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CLASSICAL REACTION TIME AND ANTICIPATION REACTION TIME IN A SIMPLE VISUAL REACTION TIME TASK

by

Denis Drouin

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Approved by

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APPROVAL PAGE

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The purpose of the study was to investigate performance on anticipation reaction time and classical reaction time as a function of practice. In the anticipation reaction time condition, the foreperiod was held constant, while in the classical reaction time condition the foreperiod was varied. Three visual stimulus durations of 154 milliseconds, 204 milliseconds and 254 milliseconds respectively were used. The hypotheses investigated were: (1) there is no significant difference between frequencies tallied within each stimulus duration for the two reaction time tasks; (2) there is no significant difference in performance between the two reaction time tasks; (3) there is no significant difference in performance with variation in the length of stimulus duration, and (4) there is no significant difference between performance of different days. The sub-problems were: (1) to identify interaction between days, tasks and stimulus duration, and (2) to identify learning curves for the two tasks.

Twelve male subjects with a mean age of nineteen years, enrolled at the University of North Carolina at Greensboro, participated in the study. The experiment was conducted for four consecutive days. Each day 150 reaction times were recorded for each subject. This total of 150 trials was composed of three blocks of twenty-five trials

for each task within each stimulus duration. After each trial, immediate visual feedback was given when reaction was either equal to, or shorter than the stimulus duration.

To compare the number of successful trials of the two tasks within each stimulus duration, the Chi Square test was used. Analysis of Variance for Factorial Design was selected to compare means in relation to tasks, stimulus duration and days of practice. The Biomedical Statistical Program, a computer package, provided the computation model.

For each day of the experiment the Chi Square test indicated a significant difference at the .05 level between successful trials tallied for the two tasks with a stimulus duration of 154 milliseconds. This significant difference favored anticipation reaction time. For the two tasks, learning curves plotted for successful trials were identified as negative accelerated curves.

The F ratio indicated that there was a significant difference in performance at the .01 level between anticipation reaction time and classical reaction time. This difference favored anticipation reaction time. When there was variation in the length of stimulus duration, the F found indicated that there was a significant difference in performance at the .01 level. The Scheffe test showed that this difference favored a stimulus duration of 154 milliseconds. A significant difference in performance at the .01 level was also found between means of the four days. The Scheffe test revealed that this difference favored means of the second, the third and the fourth day in comparison to the mean obtained the first day of the experiment. A significant difference at the .01 level was also found in favor of the fourth day in comparison to the mean of the second day.

Some significant interaction factors at the .01 level were found between days and stimulus duration, between tasks and stimulus duration, and between days, tasks and stimulus duration. Learning curves of means for the four days for the two tasks were identified as negative accelerated curves.

For the two tasks the best reaction time performance was obtained on the fourth day of the experiment. Also, for the two tasks reaction time was faster with a stimulus duration of 154 milliseconds. The data do not permit the identification of a definitive plateau, even though the experiment was conducted over a four day period.

DEDICATION

to

Pierrette and Martin.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

From early experiments in reaction time in 1850, conducted by Helmholtz, to present day the concept of reaction time has been investigated. Many studies have been conducted and much data have been published. Some of these data have dealt with the identification of reaction time, some with factors affecting reaction time such as subject's physiological and psychological characteristics, and some with the components of reaction time. A variety of measuring devices has been used.

Physiologists, psychologists and physical educators have contributed to the identification of both internal and external factors commonly associated with reaction time. Although at first consideration reaction time seems relatively simple, further investigation reveals its complexity. More than an overt response is at the core of the concept involved in the reciprocal interaction of man's receptor-effector mechanisms. Careful study of reaction time has the potential to reveal knowledge about the complexity of man's internal processes. Welford reminds us:

> We are thus led to view the human mechanisms mediating between sensory input and motor output as a communication channel of limited capacity and

reaction time as a potentially valuable measure of this capacity. (28:16)

The concept of reaction time is challenging because it reflects the state and the integrity of the central nervous system; also it is a common, although quite variable, temporal aspect of every human movement that is initiated. Reaction time becomes a critical aspect of everyday behaving. When anticipation behavior, which is a characteristic of many movement patterns, becomes a factor in reaction time, it becomes obvious that a response may be initiated faster. In sport, responses must be initiated within a critical period of time if they are to be effective.

If in performing a skill the performer waits until after the stimulus event has occurred to initiate his movement, most of the time his reaction will be too late; on the other hand by anticipating the occurrence of the stimulus event, he may initiate an earlier response. In a situation where a stimulus lasts for only 100 milliseconds the performer must anticipate the event in order to initiate the response before the physical sensory input is over.

STATEMENT OF THE PROBLEM

The purpose of this experimental study was to investigate the performance of anticipation reaction time and classical reaction time in a visual reaction time task.

Hypotheses

The study tested the hypothesis that a specific reaction time occurs as a function of the task conditions for response initiation. The following hypotheses were explored:

1. Statistically there is no significant difference in frequency tallied between classical reaction time and anticipation reaction time within each stimulus duration.

2. Statistically there is no significant difference in performance between classical reaction time and anticipation reaction time.

3. Statistically there is no significant difference in performance with variation in the length of stimulus duration.

4. Statistically there is no significant difference between reaction time performance on different days.

Sub-Problem

The sub-problems of this study were:

1. To identify the interaction factor between days and stimulus durations, between tasks and stimulus durations, and between days, tasks and stimulus duration.

2. To identify learning curves for anticipation reaction time and classical reaction time.

LIMITATIONS OF THE STUDY

The study involved two tasks, identified as classical reaction time and anticipation reaction time, and three different stimulus durations of 154 milliseconds, 204 milliseconds and 254 milliseconds respectively. The experiment was conducted for four consecutive days. Each day three blocks of 25 trials for classical reaction time and 25 trials for anticipation reaction time were recorded. For both tasks each block of trials included stimulus durations of 154 milliseconds, 204 milliseconds and 254 milliseconds. After each response, the subject received some visual feedback as to degree of success. A total of 600 reaction times were recorded for each subject, that is 300 for each task and 100 for each stimulus duration for each task.

The experiment was an attempt to investigate performance of classical reaction time and anticipation reaction time using a sample of 12 male subjects ranging in age from 18 to 21 years old.

DEFINITIONS OF TERMS

For purposes of this study, the following definitions were accepted:

Stimulus Box

Subject's unit where the preparatory set light, the light stimulus and the feedback light are located.

Stimulus Light

A white light, 2 inches in diameter, was presented on the stimulus box.

Stimulus Light Duration

The duration of the light stimulus presented is limited to time spans of 154 milliseconds, 204 milliseconds and 254 milliseconds.

Buzzer Signal

A signal to warn the subject that a trial may be started.

Preparatory Set Light

A yellow warning light on the stimulus box to indicate that a trial has begun.

Feedback Light

A red light at the bottom of the stimulus box. In the classical reaction time condition, the red light appeared when a response was shorter than or equal to the stimulus duration. In the anticipation reaction time condition, the light appeared when a response was shorter than the stimulus duration.

Reaction Time

It is the time elapsed from the initiation of the stimulus up to the initiation of the overt response.

Classical Reaction Time

It is the time elapsed from the initiation of the stimulus up to the initiation of the overt response when a varying foreperiod is used before the stimulus presentation.

Anticipation Reaction Time

It is the time elapsed from the initiation of the stimulus up to the initiation of the overt response when a fixed foreperiod is used before the stimulus presentation.

Foreperiod

Time elapsed after the preparatory set light goes on, and before the stimulus presentation.

Response Key

A telegraph key that the subject pushes to put on the preparatory set light and that he releases in response to the stimulus presentation.

A Response

Subject's finger lift movement from the response key.

A Trial

Only one stimulus presentation and one response.

A Block of Trials

A series of 25 stimuli presentations and 25 responses.

SIGNIFICANCE OF THE STUDY

The purpose underlying the study was to investigate whether anticipation reaction time is faster than classical reaction time. The experimental conditions were arranged to favor reaction time since there was a buzzer signal, a preparatory set light, adjusted short foreperiods, white light stimulus, immediate visual feedback and continued practice. The immediate visual feedback after each trial was provided for two major reasons: (1) it allowed the subject to learn something about the stimulus duration and his reaction time, and (2) it might have had a motivating effect.

The study was designed to add to present knowledge concerning visual reaction time performance, since there is an apparent dearth of studies of reaction time involving many days of practice, constant foreperiod, variation in the stimulus duration and visual feedback information.

CHAPTER II

REVIEW OF LITERATURE

ASTRONOMY AND REACTION TIME

The literature covering the concept of reaction time is quite extensive. The idea that man's response to a stimulus includes a time delay, and the study of factors affecting this delay, were first studied rather extensively during the nineteenth century. The name of Helmholtz must be mentioned since he was the first one to identify the speed of the nerve impulse. (5:94) Among his numerous experimental works one finding is still significant. In one of his experiments after stimulation of a subject's thigh and sole of the foot, he calculated the difference in reaction time and concluded that neural impulses travel at the rate of 50 to 100 meters per second. (5:94) As Fitts mentions (5:94), this speed of 100 meters per second has been confirmed by subsequent research.

After Helmholtz's findings it appears that the concept of reaction time was thoroughly investigated by astronomers. The task of recording a star's transit seems to be closely related to reaction time. Maskelyne, (3) who was chief astronomer at the Greenwich Observatory, noticed that there was almost one second difference between his observation records and those of his assistant. Another astronomer, Bessel, (3) after investigating many recording errors in different observatories in Europe, used the term "personal equation" to explain the cause of these errors. His investigations showed that delays were shorter with the more brilliant stars, and that delays increased with an event's uncertainty. He also reported that delays were much longer when the task involved simultaneous auditory and visual events.

Astronomers' concern about observing a star's transit have led to the development of the chronometric method of signaling transit, the telescope, and later, the invention of the famous Hipp Chronoscope. (5) Following the work of Helmholtz, Maskelyne and Bessel, it seems appropriate to identify as pioneer researchers in reaction time, Cattell, Dolley, Hirsch, Hipp, Donders, Wundt, Kraeplin, Exner, Lange, Kulpe and Williams. (30) Teichner (84) published an extensive review of experimental studies on simple reaction time. His article covers twenty years of research in reaction time and includes 163 studies.

STUDIES IN REACTION TIME

Generally reaction time studies have been conducted by manipulating specific variables under different conditions. These variables have included the task difficulty such as simple or choice reaction time (36, 39, 52, 55, 65, 79), the intensity of the stimulus (49, 51, 71, 80), the length of the foreperiod and the use of a warning signal (40, 85, 88, 20:29-32), temporal certainty of stimulus presentation (60), stimulus response compatibility (42, 57, 66), and the components of reaction time. (41)

Some studies dealing with reaction time have also stressed the importance of the subject's physiological and psychological characteristics. Studies in reaction time have considered: age of the subject (34, 38, 67, 30:35-36), sex (38, 54), fatigue and body condition (43, 48, 69, 70, 61, 90), effects of amphetamine and caffeine (10:265-266), the issues of practice (30:35), and motivation. (53, 54, 58, 59, 68)

ANTICIPATION IN REACTION TIME

Since the experiment in this study was focused on anticipation in reaction time and on classical reaction time, those experiments dealing with the concept of time-lag, and studies involving tracking, temporal uncertainty and activation closely related to the problem were investigated. The concept of reaction time-lag was of interest to Craik. (45, 46) He claimed that the first and most marked feature of the central process is its time-lag or central delay. He stated that the time-lag between the occurrence of a stimulus and the most rapid response for a single visual stimulus is about 0.18 seconds after a warning signal has been given. (46) Craik's speculations in relation to delays in the central nervous system involve some computing mechanism which has both latent and processing periods. His estimation of human responses to successive discrete stimuli has included 50 milliseconds for starting the human sensory system, and 450 milliseconds for processing the information and starting the discharge of impulses to motor nerves. (45, 81) Craik's estimate is still reviewed, and his critical problems about some characteristics of human sensory chain, considering its maximum power output, its optimum loads, its flexibility and its self-modifying properties are still being investigated.

As Craik was placing emphasis upon man's sensory and central capacities, Poulton and Welford were directing experimental studies involving the role of anticipation in tracking tasks. As Welford (38:17) has stated, although sensory limitations have not been considered in tracking experiments, the importance of several perceptual factors has been shown.

In reference to tracking experiments, Welford has made the point that when the display can be seen in advance of appropriate time to react, there is elimination of the usual reaction time-lag; and in the other condition, when the subject does not see the display in advance, he can, on the basis of what he sees of the track, learn its regularity and thus predict its path. It appears that Poulton (72, 73, 75) was one of the first to investigate systematically the role of anticipation in motor skills. To clarify his concept of anticipation, he made a distinction between receptor anticipation and perceptual anticipation. Receptor anticipation (72, 73, 76) is involved when a task needs rapid acquisition of a moving target whose future track is displayed ahead; one can predict the approaching event and respond to it without the lag due to traditional reaction time. According to Poulton, in receptor anticipation it is not necessary that the presentation of stimulus event be regular but more predictable stimuli presentation will favor more accurate performance. As he mentions, receptor anticipation is a type of anticipation which is dependent basically upon the timing process. Perceptual anticipation (72, 73, 76) is occurring when in a situation the subject has no information about the stimulus event, but the stimulus is presented in a regular pattern sequence so that the subject can learn the sequential timing or space location. The task may require a rapid acquisition of an object where there is no information about the display. Poulton goes further by saying that there are two classes of perceptual anticipation: spatial and temporal. Spatial anticipation requires the prediction of the place in space in which the stimulus event will occur, while temporal anticipation involves the prediction of the time of arrival of the stimulus. (72, 73)

In an experiment, Poulton (73) investigated the information which was used in anticipating, and also investigated the main deficiencies of the one-pointer display in a tracking task. He mentions that in anticipating with a two-pointer display the subject has two relevant sources of information available; while with a one-pointer display he has only one source of information while he is responding. In a one-pointer display, the subject does not get direct visual information about the speed of the stimulus movement when responding, and the display does not give him direct visual information about his control movements. Consequently it becomes very difficult for the subject in one-pointer tracking to relate his control movement directly to the stimulus movement. So, in both task conditions the source of information derives from the fact that after tracking for a while with any predictable course the subject will have learned its general characteristics. The study showed that in anticipating with a two-pointer display speed cues can be used. According to his findings, speed cues are the only available source of information upon which anticipation can be based. Poulton also mentioned that once the characteristics of the tracking course are known, these characteristics can be used in anticipating with both the two-pointer and one-pointer displays. Other results were that the accuracy of perceptual anticipation depends mainly upon the number of the events at the end of which prediction has to be made and that the time over which events are spread was of secondary importance. The main deficiency of a one-pointer display was that control movements cannot be apprehended directly in relation to the stimulus movement. The absence of stimulus speed cues in one-pointer was found to be a significant but a less serious handicap. The same observation was true for the absence of visual representation of the control movements.

In another study on perceptual anticipation and reaction time (72), 24 subjects were asked to trace out as quickly as possible a fully visible pattern which consisted of three identical V's lying on their sides one above the other. The experimental conditions were varied, since in one experiment a bell rang during performance, which indicated that the subject had to stop contact after V number two; in another condition the subject was instructed to trace only the first two V's; in another condition, the subject was directed to pay no attention to the bell when it rang. The results showed the mean reaction time at the start of the pattern tracing to be .025 seconds longer than the subject's simple reaction time when all he was instructed to do was to break the first contact with his stylus. Another interesting finding was that when the subject had suddenly and unexpectedly to change his performance, he needed a median of roughly .25 seconds longer than an ordinary complex graded reaction time before he could stop the movement and a median of 0.35 seconds longer before he could start to extend it. As a general conclusion Poulton

(73, 75) claimed that anticipation has a unifying effect in skilled performances. He also mentioned that one who is anticipating poorly may be able to respond smoothly, in a tracking task, but with poor time-on target scores and large lags in response.

In a study of two-dimensional visual tracking, Adams and Xhignesse (32) mentioned that the degree of coherency or predictability of the stimulus events is an important variable to consider. In the absence of anticipation the subject will wait for stimulus change to occur before initiating a response, which means that he will have error as a function of at least one reaction time interval. They indicated further that with anticipation the response movement will be initiated before the change and consequently the control system will be in the correct position at the time the change actually occurs. They also claimed that to be identified as beneficial anticipation the interval between the stimulus and response onset must be less than the expected reaction time interval. So, ideal anticipation would be considered perfect time coincidence of stimulus and response. In this study they found that tracking proficiency was related positively to the proximity of the stimulus source and inversely to the speed of event change when stimulus coherency was low.

In another study Adams and Boulter (31) investigated the effects of temporal and spatial uncertainty on visual monitoring behavior in a complex vigilance task. Four groups of 20 subjects each participated in the experiment with differing conditions. One group had temporal uncertainty and spatial certainty; one group had spatial uncertainty and temporal certainty; the third group had both temporal and spatial certainty and the last group had both temporal and spatial uncertainty conditions. The results indicated that temporal and spatial uncertainty was a clear-cut variable for vigilance behavior, and that when the condition was under high temporal uncertainty, the subject had poor temporal expectancies and a reduced state of readiness to react and consequently longer response latencies.

Conrad (44) stated that in almost all of the skills of everyday life, part of the process will involve dealing with an ever-changing stimulus field made up of many constituents. He mentioned that the various factors in this display compete for the attention of the operator who, with growing acquisition of skill, will be able to switch his attention so as to be closely in touch with the changes that occur. The majority of these changes will not be accompanied by warning lights or motor horns, and part of the operator's skill will be his ability to know what to attend to, because he knows that one change is imminent.

In a study dealing with time uncertainties in simple visual reaction time, Klemmer (60) used six subjects in two series of studies of simple reaction time. In one series, the subject had a warning click occurring at 11 second intervals and the foreperiods randomized with a mean foreperiod change between tests. In the second series, there was no warning click and no variability on time of stimulus occurrence during each run, but the foreperiod was changed between tests. The results showed that visual reaction time increases with foreperiod variability and also with mean foreperiod above some small optimum value less than one second. But, as he mentioned, the most striking finding in the test with variable foreperiods was that the important determiner of reaction time was not the immediate foreperiod but rather the distribution of foreperiods within which it is embedded.

After conducting a series of studies on synchronization of motor response and sensory event, Bartlett et al. (35) suggested that data on synchronization errors show that variability occurs in the central triggering and motor execution, independent of any variability in sensory processing but compounded instead with the variability in anticipatory mechanism. They claimed that whenever the interval between regularly spaced events exceeds half a second, some memory factor enters into attempts to synchronize a motor response. It appears that half a second is a critical, or the optimal, interval to permit a single stimulus to register in the central nervous system.

Wilson (87) investigated the quickness of reaction and movement time in relation to rhythmicity or nonrhythmicity of signal presentation. There were 50 subjects participating in the study. A total of 35 reaction trials were recorded under each condition. In the rhythmical condition, the rhythm light was flashed once per second for eight flashes. In the nonrhythmical condition, a series of 40 flash intervals was prepared with each consecutive interval being randomly chosen from the possible intervals of 0.05, 1.0 or 1.5 seconds. As the response movement the subject lifted his finger from a key. By allowing at least three flashes to establish the rhythm before stimulus occurrence, it was found that when a series of rhythmic signals was presented with equal probability, the average reaction time was .20 seconds and 6% faster than when the signals were nonrhythmical. The average reaction time for rhythmical signal was .198 seconds. The main conclusion was that reaction time is faster when potential stimuli are presented in a rhythmic rather than a nonrhythmic series.

An experimental study on the effects of foreperiod, foreperiod variability and probability, and probability of stimulus occurrence on visual simple reaction time was conducted by Drazin. (47) Only three subjects were used in two parallel experiments. In the first experiment the mean foreperiod was held constant throughout the test at 1.5 seconds for both the range of the foreperiod and the probability of stimulus presentation. In the second experiment the range of the foreperiod was held constant at 1.0 second and the probability of stimulus occurrence at 1.0 second with the minimum foreperiod being held at five different levels. Subjects participated in a total of 14 conditions where the minimum foreperiod, range of foreperiods and probability of stimulus occurrence were systematically mixed. The results indicated that the reaction time foreperiod relationship is subject to a range effect. In all conditions, where the range of foreperiods exceeded 0.5 second, reaction time tended to decrease initially as a negative accelerated function of the length of the foreperiod. The study also showed that reaction time varies with the foreperiods of the preceding reaction and to a less extent with the second preceding reaction. Drazin mentioned that the effect of immediate foreperiod was most marked following reactions with a short period.

In a follow up of a study by Slater-Hammel (81) Belisle (37) was concerned with coincidence-anticipation and reaction time. There were three conditions involving transit reaction where the subject was instructed to remove his hand from the signal key simultaneously with coincidence of the pointer and a fixed marker. For the first two days, no knowledge of results was given; on days three and four immediate knowledge of results was given; in the next five days knowledge of results was also given by the introduction of catch trials in which the pointer was stopped at varying intervals short of the fixed marker. Some 20 male subjects completed the 11 testing sessions under the four conditions. The results showed that performance with immediate knowledge of results and no catch trials was exceptionally accurate, and that the absolute error performance with knowledge of results was significantly smaller than the error for performance without knowledge of results.

Aiken and Lichtenstein (33) investigated the concept of reaction time to regularly recurring visual stimuli. Their study was directed toward the relationship between foreperiod length and mean reaction time, and the difference for various foreperiod lengths in the effects of practice on mean reaction time. They found that the relationship between interstimulus time interval and reaction time to regularly presented visual stimuli was best depicted as an increasing function which reaches a plateau at a different time interval for each subject. They also mentioned that practice results in a greater decrease in reaction time for the one and two second interstimulus intervals.

At the present time there are some interesting data about the relationship between reaction time and EEG activation. Even if these data are somewhat controversial, it is appropriate to mention a few studies, since they have some implications for reaction time performance. Lansing, Schwartz and Lindsley (64) measured visual reaction time of nine normal subjects under non-alerted and alerted conditions. During the non-alerted condition the visual reaction time stimulus was presented at times when the alpha-rhythm of the EEG varied spontaneously and included patterns of activity characterized as (a) good alpha waves, strong, regular waves; (b) poor alpha waves, irregular waves, and (c) no alpha waves, time when they were absent. Under the alert condition an auditory warning signal preceded the visual stimulus by intervals varying from 50 to 1000 milliseconds. Their findings indicated that reaction time means and standard deviations did not differ for the three non-alerted conditions, but were markedly reduced when the warning signal proceded alpha blocking prior to the visual stimulus. They also mentioned that the reduction in reaction time as a function of the length of the foreperiod interval followed precisely the same time course as the curve showing the degree of alpha blocking as a function of the foreperiod interval.

Another study conducted by Fedio and Mirsky et al., (50) also provided evidence to show that when a stimulus was preceded by a warning signal which resulted in EEG alpha blocking, normal subjects reacted more quickly than when there was no preparatory signal, or when the signal did not produce blocking. Hermelin and Venables (56) directed an experiment in which the interval between a warning signal and the reaction stimulus was varied irregularly. There were six normal subjects, six non-Mongol imbeciles and six Mongol imbeciles participating in the study. Some reaction time responses were given when the alpha rhythm was still blocked by the forewarning, while for others the alpha rhythm had returned. Their findings do not confirm that reaction time is faster when the stimulus falls into a period in which the alpha rhythm is blocked, than when it is not blocked.

Surwillo (83) investigated the relation of simple response time to brain-wave frequency and the effects of age. He used 100 male subjects, ranging in age from 28 to 99 years. Subjects were instructed to lie on a bed in a supine position and to respond by pressing a button of a micro-switch with the thumb. There were three separate sessions of about ten minutes duration. In sessions one and two, the auditory signal was presented approximately thirty times. Subjects were told that the time interval between successive stimuli would be varied and that these different intervals would appear in random order. In the third session, the duration of the auditory signals was changed from three seconds, the standard, to three-tenths of a second. The auditory signals were triggered by the experimenter when well defined waves were being recorded. All recording was done with the room darkened and the subject's eyes lightly closed. The major results showed that a correlation coefficient of .72 was obtained between average reaction time and the average period of the EEG. A highly significant positive correlation was obtained between age of the subjects and the average period of their brain waves; a low but statistically significant position correlation was found relating average reaction time and age. Finally, the data supported the hypothesis that the brain wave cycle is the basic unit of time in which a response is programmed by the central nervous system. Thompson and Botwinick (87) studied the role of the preparatory interval in the relationship between EEG alpha blocking and reaction time. In one experiment they used preparatory intervals of 0.5, 3.0, 6.0 and 15.0 seconds in regular and irregular series. The warning signal was a 400 cps. tone and the stimulus a 1000 cps. tone. In the second experiment, preparatory intervals used were of 0.50, 0.75, 1.00 and 1.50 seconds and the stimulus was a simple flash from a photo stimulator. A simultaneous EEG recording from parieto-occipital was made. There were fourteen male college students, with a mean age of 19.5 years, in the study. The results did not support earlier findings by Lansing et al., (64) by Fedio and Mirsky (50) and by Surwillo (83) that there was a relationship between alpha blocking and reaction time. However, the investigators reported that reaction time and alpha blockings were each independently a function of the preparatory interval. They suggested the presence of two or more distinct, and at least partially independent, neural systems which underlie behavioral and electrophysiological measures of arousal.

As indicated by the review of literature the concept of reaction time has been investigated for a considerable period of time. The work of Craik, Poulton and Adams using a tracking task is significant. Studies in transit reaction time by Slater-Hammel and Belisle are also valuable. Experiments conducted by Lansing et al., Fedio et al., Surwillo and Thompson on the relationship between reaction time and EEG activation are informative. In the past few years, the work of Schmidt (91, 77, 78), Whiting (29), Stadulis (82) and Waechter (92) in coincidence anticipation has also been meaningful.

This project is an attempt to investigate and compare performance of classical reaction time and anticipation reaction time. It parallels the idea that anticipation and timing ability are independent variables of classical reaction time. It is also in agreement with Conrad (44), Adams (32) and Poulton's (72) concepts that a distinction should be made between reaction time, the time elapse from an unanticipated stimulus event and the initiation of a response, and response time, which is the interval separating an anticipated stimulus and a response.

CHAPTER III

PROCEDURES

The investigation was conducted to study performance in anticipation reaction time and classical reaction time.

EQUIPMENT

The equipment utilized for collecting data in this study consisted of two basic units, the experimenter control unit and the subject unit. All of the equipment was located in the Rosenthal Research Laboratory of Rosenthal Gymnasium at the University of North Carolina at Greensboro where the experiment was conducted.

Experimenter Control Unit

The experimenter control unit consisted of one recording device for reaction time in milliseconds, and a special unit for controlling stimulus duration, foreperiod pattern and feedback. A push button buzzer unit was also utilized.

The recording device used was a Hunter Model 120 A klockounter. This specific recorder was selected because it can measure either the time a circuit is closed or opened, or can count pulses to speeds of 2000 counts per second. A range switch gives a time revolutuon of 0.001, 0.01 or 0.1 seconds with four decades of timing capacity in the form of glow transfer tubes. The timer also has convenient terminal connections to double throw relays. A second identical recording instrument was used to calibrate the stimulus duration.

The special control unit (Figure 1) was a small steel box containing the required relays circuit for accurate timing. (Figure 2). To calibrate the stimulus duration the control knob (A) was adjusted to the specific stimulus duration when the response key was held down. Timer 2 (Figure 2) was used to record the exact duration of the stimulus. A second control knob (B) was used to obtain the desired foreperiod in seconds. The unit also included a cue light (C) which was synchronized with the preparatory set light of the stimulus box. Finally, the unit had a feedback button mechanism (D).

The special control unit for the stimulus duration, the foreperiod and the feedback was built at the Electronic Service Center of the University of North Carolina at Greensboro.

Subject Unit

The subject unit was a steel stimulus box (Figure 3) and a response key which was plugged into the special control unit and timer number one. The stimulus box was 10½" x 8" in size and it included at the top the preparatory yellow set light visible through an opening one inch in

FIGURE 1

DIAGRAM OF SPECIAL
CONTROL UNIT

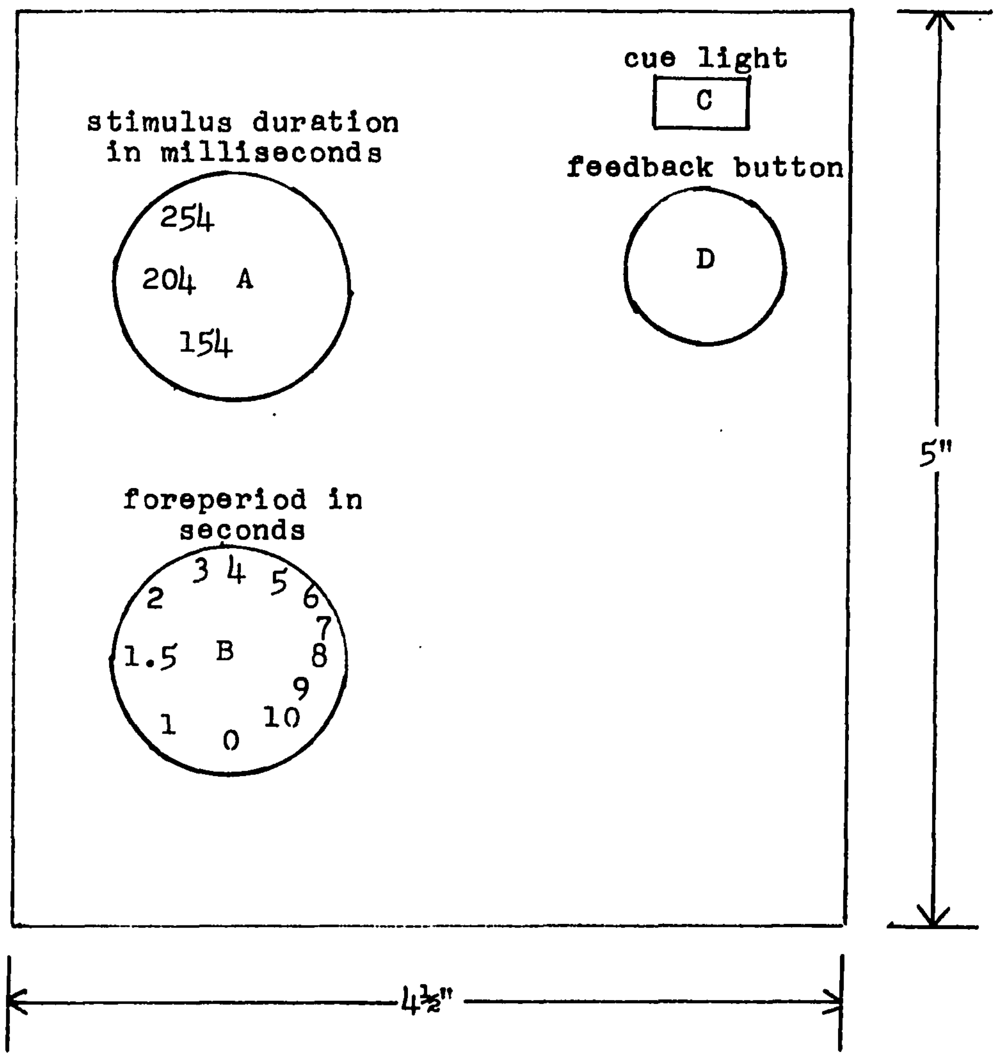


FIGURE 2

CONTROL UNIT CIRCUITS

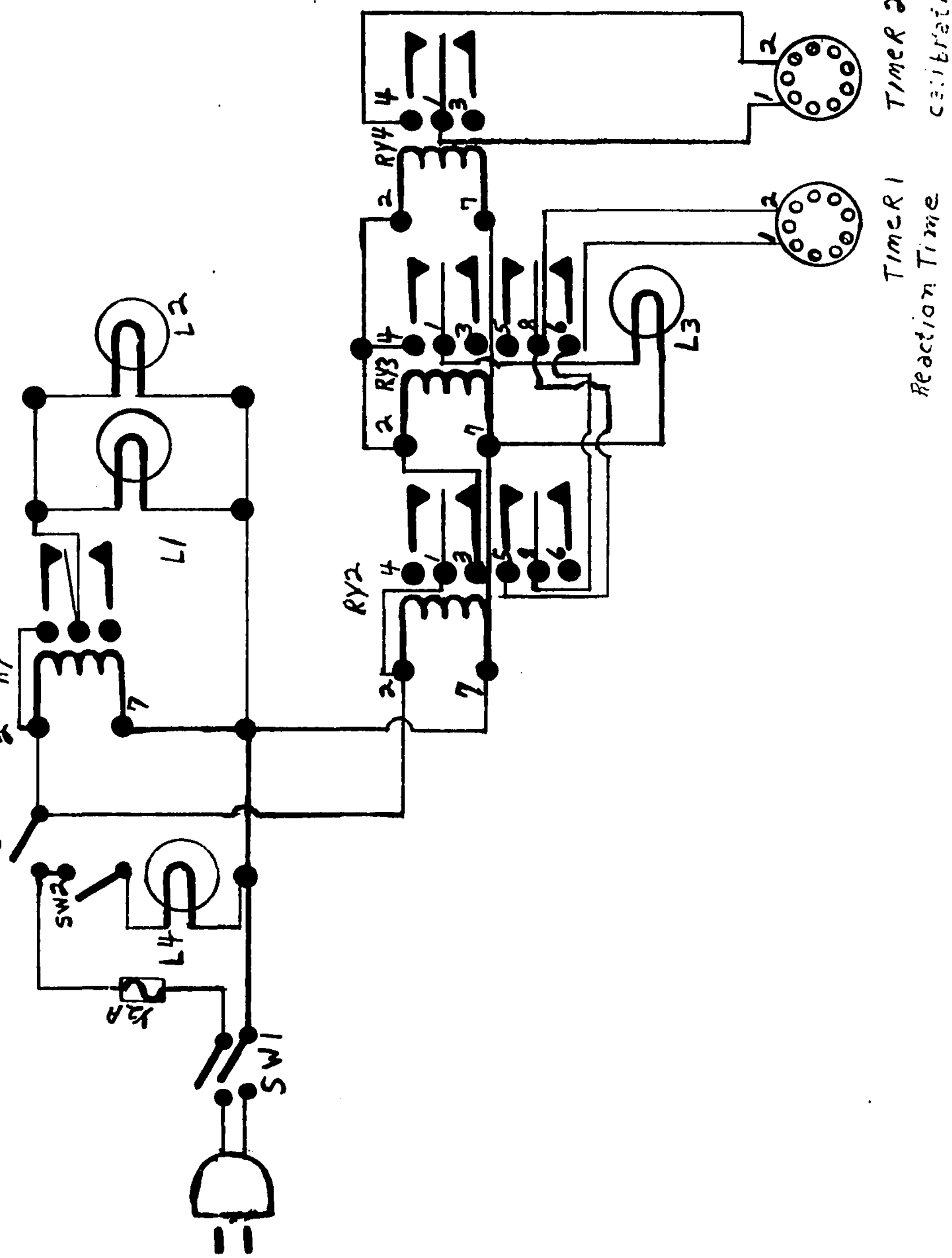
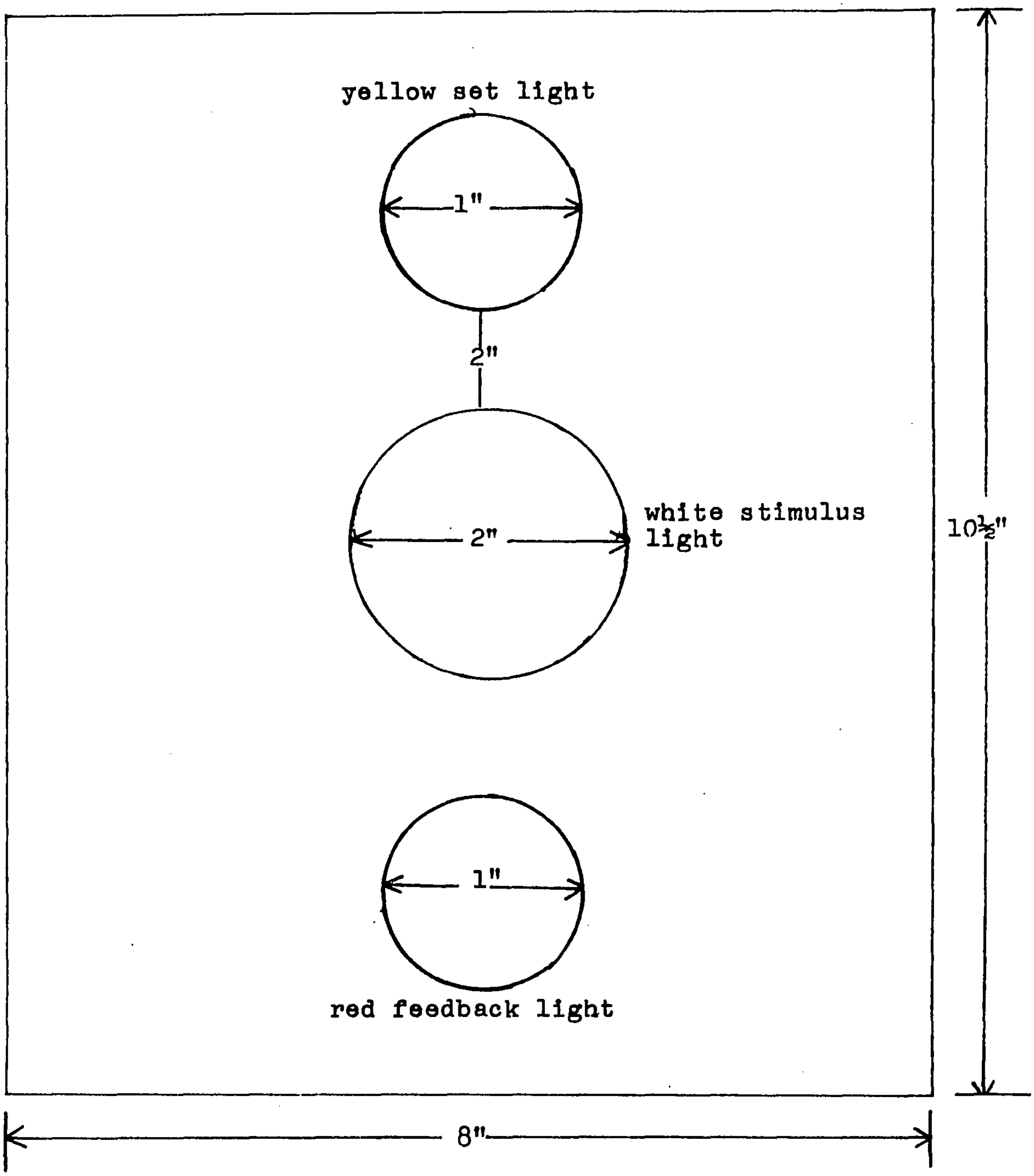


FIGURE 3

STIMULUS BOX



diameter; a white light stimulus surface with a two inch diameter opening; and at the bottom a red feedback light with a vision area one inch in diameter. A white light was chosen for the stimulus based upon Woodworth's ideas that under any given illumination no surface color can be brighter than the best available white. (30:431) The response key switch was a standard telegraph key with a response surface one inch in diameter.

SOURCE OF DATA

Twelve male students, enrolled at the University of North Carolina at Greensboro during the spring semester of 1973, participated in the experiment. A random selection of 200 male students was made from among freshmen, sophomores and juniors listed in the University of North Carolina at Greensboro Students' Directory for 1972-1973. The selection was made from the beginning of the alphabetical list of A, toward the end of A. For letter B, the reverse order was used. Each student received a number from 0 to 9. A random table was used to select 20 subjects.

Subjects were contacted by mail. (See Appendix A for copy of letter sent). Only two of the 20 students contacted were either available or willing to participate in the study. To complete the group of 12 it was decided to make a random selection of ten students from intramural participants. All subjects, who did participate, were right handed, and their mean age was 19 years. All testing was scheduled during afternoon hours.

EXPERIMENTAL CONDITIONS

Each subject was to be tested for classical reaction time and for anticipation reaction time. For both tasks, each day included three blocks of 25 trials for each stimulus duration.

In this study, the experimental design allowed manipulation of both the task conditions and the stimulus duration. The first day, the first block of trials tested classical reaction time with a stimulus duration of 254 milliseconds; the second block of trials tested anticipation reaction time with a stimulus duration of 204 milliseconds, while the third block of trials measured classical reaction time with a stimulus duration of 154 milliseconds. This order was reversed for the next three blocks of trials.

On the second day of the experiment, the first block of trials tested anticipation reaction time with a stimulus duration of 254 milliseconds; the second block of trials measured classical reaction time with a stimulus duration of 204 milliseconds, while the third block of trials tested anticipation reaction time with a stimulus duration of 154 milliseconds. A reverse order was used on the last three blocks.

The experimental design described in Figure 4 indicates how tasks (N) were manipulated (M) during the four days of the experiment. It also shows the stimulus duration

FIGURE 4

EXPERIMENTAL DESIGN

	DAY I						DAY II						DAY III						DAY IV					
NM	1	2	1	2	1	2	2	1	2	1	2	1	1	2	1	2	1	2	2	1	2	1	2	1
T	c	b	a	a	b	c	c	b	a	a	b	c	a	b	c	c	b	a	a	b	c	c	b	a

C Block of 25 trials for each task

Total: 75 trials for 1

75 trials for 2

DAY I	DAY II	DAY III	DAY IV
150	150	150	150

N = variables 1 = classical reaction time

2 = anticipation reaction time

M = manipulation of variable 1 and 2

T = stimulus duration pattern a = 154 milliseconds

b = 204 milliseconds

c = 254 milliseconds

pattern (T) and the number of daily trials (C) for each task, within each stimulus duration.

The experimental conditions of both tasks were arranged to enhance learning and performance. In the anticipation reaction time task, the foreperiod was held constant in length. It was hypothesized that the subject would learn to approximate this time interval, and consequently that he would initiate his response earlier than in the classical reaction time task.

For both tasks, the subject was isolated in a small cage 6' x 6' x 7' to minimize distractions. In both tasks the subject was seated on a standard desk chair. He then placed the response key at his convenience. The stimulus box was placed 32 to 36 inches in front of the subject's eyes.

The stimulus duration was one of the following: 154 milliseconds, 204 milliseconds or 254 milliseconds. The rationale for selecting stimulus duration of 154 milliseconds, 204 milliseconds and 254 milliseconds was based upon Poulton's tracking concept that if the subject waits for the stimulus to occur before initiating his response, as in classical reaction time, he will have a minimum off time lapse delay in the approximate range of 150 milliseconds to 250 milliseconds. It was also based upon the fact that there is almost complete agreement in the literature about visual reaction time, the range of this average being between 160 and 180 milliseconds.

For both tasks and for each block of trials, subjects were informed about the stimulus duration. Each subject was told that he was to respond with his preferred hand, and that the response key could be placed at his convenience. A ready buzzer signal was used to inform the subject that a trial could begin. When the subject was ready, he pushed the key. With the depression of the key, the yellow light at the top of the stimulus box came on indicating that the trial had started. The subject was to respond by releasing the key as quickly as he could at the onset of the white light stimulus. The key release recorded the reaction time. The red light at the bottom of the stimulus box appeared when the reaction time recorded was equal to or faster than the stimulus duration. A block of trials included 25 stimulus presentations.

<u>Classical Reaction Time Conditions</u>

The stimulus for the classical reaction time conditions occurred either at one, two or three seconds after the preparatory set light. For the purpose of this study, a balanced foreperiod pattern was used within each block of 25 trials. The foreperiod pattern (Figure 5) indicates how the two blocks of 25 trials were administered each day.

When the recorded reaction time was equal to or shorter than the stimulus duration, the feedback light came on.

FIGURE 5

FOREPERIOD PATTERN FOR CLASSICAL REACTION TIME CONDITION

Day 1	Trials
Block (1)	1-25
Block (2)	26-50
Block (1)	25-1

Day II	Trials
Block (2)	50-26
Block (1)	1-25
Block (2)	26-50

Day III	Trials
Block (2)	50-26
Block (1)	25-1
Block (2)	26-50

Day IV	Trials
Block (1)	1-25
Block (2)	50-26
Block (1)	25-1

1st block of trials

Trials	Foreperiods
1	2 sec.
2	3 sec.
3	1 sec.
4	3 sec.
5	1 sec.
6	2 sec.
7	1 sec.
8	2 sec.
9	3 sec.
10	2 sec.
11	1 sec.
12	2 sec.
13	1 sec.
14	3 sec.
15	1 sec.
16	3 sec.
17	2 sec.
18	1 sec.
19	2 sec.
20	3 sec.
21	2 sec.
22	1 sec.
23	3 sec.
24	1 sec.
25	3 sec.

Trials	F.Periods
9	1 sec.
8	2 sec.
8	3 sec.

2nd block of trials

Trials	Foreperiods
26	2 sec.
27	1 sec.
28	3 sec.
29	2 sec.
30	1 sec.
31	2 sec.
32	1 sec.
33	3 sec.
34	2 sec.
35	3 sec.
36	1 sec.
37	3 sec.
38	2 sec.
39	3 sec.
40	2 sec.
41	1 sec.
42	2 sec.
43	1 sec.
44	3 sec.
45	1 sec.
46	2 sec.
47	3 sec.
48	2 sec.
49	3 sec.
50	1 sec.

Trials	F.Periods
8	1 sec.
9	2 sec.
8	3 sec.

<u>Anticipation Reaction Time Conditions</u>

In the anticipation reaction time condition, the stimulus always occurred at 1.5 second after the preparatory set light.

In this condition when the recorded reaction time was shorter than the stimulus duration, the feedback light appeared.

TREATMENT OF DATA

To compare the number of times the feedback light appeared indicating a successful trial for both tasks, and within each stimulus duration, the Chi Square test was used. It was hypothesized that there would be no significant difference at the .05 level in the frequencies observed between anticipation reaction time and classical reaction time. In the anticipation reaction time condition a successful frequency was recorded when reaction was shorter than the stimulus duration, while in the classical reaction time condition a successful frequency was recorded when reaction time was either shorter than, or equal to, the stimulus duration.

For comparison of means in relation to tasks, stimulus duration and practice, an Analysis of Variance for Factorial Design was the statistical technique selected. The Biomedical Statistical Program, a computer package, provided the computation model. All computation was done through the Triangle University Computer Center. The .01 level was selected to check hypotheses of differences between tasks, stimulus duration and practice. When a significant F ratio was found, the Scheffe test was used to determine which of the means differed significantly.

Learning curves for frequencies observed and for means, for each type of reaction time, were plotted for comparison purposes within each stimulus duration.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF DATA

PRESENTATION OF FINDINGS

This study focused on reaction time performance. Comparisons were made between anticipation reaction time and classical reaction time with various stimulus duration over a four day period. Subjects were twelve male students at the University of North Carolina at Greensboro. For descriptive purposes graphical representations dealing with learning curves for each day of the experiment were formulated.

To compare the number of frequencies of successful trials for the two tasks within each stimulus duration, the Chi Square test was used. In the anticipation reaction time condition a successful frequency was tallied when a reaction time trial was shorter than the stimulus duration. In the classical reaction time condition a successful trial was tallied when a reaction time trial was either shorter than, or equal to, the stimulus duration. It was hypothesized that there would be no significant difference at the .05 level in frequencies tallied between the two reaction time tasks within each stimulus duration.

A significant difference between frequencies observed is noticed only with the stimulus duration of 154 milliseconds for the first day of testing. These data are presented in Table 1. Since this specific stimulus duration is faster than average visual reaction time, it must be assumed that subjects were alert to react quicker than 154 milliseconds.

TABLE 1

Comparison of Frequencies of Successful Trials for Anticipation Reaction Time and Classical Reaction Time within each Stimulus Duration for the First Day (N = 12)

Tasks	Stimulus Durations		
	.154	.204	.254
Anticipation Reaction Time	122	250	296
Classical Reaction Time	91	257	276
X^2	4.51*	0.09	0.69

* $p < .05$

The data analysis for the second day of the experiment showed that a significant difference between the two tasks existed only when the stimulus duration was 154 milliseconds. (See Table 2.) In the classical reaction time task more frequencies were recorded within each stimulus duration in contrast to the first day. The same number of frequencies was recorded in the anticipatory task with the stimulus duration of 254 milliseconds while the others showed an increase from day one to two. Some major improvement occurred in each task in comparison to the first day.

TABLE 2

Comparison of Frequencies of Successful Trials for Anticipation Reaction Time and Classical Reaction Time within each Stimulus Duration for the Second Day (N = 12)

Tasks	Stimulus Durations		
	.154	.204	.254
Anticipation Reaction Time	143	290	296
Classical Reaction Time	107	278	295
X^2	5.18*	0.25	0.001

* $p < .05$

Again during the third day of testing (see Table 3) a significant difference between the frequencies observed occurred only with the stimulus duration of 154 milliseconds. This finding is consistant with what was found on the two preceding days. In the anticipatory task with a stimulus duration of 154 milliseconds a decrease of four frequencies from day two was recorded, while in the classical reaction time condition there was an increase of one from the preceding day. When the stimulus was 204 milliseconds the combined tasks have only ten more frequencies than those observed on the second day. These results indicate that the two tasks did not improve much over the second day. The most improvement for the two tasks occurred with the stimulus duration of 204 milliseconds.

TABLE 3

Comparison of Frequencies of Successful Trials for Anticipation Reaction Time and Classical Reaction Time within each Stimulus Duration for the Third Day (N = 12)

Tasks	Stimulus Durations		
	.154	.204	.254
Anticipation Reaction Time	139	298	298
Classical Reaction Time	108	280	294
X^2	3.89*	0.56	0.02

* $p < .05$

A significant difference between the two tasks was found with the stimulus duration of 154 milliseconds on the fourth day. (See Table 4) Anticipation reaction time had a perfect score with a stimulus duration of 254 milliseconds. When the frequencies of both tasks were combined there was an increase of number of frequencies within each stimulus duration. The best performance for the two tasks within each stimulus duration was recorded for this day.

TABLE 4

Comparison of Frequencies of Successful Trials for Anticipation Reaction Time and Classical Reaction Time within each Stimulus Duration for the Fourth Day
(N = 12)

Tasks	Stimulus Durations		
	.154	.204	.254
Anticipation Reaction Time	170	297	300
Classical Reaction Time	127	285	297
X^2	6.22*	0.24	0.01

* $p < .05$

From the data presented in Table 5 it can be seen that the cumulation of frequencies recorded for the first and the second day indicates that there was a significant difference between the two tasks for a stimulus duration of 154 milliseconds. There appeared to be more discrepancy within the stimulus duration of 254 milliseconds than within the stimulus duration of 204 milliseconds.

When frequencies for the first and fourth day were combined and a comparison was made between the two types of reaction time, the value found showed that there was a significant difference at the .05 level between the two task performances when the stimulus duration was 154 milliseconds. These data appear in Table 6.

TABLE 5

Comparison of Frequencies of Successful Trials for Anticipation Reaction Time and Classical Reaction Time within each Stimulus Duration for the First and the Second Day
(N = 12)

Tasks	Stimulus Durations		
	.154	.204	.254
Anticipation Reaction Time	265	540	592
Classical Reaction Time	198	535	571
X^2	9.69*	0.02	0.37

* $p < .05$

TABLE 6

Comparison of Frequencies of Successful Trials for Anticipation Reaction Time and Classical Reaction Time within each Stimulus Duration for the First and the Fourth Day (N = 12)

Tasks	Stimulus Durations		
	.154	.204	.254
Anticipation Reaction Time	292	547	596
Classical Reaction Time	218	542	573
X^2	10.73*	0.02	0.45

* $p < .05$

The total frequency obtained by totalling the frequencies of successful performance for each day of the four days for each stimulus duration indicated that there was a significant difference between anticipation reaction time and classical reaction time when the stimulus duration was 154 milliseconds, as evidenced by the data in Table 7. This difference favored anticipation reaction time. There was no difference between the two tasks at either 204 or 254 milliseconds.

Within the limitations of the experiment, the data presented in Table 8 showed that there was a significant difference between the total frequencies recorded for anticipation reaction time and classical reaction time. This difference was significant at the .05 level.

TABLE 7

Comparison of Frequencies of Successful Trials for Anticipation Reaction Time and Classical Reaction Time within each Stimulus Duration for the Four Days
(N = 12)

Tasks	Stimulus Durations		
	.154	.204	.254
Anticipation Reaction Time	574	1135	1190
Classical Reaction	433	1100	1162
X^2	19.74*	0.54	0.33

* $p < .05$

TABLE 8

Comparison of Frequencies of Successful Trials for Anticipation Reaction Time and Classical Reaction Time with the Three Stimulus Duration Combined
(N = 12)

Tasks	Frequencies
Anticipation Reaction Time	2899
Classical Reaction Time	2695
X^2	7.43*

* $p < .05$

In summary, the Chi Square test indicated that a significant difference at the .05 level was found each day with the stimulus duration of 154 milliseconds. When the stimulus duration was either 204 or 254 milliseconds the difference in the frequencies tallied for each day was not significant. For the two tasks, and within each stimulus duration the greatest improvement occurred on the second day. The best performance for the two tasks within each stimulus duration was recorded on the fourth day.

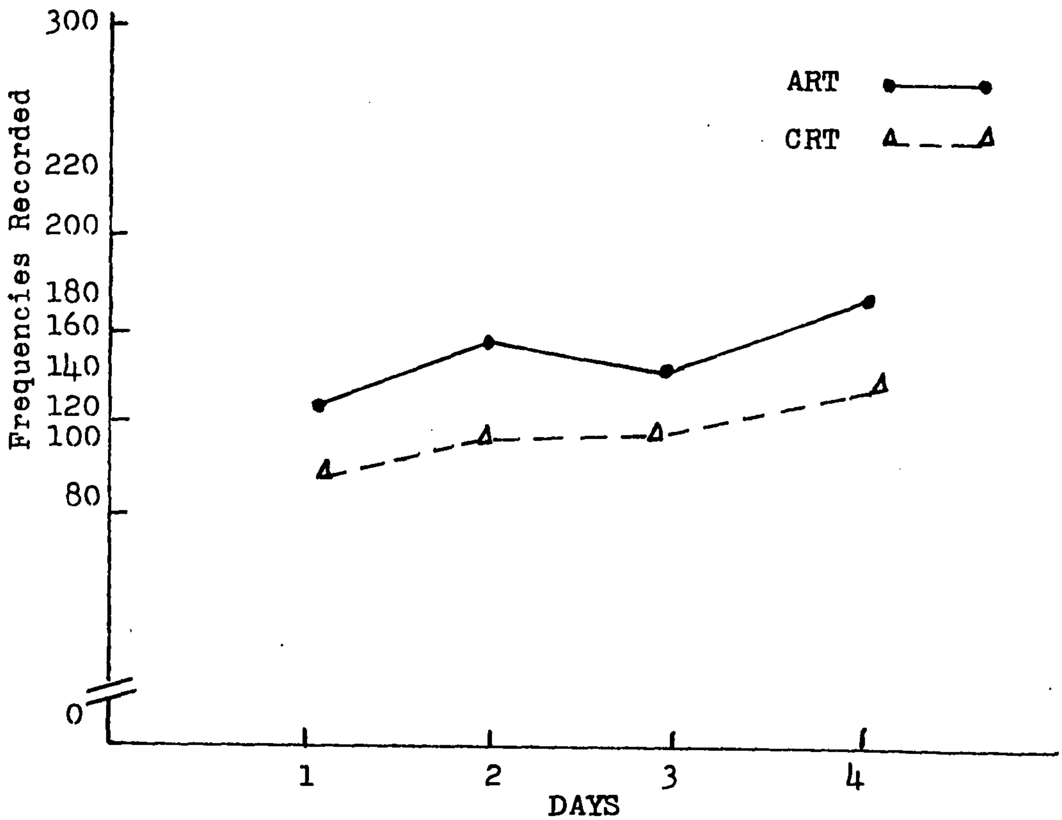
The hypothesis that there was no significant difference at the .05 level with a stimulus duration of 154 milliseconds was rejected. The hypothesis of no difference was found tenable when stimulus durations were either 204 or 254 milliseconds.

Each day, the 12 subjects were tested for 25 trials at each stimulus duration. The maximum frequency for each task within each stimulus duration was 300.

The learning curves presented in Figure 6 show performance of anticipation reaction time and classical reaction time when the stimulus duration was 154 milliseconds. The two curves are symmetrical, and can be identified as negatively accelerated curves. This specific type of learning curve is obtained when tasks are relatively easy to learn. For the two tasks, the greatest improvement on consecutive days occurred between the first and the second day of practice. The shape of the two curves seems to indicate

FIGURE 6

Learning Curves of Frequencies Recorded for Anticipation Reaction Time and Classical Reaction Time with Stimulus Duration of 154 Milliseconds



that a leveling off point appears to be reached between the second and the third day, but improvement in performance was recorded on the fourth day. The four days of practice do not seem to be sufficient for plateau identification.

The two learning curves shown in Figure 7 can be classified as negatively accelerated curves. Again the indication is that for the two tasks the most improvement in performance occurs on consecutive trials between the first and the second day of the experiment. In the anticipation reaction time condition a leveling off in performance appears to be reached between the third and the fourth day of practice. In the classical reaction time condition the level off seems to occur between the second and the third day of the experiment.

An interesting feature of the anticipation reaction time curve is the fact that the number of frequencies recorded on the first day was less than those recorded in the classical reaction time condition. This specific finding might explain the linear curve obtained in the anticipation reaction time condition between the first and the second day of practice.

When the stimulus duration was 254 milliseconds the learning curve presented in Figure 8 for anticipation reaction time shows that a leveling off in performance seems to appear after the first day of practice, since frequencies recorded from the first to the fourth day were 296, 296, 298

FIGURE 7

Learning Curves of Frequencies Recorded for Anticipation Reaction Time and Classical Reaction Time with Stimulus Duration of 204 Milliseconds

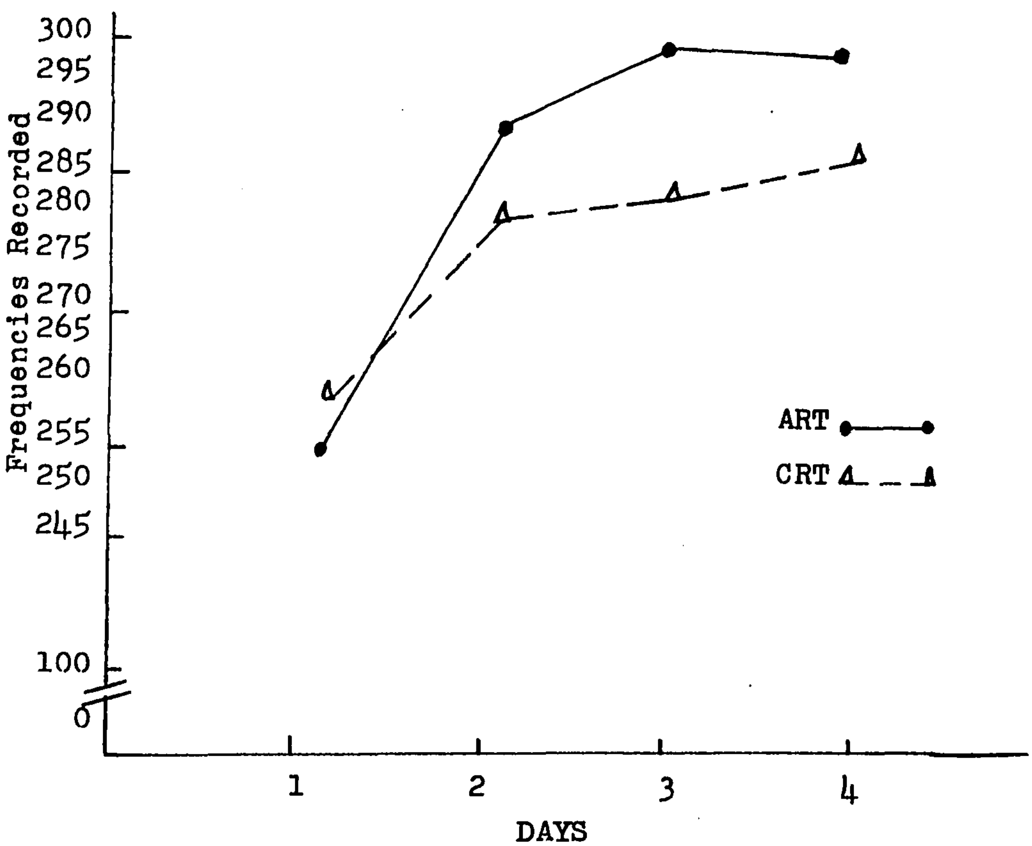
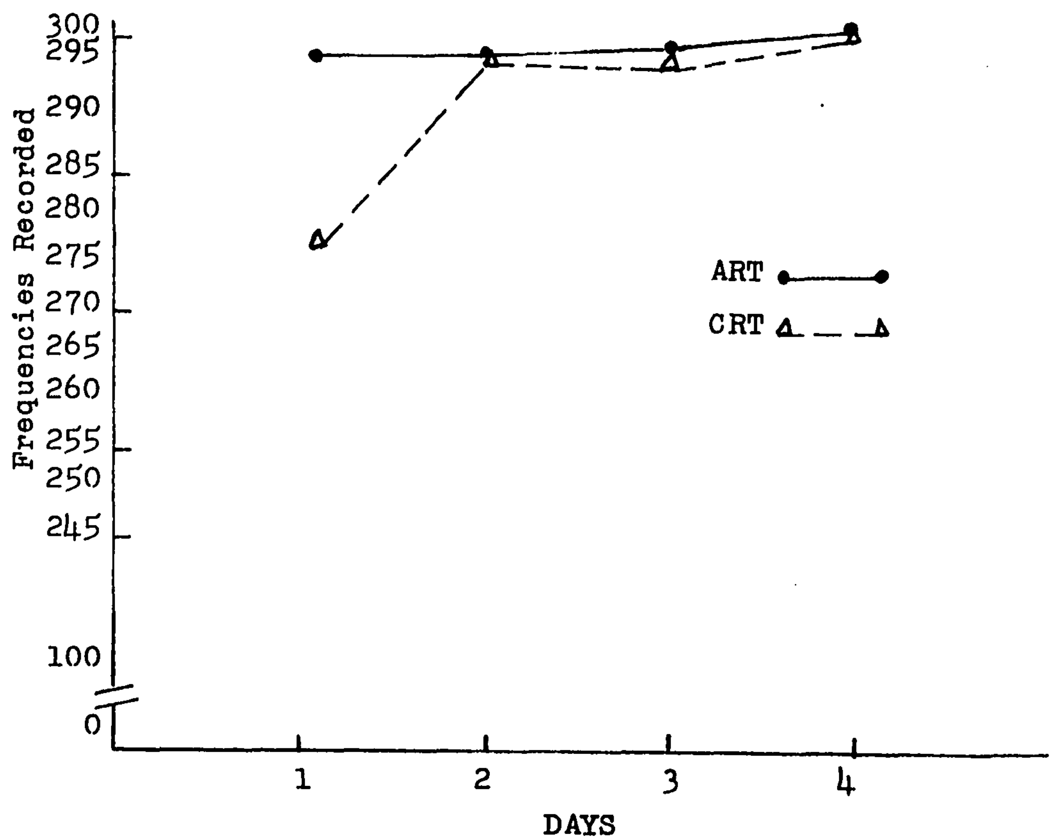


FIGURE 8

Learning Curves of Frequencies Recorded for Anticipation Reation Time and Classical Reaction Time with Stimulus Duration of 254 Milliseconds



and 300. This leveling off might be referred to as an asymptote since there was very limited improvement in the performance between the first and the final day of practice.

The learning curve for classical reaction time follows almost the same pattern with the exception that the greatest improvement was recorded between the first and the second day of practice. The classical reaction time curve can be identified as a typical negatively accelerated curve. The curve shows that a leveling off in performance appeared to be reached between the second, the third and the fourth day.

Analysis of Variance for Factorial Design allowed the experimenter to accept or to reject at the .01 level the following hypotheses: (1) there is no significant difference in performance between anticipation reaction time and classical reaction time; (2) there is no significant difference in performance with variation in the length of stimulus duration, and (3) there is no significant difference between performance on different days. The Analysis of Variance showed also whether or not there was significant interaction at the .01 level between days and stimulus duration, between tasks and stimulus duration, and between days, tasks and stimulus duration.

As is evidenced by data presented in Table 9 the null hypothesis that there was no significant difference between anticipation reaction time and classical reaction time was rejected since there was a difference significant at the .01 level. This difference favored the anticipation reaction time task.

TABLE 9

Analysis of Variance: Anticipation Reaction Time and Classical Reaction Time

Source	Error Term	df	MS	F
D	DS(T)	3/897	80421.6	78.78*
C	SC(T)	1/299	276222.6	283.60*
R	SR(T)	2/598	50666.9	59.15*
INTERACTION				
D X C	DSC(T)	3/897	563.1	0.72
D X R	DSR(T)	6/1794	5160.	5.91*
C X R	SCR(T)	2/598	9619.7	10.86*
D X C X R	DSCR(T)	6/1794	7780.3	8.92*

* $p < .01$

Note: D = days; S = subjects; C = tasks; (T) = trials; R = stimulus duration

The null hypothesis that there was no significant difference in performance with variation in the length of stimulus duration was also rejected since there was a difference significant at the .01 level. The obtained F of 59.15 indicated that there was a significant difference between stimulus duration of 154 milliseconds and those of

204 milliseconds and 254 milliseconds. To determine just where the differences were the Scheffe test was used. The results presented in Table 10 indicated that a significant difference existed between stimulus durations of 254 milliseconds and 154 milliseconds and also between 204 and 154 milliseconds. In each instance this difference favored a stimulus duration of 154 milliseconds.

The null hypothesis that there would be no difference in performance of different days was also rejected. The F value of 78.78 was more than the required value at the .01 level. To determine just where the differences were the Scheffe test was computed. The results presented in Table 11 indicated that the difference favored the second day performance in comparison to the first day. It also favored the third day performance in comparison to the first day and it favored the performance obtained the fourth to the one recorded the first day. The test also showed that the last day performance was better than the performance recorded on the second day.

Some significant interaction at the .01 level was found between days and stimulus duration, between tasks and stimulus duration and between days, tasks and stimulus duration.

For the four days, and for each stimulus duration, learning curves for anticipation reaction time and classical reaction time were plotted.

TABLE 10

Scheffe Test: Anticipation Reaction Time and Classical Reaction Time within each Stimulus Duration

Stimulus Duration	Diff.	S
3 & 1	9*	3.61
3 & 2	2	
2 & 1	7*	

* $p < .01$
Note: 1 = 154 milliseconds 2 = 204 milliseconds
3 = 254 milliseconds

TABLE 11

Scheffe Test: Anticipation Reaction Time and Classical Reaction Time for Each Day

Days	Diff.	S
1 & 4	16*	4.27
1 & 3	13*	
1 & 2	10*	
2 & 4	6*	
2 & 3	3	
3 & 4	3	

* $p < .01$

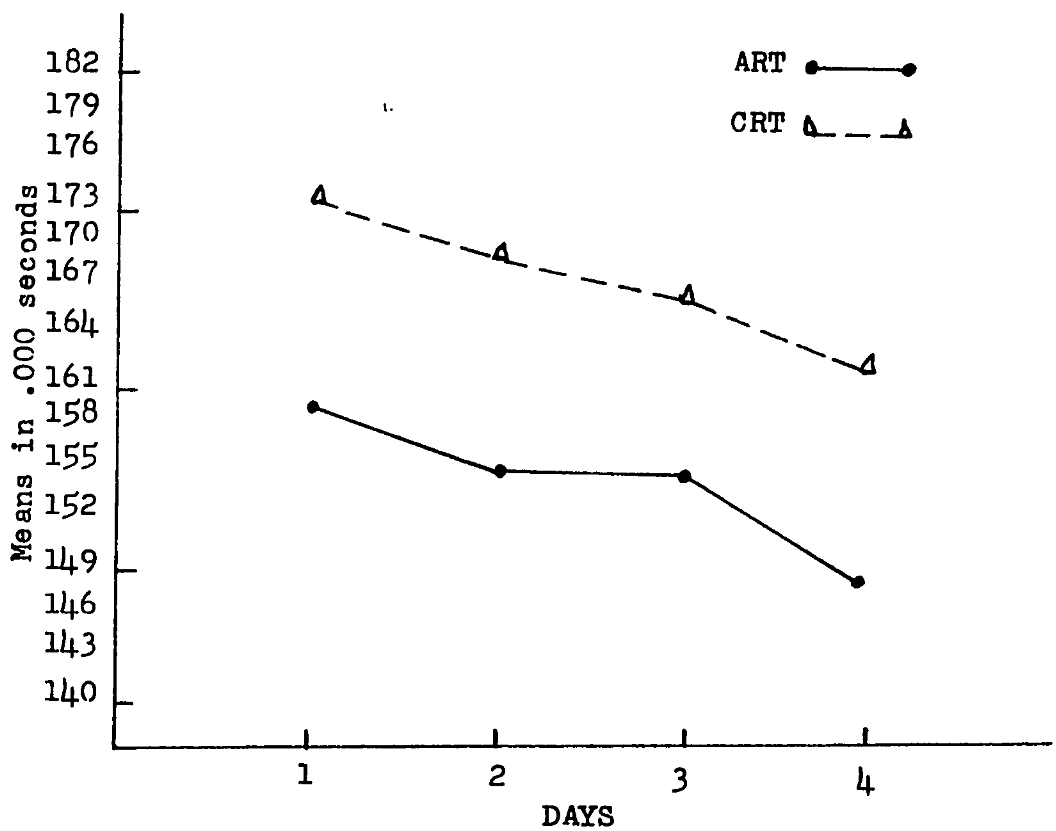
For the purpose of this study, the ordinate was organized in an ascending order. The shorter reaction time means were placed in the lower portion of the ordinate while longer reaction time means were placed in the upper portion of the ordinate. Learning curves plotted were inverted but their signification seems logical since the object is to get short reaction time, and consequently a time descending sequence. On the abscissa the days of practice were placed.

The two learning curves presented in Figure 9 for a stimulus duration of 154 milliseconds can be classified as negatively accelerated curves. In the classical reaction time condition, the greatest improvement occurs between the first and the second day since a decrease of 005 milliseconds was found. The same task shows very limited improvement between the second and the third day. (002 milliseconds) With the appearance of a leveling off in the classical reaction time performance between the second and the third day, some improvement was recorded on the fourth day.

In the anticipation reaction time condition about the same pattern was observed, with the exception that means are much shorter. As in the classical reaction time condition a kind of leveling off seems to occur between means of the second (155 milliseconds) and the third day (155 milliseconds) but a reaction time mean of 149 milliseconds was obtained the final day. For the two tasks improvement in performance was recorded the final day, and consequently the plateau phenomenon is not definitely identified.

FIGURE 9

Learning Curves of Means for Anticipation Reaction Time and Classical Reaction Time with Stimulus Duration of 154 Milliseconds



The plotted curves for a stimulation duration of 204 milliseconds shown in Figure 10 can be identified as negatively accelerated curves. For the two tasks reaction time means are greater with stimulus duration of 204 milliseconds than with stimulus duration of 154 milliseconds. In the classical reaction time condition the greatest improvement (004 milliseconds) occurred between the third and the fourth day of practice. In the anticipation reaction time condition a linear curve was recorded between the first and the second day. The same type of curve was recorded for the number of frequencies observed between the first and the second day with the same stimulus duration. In the anticipation reaction time an improvement of 016 milliseconds occurred between the first and the second day, while in the classical reaction time condition an improvement of only 003 milliseconds was recorded.

For the classical reaction time condition with a stimulus duration of 254 milliseconds a linear curve shown in Figure 11 was plotted between the first and the second day of practice. This linear curve is the result of an improvement of 024 milliseconds in reaction time. The curve seems to level off between the second and the third day but some improvement of 004 milliseconds was recorded between the third and the final day.

In the anticipation reaction time condition the curve can be identified as a negatively accelerated curve. As in

FIGURE 10

Learning Curves of Means for Anticipation Reaction Time and Classical Reaction Time with Stimulus Duration of 204 Milliseconds

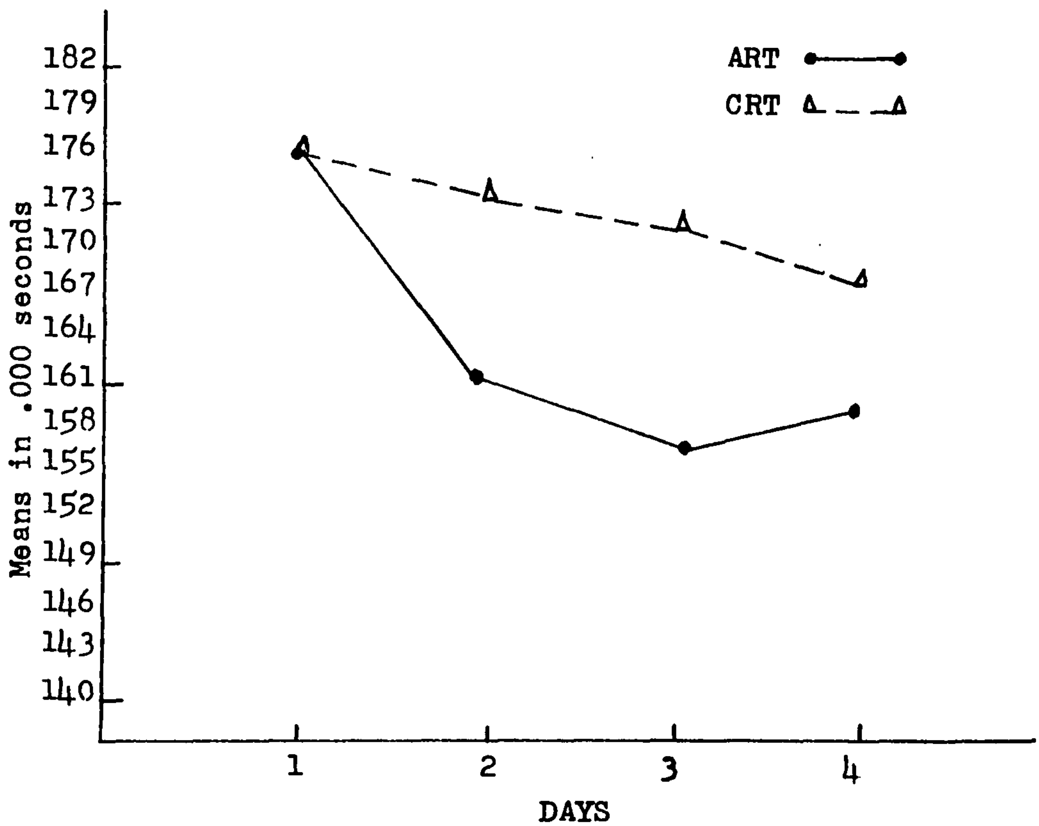
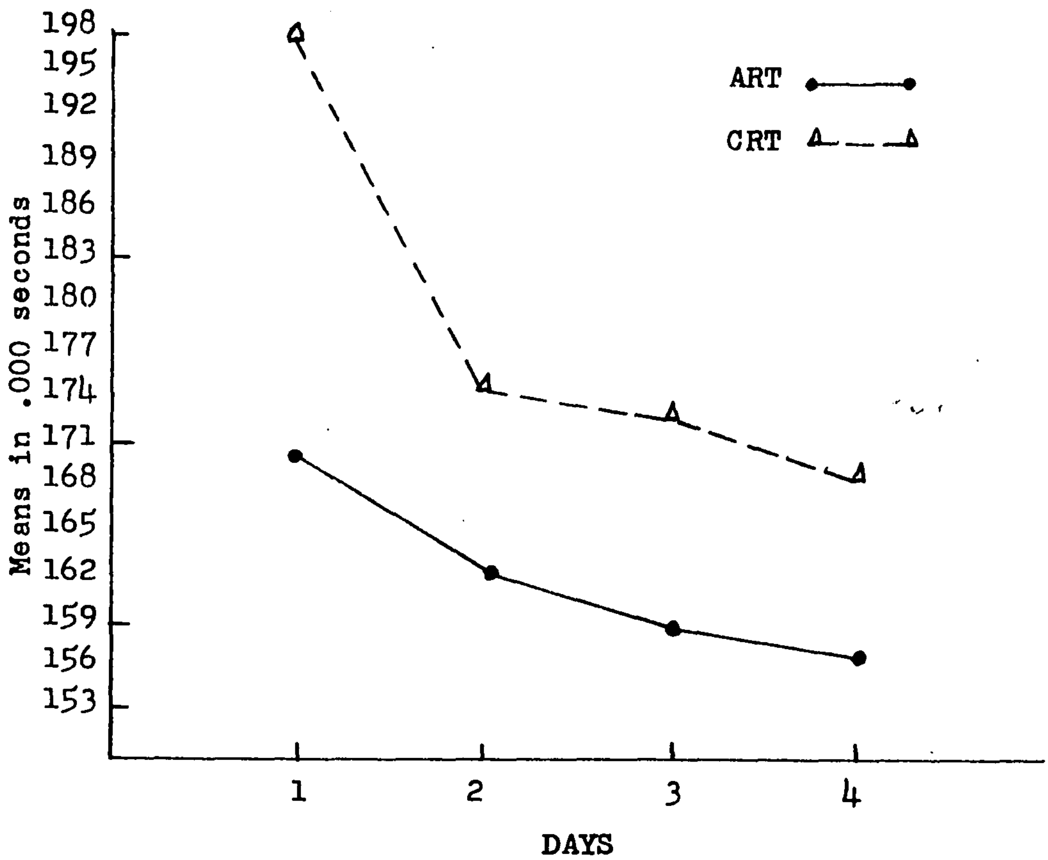


FIGURE 11

Learning Curves of Means for Anticipation Reaction Time and Classical Reaction Time with Stimulus Duration of 254 Milliseconds



the classical reaction time condition the greatest improvement was recorded the second day. An improvement of only 002 milliseconds occurred between the third and the last day of practice.

For the four days, the mean reaction time of classical reaction time was longer when the stimulus duration was 254 milliseconds. The mean reaction time of anticipation reaction time with the same stimulus duration was longer only the second and the third day of the experiment.

INTERPRETATION OF DATA

The results of the study indicated that there was a significant difference between anticipation reaction time and classical reaction time. The data revealed that in the anticipatory reaction time task, even if the experimental condition was randomized, the subject learned the timing pattern between the preparatory set light and the stimulus onset, and consequently was reacting almost with the stimulus occurrence rather than waiting for the stimulus presentation.

The data also showed that for each of the task conditions, reaction time performance was better with the shorter stimulus duration. Since this specific stimulus duration is faster than average visual reaction time, it must be assumed that interaction factors of practice, optimum alertness, anticipation and motivation might have played a major role in reaction time performance. The role of the immediate visual feedback might also be considered as an important factor. Many subjects have reported that they were aware of the number of feedback lights they were getting.

For each task some improvement in performance occurred from the first through the fourth day within each stimulus duration. However, the best performance for each task occurred on the fourth day. These findings reinforce the concept that simple visual reaction time performance gradually improved from the first through the fourth day within each stimulus duration. The plateau phenomenon does not seem to be definitely identified. It must be restated that the experimental conditions were favoring reaction time performance, since before each trial, there was a buzzer signal, then a preparatory set light, short foreperiod, the stimulus presentation, and the immediate visual feedback.

It is assumed that interaction of these specific conditions might have contributed to optimal alertness, motivation and consequently learning.

The data collected confirm the hypothesis that reaction time is a function of the task conditions for response initiation.

Discussion

It is the writer's opinion that the results of the reaction time experiment indicate three specific learning stages. The first stage, the first day, can be referred to as the differentiation stage for the stimulus and the response. It is this stage of learning when the relationship between the input and the output is very limited, or non-specific. Subjects become familiar with both task requirements and goals. It is this specific stage that Lawther (13) refers to when he talks about the gross framework idea. The second stage, the second day, when the greatest improvement occurred, subjects were able to distinguish temporal cues about stimulus presentation and stimulus duration but the motor response was still inconsistent. This second stage may be identified as the stimulus differentiation stage. Subjects have assimilated knowledge about the foreperiod and the stimulus duration, but their response initiation was still not programmed. Even if they now know task requirements and goals, they still delay before reacting.

The experimental conditions were favoring timing discrepancy because subjects were performing only 25 trials successively, then changing to differing task conditions. The third stage, which probably occurred on the third and the fourth days, might be identified as the stage of programmed differentiation of the stimulus-response pattern. As opposed to the first day, the relationship between stimulus-response was well established. With practice, subjects have developed an automatic temporal patterning which enables them to differentiate between the time elapse after the cue light and the stimulus presentation. This specific temporal patterning is indicated by the result obtained in the anticipatory reaction time task. Here when the stimulus duration was 154 milliseconds, the mean reaction time for the 12 subjects was down to 149 milliseconds.

It is the writer's belief that the three learning stages just described were affected by many factors in addition to motivation and practice.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

The purpose of the study was to investigate the performance of anticipation reaction time and classical reaction time in a simple visual reaction time task.

In the anticipation reaction time condition, a foreperiod of 1.5 seconds was held constant before each stimulus duration throughout the experiment. In the classical reaction time condition, a balance foreperiod of either one, two or three seconds was used before each stimulus presentation. Three stimulus durations of 154 milliseconds, 204 milliseconds, and 254 milliseconds respectively were used.

Twelve right handed male students with a mean age of 19 years enrolled at the University of North Carolina at Greensboro participated in the experiment.

The experiment was conducted in the Rosenthal Research Laboratory of the University of North Carolina at Greensboro. Each subject was tested on four consecutive days. Each day, three blocks of 25 trials for anticipation reaction time, and three blocks of 25 trials for classical reaction time were recorded. For each task condition a block of 25 trials included stimulus duration of either 154 milliseconds, 204 milliseconds or 254 milliseconds. In the anticipation reaction time condition, if the reaction time recorded was less than the stimulus duration, the feedback light was put on immediately. In the classical reaction time condition the feedback light came on immediately if the reaction time recorded was either equal to or shorter than the stimulus duration.

A total of 600 reaction times was obtained for each subject, that is 300 reaction times for each task consisting of 100 reaction times within each stimulus duration for each task.

The experimenter's control unit consisted of a steel box which had a control knob to calibrate the stimulus duration, a second knob to regulate the foreperiod, a cue light and a push button to activate the feedback mechanism. The recording device for reaction time was a Hunter Model 120 A klockounter. The subject's unit consisted of a stimulus box which included at the top the preparatory yellow set light, a white light stimulus surface with a two inch diameter opening, and at the bottom a red feedback light. It also included a standard telegraph key having a response surface one inch in diameter.

The experimenter's control unit, the stimulus box and the response key were built at the Electronic Service Center of the University of North Carolina at Greensboro.

To compare the number of successful frequencies observed of anticipation reaction time and classical reaction time within each stimulus duration the Chi Square test was used. In the anticipation reaction time condition a successful frequency was recorded when reaction time was shorter than the stimulus duration presented, while in the classical reaction time condition a successful frequency was recorded when reaction time was either shorter than, or equal to, the stimulus duration.

An Analysis of Variance for Factorial Design was selected to compare means in relation to tasks, stimulus duration and days. This statistical technique identified interaction between days and stimulus duration, between tasks and stimulus duration, and between days, tasks and stimulus duration. The Biomedical Statistical Program, a computer package, provided the computation model.

Scheffe test was computed to find out direction of differences of reaction time means between each day, and between the three stimulus durations.

For each day of the experiment, the Chi Square test indicated difference between observed frequencies of the two tasks with a stimulus duration of 154 milliseconds which was significant at the .05 level. The difference favored anticipation reaction time. For the two tasks, when the total frequencies observed were cumulated with the three stimulus durations a significant difference at the .05 level was found. Again the anticipation reaction time task had the greatest number of successful trials.

For the two tasks, learning curves plotted of frequencies recorded with a stimulus duration of 154 milliseconds were identified as negative accelerated curves. In the two tasks a leveling off in performance appeared to be reached between the second and the third day of the experiment but improvement in frequencies was recorded on the fourth day. With a stimulus duration of 204 milliseconds the two curves can be classified as negative accelerated curves. However, in the anticipation reaction time condition a linear curve was obtained between the first and the second day. The two curves plotted with data for a stimulus duration of 254 milliseconds can also be identified as negative accelerated curves. The learning curve of anticipation reaction time showed that a leveling off in performance seems to appear the first day of practice since very little improvement was recorded on the second, the third and the final day. In the classical reaction time a leveling off in performance appeared to be reached the second, the third and the final day of the experiment.

The F ratio showed that there was a significant difference at the .01 level between the means of anticipation reaction time and classical reaction time. This difference favored anticipation reaction time. A significant difference at the .01 level was also found between the three stimulus durations. The stimulus duration of 154 milliseconds had a faster reaction than those of 204 and 254 milliseconds. A significant difference at the same level was also found between means of the four days of the experiment. The reaction time mean obtained on the second day was significantly better than the reaction time mean recorded the first day. The same was true for the third day mean in relation to the first day, and the fourth day reaction time mean in comparison to the first day. The reaction time mean obtained on the fourth day was also significantly better than that of the second day mean.

The Analysis of Variance also revealed that there was some significant interaction at the .01 level between days and stimulus duration, between tasks and stimulus duration, and between days, tasks and stimulus duration.

The learning curves of means for the two tasks followed approximately the same pattern plotted for the frequencies observed. With a stimulus duration of 154 milliseconds the two curves were identified as negative accelerated curves. For the two tasks, a leveling off in performance seems to appear between the second and the third day, but some improvement was recorded the final day. With a stimulus duration of 204 milliseconds means for the two tasks were longer than means recorded with a stimulus duration of 154 milliseconds.

In the anticipation reaction time condition a linear curve was obtained between the first and the second day of the experiment. This curve can be explained by the fact that an improvement of 016 milliseconds was recorded on the second day. In the classical reaction time condition the greatest improvement, 004 milliseconds, occurred between the third and the final day. In the classical reaction time task when a stimulus duration of 254 milliseconds was used, a linear curve was obtained between the first and the second day. Then, a level off in performance seems to occur between the second and the third day, but again some improvement occurred on the fourth day. In the anticipation reaction time condition a negative accelerated curve was plotted from the first through the final day, with no appearance of leveling off in performance.

For the two tasks, the best reaction time performance was obtained on the fourth day of the experiment. The data do not indicate definitively a plateau phenomenon, with the exception of the perfect frequency of 300 recorded the final day for a stimulus duration of 254 milliseconds. This perfect frequency was obtained in the anticipation reaction time condition.

CONCLUSIONS

The study indicated that visual reaction time can be shortened with practice; also that a short stimulus duration produces faster reaction time than a stimulus duration somewhat longer. It also showed that a distinction should be made between classical reaction time which involves temporal uncertainty, and anticipation reaction time which involves temporal certainty. The data revealed that, when the foreperiod was held constant as in the anticipation reaction time condition, the subject reacted much faster than when the foreperiod was varied as in the classical reaction time condition. This finding reinforced Adams, Conrad and Poulton's concepts that a distinction should be made between reaction time, the time elapse from an unanticipated stimulus event and the initiation of a response, and response time, which is the time separating an anticipated stimulus and the initiation of a response. Since the feedback conditions differed for the two tasks this might have been a factor influencing the reaction time difference.

It is assumed that in the anticipation reaction time condition learning has contributed to the building of a set of biased temporal patterning for response initiation. The learned temporal patterning was matching task conditions as wholes. However, as mentioned by Spaeth (89:358), presently we do not have much information concerning the process of anticipatory functions.

Another interesting result of the experiment is that even though the study was conducted for four days, the data do not permit clear identification of a plateau phenomenon.

The results should be interpreted within the limitation of the study in which reaction time was defined as the time elapsing from the initiation of the stimulus up to the initiation of overt response.

RECOMMENDATIONS

1. A similar experiment should be conducted for either a shorter or a longer period of time.

2. A study should also be conducted to investigate the effects on reaction time of longer and shorter foreperiods.

3. An experiment in which the stimulus is presented without any preparatory signal should make interesting comparisons with results of randomized foreperiods and constant foreperiods.

4. Another study should examine the effect of stimulus duration of different lengths presented randomly.

5. Further study should investigate the value of feedback on reaction time performance.

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APPENDIX A

Greensboro, November 28, 1972

M. Mark H. Walker
Phillips Dormitory
Box 5304, Room 304
UNC, Greensboro Campus
Greensboro 27412

Dear Mark,

Presently, the writer is in the process of conducting an experimental study on visual reaction time, as a partial fulfillment for the degree of Doctor of Education in Physical Education.

This letter is to inform you that you have been selected from among many hundreds students of UNC Greensboro to participate in this experimental study. The experiment will be conducted in the Rosenthal Research Laboratory of the School of Health, Physical Education and Recreation, located in the Rosenthal Gymnasium. It will require about 30 minutes of your time per day, for four days. The main purpose of the project is to get quantitative data in visual reaction time. At this point, it is also essential to mention that without your cooperation, this doctoral study will not be possible, and also that in your educational career, sometime, you might need student body assistance. A compensation will be given for your participation.

I sincerely hope that you will consider this opportunity seriously, and that you will be present at a special meeting, <u>Wednesday</u>, <u>December 6</u>, at <u>4:00</u> <u>p.m.</u> in the Rosenthal <u>Research Laboratory of the School of Health</u>, Physical Education and Recreation, Room 104 C. At this meeting we will get acquainted and further, will answer any questions that you might have in regard to the project.

I thank you in advance for your cooperation, and look forward to seeing you Wednesday, December 6, at 4:00 p.m.

Amicalement,

Denis Drouin
UNC Greensboro
School of Health, Physical
Education and Recreation

Home Telephone: 668-0258

Greensboro, January 18, 1973

M. Mark H. Walker
Phillips Dormitory
Box 5304, Room 304
UNC, Greensboro Campus
Greensboro 27412

Dear Mark:

Your cooperation during my experimental study was greatly appreciated. It was a real pleasure to know you and more important to work with you. You can be sure that the project was much more meaningful this way.

You will find herewith a small monetary compensation on which we agreed at the beginning. I realize that it is not comparable to your participation, but at least it represents a small token of my appreciation.

Again, thank you for your assistance and let me remind you that a short abstract of the study, when available, will be mailed to you.

Amicalement,

Denis Drouin

RECORDING SHEET

NAME ______________________ DATE ____________

PREF. HAND ________ AGE ___ TIME ____________

1 = CRT

2 = ART

DAY I

	1 (154)	1 (204)	1 (254)	2 (154)	2 (204)	2 (254)
T						
1						
2						
3						
4						
5						
6						
7						
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fo						

APPENDIX B

RAW DATA

ANTICIPATION REACTION TIME

FREQUENCIES* RECORDED

Subjects		1	2	3	4	5	6
	1	1	18	8	6	14	16
Day I	2	16	12	21	20	25	24
	3	25	23	25	25	25	25
	1	9	18	1	11	23	16
Day II	2	25	20	24	23	25	25
	3	25	23	25	25	24	25
	1	6	14	7	5	20	8
Day III	2	25	25	25	25	25	25
	3	25	25	25	25	25	25
	1	7	19	5	14	16	16
Dav IV	2	25	25	25	25	24	25
	3	25	25	25	25	25	25

1 = 154 milliseconds

2 = 204 milliseconds

3 = 254 milliseconds

* Frequencies refer to successful trials

RAW DATA

ANTICIPATION REACTION TIME

FREQUENCIES* RECORDED

Subjects		7	8	9	10	11	12
	1	3	9	22	7	16	2
Day I	2	22	24	25	25	23	13
	3	25	25	25	24	25	24
	1	5	18	0	14	19	9
Day II	2	25	25	23	25	25	25
	3	25	24	25	25	25	25
	1	15	20	8	7	17	12
Day III	2	25	25	24	25	25	24
	3	25	24	25	25	25	24
	1	17	15	11	15	21	14
Dav IV	2	25	25	25	23	25	25
	3	25	25	25	25	25	25

1 = 154 milliseconds

2 = 204 milliseconds

3 = 254 milliseconds

* Frequencies refer to successful trials

RAW DATA

CLASSICAL REACTION TIME

FREQUENCIES* RECORDED

Subjects		1	2	3	4	5	6
	1	1	12	8	8	12	9
Day I	2	19	24	25	23	20	20
	3	25	17	21	25	25	24
	1	6	12	4	9	16	5
Day II	2	25	22	24	25	23	25
	3	24	24	25	25	24	25
	1	6	13	0	4	18	6
Day III	2	24	23	23	22	24	25
	3	25	25	25	23	24	25
	1	17	13	4	10	10	9
Day IV	2	25	24	24	24	24	20
	3	24	25	25	25	24	25

1 = 154 milliseconds

2 = 204 milliseconds

3 = 254 milliseconds

* Frequencies refer to successful trials

RAW DATA

CLASSICAL REACTION TIME

FREQUENCIES* RECORDED

Subjects		7	8	9	10	11	12
	1	1	9	7	14	10	0
Day I	2	21	23	24	20	25	13
	3	24	25	25	24	22	19
	1	6	13	4	13	15	4
Day II	2	21	23	24	23	24	19
	3	25	23	25	25	25	25
	1	15	16	16	9	12	4
Day III	2	23	24	24	22	24	22
	3	25	22	25	25	25	25
	1	13	10	3	14	13	11
Day IV	2	25	23	25	23	25	23
	3	24	25	25	25	25	25

1 = 154 milliseconds

2 = 204 milliseconds

3 = 254 milliseconds

* Frequencies refer to successful trials

SUMMARY RESULT

TOTAL MEAN .166

MEANS

Days	1	2	3	4
	.176	.166	.163	.160

MEANS

CRT	.172
ART	.160

MEANS

Days	CRT	ART
1	.182	.169
2	.172	.160
3	.170	.157
4	.166	.155

MEANS

Stimulus Duration	1	2	3
Days			
1	.167	.177	.184
2	.161	.167	.168
3	.160	.164	.165
4	.156	.163	.162

MEANS

	CRT			ART		
Stimulus Duration	1	2	3	1	2	3
Days 1	.173	.176	.198	.160	.177	.170
2	.168	.173	.174	.155	.161	.162
3	.166	.171	.172	.155	.157	.158
4	.162	.167	.168	.149	.159	.156

Note: CRT = Classical Reaction Time
ART = Anticipation Reaction Time
1 = 154 milleseconds
2 = 204 milliseconds
3 = 254 milleseconds

RAW DATA

ANTICIPATION REACTION TIME

TOTAL

Subjects		1	2	3	4	5	6
	1	4.584	3.744	3.929	4.125	3.863	3.538
Day I	2	5.032	5.500	4.800	4.548	3.761	3.784
	3	4.582	4.402	4.160	4.186	3.610	3.604
	1	3.952	3.719	4.402	3.916	3.396	3.693
Day II	2	4.015	4.396	4.371	4.218	3.862	3.856
	3	4.210	4.221	4.067	4.317	3.754	4.108
	1	4.004	3.814	4.032	4.195	3.576	3.996
Day III	2	4.204	3.615	4.358	3.963	3.684	3.510
	3	4.086	3.855	3.838	3.780	3.783	3.827
	1	4.011	3.697	4.025	3.843	3.761	3.601
Dav IV	2	4.083	3.845	4.490	3.616	3.894	3.824
	3	3.997	4.131	4.310	3.491	3.571	3.721

1 = 154 milliseconds

2 = 204 milliseconds

3 = 254 milliseconds

RAW DATA

ANTICIPATION REACTION TIME

TOTAL

Subjects		7	8	9	10	11	12
	1	4.306	3.967	3.688	4.109	3.763	4.484
Day I	2	4.411	3.976	4.216	3.801	4.062	5.431
	3	4.998	3.841	4.041	4.420	3.926	5.301
	1	4.095	3.727	4.443	3.834	3.513	3.983
Day II	2	4.220	3.625	4.406	3.863	3.407	4.285
	3	4.159	3.646	3.844	3.992	4.117	4.444
	1	3.820	3.440	3.977	4.062	3.665	3.971
Day III	2	3.888	3.561	4.181	4.062	3.855	4.251
	3	3.984	3.883	4.123	4.122	3.761	4.592
	1	3.704	3.745	3.831	3.805	3.564	3.359
Day IV	2	4.008	3.597	4.282	4.388	3.487	4.041
	3	3.840	3.535	4.369	4.199	3.661	4.096

1 = 154 milliseconds

2 = 204 milliseconds

3 = 254 milliseconds

RAW DATA

CLASSICAL REACTION TIME

TOTAL

Subjects		1	2	3	4	5	6
	1	4.746	4.184	4.249	4.125	4.104	4.241
Day I	2	4.796	3.894	4.092	4.183	3.935	4.729
	3	4.924	6.438	5.517	4.889	3.969	4.807
	1	4.264	4.324	4.442	4.183	3.833	4.313
Day II	2	4.240	4.293	4.598	4.268	3.819	4.210
	3	4.353	4.721	4.406	4.311	4.126	4.060
	1	4.275	4.069	4.653	4.318	4.020	4.196
Day III	2	3.966	4.170	4.235	4.456	4.118	4.376
	3	4.063	4.113	4.145	4.555	3.998	4.474
	1	3.760	3.942	4.395	4.063	3.964	4.194
Day IV	2	4.083	4.063	4.451	4.157	3.974	4.421
	3	4.137	4.138	4.540	4.224	3.985	4.098

1 = 154 milliseconds

2 = 204 milliseconds

3 = 254 milliseconds

RAW DATA

CLASSICAL REACTION TIME

TOTAL

Subjects		7	8	9	10	11	12
	1	4.722	4.301	4.294	4.008	3.996	5.181
Day I	2	4.740	4.293	4.276	4.473	3.988	5.367
	3	5.033	4.181	4.500	4.293	5.081	5.760
	1	4.401	3.920	4.405	3.993	3.885	4.371
Day II	2	4.563	4.459	4.427	4.210	4.211	4.844
	3	4.727	4.455	4.470	4.213	3.660	4.656
	1	3.839	3.759	4.198	4.039	4.091	4.503
Day III	2	4.228	4.175	4.382	4.439	4.183	4.500
	3	4.116	4.952	4.295	4.507	4.151	4.470
	1	3.925	3.922	4.299	3.909	3.808	3.958
Day IV	2	3.986	4.025	4.375	4.447	3.976	4.375
	3	4.211	4.321	4.403	4.335	3.628	4.499

1 = 154 milliseconds

2 = 204 milliseconds

3 = 254 milliseconds