 | 0 | 2.28 | 0 |
| 15 | 77 | M | 3.41 | 1 | 2.27 | 7 | 3.87 | 2 | 1.00 | 6 | 3.20 | 0 | 4.37 | 1 | 4.81 | 0 | 5.39 | 2 | 7.29 | 2 | 5.76 | 9 | 5.38 | 3 | 7.63 | 1 |
| 16 | 73 | M | 1.98 | 0 | 2.65 | 0 | 2.62 | 0 | 2.63 | 0 | 2.62 | 0 | 2.62 | 0 | 2.63 | 0 | 2.64 | 0 | 2.62 | 0 | 2.60 | 0 | 2.59 | 0 | 1.89 | 0 |
| 17 | 78 | M | 3.10 | 1 | .542 | 4 | .390 | 4 | .403 | 6 | .375 | 4 | .354 | 4 | .373 | 2 | .349 | 6 | .310 | 2 | .249 | 4 | .294 | 7 | 1.60 | 2 |
| 18 | 75 | F | 5.02 | 2 | 3.72 | 0 | 3.67 | 0 | 3.73 | 2 | 3.46 | 0 | 3.56 | 0 | 3.58 | 1 | 3.51 | 0 | 3.54 | 0 | 3.48 | 0 | 3.47 | 0 | 5.67 | 1 |
| 19 | 77 | M | 3.77 | 1 | 1.15 | 1 | 1.05 | 2 | 1.07 | 0 | 1.12 | 2 | 1.09 | 0 | 1.03 | 2 | 1.06 | 2 | 1.01 | 2 | .958 | 2 | .972 | 2 | 3.99 | 1 |
| 20 | 72 | M | 1.98 | 1 | .442 | 7 | .350 | 7 | .405 | 3 | .364 | 3 | .440 | 0 | .406 | 6 | .448 | 3 | .485 | 4 | .345 | 1 | .378 | 3 | 1.71 | 1 |

APPENDIX D (CONTINUED)

| SUBJECT # | | | PRETEST | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | | 10 | | POSTTEST | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | S | RT | E | RT | E | RT | E | RT | E | RT | E | RT | E | RT | E | RT | E | RT | E | RT | E | RT | E | RT | E |
| 21 | 76 | M | 4.11 | 1 | 3.47 | 4 | 3.45 | 2 | 3.34 | 0 | 3.29 | 1 | 3.36 | 5 | 3.23 | 2 | 3.34 | 1 | 4.00 | 2 | 3.26 | 1 | 3.03 | 0 | 5.39 | 3 |
| 22 | 75 | F | 2.79 | 0 | 2.27 | 4 | 5.37 | 11 | 5.85 | 1 | 2.16 | 3 | 2.37 | 4 | 5.67 | 3 | 5.09 | 3 | 4.20 | 0 | 4.56 | 0 | .860 | 2 | 8.89 | 2 |
| 23 | 70 | M | 3.77 | 0 | 1.52 | 3 | 1.12 | 3 | 1.09 | 1 | .989 | 0 | .872 | 1 | 1.04 | 2 | .910 | 0 | .954 | 0 | .763 | 3 | .870 | 1 | 3.78 | 0 |
| 24 | 78 | F | 3.99 | 0 | 1.04 | 1 | 1.46 | 3 | .861 | 1 | .931 | 0 | .845 | 0 | .432 | 1 | .834 | 0 | .533 | 0 | .393 | 2 | .367 | 0 | 2.23 | 2 |
| 25 | 74 | M | 11.58 | 2 | 1.54 | 2 | 1.73 | 3 | 1.96 | 0 | 2.01 | 0 | 1.39 | 0 | 3.13 | 2 | 3.18 | 2 | 3.93 | 10 | 4.80 | 3 | 7.90 | 8 | 16.8 | 0 |
| 26 | 78 | F | 8.83 | 3 | 1.46 | 3 | 1.02 | 0 | 1.40 | 0 | 1.40 | 2 | .860 | 2 | 1.87 | 1 | 2.56 | 3 | 1.63 | 7 | 3.28 | 2 | 3.13 | 1 | 14.1 | 2 |
| 27 | 70 | M | 4.95 | 0 | 1.40 | 3 | 1.03 | 3 | 1.04 | 7 | 1.08 | 11 | 1.09 | 10 | 1.00 | 6 | .966 | 4 | 1.03 | 5 | 1.12 | 7 | 1.11 | 11 | 3.59 | 1 |
| 28 | 79 | M | 8.87 | 7 | 1.22 | 15 | 1.11 | 4 | 1.04 | 3 | 1.94 | 11 | .886 | 2 | 1.48 | 2 | .790 | 1 | .685 | 2 | .471 | 3 | .533 | 3 | 2.30 | 0 |
| 29 | 73 | F | 4.58 | 3 | .754 | 1 | 2.01 | 4 | .672 | 0 | .769 | 0 | .754 | 0 | .742 | 0 | .489 | 0 | .735 | 1 | .500 | 0 | .775 | 0 | 3.62 | 5 |
| 30 | 76 | F | 2.94 | 1 | .717 | 2 | .710 | 1 | .653 | 3 | .722 | 3 | .470 | 1 | .575 | 2 | .464 | 1 | .605 | 3 | .441 | 0 | .651 | 1 | 2.17 | 1 |
| 31 | 75 | F | 3.43 | 1 | 3.76 | 2 | 2.61 | 2 | 2.46 | 6 | 2.86 | 2 | 2.38 | 1 | 3.94 | 4 | 5.14 | 9 | 3.69 | 1 | 3.54 | 6 | 4.24 | 3 | 12.2 | 1 |
| 32 | 71 | F | 8.09 | 2 | 1.82 | 4 | 1.87 | 1 | 1.36 | 1 | 1.09 | 0 | .610 | 0 | .621 | 2 | .404 | 2 | .343 | 2 | .279 | 0 | .252 | 4 | 1.90 | 0 |
| 33 | 77 | F | 11.52 | 1 | 2.12 | 4 | 2.14 | 2 | 1.84 | 4 | 1.33 | 3 | 1.31 | 0 | 1.37 | 1 | .521 | 0 | .514 | 1 | .410 | 1 | .398 | 2 | 1.57 | 1 |
| 34 | 79 | M | 10.37 | 2 | 1.62 | 1 | 1.61 | 1 | .993 | 1 | .417 | 1 | .293 | 3 | .385 | 4 | .300 | 3 | .257 | 2 | .363 | 1 | .250 | 3 | 1.72 | 1 |
| 35 | 73 | M | 14.63 | 2 | 1.62 | 4 | 1.69 | 5 | .924 | 0 | .332 | 1 | .322 | 0 | .403 | 4 | .291 | 1 | .331 | 2 | .275 | 0 | .272 | 2 | 2.10 | 0 |
| 36 | 74 | F | 2.38 | 1 | .771 | 5 | 1.56 | 7 | 1.47 | 2 | 1.07 | 2 | .646 | 4 | 1.40 | 3 | .486 | 0 | .748 | 3 | .509 | 0 | .436 | 1 | 2.02 | 0 |
| 37 | 75 | F | 10.71 | 8 | 1.32 | 3 | 1.37 | 3 | 1.09 | 3 | 1.12 | 4 | 1.13 | 1 | 1.08 | 0 | 1.04 | 0 | .943 | 4 | .801 | 2 | .806 | 4 | 3.17 | 4 |
| 38 | 71 | M | 3.20 | 5 | 1.00 | 1 | .984 | 2 | 2.46 | 2 | 1.85 | 2 | 1.95 | 1 | 1.05 | 0 | .584 | 1 | .488 | 2 | .502 | 1 | .477 | 3 | 2.46 | 0 |
| 39 | 78 | M | 10.31 | 3 | 2.22 | 5 | 2.89 | 7 | 3.23 | 3 | 2.46 | 2 | 1.29 | 1 | 1.65 | 4 | 1.41 | 1 | .760 | 0 | .359 | 0 | .306 | 1 | 1.90 | 0 |
| 40 | 75 | F | 7.86 | 3 | 1.00 | 1 | .654 | 0 | .707 | 0 | .616 | 0 | .931 | 0 | .796 | 0 | .898 | 1 | .750 | 0 | .578 | 0 | .725 | 0 | 5.31 | 5 |

Appendix E

Log Transformation Results

The mean reaction times and mean error rates for each group were transformed by taking the log (x) of session 1 and session 10 means for each subject. This was done to control for the fact that the data may have been skewed, rather than normally distributed. These transformed data were then reanalyzed utilizing a t test for correlated means to determine significant differences within groups. These data were then compared between groups using ANCOVAs to determine differences. The results of the correlated t tests after this transformation were the same as those before the transformation for both the reaction times and errors. The following table shows the results of an ANCOVA for reaction time revealed no significant differences between groups (see Table 13).

The mean reaction times and mean error rates for each group were transformed by taking the log (x) pretest and posttest scores for each subject. These data were then analyzed with a t test for correlated means to determine significant differences within groups. These data were also then compared between groups by using ANCOVAs to determine differences. The results of the correlated t tests after transformation were the same as those before for both the reaction times and errors. The second table contains the ANCOVA results for the reaction times on the pretests and posttests. This analysis revealed no significant differences between groups.

Table 38

Results of ANCOVAs Comparing the Log of the Mean Reaction Times for the First and Final Sessions of the Four Groups

| EFFECT | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| COVARIATE - 1ST SESSION | .2710 | 1 | .2710 | 5.802 | .0202 |
| IV - GROUPS | 2.0299 | 3 | .6766 | 14.485 | .00001 |
| WITHIN | 1.6350 | 35 | .0467 | | |

| GROUPS | LAST DAY | SD | N | ADJUSTED MEANS |
|---|---|---|---|---|
| 1 | -.3411 | .1594 | 10 | -.231461 |
| 2 | -.3576 | .2232 | 10 | -.326906 |
| 3 | .7879 | .3461 | 10 | .572554 |
| 4 | -.1296 | .1296 | 10 | -.054505 |

PLANNED COMPARISONS

| GROUPS COMPARED | MEANS | S.D. | VARIANCE ESTIMATE | DF | P |
|---|---|---|---|---|---|
| CROSS-MODAL & AUDITORY | -.341<br>-.358 | .159<br>.223 | .190 | 18 | .830 |
| CROSS-MODAL & COMPARISON | -.341<br>.788 | .159<br>.346 | -9.371 | 18 | .0001 |
| CROSS-MODAL & VISUAL | -.341<br>-.130 | .159<br>.130 | -3.257 | 18 | .005 |
| AUDITORY & COMPARISON | -.358<br>.788 | .223<br>.346 | -8.796 | 18 | .0001 |
| AUDITORY & VISUAL | -.358<br>-.130 | .223<br>.130 | -2.793 | 18 | .012 |
| COMPARISON & VISUAL | .788<br>-.130 | .346<br>.130 | 7.852 | 18 | .0001 |

Table 39

Results of ANCOVAs Comparing the Log of the Mean Reaction Times for the First and Final Sessions of the Four Groups

| EFFECT | SS | DF | MS | F | P |
| --- | --- | --- | --- | --- | --- |
| COVARIATE - PRETEST | .5124 | 1 | .5124 | 13.168 | .0012 |
| IV - GROUPS | 1.3843 | 3 | .4614 | 11.857 | .0001 |
| WITHIN | 1.3620 | 35 | .0389 | | |

| GROUPS | POSTTEST MEAN | SD | N | ADJUSTED MEAN |
| --- | --- | --- | --- | --- |
| 1 | .3013 | .1717 | 10 | .328530 |
| 2 | .3623 | .1771 | 10 | .289016 |
| 3 | .7673 | .3598 | 10 | .761842 |
| 4 | .3676 | .1340 | 10 | .419075 |

PLANNED COMPARISONS

| GROUPS COMPARED | MEANS | SD | VARIANCE ESTIMATE | DF | P |
| --- | --- | --- | --- | --- | --- |
| CROSS-MODAL & AUDITORY | .301<br>.362 | .172<br>.177 | -.782 | 18 | .450 |
| CROSS-MODAL & COMPARISON | .301<br>.767 | .172<br>.360 | -3.697 | 18 | .002 |
| CROSS-MODAL & VISUAL | .301<br>.368 | .172<br>.134 | -.963 | 18 | .351 |
| AUDITORY & COMPARISON | .362<br>.767 | .177<br>.360 | -3.194 | 18 | .005 |
| AUDITORY & VISUAL | .362<br>.368 | .177<br>.134 | -.076 | 18 | .899 |
| VISUAL & COMPARISON | .767<br>.368 | .360<br>.134 | 3.292 | 18 | .004 |

Appendix F

Effect Sizes

Effect sizes were calculated for each group for both number of errors and reaction times. In addition to the fact that statistical significance was found, it is useful to calculate effect sizes in order to better comprehend the magnitude of the differences in the means between groups. Effect size was utilized to describe the differences between the mean of the experimental and the comparison groups. The formula (see Glass, & Hopkins, 1984) used to calculate effect sizes was:

$$\hat{} = \frac{(X_{Cpre} - X_{Cpost}) - (X_{Epre} - X_{Epost})}{S_w}$$

where $X_{Cpre}$ is the group mean of the group's first session reaction time, the mean of the group's first session error rate, the mean of the group's pretest reaction time or the mean of the group's pretest error rate. $X_{Cpost}$ is the group mean of the group's last session reaction time, the mean of the group's last session error rate, the mean of the group's posttest reaction time or the mean of the group's posttest error rate. $X_{Epre}$ is the group mean of each of the experimental groups' first session reaction time, the mean of each of the experimental groups' first session error rate, the mean of each of the experimental groups' pretest reaction time or the mean of each of the experimental groups' pretest error rate. $X_{Epost}$ is the group mean of each of the experimental groups' last session reaction time, the mean of each of the experimental groups' last session error rate, the mean of each of the experimental groups' posttest reaction time or the mean of each of the experimental groups' posttest error rate. The $s_w$ was calculated by summing the standard deviation from the first session of the reaction time or errors, or the standard deviation from the pretest of the reaction time or errors of the experimental group being examined, and the standard deviation from the first and last sessions or the pretest and posttest of the group's reaction time and error rate. This sum was then divided by three to find the average standard deviation for the group under examination.

The results of these calculations, indicate that the largest effect sizes occurred between the mean of the first session and the mean of the last session in reaction time. The lowest effect sizes were between the means from the pretest and posttest reaction times.

# VITA

Dawn Marie Birk

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**Major Field:** Psychology (Emphasis in Analysis of Behavior)
**Minor Field:** Gerontology
**Dissertation Title:** Reaction Time in Elderly Subjects: The Effects of Practice on Two Different Reaction Time Tasks
**Vita Highlights:**

* Graduate education leading to a Ph.D. in Psychology (Emphasis in Analysis of Behavior).

* Education (21 credit hours) in sociology and social work leading to a Certificate in Gerontology.

* Two years experience as a Psychology Specialist working with emotionally disturbed, handicapped, and nonhandicapped children (e.g. autistic, Down's Syndrome, ADHD, learning disabled) in the Clinical Services Unit of the Developmental Center for Handicapped Persons, Utah State University.

* Two years experience conducting psychoeducational evaluations of school-age, preschool, and adult clients in the Clinical Services Program of the Developmental Center for Handicapped Persons, Utah State University.

* Excellent knowledge of a variety of assessment/evaluation instruments.

* Experience as an instructor/teaching assistant of undergraduate Psychology courses (History and Systems of Psychology, 1986; Social Psychology, 1986, 1987).

* Three years experience supervising graduates and undergraduates completing praticum internships, independent study, instructor apprenticeship, and independent research credits.

* Two years experience as a member of interdisciplinary teams.

* One year experience as a Research Assistant dealing with early intervention for handicapped children and parent training manuals.

* Five years experience with basic animal and human research.

* Excellent knowledge of theoretical and practical applications of behavior modification.

* Excellent knowledge of basic and applied research and single subject design.

**EDUCATION**

Ph.D. Candidate, Utah State University, Logan, Utah, 1989. Major area:Psychology (Emphasis in Analysis of Behavior).

B.A. Colorado College, Colorado Springs, Colorado, 1985. Major Area: Psychology. Cum Laude.

Further Study

Department of Sociology and Social Work, Utah State University, Logan, Utah, 1986-1988, 21 credit hours. Certificate of Gerontology. Date of Graduation: May, 1988.

**TRAINING EXPERIENCE**

TITLE: Psychology Specialist, Clinical Services Program of the Division of Services, Developmental Center for Handicapped Persons, Logan, Utah.

DATES: July, 1987 - present

RESPONSIBILITIES: Coordination of multidisciplinary evaluation teams. Participation on multidisciplinary evaluation teams. Intake interviews. Psychoeducational evaluation. Development of treatment programs based on results of evaluation. Recommendations generated for educational purposes, home/family interventions, and counseling. Client follow-ups, including counseling for clients and their parents/family, behavioral management training and programming. Evaluation and counseling involves clients of all ages with various handicapping conditions including autism, Down's Syndrome, learning disabilities, attention deficit hyperactivity disorder (ADHD), depression, substance abuse, and other emotionally and physically handicapping conditions. Recommendation to appropriate external agencies (e.g. substance abuse programs). Write comprehensive evaluation reports. Provide case consultation for other staff. Supervising graduate and undergraduate social work, special education, psychology, and communicative disorders interns. Provide inservice training. Supervisor: Phyllis Cole, Ph.D.and licensed psychologist.

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| TITLE: | Research Assistant, Early Intervention Research Institute (EIRI), Developmental Center for Handicapped Persons, Logan, Utah. |
| DATES: | July,1986 - June,1987 |
| RESPONSIBILITIES: | Analyze data concerning different types of interventions, particularly with Down's Syndrome children. Prepare figures. Review parent training manuals. Summarize, organize and present the contents of these manuals in a table for possible publication. Record data from various early intervention research projects. Supervisors: Glen Casto, Ph.D. and Carol Tingey, Ph.D. |
| TITLE: | Laboratory Manager, Department of Psychology, Utah State University, Logan, Utah. |
| DATES: | September,1985 - June,1986 |
| RESPONSIBILITIES: | Monitor electromechanical equipment and rat/pigeon chambers. Obtain specialist to repair equipment if necessary. Supervise graduate and undergraduate students using the laboratory equipment. Arrange scheduling for use of the lab. Obtain parts for all laboratory equipment and purchase new equipment.Coordinate with psychology department faculty all events occurring in the lab. Take inventories of equipment. Coordinate care and transportation of laboratory animals with the Laboratory Animal Research Center (LARC). Supervisor: Edward Crossman, Ph.D. |
| TITLE: | Coordinator of High School Psychology Day, Department of Psychology, Colorado College, Colorado Springs, Colorado. |
| DATES: | January,1985 - June,1985 |
| RESPONSIBILITIES: | Obtaining volunteers to participate in the program. Organizing activities and presentations for each volunteer to perform. Obtaining the necessary equipment and animals for the demonstrations. Building equipment when necessary. Corresponding to high schools interested in attending the program. Arranging for use of rooms,and dining areas. Obtaining tour guides. Welcoming each high school group and organizing the order in which each group |

attended the presentations. Obtaining evaluations from each group on the presentations and organization of High School Psychology Day. Obtaining and supervising a clean-up crew.
Supervisors: Donald Shearn, Ph.D., and Carl Roberts,Ph.D.

TITLE: Research Assistant,Department of Psychology, Colorado College, Colorado Springs, Colorado.

DATES: June,1984 - August,1984

RESPONSIBILITIES: Obtain subjects for human evoked potential experiment. Collect daily data. Prepare each subject for research by placing electrodes on subject appropriately. Monitor equipment. Analyze data.
Supervisor: Donald Shearn, Ph.D.

**TEACHING EXPERIENCE**

TITLE: Instructor (Psychology 351, Social Psychology), Department of Psychology,Utah State University, Logan, Utah.

DATES: January - April,1987

RESPONSIBILITIES: Plan and teach undergraduate class. Prepare and deliver lectures. Prepare and organize learning activities for the class (e.g., appropriate games, films). Prepare, and grade homework and exams. Supervise undergraduate taking instructor apprenticeship credits. Determine final course grades.
Supervisor:Richard Powers, Ph.D.

TITLE: Teaching Assistant (Psychology 510/610, History and Systems of Psychology), Department of Psychology, Utah State University, Logan, Utah.

DATES: April - June, 1986

RESPONSIBILITIES: Prepare and grade exams and homework. Provide tutorial assistance to students. Record all grades. Prepare and deliver several lectures. Arrange for audio-visuals. Participate in every class period.

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| | Assist in determining final course grade. Supervisor: Edward Crossman, Ph.D. |
| TITLE: | Teaching Assistant (Psychology 351, Social Psychology), Department of Psychology, Utah State University, Logan, Utah. |
| DATES: | January - April,1986 |
| RESPONSIBILITIES: | Prepare study guides, study questions, and exams. Grade exams and homework. Provide tutorial assistance to students. Prepare and deliver several lectures as well as other learning activities. Arrange for audio- visuals. Assist in all learning activities (e.g. group projects or games).Participate in every class period. Assist in determining final course grade. Supervisor: Richard Powers,Ph.D. |
| TITLE: | Guest Lecturer for various Psychology and Sociology classes, Utah State University, Logan, Utah. |
| DATES: | Fall, 1986 - present |
| RESPONSIBILITIES: | Prepare and deliver lectures/ presentations/ demonstration for undergraduate sociology and psychology classes of varying levels. Lectures typically consist of basic or applied behavioral principles, mental health of the elderly, assessing the elderly or behavioral gerontology. |
| TITLE: | Practicum Supervisor/Trainer, Clinical Services,Developmental Center for Handicapped Persons, Logan, Utah. |
| DATES: | July, 1987 - present |
| RESPONSIBILITIES: | Train and supervise graduate and undergraduate interns in social work, special education, psychology, and communicative disorders. Interns are trained in interviewing techniques, evaluation intstruments, counseling, and making appropriate conclusions and recommendations. |
| TITLE: | Instructor (Psychology 591, Independent Research; Psychology 593, Instructor Apprenticeship), Department of Psychology, Utah State Universty, Logan, Utah. |
| DATES: | January,1987 - present |

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| RESPONSIBILITIES: | Supervise and train undergraduate students aiding in research, independent sudy, or acting as teaching assistants. |
| TITLE: | Laboratory Supervisor, Department of Psychology, Colorado College, Colorado Springs, Colorado. |
| DATES: | June - August, 1984 |
| RESPONSIBILITIES: | Care and supervision of the laboratory and animal subjects. Provide lab instruction. Supervise students during laboratory work. Supervisors: Donald Shearn, Ph.D. and Gilbert Johns, Ph.D. |

**CONSULTATIONS**

Utah School for the Deaf, Ogden Utah, 1988-1989. School psychology services to school-age clients receiving services at the School for the Deaf and in satellite classrooms in communities in Ogden and Salt Lake City. Provide behavioral assessments and psychoeducational testing.Some sign language required. Make recommendations. Write evaluation reports.

Cache Workshop,Logan, Utah, Bear River Adult Skills Center, Brigham City, and group homes in Ogden, Utah, 1987-1989. Psychological services to adult clients receiving Title XIX benefits. Provide behavioral assessments and psychoeducational testing. Make recommendations. Write evaluation reports.

Sunshine Terrace Nursing Home, Logan, Utah, 1987-1988. Providing behavioral programming and recommendations for the nursing home staff for problem clients. Antecedent stimuli, staff/client responses, and alternative approaches to the problems were discussed with the nursing home staff.

**VOLUNTEER WORK**

Sunshine Terrace (Nursing Home) Day Care Center, Logan, Utah,March-August, 1987. Aiding staff in serving meals, moving clients, involving clients in activities, changing clients, providing companionship for clients,problem-solving with staff in order to eliminate difficulties encountered with clients in the day care setting.

**PRESENTATIONS**

Cheney, C.D., and Birk, D.M. (May, 1989). Reaction Time in Elderly Subjects: The Effects of Practice on Two Different Reaction Time Tasks. Presentation at the Association for Behavior Analysis Fifteenth Annual Convention in Milwaukee, WI.

Birk, D.M. (April, 1988). Inservice to Developmental Center for Handicapped Persons Clinical Services Program staff on behaviorally oriented parent training manuals. Developmental Center for Handicapped Persons, Utah State University, Logan, Utah.

Birk, D.M.(November, 1988). Inservice to Developmental Center for Handicapped Persons Clinical Services Program interns on intelligence tests. Developmental Center for Handicapped Persons, Utah State University, Logan, Utah.

Birk, D.M. (1986-present). Guest Lecturer for various Psychology and Sociology classes, Utah State University, Logan, Utah. Lectures typically consist of basic or applied behavioral principles, mental health of the elderly, assessing the elderly or behavioral gerontology.

Birk, D.M. and Calhoun, D.O. (May, 1988). The use of free ambulation time to decrease wandering in Alzheimer's patients. Presentation at the Association for Behavior Analysis Fourteenth Annual Convention in Philadelphia, PA.

Cheney,C. and Birk, D.M. (April, 1988). Paired adaptive living system (PALS):Housing for the elderly. Presented to the Bear River Area Agency on Aging Board, Tremonton, Utah.

Birk, D.M.(February,1988). Inservice to Developmental Center for Handicapped Persons Clinical Services Program interns on visual/motor and auditory/visual tests. Developmental Center for Handicapped Persons, Utah State University, Logan, Utah.

Birk, D.M.(September,1987). Inservice to Developmental Center for Handicapped Persons Clinical Services Program staff on behaviorally oriented parent training manuals. Developmental Center for Handicapped Persons, Utah State University, Logan, Utah.

Birk, D.M.(August,1987). Inservice to Developmental Center for Handicapped Persons Clinical Services Program interns on intelligence tests. Developmental Center for Handicapped Persons, Utah State University, Logan, Utah.

Birk, D.M.and Barnard, L.(August,1987). Inservice to Developmental Center for Handicapped Persons Clinical Services Program interns on visual/motor coordination,and auditory-visual tests. Developmental Center for Handicapped Persons, Utah State University, Logan, Utah.

Birk, D.M. and Crossman, E.K. (May,1987). The acquisition and extinction of priming in a mixed-ratio schedule. Poster presentation at the Association for Behavior Analysis Thirteenth Annual Convention in Nashville, TN. (Outstanding Poster Award)

Birk, D.M. (April,1987). Presentation to Sunshine Terrace Day Care Center clients on the analysis of behavior. Sunshine Terrace Nursing Home,Logan, Utah.

Birk,D.M. (May,1985). Operant conditioning in amphibians. High School Psychology Day, Colorado College, Colorado Springs, Colorado.

Birk, D.M. and Delisle, R.R. (1983-1984). Presentations to various Girl Scout troops on human sexuality. Girl Scouts, Colorado Springs, Colorado.

**SCHOLARSHIPS AND AWARDS**

American Association of University Women Scholarship (third place) (1988). Utah State University, Logan, Utah.

Pam Cheney Scholarship Fund for Female Analysis of Behavior Student (1988,1989). Utah State University, Logan, Utah.

William F. Blakely Outstanding Psychology Student Award (1985). Colorado College, Colorado Springs, Colorado.

Viola Vester Scholarship (1982-1984). Colorado College, Colorado Springs,Colorado.

**MANUSCRIPTS IN PREPARATION**

Birk,D.M.(1988). Learned helplessness and attribution theory in the elderly.

Birk,D.M.(1988). Psychological well-being and housing alternatives for the elderly.

**IN SUBMISSION**

Birk, D.M. and Calhoun, D.O. (March, 1989). The use of free ambulation time to decrease wandering in Alzheimer's patients. Submitted to Journal of Applied Behavior Analysis.

Cheney, C. and Birk,D.M.(1988). Locus of control and related factors in the elderly: A review. Submitted to Research on Aging.

**GRANTS**

Cheney, C. and Birk, D.M. (1987). Paired adaptive living system (PALS): Housing for the elderly. (unfunded)

**UNPUBLISHED MANUSCRIPTS**

Crossman, E.K., Birk, D.M. and Gatch, M.B. (1987). The acquisition and extinction of priming in a mixed-ratio schedule. Submitted March, 1987 to Journal of the Experimental Analysis of Behavior.

**PUBLICATIONS**

Birk, D.M. (1988). New ways of thinking. The Association for Behavior Analysis Newsletter, 10(2), 12.

**TECHNICAL EXPERIENCE**

Computer programming in BASIC
Some knowledge of electromechanical equipment, interfaces, and switching

**ASSESSMENT KNOWLEDGE**

Academic Tests
Intelligence Tests
Interest Inventories
Aptitude Tests
Behavior Checklists and Inventories
Developmental Checklists and Assessments
Human Resource/ Personnel Evaluations
Projective Techniques

**AFFILIATIONS**

Student Affiliate, American Psychological Association, 1988-present.

Student Member, The Association for Behavior Analysis, 1985-present.

Student Member, The Gerontological Society of America, 1988-present.

Member, Behavioral Gerontology Special Interest Group of The Association for Behavior Analysis, 1988-present.

Member, Logan Mental Health Organization, 1988.

**TEACHING INTERESTS**

Behavioral gerontology
Applied behavior analysis
Experimental analysis of behavior
Behavior modification
Behavioral assessment and single subject design
Introductory psychology
Human Resource Management
Social Psychology
Testing/Evaluations
Research Design

**RESEARCH INTERESTS**

Experimental/Applied analysis of behavior
Behavior modification
Testing and clinical assessment
Business/Industrial psychology
Behavioral gerontology
Artificial intelligence
Behavioral economics
Marketing
Ecology
Family interventions
Behavioral techniques in the community
Behavioral techniques in nontraditional settings

**CURRENT RESEARCH**

Reaction time in the elderly (dissertation) with Carl Cheney, Ph.D.

Autism grant, delineating guidelines for diagnosing autism, with Clinical Services,Developmental Center for Handicapped Persons. Supervisor: Phyllis Cole, Ph.D.

**PERSONAL DATA**

Date of Birth: July 9, 1963
Place of Birth: Saddle Brook, N.J.
Marital Status: Single

**REFERENCES**

Dr. Carl Cheney
UMC 2810, Psychology Department
Utah State University
Logan, Utah 84322
(801)750-1460

Dr. Edward Crossman
1811 West 41st Street
Kearney, Nebraska 68847
(308)234-6996

Dr. Phyllis Cole
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Dr. J. Grayson Osborne
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