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Temporal Discrimination Training of Adults with Traumatic Brain Injury Using Computer-Based Operant Procedures

Robert Edward Obrecht

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TEMPORAL DISCRIMINATION TRAINING OF ADULTS WITH TRAUMATIC BRAIN INJURY USING COMPUTER-BASED OPERANT PROCEDURES

by

Robert Edward Obrecht

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Master of Arts
Department of Psychology

Western Michigan University
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Reaction-time experiments could occupy a researcher for a lifetime (Skinner, 1986). While not a lifetime, it took me a while to complete this manuscript, and I would like to acknowledge those who were especially important in my finishing it. First and foremost, I want to acknowledge and thank my wife, Gayle, for sharing in the many and varied vocational and familial responsibilities that go into completing a Master's Thesis. Your love and support is invaluable to me. Thank you Gayle, I like you, and I love you.

I commend Chris Koronakos, my committee chairperson, for going above and beyond the call of duty in assisting me to keep the flow of the narrative clear and concise. The others on my committee, Fred Gault, Paul Mountjoy, and Mal Robertson, merit a special salute. I thank all of them for acting in my behalf during the developmental and finishing stages of this Thesis. Fred was especially helpful in providing some needed theoretical direction, and for introducing me to Roger Graham who encouraged me to set realistic goals and to learn the computer skills that were necessary to complete this project.

I also want to thank those in my family who gave me their heart-felt encouragement. In many ways, my Dad, Richard, has been my biggest fan, and this support has always helped me to "Go get em!" A big thanks goes to the Wharrie Family for opening their home to me in Toronto. Finally, I wish to dedicate this Master's Thesis to my mom, Emily, who stands as a tower of strength for all of those persons who are experiencing the trials and tribulations of recovering from the effects of traumatic brain injury.

Robert E. Obrecht
Computer-based interresponse time (IRT) and matching-to-sample (MTS) procedures were employed in two experiments to assess and effect changes in temporal discriminations made by adults with a history of traumatic brain injury. The results of Experiment One support the interpretation that maintaining correct IRT > t performance was a function of stimulus conditions that included signalled IRTs, values of t less than 3-seconds, a contract agreement to maintain performance, and other contingencies not explicitly part of the design. The results of Experiment Two, that minimal response latencies on MTS tasks are mediated equally well by an experimenter's verbal prompting as well as by computer-generated temporal reinforcement contingencies, supports the interpretation that subjects with TBI history can be trained to reduce their reaction times by using contingency specifying verbal instructions which alter the function of computer-generated stimuli as discriminative stimuli, or as stimulus reinforcers.
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CHAPTER I

EXPERIMENTS ONE AND TWO

General Introduction

Efforts to provide rehabilitation for persons recovering from the effects of head injury have increased substantially over the past decade or so. The benchmark year was 1977 when the Medical College of Virginia sponsored the first annual post-graduate course on the rehabilitation of the brain-injured adult. Every year since, thousands of health-care professionals have been involved in annual courses in head injury and the establishment of hospitals and rehabilitation centers with specialized head-injury units (Rosenthal, 1983). Unfortunately, the rise in interested health-care professionals was based on the need for more and better rehabilitation for a growing population of persons sustaining and recovering from the effects of head injury.

The increased interest in rehabilitation for the head-injured population was generated in part because old attitudes about recovery after head injury were replaced by new attitudes. The old attitudes were based on the theory of irreversibility of damage to brain tissue, i.e., damaged neurons do not replicate, and the reacquisition of skills is too difficult and slow to be practical (Kottke, 1980). The new attitude is based on the theory of synaptic processes having remarkable plasticity and the ability to be modified with respect to brain-related behavior (Cotman, 1978; Finger, 1978). As a result
of this increased optimism, and because advanced technology is more assessable, computer aided rehabilitation techniques have been used to foster the recovery of lost/impaired verbal and behavioral skills. This study addresses how personal computers can be used during the rehabilitation process to assess and/or effect the time course of recovery of a person’s lost or impaired behavioral and verbal skills.

A major goal of the rehabilitation of persons recovering from head injury is to provide retraining techniques so persons can reattain lost or impaired verbal and behavioral skills, and more quickly come to live fuller lives—vocationally, socially, and interpersonally. Essential to this goal is the clinician’s ability to use computer technology to describe and quantify in a reliable and valid manner those behaviors that are part of the whole rehabilitative picture. With respect to a clinical population different from the head-injured, Kelly and St. Lawrence (1988) describe why neurological and neuropsychological evaluations are needed:

Neurological and neuropsychological evaluation is needed in some cases to characterize the nature and severity of central nervous system involvement in order to provide information relevant to treatment, social service, and other care planning. Research is necessary to investigate factors that predict rapid illness on-set versus long-term clinical health in persons who are HIV infected and to explore differences between persons who quickly succumb to AIDS versus those who survive for long periods following an AIDS diagnosis. If behavioral or biological factors accounting for this variability [in survival] can be identified, and if those factors can be modified, it may be possible to prevent the development of illness and health deterioration. (pp. 271-272)

It is important to note that the evaluation process itself was emphasized. Regardless of the population, or technology used, the point
is that the process of identifying sources of variability in rates of recovery/decline, through evaluation, quantification, description, and analysis, is by itself challenging and clinically relevant to the eventual modification of the processes relevant to health impairments of any severity or etiology. Fisher, as cited by Carstensen (1988), stressed the clinical utility of quantifying and describing the behavior of persons of the Alzheimer population. Carstensen cited:

Information about learning decrements associated with the course of disease may lead to improvements in the timing of interventions. Research directed toward the identification of optimal reinforcement schedules and the effects of delay of reinforcement will allow for much greater sophistication in intervention strategies. (p. 269)

More work still needs to be done to come to a better understanding about what is required to develop reliable and valid methods of gathering information relevant to quantification and description. The ultimate impact of improving the reliability and validity of assessment tools will be the development of more appropriate treatment methods and treatment evaluation.

The development of reliable and valid rehabilitation tools is consistent with the use of computers. Computers are available tools which should be used by clinicians to quantify and describe the verbal and behavioral effects of head injury. Since the clinician's goal is to provide effective treatment, available computer technology that can be of assistance should be utilized. Clinicians should be concerned about how computers can be used to make observations, descriptions, and quantifications of the verbal and behavioral effects of traumatic brain injury (TBI).
Clinicians need to know that the best thing about the computer may be that it allows quantification and description to be done accurately, reliably, and with less intrusion, and, the assessment process even may be enjoyable. Messages with reinforcing value may be delivered in a sustained and varied manner that would perhaps fatigue a human being trying to do the same thing. Additionally, the use of the computer as a measuring and recording instrument may get around some of the older arguments about whether one can record effectively all the nuances of the behavior, and whether it is possible to motivate both the client and the clinician for sufficient time periods to complete their respective tasks.

It was the purpose of this study to design and evaluate an innovative computer-aided assessment tool used to empirically analyze the behavioral and verbal effects of TBI. The rest of the general introduction defines terms and explains concepts related to the nature and severity of the effects of TBI. Also, information is presented that describes the efforts of contemporary researchers who have been involved in observing and describing the sequelae of acquired brain injury using different assessment techniques. Lastly, an overview is given of the two experiments conducted in this study.

Terms and concepts related to brain injury are as follows. Brain injury secondary to head trauma, or traumatic brain injury (TBI), occurs when injury leads to loss of consciousness, evidence of neurological deficit develops, or results of neuro-diagnostic tests show changes in verbal and behavioral repertoire which indicate of neurological damage (modified from Bigler, 1984). Griffith (1983)
and Van Zomeren (1981) have stressed the need for identifying the effects of TBI on intellectual and behavioral skills. In particular, Griffith (1983) comments that the great number of dysfunctions resulting from TBI requires a systematic method of identification and quantification. A basic clinical use of quantification is for the description of neuropsychological conditions or states of recovery.

Description may be defined as the act of quantifying some aspect of behavior by assigning a number to a level of neurological impairment. The purpose of description in the current study is to be better able to compare and differentiate between: (1) different levels of loss of consciousness, e.g., as in the Classification of Head Injuries according to Russell (1971), (2) evidence of neurological deficit development, and (3) results of neuro-diagnostic testing showing changes in verbal and behavioral repertoires. Jennett (1983) stresses the importance of accurate description in the field of rehabilitation. He states, "...the effectiveness of therapy, whether an organized system or a single technique, can be judged only if there are reliable [and valid] means of comparing either the rate of recovery or the state of recovery at given (fixed) times after injury" (p. 7). A reliable means of comparing any two or more events is more probable if quantification occurs. The methodology used in the experimental analysis of behavior (Skinner, 1974) lends itself well to the task of describing, identifying, and analyzing the effects of brain damage on specific behavioral and verbal phenomena.

Contemporary neuropsychological research has involved a number of researchers describing the effects of acquired brain damage
[acquired through TBI, Korsakoff’s Syndrome, or the natural aging process] on a number of dependent variables (Baron and Menich, 1983; Miller, 1970; Oscar-Berman, Oberg, Zola-Morgan, and Bonner, 1982; Van Zomeren, 1981). For example, Baron and Menich (1983), extending Skinner’s (1950) operant methodology, studied the natural aging process, and used reinforcement contingencies to reduce response latencies of younger and older men. Another example was Miller’s (1970) description of the effects of aging and TBI. Miller drew an analogy between the effects of the natural aging process and TBI. The effects were inferred to be similar because the natural aging process and TBI both involve the diffuse loss of cerebral neurons. If the effects of TBI and the natural aging process can be considered to be similar then it may be possible to assume that the effects can be ameliorated by the use of the same methodology. That is, the methodology used to reduce reaction times in males of advanced age should be as effective in reducing the reaction times in persons recovering from TBI. An empirical framework within which one can analyze temporal relations between stimuli, responses, and contingencies provided by Oscar-Berman’s et al. (1982) study of the effects of chronic alcohol use on DRL performance, and Van Zomeren’s (1981) investigation of the effects of TBI on reaction time.

The following is an overview of current study, which was carried out in two experiments respectively incorporating some of the procedures used by Oscar-Berman et al. (1982), and Van Zomeren (1981). The overall objective of both experiments was to employ a methodology that addressed the problem of describing behavioral and
and verbal-effects of TBI. Personal computer technology was used to develop a method of assessing attention in persons with and without histories of TBI. The two experimental procedures that were used to cumulatively record, observe, describe, and analyze moment-to-moment responses in persons with and without TBI history were: (1) the IRT > t (interresponse time greater than t, where t equals a given time period) procedure which was used in Experiment One, and (2) the MTS (matching-to-sample) procedure which was used in Experiment Two. It should be noted that other authors such as Oscar-Berman et al. 1982, used DRL, the differential reinforcement of low rates of behavior, to designate the same schedule as IRT > t. The terminology, IRT, will be used in this study because it more accurately describes the contingencies in effect during testing.

Experiments One and Two are presented separately. The introduction, methods, results, and discussion section are presented for each experiment. A general discussion regarding both experiments concludes this study.
CHAPTER II

EXPERIMENT ONE

Introduction

Conventional wisdom concerning treatment of disorders secondary to brain damage resulting from head trauma suggests recovery of function is at best slow and difficult, and if it happens at all, it will be due to initial direct organic intervention or to the adventitious spontaneous recovery process (Rosner, 1974; Gouvier, 1987; Delprato & McGlynn, 1986). This conventional wisdom is challenged by contemporary research and rehabilitation experience that have demonstrated timely and successful treatment results using relatively simple procedures on persons who have supposedly passed the point of time where spontaneous recovery of function is considered possible (Horton, 1979; Horton, 1982; Miller, 1980). A procedure is created in Experiment One that can be used to chart the time course of recovery from traumatic brain injury (TBI), and develop a methodology to effect the recovery of lost/impaired behavioral/cognitive skills. Behavioral and cognitive disorders include deficits in at least the functional areas of arousal, visual perception, language, memory, attention, problem solving and abstract reasoning (Webster & Scott, 1988).

Experiment One is based on the premise that personal computer technology and the technology of the experimental analysis of behavior (EAB) can be interfaced to study attention and problem solving. If one’s intent is to chart the course of recovery of lost or
impaired behavioral repertoires, then it is necessary to ensure that the charting be done in a manner that is both valid and reliable. Furthermore, if one's intent is to effect the course of recovery, as well as charting it, then this goal can be accomplished by using EAB principles. Thus, a computer was programmed in Experiment One on the basis of established EAB principles with the combined but separable goals of charting and effecting (1) maintained task-related responses for prolonged time periods, and (2) task-related correct responses during the same time periods. The former behavior may be called vigilance, and the latter may be called problem solving accuracy. Both are related to what is colloquially referred to as attention.

The use of the terms such as attention/vigilance and problem solving may create semantic problems that complicate the study of behavioral sequelae of TBI. It is suggested that the root of the semantic problem goes back to differences between two traditional schools of thought: mentalism and empiricism. Mentalistic concepts such as attention, vigilance, etc., may be convenient to use because, to paraphrase William James (1890), everybody knows what attention and these other constructs are. The problem is that using intuition to understand terms does not help researchers and clinicians define the conditions under which behavior can be observed and/or effected in specific manners. Mentalism and empiricism are usually respectively based on theoretical and atheoretical accountings of observed sets of data. The use of mentalistic terms such as vigilance and problem solving accuracy are used as summary terms in Experiment One with the following qualifications based on Skinner's
(1950) and Holland's (1958) discussions on atheoretic approaches to learning. A person's maintained task-related responses for prolonged durations is vigilance rather than a result of vigilance, attention, or expectancy. Furthermore, a person's maintained task-related correct responses for prolonged durations is problem solving accuracy rather than a result of problem solving ability.

Experiment One was based on an experiment conducted by Oscar-Berman et al. (1980) who used a procedure called differential reinforcement of low rates of response (DRL) [called IRT > t in Experiment One] as a prelude to their study of possible attention deficits in Korsakoff subjects. They were interested in the possibility of whether Korsakoff subjects made premature responses to incoming information. The evidence they obtained suggested that Korsakoff subjects do respond prematurely, at least when required to withhold a response for a time interval in order to receive a monetary reward. They next questioned whether the tendency to respond prematurely interferes with problem-solving ability, and if so, then how. These questions led to the development of a different experimental procedure, the conclusion of which was that subjects with alcoholic Korsakoff's disease could formulate and use hypotheses but that their strategies usually did not lead to correct solutions. Rather, these subjects used one or two strategies over and over again throughout the test, even when they were told they were wrong. Oscar-Berman et al. were able to cumulatively record the behavior of Korsakoff subjects where they kept on using unsuccessful strategies. That cumulative response records were used was one of the most desirable aspects
of their methodology. Cumulative response records are response products that yield moment-to-moment records of a person's performance.

Oscar-Berman's et al. results indicated that Korsakoff's subjects responded thousands of times without obtaining any monetary reward. Responses that were not followed by a monetary reward may be interpreted as being performance feedback information that subjects did not take advantage of to alter their problem solving strategy. Based on the appearance of the cumulative response records it is clear that subjects with Korsakoff's disease kept using a problem solving strategy that failed. The researchers used a different experimental procedure because their DRL procedural equipment did not allow for the problem solving strategy to be examined. The use of a personal computer would have allowed the problem solving strategy to be examined because the time and occurrence of each individual key press could have been cumulatively recorded and graphed.

Experiment One was a modification of Oscar-Berman's et al. methodology, and as such it accomplishes the following. First, it suggests how a more complete analysis of a DRL procedure may be made, i.e., by recording which key or keys are pressed in what order and at what rate during a particular session period, and how successful DRL performance may be differentially reinforced. Second, charting the course of recovery is done in a way that reliably indicates under what conditions performance is and is not successful and/or maintained for specific durations. At the end of the experimental session a response product can be created that provides contextual, behavioral, and consequential information about moment-to-moment
performance for subjects. This information can be used in a number of ways including using as a baseline against which to chart the course of recovery and/or decline of specific repertoires. Third, the probability of effecting changes of behavior during the course of recovery is enhanced because more is known about the stimulus conditions under which subjects perform well or perform poorly.

In Experiment One it was posited that an effective computer-based technology that utilizes EAB principles could act to mitigate the expected differences between subjects with and without TBI history. It was predicted that subjects with TBI history would demonstrate poorer maintained performance when compared to subjects without TBI history. Furthermore, it is predicted that under the technology used in Experiment One, subjects with TBI history would demonstrate both maintained and accurate performance that would be contrary to what conventional wisdom would say is possible. Confirmation of both predictions would lend strong support to the contention that appropriate techniques can be employed to enhance the recovery of lost or impaired skills in this population.

In conclusion, the objective of Experiment One was to modify and extend Oscar-Berman's et al. DRL methodology in such as way as to study vigilance and problem solving skills in persons with TBI history. The two experimental hypotheses in Experiment One were as follows. Hypothesis One states that there will be a difference in maintained performance between subjects with and without TBI history during IRT > t session phases. Specifically, it is predicted that subjects with TBI history will show more periods of not maintaining
performance than subjects without TBI history for the duration of each IRT > t session phase.

Hypothesis Two states that there will be a difference in the rate of correct white key pressing between subjects with and without TBI history. Specifically, it is predicted that subjects with TBI history will have lower rates of correct white key pressing during IRT > t session phases than subjects without TBI history, regardless of the value of t, or whether the session phase was signalled or unsignalled.
CHAPTER III

EXPERIMENT ONE

METHOD

Subjects

The three subjects with TBI history were recruited in Toronto, Ontario, at a transitional living center for adults with TBI history. The two subjects without TBI history that were recruited were employed as staff members at the same facility. The five subjects ranged in age from 25 to 36. Prior to subject selection, an interview and screening procedure with the following inclusion and exclusion criteria was conducted with each prospective subject. Limited descriptions of subjects TBI history, medication use, and other behavioral sequelae of TBI can be found in Appendix A.

Inclusion Criteria

Subjects with TBI history were under the supervision of a psychiatrist. After a general introduction to the task requirements, subjects gave their informed consent to participate in the research project, and to have their medical records reviewed, by signing a contract in front of a witness. The informed consent contract (see Appendix B) was an agreement to serve for at least 20 hours scheduled over 4 weeks, the same hour each day, Monday thru Friday. A thorough description of this study's compliance with human subject protection guidelines is found in Appendix C.
Subjects with TBI history were included if a review of medical records confirmed a diagnosis of TBI. Diagnosis of TBI was confirmed if the following two criteria, based on Bigler's (1984) diagnostic schema, were met. The first criterion was that the brain injury had to be secondary to an open versus a closed head injury. An open head injury occurs when the skull is perforated or penetrated. A closed head injury is where the skull remains intact. The second criterion was that the duration of coma had to be longer than 7 days. In addition, there had to be medical confirmation that subjects had TBI history, and psychological confirmation that there was evidence of abnormal changes in subjects' ability to function physically, emotionally, intellectually, vocationally, and/or interpersonally. Subjects without TBI history were included in the study if there was no known history of brain injury secondary to open or closed head injury, or developmental disorder in brain structure or function.

After the inclusion criteria were established for each subject, no further attempt was made to differentiate subjects in any procedural way. Subjects with and without TBI history were exposed to the same experimental conditions throughout each of the five values of t for the IRT > t schedule described below.

**Exclusion Criteria**

Subjects with and without TBI history where not screened out for using medication, i.e., they were not restricted from the study, nor were they required to discontinue routine medication. However, subjects with TBI history were required to maintain constant dosages
throughout the study. Subjects were screened out for functional problems that prohibited interaction with the computer, e.g., inability to attach meaning to sensory impression (agnosia), or inability to coordinate voluntary movement (ataxia) such that it was impossible to press the keyboard keys. Subjects were also screened out for poor frustration tolerance while interacting with the computer during the orientation phase (assessed by subject self report). For example, a potential male subject with TBI history was excluded because he reported that the task demands made him too anxious, and he didn’t want to get angry and put his fist through the monitor.

Experimental Setting

The investigation was conducted in a small, moderately illuminated, and sound attenuated room. The room was rectangular shaped and was approximately 15 feet by 7 feet. Room windows were covered with opaque paper to prevent outside light from creating excess glare on the monitor. The computer was placed on the card-table with subjects sitting facing the computer. To make accurate observations of subject’s performance, the experimenter sat at a 45 degree angle to the right of the subject.

Apparatus

Computer Hardware

A Compaq Portable Model I (IBM compatible) personal computer was used. It had a self-contained 9" diagonal monochrome monitor on
which visual stimuli was presented, and an 18" X 7" computer keyboard with 24 grey, and 48 white keys on which responses were made and recorded. The monitor screen was approximately 18 inches away from the subjects at eye level. The keyboard was positioned on an adjustable pedestal so that subjects could move the monitor for optimum personal viewing comfort. Auditory signals were sounded through a speaker inside the computer.

**Computer Software**

The IRT > t data were collected using software programmed by this researcher. The software was based on state diagrams (see Appendix D) of the IRT > t procedure. Data imported into Lotus 123 spreadsheet software was transduced into cumulative response records for subjects' IRT > t performance following the procedures used by Baron, Menich, and Perone (1983). They used a computer to accurately and reliably record when subjects correct responses were followed by the delivery of a coin. Unlike the process used by Oscar-Berman, Experiment One followed correct responses with a 1-cent credit message. For the IRT > t procedure, key presses that had an interresponse time equal to or greater than the prescribed time interval were followed by the message visually presented on the monitor: **CORRECT! YOU HAVE EARNED A 1-CENT CREDIT, YOUR TOTAL IS: $ #.##.** Premature responses, i.e., responses that had an interresponse time less than the prescribed time interval, were immediately followed by resetting of the interresponse timer back to zero, and no message of any kind followed.
Accuracy Checks

The computer was checked each day to make sure that the internal timers were operating properly and recording time dependent responses accurately. A replacement power cord was purchased when it was discovered the computer could be disengaged by touching the base of the cord that plugged into the computer. With the new cord, the computer could not be disengaged unless the plug was pulled completely out of the socket.

Dependent Measures

IRT > t Performance

The dependent measures were maintained and accurate performance on four consecutive IRT > t schedules. On each of four successive IRT > t schedules subjects had to wait a prescribed interval of time (3-seconds, 6-seconds, 12-seconds, and 18-seconds, respectively) before pressing a white colored key, after which a 1-cent credit message appeared on the monitor. The operational definition of subjects maintaining performance for the duration of an IRT > t session phase is defined in terms of the slope of the cumulative response record always being greater than zero for a period of 100-seconds or longer. The operational definition of subjects not maintaining performance for the duration of an IRT > t session phase is defined in terms of the slope of the cumulative response record ever being equal to zero for a period of 100-seconds or longer. The computer measured the number of white key presses per second, and the
number of correct white key presses per second during the different IRT > t session phases.

**Response Class**

A response was defined as a press of any white key on the computer keyboard that resulted in an auditory click. The click created by fully depressing a key was different than the sound created by lightly touching the keys. The click helped subjects distinguish between key presses that were too light for the computer to detect and key presses that were detectable by the computer. Subjects were required to press the white colored key. A grey key press did not reset the timer, nor did it produce any credit/error message.

The computer recorded responses onto a floppy disk. Data was then imported into Lotus 123 spreadsheet files, where columns were set-up for the time of each response, the number and order of each response, the responses that were and were not reinforced, and the latency between responses. Appendix E presents examples of how the Lotus 123 spread sheets were set up for further analysis. Cumulative response records were generated from these data.

**General Procedure**

**Experimental Design**

The nature of TBI rendered the brain injury effects as being irreversible thus disqualifying the use of withdrawal designs. Experiment One used a modified multiple baseline across subjects
design. One element of the current design involved the use of a "B" Design where baseline measurement was omitted, but a single target or dependent measure was monitored throughout the course of introducing several levels of the independent variable (Hersen & Barlow, 1976). Campbell and Stanley (1963) referred to such designs as quasi-experimental designs. The design of Experiment One involved the use of subject groups with and without TBI history, albeit of very small numbers. Subjects without TBI history were needed to validate whether or not the recording instrument was capable of detecting behavioral deficits.

The personal computer was used to collect and record data, and the experiment was designed to be able to compare performances between and within subjects with and without TBI history. The design included two different subject types because it was desirable to know whether one could use the computer-assisted recording procedure to discriminate between subjects with and without TBI history on the basis of rate of correct key pressing. The ability to make discriminations is important for reasons related to the assessment of behavioral effects of TBI, and the charting the time course of their recovery and/or decline in function.

A behavioral contract was developed to encourage project completion. Payment included a daily bonus of up to $1.00 dependent on being on time ($0.25 bonus), getting to the correct room ($0.25 bonus), working for part of the session ($0.25 bonus), and working for the entire session ($0.25 bonus). This bonus money was in addition to money earned during experimental sessions when each
correct response earned 1-cent ($2.00 per session, maximum). Each subject was paid after each session. The session days were numbered consecutively, and conducted only on Monday thru Friday.

The IRT > t experiment was intended to last one day and consist of five levels of increasing predetermined delay intervals. For several reasons Experiment One lasted four days, instead of one. One reason was that an unanticipated problem occurred in how the computer was programmed to store the data on the floppy disk. Another reason was because the subjects obtained less than 25% of the theoretically available reinforcements on the easiest non-signalled IRT > t tasks. Therefore, a signalled IRT > t phase was included with the intent to maximize a subject's success.

Orientation Phase

Prior to the initiation of Experiment One, subjects were given a one-week orientation phase where they were briefly exposed to several of the experimental IRT > t session phases. The purpose of this orientation phase was to mitigate performance-impairing "computer phobia," and to determine if each subject was able to make the requisite key presses in response to stimuli presented on the screen. The IRT > t orientation consisted of having subjects perform ten unsignalled IRT = 0-second trials, followed by practice on ten signalled IRT > 3-second trials. In the IRT = 0-second, orientation phase, subjects earned 1-cent for each correct white key press. In the signalled IRT > 3-second, orientation phase, subjects were informed that the conditions had changed yet their task was still to
earn the 1-cent credit message. The first white key press was followed by the 1-cent credit message. Availability of following credit messages was indicated by a tone which sounded 3-seconds subsequent to the appearance of the PRESS ANY WHITE KEY message on the computer screen. The duration of the tone was 1/2 second, and after the signal any white key press resulted in a 1-cent credit message. This signalled 3-second IRT > t orientation phase was discontinued after nine consecutive correct responses were made at both the signalled and unsignalled IRT > t levels.

Instructions

All subjects were given the following instructions at the beginning of each level of the IRT > t orientation and experimental sessions. The bracketed words were not spoken.

This task is like a game. I call it the waiting game. You can win some money, but the amount you win depends on how you play. What you are to do is to press any white key [the researcher presses one of the white keys] on the keyboard when you see the words PRESS ANY WHITE KEY on the computer monitor. Try it! [Pause for subject’s response] Good! By doing this, you earn a 1-cent credit [Canadian currency]. A message on the screen tells you when you have earned a 1-cent credit. The message also tells you what your running total is. At the end of the day’s session[s] the computer adds up your earnings and displays the amount on the screen. You will receive from me that much money in cash. All the money you earn will be yours to keep. Any Questions? In the beginning the task will be very easy. Later on I am going to make some changes, and you will have to find out how to keep getting your 1-cent credits. I won’t make a change without telling you; but, I won’t tell you what the change is. Don’t think the computer is broken if you do not get a 1-cent credit message. Just keep playing the game. Remember that all I want you to do is to get as many 1-cent credits as you can. The more you get, the more money you will earn. Do you have any questions?
Independent Variable Phases

The independent variable in Experiment One was the common sequence of IRT > t schedules to which subjects were exposed. The values of t increased from session phase to session phase. The values of t in the IRT > t schedule were systematically altered from session phase to session phase as follows: 0-seconds, 3-seconds, 6-seconds, 12-seconds, and 18-seconds. With each new session phase encountered, subjects were presented with a different value of t where they had to wait for progressively longer time periods before a response to a stimulus was followed by a 1-cent credit message.

IRT > t Phases--Day One

Day one consisted of the following five unsignalled (US) IRT > t session phases of successively increasing interresponse time intervals: 0-seconds, 3-seconds, 6-seconds, 12-seconds, and 18-seconds. The IRT > t levels were successively conducted and separated by a 30-second break during which the interresponse time interval was changed by the experimenter. The IRT > t session phases for day one were as follows:

<table>
<thead>
<tr>
<th>DAY</th>
<th>PHASES</th>
<th>EXPLANATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONE</td>
<td>00s-US</td>
<td>unsignalled, 0-second IRT interval</td>
</tr>
<tr>
<td></td>
<td>03s-US</td>
<td>unsignalled, 3-second IRT interval</td>
</tr>
<tr>
<td></td>
<td>06s-US</td>
<td>unsignalled, 6-second IRT interval</td>
</tr>
<tr>
<td></td>
<td>12s-US</td>
<td>unsignalled, 12-second IRT interval</td>
</tr>
<tr>
<td></td>
<td>18s-US</td>
<td>unsignalled, 18-second IRT interval</td>
</tr>
</tbody>
</table>
IRT > t Phases--Day Two

Day two followed the same procedures as used on day one. Day two of the IRT > t sessions consisted of five unsignalled (US) IRT > t phases of successively increasing interresponse time intervals. The value of t was increased by the experimenter after the subjects were exposed to the current value of t for approximately 5-minutes. Each IRT > t session phase was separated by a 30-second break. The IRT > t session phases for day two were as follows.

<table>
<thead>
<tr>
<th>DAY</th>
<th>PHASES</th>
<th>EXPLANATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>TWO</td>
<td>00s-US</td>
<td>unsignalled, 0-second IRT interval</td>
</tr>
<tr>
<td></td>
<td>03s-US</td>
<td>unsignalled, 3-second IRT interval</td>
</tr>
<tr>
<td></td>
<td>06s-US</td>
<td>unsignalled, 6-second IRT interval</td>
</tr>
<tr>
<td></td>
<td>12s-US</td>
<td>unsignalled, 12-second IRT interval</td>
</tr>
<tr>
<td></td>
<td>18s-US</td>
<td>unsignalled, 18-second IRT interval</td>
</tr>
</tbody>
</table>

IRT > t Phases--Day Three

The effect of signalling when the predetermined interresponse interval ended on the rate of correct white key pressing was studied on day three. The signal was a tone programmed to sound when the requisite interresponse interval ended. Day three consisted of the following five signalled (S) IRT > t session phases of successively increasing interresponse intervals: 0-seconds, 3-seconds, 6-seconds, 12-seconds, and 18-seconds. The auditory signal indicated when the predetermined interresponse time interval had elapsed. The IRT > t phases were successively conducted and separated by a 30-second break during which the experimenter changed the interresponse interval. The IRT > t session phases for day three were labeled as follows:
Day four was conducted to reintroduce the unsignalled $IRT > t$ conditions so the effect of preceding the four signalled $IRT > t$ session phases with three signalled $IRT > t$ session phases could be examined. Day four consisted of the following three signalled ($S$) $IRT > t$ session phases of successively increasing interresponse intervals: 6-seconds, 12-seconds, and 18-seconds. After these signalled session phases were completed, the following four unsignalled (US) $IRT > t$ session phases of successively increasing interresponse intervals were conducted: 3-seconds, 6-seconds, 12-seconds, and 18-seconds. The signalled 0-, and 3-second, and unsignalled 0-second IRT values of $t$ were not used because subjects demonstrated near-perfect performance under these conditions, and to save session time. The $IRT > t$ session phases were conducted successively and were separated by a 30-second break during which the value of $t$ was changed. The $IRT > t$ session phases on day four were as follows:

<table>
<thead>
<tr>
<th>DAY</th>
<th>PHASES</th>
<th>EXPLANATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>THREE</td>
<td>00s-S</td>
<td>signalled, 0-second IRT interval</td>
</tr>
<tr>
<td></td>
<td>03s-S</td>
<td>signalled, 3-second IRT interval</td>
</tr>
<tr>
<td></td>
<td>06s-S</td>
<td>signalled, 6-second IRT interval</td>
</tr>
<tr>
<td></td>
<td>12s-S</td>
<td>signalled, 12-second IRT interval</td>
</tr>
<tr>
<td></td>
<td>18s-S</td>
<td>signalled, 18-second IRT interval</td>
</tr>
<tr>
<td>IRT &gt; t Phases—Day Four</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DAY</th>
<th>PHASES</th>
<th>EXPLANATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOUR</td>
<td>06s- S</td>
<td>signalled, 6-second IRT interval</td>
</tr>
<tr>
<td></td>
<td>12s- S</td>
<td>signalled, 12-second IRT interval</td>
</tr>
<tr>
<td></td>
<td>18s- S</td>
<td>signalled, 18-second IRT interval</td>
</tr>
<tr>
<td></td>
<td>03s-US</td>
<td>unsignalled, 3-second IRT interval</td>
</tr>
<tr>
<td></td>
<td>06s-US</td>
<td>unsignalled, 6-second IRT interval</td>
</tr>
<tr>
<td></td>
<td>12s-US</td>
<td>unsignalled, 12-second IRT interval</td>
</tr>
<tr>
<td></td>
<td>18s-US</td>
<td>unsignalled, 18-second IRT interval</td>
</tr>
</tbody>
</table>
CHAPTER IV

EXPERIMENT ONE

Results

Experiment One modified Oscar-Berman et al.'s DRL methodology to study vigilance and problem solving. Computer technology and principles of the experimental analysis of behavior were used to record, quantify, describe and analyze the operant behavior of persons with and without TBI history. Cumulative response records were generated for each subject's IRT > t performance. The full array of these cumulative response records can be found in Appendices F to J.

Hypothesis One stated that there would be differences in maintained performance between subjects with and without TBI history during IRT > t session phases. Specifically, it was predicted that subjects with TBI history would show fewer periods of maintained performance than subjects without TBI history for the duration of the IRT > t session phases. Inspection of Table 1 reveals that for both subject groups there were no instances when the slope of the cumulative response records (see the individual cumulative response records in Appendices F to J) was ever equal to zero for periods of 100-seconds or longer, i.e., as operationally defined, subjects in both groups demonstrated a maintained pattern of key press responses. It should be noted that all subjects maintained performance for the duration of the IRT > t session phases. Thus, Hypothesis One was not confirmed.
<table>
<thead>
<tr>
<th>Day</th>
<th>Session</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>S1</th>
<th>S2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>00s-US</td>
<td>M</td>
<td>M</td>
<td>*</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>03s-US</td>
<td>M</td>
<td>M</td>
<td>*</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>06s-US</td>
<td>M</td>
<td>M</td>
<td>*</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>12s-US</td>
<td>M</td>
<td>M</td>
<td>*</td>
<td>M</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>18s-US</td>
<td>M</td>
<td>M</td>
<td>*</td>
<td>M</td>
<td>*</td>
</tr>
<tr>
<td>2</td>
<td>00s-US</td>
<td>M</td>
<td>M</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>03s-US</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>06s-US</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>12s-US</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>18s-US</td>
<td>M</td>
<td>*</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>3</td>
<td>00s-S</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>*</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>03s-S</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>*</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>06s-S</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>*</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>12s-S</td>
<td>M</td>
<td>*</td>
<td>M</td>
<td>*</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>18s-S</td>
<td>M</td>
<td>*</td>
<td>M</td>
<td>*</td>
<td>M</td>
</tr>
<tr>
<td>4</td>
<td>06s-S</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>*</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>12s-S</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>*</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>18s-S</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>*</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>03s-US</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>*</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>06s-US</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>*</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>12s-US</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>*</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>18s-US</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>*</td>
<td>M</td>
</tr>
</tbody>
</table>

Note: Lost data are represented by an asterisk (*). Values of \( t \) equaled 0-seconds, 3-seconds, 6-seconds, 12-seconds, or 18-seconds; the end of each value of \( t \) was either signalled (S) or unsignalled (US). M = slope greater than zero; NM = slope equal to zero for 100 seconds.
Hypothesis two stated that there would be differences in the rate of correct white key pressing between subjects with and without TBI history. Specifically, it was predicted that subjects with TBI history would have lower rates of correct white key pressing during IRT > t session phases than subjects without TBI history, regardless of the value of t, or whether the session phase was signalled or un-signalled. This prediction received some support, but the data were equivocal. Inspection of the rates of correct white key presses per total number of seconds in Table 2 reveals the equivocal outcome. This means that some subjects with TBI history had higher rates than subjects without TBI history, and some subjects without TBI history had lower rates than expected given the absence of any known evidence of TBI. Given the equivocal findings it was concluded that Hypothesis Two was not confirmed.

Table 2 presents information on each subject's performance for a given IRT > t session phase. The list of values represents the quotients derived from the number of correct white key presses divided by the total session phase time. The session phase time was not kept constant due to a computer programming error. This complicated comparing the quotients in Table 2. It was still possible, however, to make reasonable comparisons based on cumulative response records and visually estimating how the curves might have appeared had the total session phase time been kept constant.

Cumulative response records serve another function when reporting on the results of Experiment One. A visual inspection of cumulative response records is suggested when one is attempting to decide
Table 2

Rate of Correct White Key Presses per Total Number of Seconds for Subjects With and Without TBI History, for Each of Four Days of IRT > t Session Phases

<table>
<thead>
<tr>
<th>Day</th>
<th>Session</th>
<th>Subjects With TBI History (R1, R2, &amp; R3)</th>
<th>Subjects Without TBI History (S1 &amp; S2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>R1</td>
<td>R2</td>
</tr>
<tr>
<td>1</td>
<td>00s-US</td>
<td>0.0790</td>
<td>0.0772</td>
</tr>
<tr>
<td></td>
<td>03s-US</td>
<td>0.0118</td>
<td>0.0341</td>
</tr>
<tr>
<td></td>
<td>06s-US</td>
<td>0.0062</td>
<td>0.0181</td>
</tr>
<tr>
<td></td>
<td>12s-US</td>
<td>0.0036</td>
<td>0.0109</td>
</tr>
<tr>
<td></td>
<td>18s-US</td>
<td>0.0026</td>
<td>0.0038</td>
</tr>
<tr>
<td>2</td>
<td>00s-US</td>
<td>0.0814</td>
<td>0.0810</td>
</tr>
<tr>
<td></td>
<td>03s-US</td>
<td>0.0127</td>
<td>0.0225</td>
</tr>
<tr>
<td></td>
<td>06s-US</td>
<td>0.0059</td>
<td>0.0058</td>
</tr>
<tr>
<td></td>
<td>12s-US</td>
<td>0.0021</td>
<td>0.0045</td>
</tr>
<tr>
<td></td>
<td>18s-US</td>
<td>0.0000</td>
<td>****</td>
</tr>
<tr>
<td>3</td>
<td>00s--S</td>
<td>0.0846</td>
<td>0.0829</td>
</tr>
<tr>
<td></td>
<td>03s--S</td>
<td>0.0635</td>
<td>0.0664</td>
</tr>
<tr>
<td></td>
<td>06s--S</td>
<td>0.0567</td>
<td>0.0122</td>
</tr>
<tr>
<td></td>
<td>12s--S</td>
<td>0.0332</td>
<td>****</td>
</tr>
<tr>
<td></td>
<td>18s--S</td>
<td>0.0367</td>
<td>****</td>
</tr>
<tr>
<td>4</td>
<td>06s--S</td>
<td>0.0533</td>
<td>0.0533</td>
</tr>
<tr>
<td></td>
<td>12s--S</td>
<td>0.0425</td>
<td>0.0440</td>
</tr>
<tr>
<td></td>
<td>18s--S</td>
<td>0.0306</td>
<td>0.0364</td>
</tr>
<tr>
<td></td>
<td>03s-US</td>
<td>0.0163</td>
<td>0.0551</td>
</tr>
<tr>
<td></td>
<td>06s-US</td>
<td>0.0000</td>
<td>0.0548</td>
</tr>
<tr>
<td></td>
<td>12s-US</td>
<td>0.0061</td>
<td>0.0000</td>
</tr>
<tr>
<td></td>
<td>18s-US</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Note: Lost data are represented by an asterisk (*). Values of t equalled 0-seconds, 3-seconds, 6-seconds, 12-seconds, or 18-seconds, the end of the interval t was either signalled (S) or unsignalled (US).
on the basis of a single quotient whether a value means that a sub-
ject did not maintain performance during the session such that no
responses were made, or whether the quotient reflects the fact that
many responses were made, however, all of them were incorrect. Visual
inspection of the cumulative response records would instantaneously
inform the experimenter that there was a high rate of white key
pressing reflected by a near-vertical slope, or whether white key
pressing was not maintained as reflected by a horizontal slope for
the entire session phase duration. Both Table 2 and selected cumula-
tive response records are used to discuss the observed effect of in-
creasing the value of $t$ for unsignalled and signalled IRTs, on a
subject’s pattern of correct key press responses.

The effect of increasing the value of $t$ for unsignalled IRTs
was to increase inter-group differences especially when $t$ exceeded
6-seconds and, to decrease the rate of correct white key pressing for
all subjects regardless of TBI history. That there were inter-group
differences meant that some subjects with TBI history had higher
rates of correct responding than subjects without TBI history. The
increase in the inter-group differences in correct response rates was
usually in the direction favoring subjects without TBI history.
Listed below are several instances when subjects with TBI history,
(R1, R2, and R3) had higher rates of correct key presses than a
subject without TBI history ($S2$) under unsignalled IRT $> t$ schedules.

- day 1, 03-second phase, $R1$’s rate was greater than $S2$’s,
- day 1, 03-second phase, $R2$’s rate was greater than $S2$’s,
- day 1, 06-second phase, $R1$’s rate was greater than $S2$’s,
- day 1, 06-second phase, $R2$’s rate was greater than $S2$’s,
- day 1, 12-second phase, $R1$’s rate was greater than $S2$’s,
- day 1, 12-second phase, $R2$’s rate was greater than $S2$’s,
day 1, 12-second phase, R2's rate was greater than S2's,
day 1, 18-second phase, R1's rate was greater than S2's,
day 1, 18-second phase, R2's rate was greater than S2's,
day 2, 18-second phase, R3's rate was greater than S2's,
day 4, 18-second phase, R2's rate was greater than S2's,
day 4, 06-second phase, R2's rate was greater than S2's.

Under conditions when the IRT interval was unsignalled, there
was an observed inverse relationship between the increased interval t
and the decrease in the rate of correct white key pressing for all
subjects regardless of TBI history. Noted exceptions to this inverse
relationship can be seen in Table 2 and are summarized as follows:
An inverse relationship was not observed for R1 on day 3, and, on day
4. An inverse relationship was not observed for R3 on day 2, and on
day 4. And, an inverse relationship was not observed for S2 on day
1, on day 3, and on day 4.

The four visual effects of increasing the value of t for
unsignalled IRTs on subjects' cumulative response records were as
follows. First, there was a decrease in the visual discernability of
the diamond-shaped pips which indicated when a white key press had
been made. In general, discernability was lacking for subjects with
TBI history, but not for subjects without TBI history. Second, there
was an increase in the steepness of the slope of the ascending lines,
on which were the diamond-shaped pips, along the X-Y quadrant. It
was typically the case that subjects with TBI history demonstrated
steeper ascending lines, which meant that the ascending lines had to
be reset more often. Third, there was an increase in the prevalence
of step-like features that indicated response pausing. This was more
evident for subjects with TBI history than for subjects without TBI
history. And, fourth, there was a decrease in the demarcations of the short vertical lines rising above the -10 x-axis line. Sometimes subjects with TBI history earned more demarcations than subjects without TBI history on a comparable day’s session phase.

The first visual effect of increasing the value of \( t \) for unsignalled IRTs was to decrease the visual discernability of the diamond-shaped pips which indicated when a white key was pressed. This visual effect can be seen by examining the records of one of the subjects with TBI history, because the records of the three subjects with TBI history were reasonably comparable, and the record for R1 was the most complete. Figure 1 represents R1’s unsignalled IRT > \( t \) schedule where the pressing of any white colored key was correct because \( t \) equalled 0-seconds. The result of this IRT schedule was a straight line on which the diamond-shaped pips were visually discernable, evenly spaced, and not next to one another. A one-to-one correspondence between the vertical lines rising above the -10 x-axis line, and the diamond-shaped pips on the ascending line indicate that R1 performed perfectly during the session phase. These visual effects were the same for all subjects.

For subjects with TBI history, such as R1, during unsignalled IRT > \( t \) session phases with values of \( t \) greater than 0-seconds, the cumulative response records had steeper ascending lines on which diamond shaped pips were next to each other, were not visually discernable, and had the appearance of thick jagged lines. For example, the effect of increasing the value of \( t \) for unsignalled IRTs from 0-seconds to 3-seconds is seen by comparing Figures 1 thru 5.
Figure 1. Cumulative Response Record of An Unsignalled IRT > t Session, With t = 0-Seconds, on Day One.

Note

The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 14/177.19 or .0790. A 1-cent credit message followed a key press only if a certain amount of time (0-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Cumulative Response Record of An Unsignalled IRT > t Session With t = 3-Seconds, on Day One.

The subject, Rl, was a male adult with a history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 7/591.04 or .0118. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 3/482.73, or .0062. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Figure 4. Cumulative Response Record of An Unsignalled IRT > t Session With t = 12-Seconds, on Day One.

The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 2/555.7 or .0036. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Cumulative Response Record of An Unsignalled IRT > t Session With t = 18-Seconds, on Day One.

The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 1/380.15, or .0026. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
For example, in Figure 2, diamond-shaped pips are superimposed next to each other on steep ascending lines that appear jagged. The jagged appearance was created by superimposed pips. The superimposed pips were the result of many responses being made closely in time. The second visual effect of increasing the value of $t$ for un-signalled IRTs was to increase the steepness of the slope of the ascending lines (constructed by connecting the diamond-shaped pips) along the X-Y quadrant. This effect was most evident when comparing subjects with and without TBI history. The records of subjects with TBI history were characterized more often by ascending lines with slopes greater than 45 degrees on which diamond-shaped pips were superimposed. The records of subjects without TBI history where characterized more often by ascending lines with slopes less than 45 degrees on which diamond-shaped pips were not usually superimposed.

The following example shows how the visual effect of increasing the value of $t$ for unsignalled IRTs differed between subjects with and without TBI history. Figures 6 thru 9 are S2’s cumulative response records where the interval $t$ was successively increased. S2’s records differ markedly from R1’s records (Figures 1 thru 5) even though the IRT conditions were the same. Noted should be the difference in visual discernability of the diamond-shaped pips between S2’s and R1’s cumulative response records. R1’s records showed that a greater number of responses were emitted in a relatively short period of time. S2’s records did not generally have the superimposed diamond-shaped pips while R1’s records did. The corresponding lower rates of correct white key presses for R1 should also be noted.
Figure 6. Cumulative Response Record of An Unsignalled IRT > t Session With t = 3-Seconds, on Day Two.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 27/509.97 or .0529. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Cumulative Response Record of An Unsignalled IRT > t Session With t = 6-Seconds, on Day Two.

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was $15/466.81$. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Figure 8. CUMULATIVE RESPONSE RECORD

Cumulative Response Record of An Unsignalled IRT > t Session With t = 12-Seconds, on Day Two.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 8/433.09 or .0185. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Figure 9. Cumulative Response Record of An Unsignalled IRT > t Session With t = 18-Seconds, on Day Two.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 4/359.48 or .0111. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Figures 6 to 9 have ascending lines on which the diamond-shaped pips were more visually discernable. The total number of responses is lower, and the rate of correct white key presses is higher for S2, without TBI history, than for R1, with TBI history.

For subjects with TBI history, during unsignalled IRT > t session phases with values of t greater than 0-seconds, the cumulative response records showed steep ascending lines on which diamond-shaped pips were superimposed next to each other, were not individually discernable, and had the appearance of thick jagged lines.

The third visual effect of increasing the value of t for unsignalled IRTs was to increase the appearance of step-like features, i.e., near-horizontal lines on which were closely spaced diamond-shaped pips. The horizontal steps, depicted in Figure 2, represented moments when R1 either paused. While R1 was pausing he was also in effect waiting. If the pause was long enough, the interval t passed, and R1’s next key press was followed by a 1-cent credit message. This would be reflected by a demarcation on the -10 x-axis line. The pattern of R1’s responding in Figure 2 was a rapid sequence of keyboard key presses, followed by a brief period of no responding, followed by a delivery of a 1-cent credit message, and followed by another rapid sequencing of keyboard key presses. This pattern repeated itself four times in Figure 2. R1’s response pattern in Figures 3 to 5 was similar to that of Figure 2, but there were two notable differences. The first difference was that as the value of t increased from 3-, to 6-, to 12-, to 18-seconds, the rate of correct white key presses decreased respectively. The second difference was
that as the value of t for unsignalled IRTs increased, the number of step-like features diminished (Figure 5).

The fourth visual effect of increasing the value of t for unsignalled IRTs t was to decrease the number of demarcations, i.e., the short vertical lines rising above the -10 x-axis line. With respect to Figures 6 to 9 and Figures 1 to 5, the number of demarcations on the -10 x-axis of the cumulative response records reflect well the generally observed visual effect that subjects with TBI history made more incorrect and perseverative responses than subjects without TBI history. This is reflected in Table Two as lower quotients, and in the cumulative response records as fewer demarcations on the -10 x-axis. The visual effect of the latter are steep ascending lines on which superimposed diamond-shaped pips appear to correspond with lower rates of correct white key presses, and more perseverative key presses, made by subjects with TBI history. Also, higher rates of correct white key presses made by subjects without TBI history appear to correspond with less steep ascending lines on which diamond-shaped pips are readily discernable. There is, however, an exception to this general observation. The exception involves the cumulative response records of S1 (Figures 10 to 14).

Some cumulative response records for S1 were both similar to S2, without TBI history, and to R1, R2, and R3, with TBI history. This inter-group similarity resulted when none of S1's white key presses were correct on day one when t equalled 3-, 6-, 12-, and 18-seconds respectively. Figures 10 to 14 represent S1's cumulative response records that are more similar to subjects with TBI history.
Figure 10. Cumulative Response Record of An Unsignalled IRT > t Session With t = 0-Seconds, on Day One.

Note

The subject, S1, was a female adult with no history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 13/150.11 or .0866. A 1-cent credit message followed a key press only if a certain amount of time (0-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Figure 11. Cumulative Response Record of An Unsignalled IRT > t Session With t = 3-Seconds, on Day One.

The subject, S1, was a female adult with no history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 0/557.28 or .0000. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Figure 12. Cumulative Response Record of An Unsignalled IRT > t Session With t = 6-Seconds, on Day One.

Note

The subject, S1, was a female adult with no history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 0/585.71 or .0000. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Figure 13. Cumulative Response Record of An Unsignalled IRT > t Session With t = 12-Seconds, on Day One.

Note

The subject, S1, was a female adult with no history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 0/544.63 or .0000. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit.
Figure 14. Cumulative Response Record of An Unsignalled IRT > t Session With t = 18-Seconds, on Day One.

Note

The subject, S1, was a female adult with no history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 0/207.21 or .0000. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit.
Figure 10 appears as expected, e.g., a straight line graph on which diamond-shaped pips are visually discernable and not superimposed. However, Figures 11 to 14 for S1 were more similar to those of R1. (Figures 2 to 5) than they were to S2 without TBI history.

Despite the similarities between cumulative response records of S1 and subjects with TBI history, the visual comparison was not exact. There was a subtle visual difference between S1's cumulative response record and those of subjects with TBI history. The difference was that S1 lacked any correct responses for the IRT > t values of t greater than 0-seconds. This meant that S1 did not pause once during these IRT > t session phases. This is reflected by the fact that there were no step-like features in Figures 11 to 14 for S1. Thus, while there appeared to be a similar pattern of responding between S1 and subjects with TBI history, under closer inspection of the graphs, the above-described pattern of not pausing differentiated S1 from subjects with TBI history on day one.

On day 2, S1's cumulative response records (Figures 15 to 18) are more visually similar to those of S2, also without TBI history, than to subjects with TBI history. Inspection of Figure 15 reveals the absence of steep ascending lines on which diamond-shaped pips were superimposed, and the presence of a less steep and more discernable diamond-shaped pips. The rate of S1's correct white key presses on day 2 was considerably higher than S1's performance on day 1. Inspection of Figures 16 to 18 reveals that S1 made more correct white key presses on day 2 than on day 1, the ascending lines were less steep, and the appearance of the step-like features was similar.
Figure 15. Cumulative Response Record of An Unsignalled IRT > t Session With t = 3-Seconds, on Day Two.

Note

The subject, S1, was a female adult with no history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 30/625.91 or .0479. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Figure 16. Cumulative Response Record of An Unsignalled IRT > t Session With t = 6-Seconds, on Day Two.

Note

The subject, S1, was a female adult with no history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 14/500.79 or .0280. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Figura 17. Cumulative Response Record of An Unsignalled IRT > t Session With t = 12-Seconds, on Day Two.

Note

The subject, S1, was a female adult with no history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 4/520.00 or .0077. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Figure 18. Cumulative Response Record of An Unsignalled IRT > t Session With t = 18-Seconds, on Day Two.

Note

The subject, Sl, was a female adult with no history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 0/377.10 or .0000. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
to that displayed by subjects with TBI history. Also, there was an associated drop in the rate of correct white key presses as S1 was exposed to session phases with increasing IRT > t values of t. S1's Figures 16 to 18 also differed from those of S2 because of a reappearance of superimposed diamond-shaped pips, a steeper ascending line, and more step-like features. Thus, while Figure 15 for S1 is suggestive of a pattern of responding more similar to S2, the pattern of responses reflected in Figures 16 through 18 show an idiosyncratic pattern similar to subjects with TBI history. Thus, S1's record was like S2's because the number of responses in Figure 15 never exceeded 100, so it was never necessary to reset the ascending line on the cumulative response record. However, S1's cumulative response record was less like that of S2, and was more like subjects with TBI history because of a reappearance of superimposed diamond-shaped pips, the appearance of step-like features, and steeper ascending lines in Figures 16 to 18.

The effect of increasing the value of t for signalled IRTs was to diminish inter-group differences, and to increase the rate of correct responses for all subjects regardless of TBI history. The decrease in the inter-group differences were reflected in the rate quotients in Table 2. These quotients were very close numerically, although small differences still favored subjects without TBI history, i.e., subjects without TBI history had slightly higher correct response rates. Noted exceptions to this difference favoring subjects without TBI history, under the signalled IRT > t schedules, are as follows:
day 3, 00-second phase, R1’s rate was greater than S2’s,  
day 3, 00-second phase, R2’s rate was greater than S2’s,  
day 3, 00-second phase, R3’s rate was greater than S2’s,  
day 3, 03-second phase, R1’s rate was greater than S2’s,  
day 3, 03-second phase, R2’s rate was greater than S2’s,  
day 3, 03-second phase, R3’s rate was greater than S2’s,  
day 3, 06-second phase, R3’s rate was greater than S2’s,  
day 3, 12-second phase, R3’s rate was greater than S2’s,  
day 3, 18-second phase, R3’s rate was greater than S2’s,  
day 4, 06-second phase, R3’s rate was greater than S2’s.

There were minimal inter-group differences between correct response rates, under the signalled IRT > t schedules. Table 2 reflects evidence of these minimal inter-group differences, e.g., on Day 3 under the 0-second IRT > t value of t, the common rate for all subjects was .08. Even when the value of t was 18-seconds, the common rate was about .35. Thus, under the signalled condition the inter-group differences in correct response rate were minimal. Such inter-group differences were more noticeable under unsignalled IRT > t conditions. Inspection of Table 2 reveals that, for all subjects, the rates of correct white key pressing for the signalled conditions were greater than for the unsignalled conditions.

When the value of t for signalled IRTs was increased, there was minimal visual effect on the cumulative response records regarding discernability of diamond-shaped pips, slope of the ascending line, appearance of step-like features, or number of demarcations. The cumulative response records were visually comparable across all subjects, and generally resembled the records shown in Figures 1 and 10.
CHAPTER V

EXPERIMENT ONE

Discussion

Experiment One modified Oscar-Berman’s et al. (1982) DRL methodology to study vigilance and problem solving. Computer technology and principles of the experimental analysis of behavior were used to record, quantify, describe and analyze the operant behavior of persons with and without TBI history. Cumulative response records were generated for each subject’s IRT > t performance. It was predicted that subjects with TBI history would demonstrate poorer maintained performance when compared to subjects without TBI history. Furthermore, it was predicted that under the design used in Experiment One subjects with TBI history, contrary to what conventional wisdom would say is possible, would demonstrate performance that is both maintained and accurate. Confirmation of both predictions would lend strong support to the contention that appropriate technologies can be employed to enhance the recovery of lost and/or impaired behavioral skills in this population.

The results of Hypothesis One strongly support several interpretations for why, contrary to original expectations, subjects with TBI history maintained key presses during IRT > t session phases. It is plausible that contingencies of reinforcement explicitly part of the experimental design were operating to maintain a subject’s key presses. Three examples are as follows.
First, verbally mediated reinforcers, i.e., the presentation on the computer screen of a 1-cent credit message subsequent to a key press, may have effectively operated to maintain performance under signalled IRT schedules for any value of t, and unsignalled IRT schedules for values of t equal to 0- and 3-seconds.

Second, the behavioral contract agreement, i.e., contingency specifying verbal stimuli, over and above what was presented on the computer screen, may have operated to maintain performance under unsignalled IRT schedules for values of t equal to and greater than 6-seconds. When the value of t equalled or exceeded 6-seconds, subjects with TBI history were encountering the 1-cent credit message infrequently, e.g., hundreds of responses were being made that were not followed by the 1-cent credit message. In this case, it would be expected that subjects would be most prone to distraction, discouragement, irritation, and a desire to quit. However, inspection of Table 1 clearly showed that subjects maintained performance for the duration of all IRT session phases. Thus, it can be argued that a concurrent rule, which was the behavioral contract agreement, operated to maintain a subject's key presses under unsignalled IRT conditions when the value of t equalled or exceeded 6-seconds.

And third, it may also be argued that the presence of the experimenter may have acted as a discriminative stimulus, or generalized reinforcer, for key presses. This suggestion should be considered because it was often necessary for the experimenter to go to the TV room and remind subjects that they had an experimental session. It is equally important to consider the instance in the
orientation phase when a male subject was allowed to withdraw from the study because he reported feeling nervous and mad when working on the computer tasks. Here, the presence of the experimenter did not promote the subject staying in the experiment. Thus, the effect of the experimenter remains uncertain.

It is also plausible that contingencies of reinforcement not explicitly part of the experimental design operated to maintain a subject's key presses during IRT > t session phases. Two examples are as follows. First, staff members not directly involved in the experiment may have functioned as a generalized reinforcer when they admonished subjects with TBI history to continue in a task these subjects found boring and frustrating. For example, it was reported by a staff member not participating in Experiment One that R2 was encouraged to stay involved in the experiment. Second, it is reasonable to assume that the manner in which the computer was programmed to schedule the delivery of 1-cent credit messages was leading subjects to consider other rules for earning money, the result of which was a maintained idiosyncratic pattern of key presses. Two examples of this superstitious-like behavior were that R2 repeatedly entered his name, and that several subjects methodically pressed every white key starting at the top of the keyboard and continuing from left to right for all four rows of keys—and then repeating this sequence.

The results of Hypothesis Two provide some support for interpretations for why subjects with TBI history maintained correct key presses under signalled IRTs for any value of t, and under unsig- nalled IRTs for values of t up to 3-seconds. Furthermore, these
results support interpretations for why subjects with TBI history failed to maintain correct key presses under unsignalled IRTs especially for values of t equal to or greater than 6-seconds. Lastly, the results provide little support for interpretations for why some subjects with TBI history had higher rates of correct key presses than subjects without TBI history, although there were some noted exceptions.

Subjects with TBI history maintained correct key presses under signalled IRTs for any value of t, and under unsignalled IRTs for values of t up to 3-seconds. This is attributed to the presence of a salient auditory stimulus that established a point-to-point correspondence between the message on the screen, PRESS ANY WHITE KEY, and the contingencies in effect when subjects pressed a white key. For example, under signalled IRTs for any value of t, after the signal sounded, any white key press was followed by a 1-cent credit message. Thus, there was a point-to-point correspondence between the rule presented on the screen and the effect of following the rule. The key stimulus feature was an auditory signal that helped subjects establish a temporal discrimination for when responses would be followed by a 1-cent credit message.

The fact that subjects with TBI history failed to maintain correct key presses under unsignalled IRTs especially for values of t equal to or greater than 6-seconds is attributed to the absence of a salient auditory stimulus, or some other stimulus that would help subjects establish a temporal discrimination for when responses would be followed by a 1-cent credit message. Subjects with TBI history
might only respond effectively when discriminative stimuli are immediately available, verbal, salient, or not delayed in time. The 3-, 6-, 12-, or 18-second waiting periods were not specified by the message "PRESS ANY WHITE KEY." Instead, subjects had to learn the unspecified temporal discrimination, i.e., subjects had to learn to wait before responding, in order to receive the 1-cent credit message. As anticipated, under these conditions subjects without TBI history had higher rates of correct responding than subjects with TBI history.

The finding that some subjects with TBI history had higher rates of correct key presses than subjects without TBI history may be attributed to the fact that the times of the IRT session phases were not kept constant, thereby making it difficult to compare rates across session phases. If the session times had been kept constant then the prediction that all subjects with TBI history would have lower rates of correct key presses than subjects without TBI history may have been confirmed.

The findings of Experiment One are in accord with the findings of experimenters who trained subjects with brain disorders to maintain responding for sessions lasting at least 45-minutes (Oscar-Berman et al., 1982; Gianutsos, 1981; Van Zomeren, 1981). For example, Oscar-Berman et al. (1982) conducted their study of DRL performance by having the experimenter sit in the same room with the subject. There was a framed curtain that separated the subject and experimenter who sat facing each other at a table. The experimenter's face was concealed by a black curtain during the trials, but
the hands were still visible to the subjects. A review of the relevant literature would do well to determine how often it was that subjects were left in the room alone during experimental sessions. It would also be instructive for future researchers to determine how often it was reported that subjects with brain disorders became distracted by stimulus events to the point where they left their seat, or turned away at the time when they should have made a response.

The results generated by Hypothesis One were not in accord with what one might conclude when viewing the medical records of subjects with TBI history. The medical records generally described the subjects with TBI history as being highly distractable, hyperactive, and having short attention spans. Unfortunately the medical records did not provide a specific rationale or documentation which explained why these descriptive labels were used. Based on these records it would have been reasonable to expect that subjects with TBI history would have displayed behavior that was incompatible with pressing keys for the entire session time. This was not found to be the case.

The results of Hypothesis Two were in partial accord with findings obtained by Oscar-Berman et al., (1982). Although there were subject, setting, and procedural differences between the present experiment and Oscar-Berman’s et al. study, both studies concluded that subjects with brain disorder, regardless of the etiology, would demonstrate high rates of correct responding only when the discriminative stimuli are salient and immediately available.

There were three major methodological weaknesses in Experiment One. First, there were several programming errors that led to the
loss of data. Improved data collection procedures (i.e., changing the computer program so that data is read and stored in files in a manner where new data could not be written on top of old data) would prevent the loss of data and enable inter- and intra-subject comparisons to be made for each IRT > t session phase. Second, a methodological weakness was the failure to monitor the behavior of the experimenter during the session. If the experimenter’s presence was indeed influencing the subjects’ performance then a formal analysis of the experimenter’s behavior needs to be made. In addition, the length of time that a subject was exposed to a particular IRT > t session phase needs to be kept constant so that rates of correct key pressing can be compared directly. Consistent session times can be achieved in future similar experimentation by rewriting the program to only present trials for a given period of time. This may necessitate the experimenter studying fewer IRT > t conditions during a session. This would allow the experimental session to have more flexible time demands which may be needed in case subjects are tardy getting to the experimental room on time.

Future experimental research would do well to determine the relative effectiveness of verbally mediated and behaviorally contracted contingencies in establishing and maintaining key pressing by persons with TBI history. This focus of research would add to what is already known about the performance of these subjects in clinical settings where rehabilitation professionals are present, and in the privacy of a subject’s home where rehabilitation professionals are absent. Cumulative response records of a subject’s moment-to-moment
session performance are response products that provide tangible evidence with which rehabilitation-related performance can be monitored and contingently reinforced. If these variables can be identified then software developers will be better able to use this information and design more effective retraining packages.

A further question growing out of the current research is to determine if subjects with TBI history can learn to respond effectively to non-salient discriminative stimuli. This line of inquiry would lead to a greater understanding of whether a person with TBI history has permanently lost the ability to make temporal discriminations. It is plausible that these subjects may need longer exposures to the IRT > t schedules. Furthermore, it is suggested that shaping techniques can be used to retrain what may be an impaired ability to form temporal discriminations in the absence of salient cues. Exploration of this question would involve exposing the subjects with TBI history to the specific IRT > t schedules for longer periods of time, and reducing the value of t in the IRT > t schedule, e.g. use criterion values from 0-seconds to 3-seconds that increase by 1/4, or 1/2-second intervals. In this way naturally occurring contingencies may shape behavior that marks time, e.g., tapping fingers and looking at watches, such that persons with TBI history will be able to construct their own salient discriminative stimuli that allows them to form a temporal discrimination within optimal IRT exposure time.
CHAPTER VI

EXPERIMENT TWO

Introduction

Experiment Two was conducted to analyze the effect of contingencies of reinforcement on reaction time scores, and to determine under what conditions persons with and without TBI history have the shortest response latencies. Van Zomeren (1981) used reaction time scores to describe the time rate of recovery of persons with TBI history. It may be argued, however, that Van Zomeren did not achieve a complete explanation of the effect of TBI on reaction time scores because the effects of a verbal prompt, and contingencies of reinforcement on reaction time scores were not systematically analyzed. It is possible that Van Zomeren's experimental subjects were not responding as quickly as possible because contingencies of reinforcement were not in effect, although his subjects were verbally prompted to make their responses as quickly as possible.

The objective of Experiment Two was to improve upon Van Zomeren's methodology by studying the temporal relationship between stimuli, responses, and reinforcement contingencies on the rate of correct matching key presses, and on response latencies, of subjects with and without TBI history. Specifically, response latency was studied in Experiment Two under conditions when neither verbal prompting nor reinforcement contingencies were in effect, when verbal prompting was in effect but reinforcement contingencies were not, and
when both verbal prompting and reinforcement contingencies were in effect. The matching-to-sample (MTS) procedure was used to study the differential effects of reinforcement contingencies on the response latencies of persons with and without TBI history.

The dependent variable studied in Experiment Two was response latency [reaction time] because the temporal relation of responses to discrete environmental events is purported here to be dependent on the reinforcement contingencies that follow the response (Johnston and Pennypacker, 1980).

The independent variable in Experiment Two was the common sequence of MTS conditions to which subjects were exposed. The MTS session phases were systematically varied along the following conditions as the experiment progressed: zero time delay [ZD-MTS] versus variable time delays [VD-MTS] between off-set of sample stimuli and on-set of comparison stimuli; simultaneous [S-MTS] versus non-simultaneous presentations of sample stimulus and comparison stimuli; verbal prompting versus no verbal prompting to make matching response as quickly as possible; and computer-generated temporal reinforcement contingencies versus no computer-generated temporal reinforcement contingencies, i.e., matching responses had to be both correct and prompt. The two hypotheses in Experiment Two were as follows. Hypothesis One stated that subjects with TBI history would have lower rates of correct key pressing than subjects without TBI history for each of the MTS conditions. Hypothesis Two stated that subjects with TBI history would have slower response latencies than subjects without TBI history, for each of the MTS conditions. Specifically,
regardless of TBI history, subjects would show response latencies from fastest to slowest in the following order: (1) the verbal prompt is given, and the computer-generated temporal reinforcement contingencies are in effect, (2) the verbal prompt is given, but the computer generated temporal reinforcement contingencies are not in effect, and (3) the verbal prompt is not given, and the computer-generated temporal reinforcement contingencies are not in effect.
CHAPTER VII

EXPERIMENT TWO

Method

Subjects

The subjects from Experiment One continued their involvement in Experiment Two. There were no changes in the inclusion and exclusion criteria, or informed consent contract.

Experimental Setting and Apparatus

The only changes in setting and apparatus from Experiment One involved changing from IRT to MTS procedures which involved different software and was based on the state diagram seen in Appendix D.

Dependent Measures

MTS Performance

The two dependent measures in Experiment Two were the rate of correct MTS key presses per second, and the latency of MTS key press that corresponded to the sample stimulus, after the two comparison stimuli appeared on the computer monitor.

Response Class

For the MTS tasks, a response was defined as the pressing of a key on the computer keyboard that resulted in an auditory click.
This computer-generated auditory click was of a different tone than the sound made by lightly touching the keys. The click was to help subjects differentiate between key presses that were too light for the computer to detect and those that were detectable by the computer. Different colored stickers were put on the spacebar, V, B, and keys to help subjects find the primary keys used in MTS phases.

**Experimental Design**

Experiment Two used the same modified multiple baseline across subjects design as was used in Experiment One. This design involved the use a so-called multiple "B" design where baseline measurement was omitted, but a single dependent measure was monitored during the course of presenting the five levels of the MTS procedure [levels of an independent variable] to subjects in the manner described below.

**Procedure**

**General Procedure**

Figure 19 graphically represents an example of the stimuli presented on the computer screen to subjects. The foreground grid and geometric figures were green, and the background screen color was black. The stimuli presented were always either a triangle, circle, or square. The effective keys on the keyboard (SPACEBAR, B, V, and N) were covered with colored rectangular stickers (9/16" x 7/16"). A red sticker was placed at the middle of the spacebar, under the B key. A blue sticker was placed on the B key. Two yellow stickers
Figure 19. A nine-celled grid with square sample stimulus in center, and square and triangular comparison stimuli in left and right cells respectively.
were placed on the V and N keys. Stickers were not on any other keyboard keys. Subjects showed that they understood which keys had to be pressed, and which key presses had no effect.

Subjects earned, but never lost, a 1-cent credit for a correct MTS key press. The amount earned during a MTS session was added to the amount earned daily if subjects arrived promptly ($0.25 bonus), arrived in the correct room ($0.25 bonus), worked part of the session ($0.25 bonus), and worked for the entire session ($0.25 bonus).

Appendix K contained examples of MTS response sequences and credit/error messages. Each schematic representation consisted of four or five "screens" set between rows of asterisks, and were based on those of Cumming and Berryman (1965).

After-image was an inherent monitor problem that affected how stimuli were presented to subjects. Before the credit message fully disappeared from the monitor the after-image of the message had to vanish. When the after-image disappeared a new stimulus set appeared, indicating a new trial. Matching responses could be aided by the faint images of the sample stimuli that would be present when the comparison stimuli were visible on the screen. The problem was solved by programming delay intervals that allowed the after-image to disappear before a new stimulus set appeared on the screen.

**Independent Variable Level**

The reinforcement schedules were as follows. The basic schedule was a modifiable matching-to-sample (MTS) procedure in which only one of two stimuli presented on the computer screen matched a
displayed sample stimulus, and in which only responses that correctly matched the sample stimulus were reinforced. A sample stimulus (triangle, square, or circle) randomly appeared in the center of a grid. A blue [B] key press turned on the comparison stimuli to the left and right of the sample stimulus respectively; one comparison stimulus matched the sample stimulus. A press on the yellow key that corresponded to the matching comparison stimulus was followed by a 1-cent credit message. A press on the yellow key that corresponded to the non-matching comparison stimulus was followed by an error message.

Several aspects or levels of the MTS procedure were varied as the experiment progressed. The MTS procedural variations were related to: (1) whether the comparison stimuli were displayed simultaneously with the sample stimulus [simultaneous matching-to-sample (S-MTS)], (2) whether the comparison stimuli were not displayed simultaneously with the sample stimulus, and instead there was a delay of 0-seconds between the off-set of the sample stimulus and the on-set of the comparison stimuli [zero-delay matching-to-sample (ZD-MTS)], (3) whether the delay period between off-set of the sample stimulus and the on-set of the comparison stimuli was longer than 0-seconds, and whether this was a fixed or variable delay interval [variable-delay matching-to-sample (VD-MTS)], (4) whether verbal prompting, to respond as quickly as possible, was added to the ZD-MTS reinforcement contingencies [zero-delay matching-to-sample with verbal prompting (ZD-MTS-VP)], and (5) whether verbal prompting, to respond as quickly as possible, along with latency requirements were added to ZD-MTS reinforcement contingencies that covertly specified
the time limit within which a correct response had to be made [zero-delay matching-to-sample with verbal prompting and computer-generated temporal contingencies (ZD-MTS-VP-TC)]. The session days were numbered consecutively and were conducted Monday thru Friday.

Orientation Phase

Subjects were briefly exposed to several of the experimental phases involved in Experiment Two during the orientation sessions. These orientation sessions were run to reduce "computer phobia" that might impair performance, and to determine if subjects were able to make the requisite key presses in response to stimuli presented on the screen. The MTS orientation phase consisted of subjects performing several trials on each of the different MTS tasks listed above. Each subject's response latency in the ZD-MTS condition was measured. Also measured was the length of delay interval in the VD-MTS condition. These measurements made it possible to tell what times to use during the different MTS conditions.

S-MTS Schedule

S-MTS data were recorded for three consecutive sessions; each session lasted no longer than 50-minutes. The sessions were labeled as follows:

<table>
<thead>
<tr>
<th>DAY</th>
<th>PHASE</th>
<th>EXPLANATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>S-MTS</td>
<td>The sample stimulus was not off-set when</td>
</tr>
<tr>
<td>6</td>
<td>S-MTS</td>
<td>the comparison stimuli were on-set. All</td>
</tr>
<tr>
<td>7</td>
<td>S-MTS</td>
<td>3 stimuli were on the screen when a response was made.</td>
</tr>
</tbody>
</table>
Subjects were given the following instructions at the start of each of S-MTS sessions. Bracketed words were not spoken.

This game is called simultaneous matching. You can win some money, but the amount you win depends on how you play. To begin, press the red key when a message on the monitor tells you to begin. By doing this you will make a grid appear on the screen. In the middle of the grid, you will see either a circle, or a square, or a triangle. The figure in the center of the square is called the sample figure. When you see the sample figure in the center of the grid, press down the blue key once. [Pause for a response.] That’s right! By doing this you make two comparison figures appear on each side of the sample figure [Point to them]. Your task is to compare the sample figure [Point to it] with the comparison figure on the right [Point to it] and with the comparison figure on the left [Point to it]. If the right comparison figure [Point to it] matches the center sample figure [Point to it] then press the right yellow key [Press it]. If the left comparison figure [Point to it] matches the center sample figure [Point to it] then press the left yellow key [Press it]. Now you make the comparison. [Pause for a response] Good! When you make a correct match you will see a message that says you are correct, and that you earned a 1-cent credit, and what your total so far is. When you make an incorrect match you will see an error message. Money credits will never be taken away for incorrect matches. The reward or error message will go off after a few seconds, and a message will appear and will tell you to press down the red key [point to it] to start a new trial. The computer will keep track of your earnings, and you will get this amount in cash when you finish. You are to make as many correct matches and earn as much money as you can. Do you have any questions?

ZD-MTS Schedule

Zero-delay MTS data were recorded for three consecutive 50-minute sessions, and were labeled as follows.

<table>
<thead>
<tr>
<th>DAY</th>
<th>PHASE</th>
<th>EXPLANATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>ZD-MTS</td>
<td>The delay between off-set of sample stimulus and on-set of comparison stimulus was 0-seconds (ZD).</td>
</tr>
</tbody>
</table>
Subjects were given the following instructions at the start of each ZD-MTS session. Bracketed words were not spoken.

This task is like a game. I call it no-delay matching. You can win some money, but the amount you win depends on how you play. The game is more difficult than the game we called simultaneous matching. Thus, you may not earn as much money as you did before. But, remember, the amount you earn depends on how you play. To begin, press the red key message on the monitor tells you to begin. [Pause for a response.] Good! By doing this you will make a grid appear on the screen. In the middle of the grid, you will see either a circle, or a square, or a triangle. The figure in the center of the square is called the sample figure. When you see the sample figure in the center of the grid, press the blue key once. [Pause for a response.] That's right! By doing this you make the sample figure disappear, and make 2 comparison figures appear on each side of where the sample figure was. Your task is to compare the sample figure [Point to where it was] that was here, with the comparison figure on the right [Point to it] and with the comparison figure on the left [Point to it]. If the right comparison figure [Point to it] matches the figure that was in the center [Point to the center] then press the right yellow key [Press it]. If the left comparison figure [Point to it] matches the figure that was in the center [Point to the center] then press the left yellow key [Point to it]. Now you make the comparison. [Pause for a response] Good! When you make a correct match you will see a message that says you are correct, and that you earned a 1-cent credit, and what your total so far is. When you make an incorrect match you will see an error message. Money credits will not be taken away for incorrect matches. The reward or error message will go off after a few seconds, and a message will appear and will tell you to press down the red key [Point to it] to start a new trial. The computer will keep track of your earnings, and you will get this amount in cash when you finish. You are to make as many correct matches and earn as much money as you can. Do you have any questions?"

**VD-MTS Schedule**

Variable-delay MTS data were recorded for three consecutive 50-minute sessions, and were labeled as follows:
The variable delay (VD) between off-set of the sample stimulus and on-set of comparison stimuli were 150-, 200-, and 250-seconds.

Subjects were given the following instructions at the start of each VD-MTS session. Bracketed words were not spoken.

This task is called different delay matching. You can win some money, but the amount you win depends on how you play. The game is more difficult than the game we called simultaneous matching, or no-delay matching. So, you may not earn as much money as you did before.

To begin, press the red key when a message on the monitor tells you to begin. [Pause for a response.] Good! By doing this you make a grid appear on the screen. In the middle of the grid, you will see either a circle, or a square, or a triangle. The figure in the center of the grid is called the sample figure. When you see the sample figure press the blue key once. [Pause for a response] That's right! By doing this you will make the sample figure disappear. A short delay will then follow, and 2 comparison figures will appear on each side of where the sample figure was.

Your task is to compare the sample figure [Point to where it was] that was here, with the comparison figure on the right [Point to it] and with the comparison figure on the left [Point to it]. If the right comparison figure [Point to it] matches the figure that was in the center [Point to the center] then press the right yellow key [Point to it]. If the left comparison figure [Point to it] matches the figure that was in the center [Point to the center] then press the left yellow key [Point to it]. Now you make the comparison. [Pause for a response] Good!

When you make a correct match you will see a message that says you are correct, and that you earned a 1-cent credit, and what your total so far is. When you make an incorrect match you will see an error message. Money credits won't be taken away for incorrect matches. The computer keeps track of how much money you earn, and you will get this amount in cash when you finish.

Your task is to make as many correct matches and earn as much money as you can. Do you have any questions?
ZD-MTS-VP schedule

Data for zero-delay matching-to-sample with verbal prompting were recorded for three consecutive 50-minute sessions. The verbal prompt was for subjects to make the correct matching response as quickly as possible. The sessions were labeled as follows:

<table>
<thead>
<tr>
<th>DAY</th>
<th>PHASE</th>
<th>EXPLANATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>ZD-MTS-VP</td>
<td>The delay interval between off-set of sample stimulus and comparison stimuli was 0-seconds (ZD). Subjects were verbally prompted (VP) to make the correct matching-to-sample key press as quickly as possible in response to the comparison stimuli.</td>
</tr>
<tr>
<td>15</td>
<td>ZD-MTS-VP</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>ZD-MTS-VP</td>
<td></td>
</tr>
</tbody>
</table>

ZD-MTS-VP schedule

The ZD-MTS-VP procedure differed from the ZD-MTS schedule because the ZD-MTS-VP schedule involved adding the verbal phrase, "make your matching response as quickly as you can" to the instructions. Whether or not subjects received the 1-cent credit message was contingent only on an accurate matching-to-sample key press, and not on whether the matching-to-sample key press was made within a time interval after the comparison stimuli were presented on the screen.

A 1-cent credit message followed each correct matching-to-sample key press. During the session trials, subjects were given unlimited time within which to make the matching-to-sample key presses in response to the comparison stimuli.

Subjects were given the following instructions at the start of each ZD-MTS-VP session. Bracketed words were not spoken.
This task is like a game. I call it no-delay quick matching. This game is more difficult than the other games you have played. Therefore, you may not earn as much money as you did before. Remember, the amount you earn depends on how you play. To begin, press the red key when a message on the monitor tells you to begin. By doing this you will make a grid appear on the screen. In the middle of the grid, you will see either a circle, or a square, or a triangle. The figure in the center of the square is called the sample figure. When you see the sample figure in the center of the grid, press the blue key once. [Pause for a response.] That's right! By doing this you will make the sample figure disappear and two comparison figures will appear on each side of where the sample figure first appeared. One of the comparison figures will match the sample figure, and the other comparison will not. Your task is to, as quickly as you can, compare the sample figure [Point to where it was] that was here, with the comparison figure on the right [Point to it] and with the comparison figure on the left [Point to it]. If the right comparison figure [Point to it] matches the figure that was in the center [Point to the center] then, as quickly as you can, press the right yellow key [Point to it]. If the left comparison figure [Point to it] matches the figure that was in the center [Point to the center] then, as quickly as you can, press the left yellow key [Point to it]. Now you make the comparison. [Pause for a response] Good! [or correct as needed]. When you make a correct match you will see a message that says you are correct, and that you earned a 1-cent credit, and what your total so far is. When you make an incorrect match you will see an error message. Money credits won't be taken away for incorrect matches. The reward or error message will go off after a few seconds, and a message will appear and will instruct you to press down the red key to start a new trial. The computer will keep track of how much money you earn, and you will get this amount in cash when you finish. Remember, your task is to make as many correct matches, and earn as much money as you can. Do you have any questions?"

ZD-MTS-VP-TC schedule

The final phase of Experiment Two, zero-delay matching-to-sample with verbal prompting and computer-generated temporal contingencies, was conducted for three consecutive 50-minute sessions, and was labeled as follows:
The delay interval between off-set of sample stimulus and on-set of comparison stimuli was 0-seconds (ZD). Subjects were verbally prompted (VP) to make the key press as quickly as possible. Computer-generated temporal contingencies (TC) programmed correct responses to be followed by a 1-cent credit if made within a set interval after on-set of comparison stimuli.

The ZD-MTS-VP-TC procedure made the receipt of a 1-cent credit message contingent on both an accurate matching key press, and on making the matching response within a given interval after the on-set of comparison stimuli. The object of the second latency phase was to differentially reinforce favorable waiting behavior and more vigorous responses. Under ZD-MTS-VP-TC, computer-generated temporal contingencies were introduced such that a 1-cent credit message did not follow a key press if the response was slower than 1-second. An error message, "Your Matching Response Was Not Quick Enough," appeared on the screen for 5-seconds. The screen went blank, and after the after-image disappeared, another trial began. This procedure exposed subjects to a series of progressively decreasing duration times. The initial criterion was established during the orientation session and was set at 0.6 seconds for subjects with TBI history, and 0.45 seconds for subjects without TBI history. When five consecutive correct-and-quick enough responses were made at 0.6/0.45 seconds, the interval was reduced by 0.01 seconds. If five consecutive correct-and-quick enough responses were made at this newest criterion, the time limit was again reduced by another 0.01 seconds.
The lowest-latency titration process, of reducing the duration criterion by 0.01 seconds after 10 consecutive correct-and-quick-enough MTS responses were made, continued until a criterion was reached where subjects were unable to emit 5 consecutive correct-and-quick-enough MTS responses, or, when subjects emitted 10 consecutive correct-but-not-quick enough MTS responses. If a session ended without subjects emitting 5 correct-and-quick-enough responses, the next session began with the criterion set 0.01 seconds above the original criterion. If a subject emitted 10 consecutive correct-and-quick-enough MTS responses, the criterion was immediately decreased by 0.01 second. The goal of the lowest-latency titration process was to determine the shortest duration criterion at which subjects maintained accurate MTS responses. Two situations were described above in which subjects could not maintain a minimal level of performance at a given criterion. When this level was determined, the criterion was raised to the next highest criterion (to make the task easier). This next highest criterion was the last criterion under which subjects maintained accurate-and-quick-enough MTS responses.

Instructions for the ZD-MTS-VP-TC schedule were similar to the ZD-MTS-VP except for a few changes which involved introducing computer-generated temporal contingencies to the already existing MTS requirements. Subjects were given the following instructions at the beginning of each session. Bracketed words were not spoken.

This task is called 'no-delay, quick matching.' You can win some money, but the amount you earn depends on how you play. This game is a more difficult than the one we called 'quick matching.' So, you may not earn as much money as you did before. To begin, press the red key
once, when a message on the screen tells you to do so. [Pause for a response] Good! By doing this you make the grid appear on the screen. In the middle cell of the grid you will again see a sample figure. The sample figure will be either a circle, square, or triangle. When you see the sample figure, press down the blue key once. [Pause for a response] Good! By doing this you make the sample figure disappear, and at the same time, you make two comparison figures appear. One comparison figure will be in the cell to the right of where the sample figure was. The other comparison figure will be in the cell to the left of where the sample figure was. One of the comparison figures will match the sample figure that just disappeared. The other comparison figure will not match the sample figure. If the comparison figure in the right-hand cell matches the sample figure that was in the center, then as quickly as you can, push down one time on the yellow key to the right of the blue key. If the comparison figure in the left-hand cell matches the sample figure that was in the center, then as quickly as you can, push down one time on the yellow key to the left of the blue key. When you make a correct match, and, if your response was quick enough, then you will see a 1-cent credit message on the monitor. The reward message will tell you that you made a correct and quick enough match, that you earned a 1-cent credit, and what are your total earnings so far. If you do not make a correct match, then an error message will say that your match was incorrect. If your response was not quick enough, an error message will say your response was not quick enough. If you match was incorrect and too slow, then an error message will tell you that your match was incorrect and not quick enough. You are to solve as many matching problems as you can, and, to make your matching responses as quickly as you can. The more you solve, the more money you will earn. The computer keeps track of your earnings. You will receive the money you earn when the session is over. All the money you earn is yours to keep. You have 50-minutes to solve as many matching problems as you can. Do you have any questions?
Experiment Two modified Van Zomeren’s (1981) methodology to analyze the effect of using reinforcement contingencies to reduce reaction times, and to determine under what conditions subjects with and without TBI history have the shortest latencies. Although verbally prompted to make their responses as quickly as possible, subjects with TBI history may not have responded as quickly as possible in Van Zomeren’s study because reinforcement contingencies were not used. Thus, in Experiment Two response latency performance was studied under conditions when reinforcement contingencies were not in effect, verbal prompting “respond as quickly as possible,” was used without reinforcement contingencies, and verbal prompting and reinforcement contingencies were both used. Cumulative response latency records were generated for each subject’s matching-to-sample (MTS) performance which also yielded reaction time scores. The full array of the cumulative response latency records are in Appendices L to P.

Hypothesis One specifically predicted that subjects with TBI history would have lower rates of correct key pressing than subjects without TBI history under the following MTS conditions: S-MTS, ZD-MTS, VD-MTS, ZD-MTS-RT-VP, and ZD-MTS-RT-VP-TC. This prediction received some support but the data were equivocal. Subjects with TBI history had higher rates than one subject (S2) without TBI history,
and one subject without TBI history had lower rates than expected given the absence of any evidence of TBI. Given the equivocal findings it was concluded that Hypothesis One was not confirmed.

Inspection of Table 3, which summarizes information in the cumulative response latency records, revealed that rates of correct MTS responding got lower as subjects progressed from S-MTS to ZD-MTS, and to VD-MTS. The list of values represents the quotients derived by dividing the number of correct white key presses by the total session phase time. The session phase time was not kept constant due to a computer programming error which complicated comparing the quotients in Table 3. It was still possible, however, to make reasonable comparisons based on cumulative response latency records and visually estimating how the curves might have appeared had the total session phase time been kept constant.

Under each of the MTS conditions there were instances when subjects with TBI history had higher rates of correct MTS responses than subjects without TBI history. Regardless of TBI history, subjects performed poorest under the variable delay MTS condition. Furthermore, the effect of the verbal prompt was to reduce the rate of correct MTS responses under zero delay MTS conditions. When comparing the available data for S1 with corresponding MTS conditions for S2, S1 had lower rates of correct MTS responses. The effect of the computer-generated temporal contingencies of reinforcement was to reduce the rate of correct MTS responses under zero delay MTS conditions. Inspection of Table 3 reveals that the use of both computer-generated temporal contingencies of reinforcement and a
# Table 3

Rate of Correct Matching-to-Sample (MTS) Key Presses Per Total Number of Seconds for Subjects With and Without TBI History, Under Different MTS Schedules

<table>
<thead>
<tr>
<th>Day</th>
<th>MTS Condition</th>
<th>Subjects With TBI History (R1, R2, &amp; R3)</th>
<th>Subjects Without TBI History (S1 &amp; S2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>R1</td>
<td>R2</td>
</tr>
<tr>
<td>5</td>
<td>S-MTS</td>
<td>.0355</td>
<td>.0333</td>
</tr>
<tr>
<td>6</td>
<td>S-MTS</td>
<td>.0358</td>
<td>.0396</td>
</tr>
<tr>
<td>7</td>
<td>S-MTS</td>
<td>.0364</td>
<td>.0392</td>
</tr>
<tr>
<td>8</td>
<td>ZD-MTS</td>
<td>.0259</td>
<td>.0288</td>
</tr>
<tr>
<td>9</td>
<td>ZD-MTS</td>
<td>.0304</td>
<td>.0318</td>
</tr>
<tr>
<td>10</td>
<td>ZD-MTS</td>
<td>.0294</td>
<td>.0320</td>
</tr>
<tr>
<td>11</td>
<td>VD-MTS-150s</td>
<td>.0091</td>
<td>.0100</td>
</tr>
<tr>
<td>12</td>
<td>VD-MTS-200s</td>
<td>.0082</td>
<td>.0060</td>
</tr>
<tr>
<td>13</td>
<td>VD-MTS-250s</td>
<td>.0066</td>
<td>.0056</td>
</tr>
<tr>
<td>14</td>
<td>ZD-MTS-RL-VP</td>
<td>.0289</td>
<td>.0305</td>
</tr>
<tr>
<td>15</td>
<td>ZD-MTS-RL-VP</td>
<td>.0187</td>
<td>.0175</td>
</tr>
<tr>
<td>16</td>
<td>ZD-MTS-RL-VP</td>
<td>.0208</td>
<td>.0148</td>
</tr>
<tr>
<td>17</td>
<td>ZD-MTS-RL-VP-TC</td>
<td>.0209</td>
<td>.0206</td>
</tr>
<tr>
<td>18</td>
<td>ZD-MTS-RL-VP-TC</td>
<td>.0193</td>
<td>.0194</td>
</tr>
<tr>
<td>19</td>
<td>ZD-MTS-RL-VP-TC</td>
<td>.0199</td>
<td>.0212</td>
</tr>
</tbody>
</table>

**Note**

Lost data are represented by asterisks (****), and subject absences are represented by plus signs (+++++). S-MTS = simultaneous MTS. ZD-MTS = zero delay MTS. VD-MTS = 150-, 200-, and 250-second variable delay MTS. ZD-MTS-RL-VP = zero delay MTS with response latency recorded and verbal prompt given. ZD-MTS-RL-VP-TC = zero delay MTS with response latency recorded, verbal prompt given, and computer-generated temporal contingencies of reinforcement in effect.
generated temporal contingencies of reinforcement and a verbal prompt does not result in lower rates of correct MTS responses than just using a verbal prompt without computer-generated temporal contingencies of reinforcement.

Hypothesis Two predicted that subjects with TBI history would have slower response latencies than subjects without TBI history, for each of the MTS conditions. Specifically, regardless of TBI history, subjects were expected to have response latencies from fastest to slowest in the following order. Quickest latencies would occur when the verbal prompt is given, and the computer-generated temporal reinforcement contingencies are in effect. The next fastest latencies would occur when the verbal prompt is given, but the computer-generated temporal reinforcement contingencies are not in effect. The slowest latencies would occur when the verbal prompt is not given, and the computer-generated temporal reinforcement contingencies are not in effect.

Inspection of Table 4, which summarizes the information in the cumulative response latency records, reveals that regardless of TBI history, subjects had the slowest median response latencies under the variable delay MTS condition when the verbal prompt was not given and the computer-generated temporal reinforcement contingencies were not in effect. The median was used for the measure of central tendency because mean response latency distributions tend to be positively skewed, meaning that very long latencies are possible while negative ones are not (Van Zomeren, 1981; Baron, 1985). Contrary to prediction, the introduction of the verbal prompt had the same general
Table 4

Median Response Latencies, in Seconds, of Matching-to-Sample (MTS) Key Presses for Subjects With and Without TBI History, Under Different MTS Schedules

<table>
<thead>
<tr>
<th>Day</th>
<th>MTS Condition</th>
<th>Subjects With TBI History (R1, R2, &amp; R3)</th>
<th>Subjects Without TBI History (S1 &amp; S2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>R1</td>
<td>R2</td>
</tr>
<tr>
<td>5</td>
<td>S-MTS</td>
<td>0.91</td>
<td>1.15</td>
</tr>
<tr>
<td>6</td>
<td>S-MTS</td>
<td>0.87</td>
<td>0.91</td>
</tr>
<tr>
<td>7</td>
<td>S-MTS</td>
<td>0.99</td>
<td>0.99</td>
</tr>
<tr>
<td>8</td>
<td>ZD-MTS</td>
<td>0.95</td>
<td>0.83</td>
</tr>
<tr>
<td>9</td>
<td>ZD-MTS</td>
<td>1.03</td>
<td>0.91</td>
</tr>
<tr>
<td>10</td>
<td>ZD-MTS</td>
<td>1.19</td>
<td>0.95</td>
</tr>
<tr>
<td>11</td>
<td>VD-MTS-150s</td>
<td>2.14</td>
<td>2.10</td>
</tr>
<tr>
<td>12</td>
<td>VD-MTS-200s</td>
<td>2.14</td>
<td>3.40</td>
</tr>
<tr>
<td>13</td>
<td>VD-MTS-250s</td>
<td>2.38</td>
<td>5.94</td>
</tr>
<tr>
<td>14</td>
<td>ZD-MTS-RL-VF</td>
<td>0.67</td>
<td>1.11</td>
</tr>
<tr>
<td>15</td>
<td>ZD-MTS-RL-VF</td>
<td>0.28</td>
<td>0.40</td>
</tr>
<tr>
<td>16</td>
<td>ZD-MTS-RL-VF</td>
<td>0.32</td>
<td>0.52</td>
</tr>
<tr>
<td>17</td>
<td>ZD-MTS-RL-VF-TC</td>
<td>0.28</td>
<td>0.36</td>
</tr>
<tr>
<td>18</td>
<td>ZD-MTS-RL-VF-TC</td>
<td>0.28</td>
<td>0.32</td>
</tr>
<tr>
<td>19</td>
<td>ZD-MTS-RL-VF-TC</td>
<td>0.32</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Note: Lost data are represented by asterisks (****), and subject absences are represented by plus signs (++++). S-MTS = simultaneous MTS. ZD-MTS = zero delay MTS. VD-MTS = 150-, 200-, and 250-second variable delay MTS. ZD-MTS-RL-VF = zero delay MTS with response latency recorded and verbal prompt given. ZD-MTS-RL-VF-TC = zero delay MTS with response latency recorded, verbal prompt given, and computer-generated temporal contingencies of reinforcement in effect.
effect as the introduction of the computer-generated temporal contingencies of reinforcement on response latencies, i.e., there was no significant difference between response latencies when a verbal prompt was used alone or with computer-generated temporal contingencies of reinforcement. A noted exception was on the first day of ZD-MTS-RL-VP when the latencies were noticeably higher than for the scores on the next two days. On days 2 and 3 of the ZD-MTS-RL-VP condition the latencies were similar to those under the ZD-MTS-RL-VP-TC condition. Introducing the verbal prompt and/or computer-generated temporal contingencies of reinforcement had the effect of lowering response latencies as compared to higher response latencies under ZD-MTS conditions when neither the verbal prompt nor computer-generated temporal contingencies of reinforcement were used. Inspection of Table 4 also reveals that in almost every comparable MTS condition subjects without TBI history had lower response latencies than subjects with TBI history. The only noted exception concerns Rl's greater average and median latencies for day one of the ZD-MTS-RL-VP condition as compared to S2's.

There were three main visual effects on the appearance of cumulative response latency records when the MTS conditions were changed. First, the number of demarcations on the -1 x-axis horizontal line decreased as the conditions changed from S-MTS to ZD-MTS to VD-MTS. This effect can be seen by comparing the density, number of demarcations per unit time, of Figures 20, 21, and 22. Second, the grouping of the data points was differentially higher or lower on the y-axis under certain MTS conditions. For example, Figure 23 shows
Figure 20. Response Latency Record of A S-MTS Session Phase.

Note: The subject, R1, was a male adult with a history of traumatic brain injury. S-MTS = simultaneous matching-to-sample. There was no off-set of the sample stimulus when the comparison stimuli were presented on the screen. The reinforcement rate, number of reinforced responses per total number of seconds, was 98/2689.08 or .0364. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Latency of response was measured in seconds from the onset of the sample stimulus to the pressing of a key which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.
Figure 21. Response Latency Record of A ZD-MTS Session Phase.

The subject, Rl, was a male adult with a history of traumatic brain injury. ZD = zero delay interval between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The reinforcement rate, number of reinforced responses per total number of seconds, was 69/2659.14 or .0259. Diamond-shaped pips on the ascending and descending lines along the S-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from the onset of the sample stimulus to the key press which corresponded to comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.
Figure 22. Response Latency Record of A VD-MTS-150s Session Phase.

Note
The subject, R1, was a male adult with a history of traumatic brain injury. VD = variable delay interval between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The average delay interval was 150 seconds. The reinforcement rate, number of reinforced responses per total number of seconds, was 24/2648.37 or .0091. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of the sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.
Figure 23. Response Latency Record of A ZD-MTS-RT-VP-TC Session Phase.

Note

The subject, R1, was a male adult with a history of traumatic brain injury. ZD = zero delay between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. TC = computer-generated temporal contingencies of reinforcement. The rate of correct key presses per total number of seconds was 65/3258.92 or .0199. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.
the positioning of the data points under the ZD-MTS-RT-VP-TC condition. All of the data points are grouped underneath the y-axis line indicating a 1-second latency of response. The positioning of the data points in Figure 23 is different than that in Figure 22. In the latter figure, which depicts R1’s performance under the VD-MTS-150s condition, the data points are grouped in a range from a response latency of about 1-second to about 4-second. A final example involves Figure 24, which depicts R1’s performance under the S-MTS condition. Here, all of the data points except one are grouped in a range below the 2 seconds response latency. The one datum point is at about the 12-second response latency level.

And third, the addition of computer-generated temporal contingencies of reinforcement and the incorporation of the verbal prompt had the effect of grouping all data points below the 1-second response latency line. These effects are readily seen in Figures 25, 26. The effect is not seen in Figure 27. This finding is in accord to the above-mentioned observation that on the first day of the ZD-MTS-RL-VP, the average and median response latencies were noticeably higher than the next two days under the same MTS conditions. The appearance of Figures 28 and 29 are clearly different than that of Figure 26, and this difference typifies the difference in response latency between day one and days two and three of ZD-MTS-RL-VP.
The subject, R1, was a male adult with a history of traumatic brain injury. S-MTS = simultaneous matching-to-sample. There was no off-set of the sample stimulus when the comparison stimuli were presented on the screen. The reinforcement rate, number of reinforced responses per total number of seconds, was 61/1719.51, or .0355. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Latency of response was measured in seconds from the onset of the sample stimulus to the pressing of a key which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.
Figure 25. Response Latency Record of A ZD-MTS-RL-VP Session Phase.

Note
The subject, S2, was a male adult with no history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. The rate of correct key presses per total number of seconds was 46/2688.33 or .0171. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
Figure 26. Response Latency Record of A ZD-MTS-RL-VP-TC Session Phase.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. ZD = zero delay between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. TC = computer-generated temporal contingencies of reinforcement. The rate of correct key presses per total number of seconds was 49/2702.43 or .0181. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
Figure 27. Response Latency Record of A ZD-MTS-RL-VP Session Phase.

Note

The subject, Rl, was a male adult with a history of traumatic brain injury. ZD = zero delay interval between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. The reinforcement rate, number of reinforced responses per total number of seconds, was 80/2770.33 or 0.0289. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.
Figure 28. Response Latency Record of A ZD-MTS-RL-VP Session Phase.

Note

The subject, Rl, was a male adult with a history of traumatic brain injury. ZD = zero delay interval between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. The reinforcement rate, number of reinforced responses per total number of seconds, was 50/2674.98 or .0187. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
Figure 29. Response Latency Record of a ZD-MTS-RL-VP Session Phase.

Note

The subject, R1, was a male adult with a history of traumatic brain injury. ZD = zero delay interval between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. The reinforcement rate, number of reinforced responses per total number of seconds, was 55/2638.87 or .0208. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.
Experiment Two modified Van Zomeren's (1981) methodology to analyze the effect of using both verbally-generated and computer-generated temporal reinforcement contingencies to reduce the response latency of subjects with and without TBI history. Response latency performance was studied under conditions when computer-generated reinforcement contingencies were not in effect, verbal prompting was used without computer-generated reinforcement contingencies, and verbal prompting and computer-generated reinforcement contingencies were both used. Cumulative response latency records were generated for each subject's matching-to-sample (MTS) performance.

The results of Hypothesis One provide little support for interpretations of why some subjects with TBI history had higher rates of correct MTS key presses than a subject without TBI history, although there were some noted exceptions. The finding that some subjects with TBI history had higher rates of correct MTS key presses than subjects without TBI history may be attributed to the fact that the times of the MTS session phases were not kept constant, thereby making it difficult to compare rates across session phases. It is purported that if session times were the same then the prediction that all subjects with TBI history would have lower rates of correct key presses than subjects without TBI history would have been confirmed.
The results of Hypothesis Two provide little support for interpretations for why, contrary to original expectations, the response latency was more effectively mediated by the introduction of the verbal prompt than by the introduction of computer-generated temporal contingencies of reinforcement on response latencies, i.e., the response latencies were not significantly lower when a verbal prompt was used alone as compared to when used in conjunction with computer-generated temporal contingencies of reinforcement. A noted exception was on the first day of ZD-MTS-RL-VP when the latencies were noticeably higher than for the scores on the next two days. On days two and three of the ZD-MTS-RL-VP condition the latencies were similar to those under the ZD-MTS-RL-VP-TC condition. In terms of the cumulative response latency records, a significant difference between response latencies when verbal prompt and computer-generated temporal reinforcement contingencies were in effect, would have resulted in a clearer separation of the grouping of the data points. This visual separation was only observed in the cumulative records for the noted exception described above. This finding suggests that definite conclusions about the beneficial effect of temporal reinforcement contingencies on effective waiting behavior and more vigorous responding over and above those of only using verbal prompts may be premature.

The fact that the effect of the verbal prompt was similar to the effect of computer-generated temporal reinforcement contingencies may be attributed to the function altering effect of the set of instructions, i.e., contingency specifying verbal stimuli, that included the verbal prompt for subjects to press a key as quickly as
they could—under certain stimulus conditions. The function of the stimulus described by the contingency specifying stimuli (verbal prompt), e.g., the appearance of the comparison MTS stimuli, may have been altered in the following manner. Under the ZD-MTS-VP conditions, the comparison MTS stimuli may have evoked effective waiting behavior and more vigorous MTS key pressing, whereas under ZD-MTS it may have evoked non-effective waiting behavior and non-vigorous MTS key presses.

There are, however, alternate explanations for why subjects did not have faster response latencies under ZD-MTS-VP-TC conditions as compared to ZD-MTS-VP conditions. One reason is that under the ZD-MTS-VP-TC condition, the error message "response too slow, sorry" which appeared on the monitor after a too-slow MTS key press did not differentially punish less effective waiting behavior and less vigorous responses. A procedure where 1-cent was deducted from the total earnings may have more effectively punished ineffective waiting behavior and less vigorous responses. As it was, ineffective waiting behavior and less vigorous responses only resulted in 1-cent credits not being accumulated, rather than being deducted.

It is also plausible that the 1-cent credit message was only functioning to reinforce maintained key pressing throughout the session, rather than to differentially reinforce more effective waiting behavior and more vigorous MTS key presses. This suggestion is supported by the fact that faster response latencies resulted only when the verbal prompt was used, and that computer-generated temporal reinforcement contingencies had little additional effect on producing
faster response latencies. Future researchers would do well to investigate the effect of a condition not used in the current study, namely ZD-MTS-TC, where the verbal prompt is not used. If verbal prompting is functioning to alter the effectiveness of the 1-cent credit message as a reinforcer, then not using the verbal prompting under the ZD-MTS-TC condition may result in slower, not faster response latencies as compared to the ZD-MTS-VP condition.

Limitations in the sensitivity of the computer keyboard may have masked substantial differences in response latency between ZD-MTS-VP and ZD-MTS-VP-TC conditions. There may be a cellular effect in the technical ability of the computer hardware to record latencies of responses entered through the computer keyboard. This problem may be alleviated by using a response input device that bypasses the computer keyboard.

The findings of Experiment Two were in accord with findings obtained by Van Zomeren (1981). Although there were subject, setting, and procedural differences between the present experiment and the Van Zomeren study, both studies reached similar conclusions about the effect of head injury on reaction time. The clear difference in response latencies between subject groups can be attributed to the presence or absence of a history of TBI. The instance when a subject with TBI history had a faster median response latency than that of a subject without TBI history is considered to be either an artifact or an instance when performance variation resulted in an unusual finding. The former explanations should not be taken for granted. If the latter explanation is the case, it then behooves future
researchers to more thoroughly analyze the conditions under which such performance was obtained. This may be done by video- and audio-taping the sessions. Regardless of TBI history, subjects may have been performing under different levels of fatigue, emotional upset, or distraction due to self-statements based on pre-session daily occurrences. Such determinants may have altered the subjects' performance to produce the unexpected results.

Van Zomeren reported that the most frequent complaint by 62 head-injured patients in a later stage of recovery was memory problems. He did not, however, study short-term memory. By the appropriate manipulation of certain parameters, the matching-to-sample procedure may be altered to study short-term memory. This was the point of using the VD-MTS condition in the current study, and the results indicated that variable delays as great as 250 seconds did not affect subjects matching accuracy. This finding is in partial accord with a classic study of memory conducted by Sidman, Stoddard, and Mohr (1968), who tested a patient known as H.M., some 12-years after undergoing a radical bilateral medial temporal-lobe resection in the hope of lessening the occurrence of incapacitating seizures which were not controllable by medication, on a delayed matching-to-sample problem with verbal and nonverbal material.

H.M.'s seizures were reduced in frequency and severity after the operation, but he showed a complete post-operative loss of memory for events subsequent to the resection, together with a partial retrograde amnesia for the three years leading up to the operation; but early memories were seemingly normal and there was no
impairment of personality or general intelligence (Scoville & Milner, 1957). Sidman et al., (1968) reported that H.M. had shown little change in his previously-reported severe loss of memory for recent events, e.g., inability to remember events that happened minutes previously, failure to recognize people with whom he had recently spent many hours, and inability to name places to which he had just come or places he had been during previous days.

During Sidman’s et al. MTS testing sessions, H.M. was able to make correct matching responses even after a 40-second delay between the off-set of the sample stimulus and the on-set of the comparison stimuli; subjects with TBI history in the current study were able to make correct matching key presses even after delays of 250 seconds. However, H.M. was not able to make correct matching responses after extended delays when the MTS stimuli were nonverbal in nature; however, subjects with TBI history in the current study were able to make correct matching key presses after extended delays when the MTS stimuli were nonverbal in nature.

The essential determinant H.M.’s poor nonverbal MTS responding was purported to be his inability to rehearse what the key stimulus was during the delay interval. This inability was supposedly the result of H.M. not inventing a verbal code for differently shaped ellipses, the nonverbal stimuli, although normal subjects did. In the current study, the nonverbal MTS stimuli were easily recognizable shapes, e.g., circle, triangle, and square, and therefore, may have contributed to rehearsal during the VD-MTS delay interval the result of which was near-perfect performance. The near-perfect VD-MTS
performance in the current study, as compared to H.M.‘s poor non-verbal MTS performance, may be attributed to the more specific locus of the bilateral hippocampal lesion for H.M., versus a more diffused brain injury for subjects with TBI in the current study.

The findings of Experiment Two were not in accord with findings obtained by Baron and Menich (1983). Given that there were subject, setting, and procedural differences between the present experiment and the Baron and Menich study, both studies reached different conclusions about the effect of imposing increasingly stringent time limits on reaction time measures as compared to conditions when the limits were not imposed and subjects were verbally prompted to make MTS key presses as quickly as possible under specific stimulus conditions. Unlike the present study which used response latency, the Baron and Menich study, which used response speed, reported that imposing stringent time limits resulted in faster response speeds which exceeded those when only verbal prompting was imposed. It may be the case in the present study that the lack of traditional data analysis techniques masked statistically significant differences in response latency scores.

It is strongly suggested, however, that visually inspecting the current study’s cumulative response latency records constituted a more severe test and determination of what is, and is not, a substantial difference in response latency under various stimulus conditions. The criterion of statistical significance may not be sufficient to result in a visually apparent separation of groups of data points when comparing cumulative records for different conditions.
Visually inspecting the grouping of the data points in cumulative response latency records has clinical implications for how these records may be used as response products to monitor the on-going in-the-clinic and/or in-the-home usage of specific computer software packages which may, among other things, measure response latency and then graphically present a person's performance.

Traditional measures of central tendency, as were used in the Baron and Menich study, may provide little clinical utility in providing a visual demonstration of a subject's moment-to-moment latency-related behaviors. Cumulative response latency records indicate more readily when performance varied during the session. Knowing when during a session performance varied will enable clinicians to analyze what environmental determinants and/or a subject's self-statements may be impacting on performance outcome.

The methodological weaknesses in Experiment Two are as follows. First, the experimental design was not balanced to control for possible sequence effects. Altering the design is discussed in the section below that deals with future experimental research. Second, the length of the session phases were not kept constant and this impaired the ability to make direct comparisons between the rate of correct MTS key presses, and may have affected the values for median response latency scores. Methods for correcting the session phase duration recording time was discussed previously in Experiment One's discussion section.

Third, programming limitations involving the computer keyboard did not make it possible to mandate that subjects keep the blue key
pressed down until the comparison stimuli appeared on the monitor. This limitation created the following two problems. One, subjects were able to make guessing-like pre-response behaviors by hovering their fingers above one of the two alternative response keys. And, second, it was impossible to split up the total response latency into a decision time component and a movement time component. It is plausible that function-altering contingency specifying verbal stimuli may influence decision time and movement time differently.

And, fourth, the current MTS experimental design was not a free operant situation where subjects were free to emit responses at any time. If responses were not made within a specified time period, then the "response" was considered wrong, recorded as such, an error message was delivered, and a new trial was eventually initiated. The problem is that in the non-free operant situation, a cumulative response record (note the difference between a cumulative response latency record), on which the number of responses are graphed against time, cannot be created in such a way that not maintaining responses is reflected as a horizontal slope, and that increases in response rates are reflected in steeper slopes. One factor that argues against a free-operant response latency design is that the "real world" does not wait until one finally makes the response before stimulus feedback of some kind is delivered indicating whether the response was or was not fast enough. For example, one may have a split second to successfully apply the brakes of a vehicle in order to avert a collision. The collision will occur regardless if the response is made too slow or not at all. The answer from a
programming perspective is to record the response latency of a response, while simultaneously determining whether the response was made within stringent time limits. From a real world perspective, there may be little point in recording response latencies that are longer than the stringent time limit. It may be informative from an instructional point of view to know how slow the response was given the fact that it did not meet the requirements of the stringent time limit. This knowledge would give clinicians a criterion with which rehabilitative goals can be targeted that may focus on either or both of the movement or decision reaction time performance components.

Future experimental research would do well to determine if the results obtained in the current study are due to the effect of sequencing the MTS conditions, e.g., compare performance between the following sequences of MTS session phases: ZD-MTS-VP ZD-MTS-VP-TC ZD-MTS-TC versus ZD-MTS-TC ZD-MTS-VP ZD-MTS-VP-TC. A person’s learning history may be such that the effect of a command may carry over to conditions when the command is not given.

Furthermore, it would be clinically relevant to determine if computer-generated temporal reinforcement contingencies can effect minimal response latencies. This effect could be studied by introducing computer-generated temporal reinforcement contingencies without introducing the verbal prompt. It would be clinically relevant because the in-the-home setting would not provide function-altering contingency specifying verbal instructions to make MTS key presses as quickly as possible under specific stimulus conditions in order to earn credit toward the receipt of money.
CHAPTER X

EXPERIMENTS ONE AND TWO

General Discussion

This study addressed how rehabilitation-oriented professionals can use computers during the rehabilitation process to assess and/or effect the time course of recovery of a person's behavioral skills that were lost or impaired due to a traumatic brain injury. A computer-aided operant methodology which used interresponse time (IRT), and matching-to-sample (MTS) procedures, was employed to empirically investigate some of the moment-to-moment behavioral effects of TBI on temporal relationships between stimuli, responses, and contingencies.

The main conclusion of this study was that a relatively simple computer-aided operant methodology can be employed to effect immediate changes in maintaining both accurate and prompt learning-related behavior of persons with TBI history. There are, however, some stimulus conditions under which subjects with TBI history perform more accurately. For example, clinical neuro-psychologists would do well to use discriminative stimuli that are immediately available, verbal, salient, or not deferred in time during rehabilitation learning tasks that involve temporal discriminations. Also, rehabilitative efforts should be focused on helping persons with TBI history to retrain what may be an impaired ability to form temporal discriminations in the absence and/or presence of salient stimulus cues. Examples of the need for temporal discriminations to be made in the real world
involve cooking, traveling, and inter-personal social communications. It is likely that not learning to wait before making key responses can result in poor tasting food, getting lost, and being socially isolated due to interrupting others.

The notion of learning to wait to make a response is one part of the general IRT experimental procedure. Learning to wait is associated with IRT > t. However, learning to make a response before it is too late, i.e., before an interval t elapses, is associated with IRT < t. This study found that verbally-generated temporal reinforcement contingencies effectively mediated minimal response latencies on a MTS learning task as well as computer-generated temporal reinforcement contingencies did. This finding suggests that the behavior of persons with TBI history can be effectively mediated in naturalistic rehabilitation settings by using contingency specifying verbal stimuli, e.g., instructions which alter the function of stimulus objects as discriminative stimuli, or as stimulus reinforcers.

Learning to make responses before certain intervals elapse is equally as important when it comes to cooking, traveling, and inter-personal social communications, as well as during actual or simulated drivers retraining courses, taking timed entrance exams, or performing various vocationally related behavioral skills that mandate certain decisions be made before emitting a response. Thus, learning to wait, but not waiting too long, is closely associated with developing and providing retraining techniques so persons can reattain lost or impaired verbal and behavioral skills and more quickly come to live fuller lives--vocationally, socially, and interpersonally.
Appendix A

Subjects' History of Traumatic Brain Injury
Resident One (R1). Approximately five years ago, and at the age of 20, R1 was injured by a self-inflicted shot gun wound to the head. The surgical attention he required included a bifrontal craniotomy (the available report does not specify the degree to which the frontal lobe material was removed during the surgery on the cranium), and a right parietal lobectomy (the surgical ablation of brain area) with evacuation of bilateral subdural hematoma (bleeding between the brain and the dura membrane covering the brain). The bullet caused massive destruction to the right side of the face, loss of the right eye, and destruction to both hemispheres, mainly the frontal lobes. R1 has experienced at least 10 grand mal (generalized convulsions and loss of consciousness) seizures as a result of the brain injury. The last known seizure activity was in December of 1984; R1 continued to take Dilantin seizure control medication.

R1 was physically healthy but was not in good cardiovascular shape. Approximately one year prior to his injury, R1 was in a motorcycle accident during which he fractured his skull and broke his collarbone. During his recovery he began using alcohol and marijuana. It was not clear to what extent he was still using these drugs; no recreational drug use was allowed at Ashby House. It was clear that he smoked at least three packs of cigarettes per day. Prior to his most current head trauma, he experienced emotional problems such that he required in-patient hospitalization for depression. Issues regarding his depression lead up to R1's suicide attempt, and resulting traumatic brain injury. R1 spent slightly more than one year in the hospital for acute medical care and rehabilitation services. Since his discharge, R1 continued to receive
rehabilitation training in activities of daily living. Prior to his motorcycle accident, Rl had quit high school after grade 10, planned to work on the family farm, had no other work experiences, and possessed few independent living skills. Most currently, Rl still had few independent living skills, but was able and eager to learn how to function on his own. Rl's vocational goals were to live in the city and get a job in a structured and supportive work setting.

Specific documentation was not available regarding the following: mental health status exam, length of post-traumatic amnesia, quality of coma, Glasgow outcome data, and WAIS-R scores. Further available information included that Rl initially exhibited perceptual and cognitive deficits, poor memory and reasoning ability, inappropriate social behavior, and lack of insight into the severity of his condition. Most currently, Rl remained single, and socially isolated except for interpersonal relationships with fellow residents at Ashby House. He was fully ambulatory and had functional use of all limbs and extremities. Except for the lack of taste and smell, Rl currently experienced no inability to attach meaning to sensory information (agnosia). There were no disabling movement disorders, nor are there any reports of visual field deficits in his left eye. In short, Rl's deficits were apparently more marked in the behavioral realm than in cognitive functioning, the behavioral deficits taking the form of problems in self-awareness and behavior control and regulation in social situations (closely related to this finding is the fact that he exhibited poor abstract reasoning, e.g., game impulsive responses to questions involving practical and social judgement). Cognitive deficits included impaired long-term memory
for tasks which included a delay before recall was required. How-
ever, it was reported that Rl did have intact immediate memory for
verbal materials.

Documentation of Rl’s so-called attention deficits included the
following: occasional need for instructions to be repeated, rest-
lessness and distractibility, tangential and perseverative thought
processes, and difficulty maintaining attention on unstructured
tasks.

On the basis of no pta information, and on his being in a coma
(of unknown depth or responsiveness to external stimuli) for six
weeks, Rl’s brain injury was suggested to be categorized as a pro-
found brain injury. This was based on the fact that, for Rl, im-
paired consciousness persisted longer than seven days (up to 1-hour
of impaired consciousness categorizes a mild brain injury, 1- to 24-
hours tentatively categorizes a moderate brain injury, 24-hours to 7-
days tentatively categorizes a severe brain injury, and longer than
7-days tentatively categorizes a profound brain injury (Bigler).

Severity of the brain injury is often but not always correlated
with poor outcome, or even death. For instance, Bigler suggested
that the prognosis for persons recovering from profound brain injury
is poor, and that if the person survived and was functioning well
above the vegetative state, then the resulting deficits would be
chronic and permanent in nature (pg. 115). Rl was clearly function-
ing well given the extent of the damage to the brain. With respect
to Bigler’s conclusions, Rl’s noted behavior and cognitive changes
were supposedly permanent neurological deficits.
Resident Two (R2). Approximately six years ago, and at the age of 25, R2 experienced brain injury secondary to an open head injury due to a car accident. The injuries included basal skull fracture, bilateral frontal lobe hemorrhage, cerebral edema (fluid collecting in the brain), and right pneumothorax (collapsed right lung). R2 also developed raised intracranial pressure and left temporal lobe swelling. Available records indicate that R1 was unconscious for approximately six months, and that after one month he had started to show some response to the surrounding environment. While at Ashby House R2 did not take any medications, occasionally drank alcohol, and smoked at least one pack of cigarettes per day.

R2 possessed excellent health prior to his automobile accident. Currently he was healthy with no apparent physical disabilities, e.g., he was fully ambulatory, and had no sensory deprivations. Before his accident, R2 was described as soft spoken, good natured, and never swearing. Behavior changes of note include frequent agitation, sporadic verbal outbursts, restlessness, and reacting quickly to situations without contemplation.

Documentation of R2's so-called attention deficits include the following: below average reaction time related to braking and steering (no data given), restlessness, and distractibility. R2 currently experienced no inability to attach meaning to sensory information (agnosia). There were no disabling movement disorders, nor were there any reported visual field deficits in either eye.

R2's pre-injury vocational activities included truck driving, stock car racing, and back yard mechanics. He received his high school diploma, and did not pursue any more formal education. His
post-injury personal/vocational goals were to return to his former occupation and move back home with his wife and children (he has lived in various structured institutional settings since his injury). Specific documentation was not available regarding the following: mental health status exam, length of post-traumatic amnesia, Glasgow outcome data, and WAIS-R scores. Additional available documentation allowed for the following conclusion. On the basis of no pta information, and being in a coma for six months, R1's brain injury was suggested to be categorized as a profound brain injury. This was based on the fact that, for R1, impaired consciousness persisted longer than seven days.

Resident Three (R3). Approximately ten years ago, and at the age of 19, R3 suffered brain damage secondary to open head trauma due to a car accident. Complications included secondary encephalitis (inflammation of the brain) and hydrocephalus (excessive amount or pressure of the cerebrospinal fluid in the ventricular system), and cerebral seizures. Required surgical attention included a craniotomy and the implanting of a ventricular-peritoneal shunt to reduce ventricular pressure and cerebral displacement. The available medical records did not indicate R3's specific area of brain damage; however, through deductive reasoning based on available reports, the area of damage was suggested to be primarily in the right hemisphere (the existence of left hemisphere damage due to contrecoup contusions and/or hydrocephalus are also acknowledged).

The rationale for right hemisphere involvement was that R3 exhibited motor coordination and ambulatory problems to the left arm and leg. Furthermore, he exhibited language difficulties, which
suggested right hemisphere damage in the pre-morbidly right-handed individual. R3’s head trauma was apparently open, but of a less penetrating ilk; the rationale for this speculation is that R3 exhibited a generalized language disorder; a focal assault, e.g., penetrating object, or vascular stroke, usually results in a motor speech disorder (Broca’s aphasia) or a comprehension disorder (Wernicke’s aphasia), possibly both depending on the extent of involvement. Yet, R3 showed clinical signs which suggested generalized cerebral damage of the right hemisphere, with primary damage to the temporal and frontal lobes. The clinical signs included impairment of motor speech production, and deficits of reading and auditory comprehension.

Unfortunately, R3’s available medical records indicated neither the duration and quality of PTAs, nor of unconsciousness (coma). One document did indicate that R3 suffered, a "severe head injury," but the justification for the phrase was not given. Furthermore, if the length of the hospital stay was in any was a determinant of severity, then one may suggest, given R3 was initially in the hospital for three months and then transferred to a rehabilitative facility for 24 months, that the degree of brain injury was more than moderate, at least severe, and possibly profound. The head trauma was severe enough to warrant invasive surgery and the implanting of a shunt to drain pressure and displacement causing cerebrospinal fluid from the ventricles to the abdominal cavity. Lastly, the degree of brain injury secondary to open head trauma was sufficiently severe such that R3 continued to exhibit behavior impairments some ten years after the trauma.
R3 was in good health for an individual with severe ambulatory problems (it takes him a long time to walk short distances). He took several medications (phenobarbital, and tegretal) for seizure control; he had not had a seizure since at least 1984. R3 also took apocarbamazepam (a tranquilizer and anti-rigidity drug), and other dermatological, gastrointestinal, and pain medications.

Pre-injury information indicated that he attended college, worked in a mill setting, had many friends, and enjoyed social activities. Currently, he was pleasant, got along well with others, had a kind disposition, was sensitive to people around him, but had limited insight into the full extent of his disability. His current vocational goals were vague, and he did not demonstrate a strong interest in any one area. However, he did have an aptitude for budgeting his money. He was also treated for depression and problem drinking prior to his injury. Post-injury reports indicated that drinking still may be problematic, and that he smoked at least two packs of cigarettes per day.

Specific documentation was not available regarding the following: chronology of medical condition, mental health status exam, length of post-traumatic amnesia, degree of coma, Glasgow outcome data, and WAIS-R scores. Further available information indicated that his open head trauma resulted in motor deficits, cognitive deficits, and impairments in swallowing, speech production, and language.

Specific impairments included auditory comprehension for commands involving three or more items of information and word finding difficulties in naming tasks and in spontaneous speech.
Reading comprehension was slow and limited to simple sentences. Writing was also slow (due in part to generalized movement disorder which was more severe on the left side) with errors in spelling and grammar (not necessarily a result of the injury).

Past assessment of cognitive abilities indicated that R3's memory was severely affected, e.g., immediate memory was 2 out of 5 objects, and after five minutes of delay, was 0 out of 5 objects. He was able to follow two, but not three commands. Abstract reasoning and goal oriented behavior (daily and vocational related planning) were also impaired. Although R3 obviously exhibits aphasic behavior, he currently experienced no inability to attach meaning to sensory information (agnosia). Nor did R3 have any uncorrected visual field deficits in either eye.

Resident Three (R4). Approximately seven years ago, and at the age of 29, R4 suffered brain damage secondary to head trauma due to a car accident. R4 was allowed to voluntarily withdraw from the current study during the orientation phase (during which time he was becoming familiar with the computer and the basic tasks). He suggested that he withdraw because he experienced too much stress while working on some of the tasks where receipt of reinforcement was not easy. The more challenging tasks got more difficult as one showed steady improvement, and got easier as one showed a decline in performance. In response to these contingencies R4 became overtly and verbally agitated and suggested that he stop or else he might end up putting his fist through the computer monitor. During the signing of the informed consent form, such a possibility of withdrawal was discussed, and later was mutually agreed upon by R4 and researcher.
Appendix B

Statement of Informed Consent
My name is Robert Obrecht and I am a masters student in Clinical Psychology at Western Michigan University. Western Michigan University is located in Kalamazoo, Michigan, USA. The study described below is research for my master's thesis.

The purpose of this study is to develop a method of assessing attention in persons who are recovering from traumatic brain injury. The assessment method will utilize personal computer and audio-visual recording equipment. As a participating subject, your task will be to play several computer games that were developed by this researcher. The computer will record your performance for the entire time that you play each different game. You will earn 1-cent for each correct response you make during every game you play. The amount of money you earn depends on how well you play. Each session will last for about one hour. Audio-video equipment will be used to record what happens during each session. The audio-video recordings will help me understand what behaviors are related to attention, and related to how you perform. The audio-video recordings of your sessions will be erased after I have had a chance to count and describe the types of behavior that occurred during each session. If you do not want to be photographed, you do not have to be photographed. If you do not want your voice recorded, it does not have to be recorded. There is a place below where you can indicate whether you do or do not wish your performance to be video taped, or audio (tape) recorded. Please consider that your audio-video recordings will never be seen by anyone other than this researcher, unless your, or your guardian's permission is given. All audio-video recordings, and
computer records, will be kept in a locked file. Your name will not be used in any written documents describing the study, nor will your name ever be provided during oral reports. Lastly, your performance will never be discussed with any other resident, or staff member of Ashby House, without your, or your guardian’s prior permission.

Sessions will be run for a maximum of four weeks, Monday thru Friday, for approximately one hour, the same hour, each day. Your session time will be arranged to fit conveniently into your schedule. A record will be kept of the amount of money you earn during each session. You will receive the total amount that you earned, during all of your sessions, at the end of your participation of the study.

Your participation in this study is completely voluntary, and you may withdraw from the study at any time. Any data relevant to you as a subject, will be destroyed upon reasonable request.

I have read the above description and understand the nature of my participation in this study; and, I agree to participate in this research project.

It is OK for my performance to be video taped: (yes/no).
It is OK for my performance to be audio taped: (yes/no).

Signed __________________________ Date____________________
participating subject

Witness __________________________ Date____________________

Co-Signature ______________________ Date____________________
(if necessary)

Relationship of Co-Signer to subject __________________________
1. I, /We

(print full name of person)

of

(address)

hereby consent to the disclosure or transmittal to or the examination by

(print name)

of the clinical record compiled in

(or report)

(name of psychiatric facility, agency, school/board, or professional)

in respect of

(name of patient) and/or family members

The following information:

For the purpose of:

See Note 5.

(signature)

(Witness)

Relationship to Client

Dated the ______ day of ___________ 19____

Expiration Date:

This consent may be rescinded or amended in writing at any time prior to the expiration date, except where action has already been taken on the authority of the consent.

Notes:
1. Consent to the disclosure, transmittal or examination of a clinical record may be given by the patient or (where the patient has not attained the age of majority or is not mentally competent) by the nearest relative of the patient. See subsection 29(3) of the Act.

2. Patient.

Clause 29(1)(b) of the Act states that "'patient' includes former patient, out-patient and former out-patient".

3. Mentally competent.

Clause 1(h) of the Act defines "mentally competent" as "having the ability to understand the subject-matter in respect of which consent is requested and able to appreciate the consequences of giving or withholding consent".

4. Nearest relative.

Clause 1(i) of the Act is as follows:

"'nearest relative' means,

(i) The spouse who is of any age and mentally competent, or
(ii) if none or if the spouse is not available, any one of the children who has attained the age of majority and is mentally competent, or
(iii) if none or if none is available, any of the brothers or sisters who have attained the age of majority and is mentally competent, or
(iv) if none or if none is available, any one of the next of kin who has attained the age of majority and is mentally competent, or
(v) if none or if none is available, any other of the next of kin who has attained the age of majority and is mentally competent, or
(vi) if none or if none is available, any other of the next of kin who has attained the age of majority and is mentally competent, or
(vii) if none or if none is available, any of the next of kin who has attained the age of majority and is mentally competent, or
(viii) if none or if none is available, any other of the next of kin who has attained the age of majority and is mentally competent, or
(ix) if none or if none is available, any of the next of kin who has attained the age of majority and is mentally competent, or
(x) if none or if none is available, any other of the next of kin who has attained the age of majority and is mentally competent, or
(xi) if none or if none is available, any of the next of kin who has attained the age of majority and is mentally competent, or
(xii) if none or if none is available, any other of the next of kin who has attained the age of majority and is mentally competent, or
(xiii) if none or if none is available, any of the next of kin who has attained the age of majority and is mentally competent, or
(xiv) if none or if none is available, any other of the next of kin who has attained the age of majority and is mentally competent, or
(xv) if none or if none is available, any of the next of kin who has attained the age of majority and is mentally competent, or
(xvi) if none or if none is available, any other of the next of kin who has attained the age of majority and is mentally competent, or
(xvii) if none or if none is available, any of the next of kin who has attained the age of majority and is mentally competent, or
(xviii) if none or if none is available, any other of the next of kin who has attained the age of majority and is mentally competent, or
(xix) if none or if none is available, any of the next of kin who has attained the age of majority and is mentally competent, or
(xx) if none or if none is available, any other of the next of kin who has attained the age of majority and is mentally competent, or

5. Signature.

Where the consent is signed by the nearest relative, the relationship to the patient must be set out below the signature of the nearest relative.
Appendix C

Compliance with Human Subjects Institutional Review Board
Compliance with Human Subjects Institutional Review Board

The following pages represent how the current study complied with the guidelines established by the Western Michigan University Human Subjects Institutional Review Board (HSIRB). Included in Appendix C are: (one) a copy of the completed and approved HSIRB APPROVAL FORM; (two) a copy of a letter from the HSIRB Chair Person regarding confirmation of approval of the research protocol; (three) a copy of a letter from the Board of Directors of Ashby House regarding confirmation of approval to conduct the current research project on site. The WMU HSIRB approval form provided information regarding confidentiality, benefits, risks to subjects, protection for subjects, and informed consent. The informed consent information is provided separately in Appendix B. The reader should note that the approval form mentions the use of audio and video recording equipment. No such equipment was actually used because of a lack of affordable and reliable video/audio equipment.
Western Michigan University
Human Subjects Institutional Review Board
Human Subjects Approval Form

DIRECTIONS: Please type or print each response - except signatures. Refer to the Western Michigan University Policy for the Protection of Human Subjects to determine the appropriate level of review.

PRINCIPAL INVESTIGATOR Robert_Edward_Obrecht DEPARTMENT Psychology
Home Phone 603-988-6581 Office Phone 603-432-4200 ext: 396
Home Address P.O. Box 235 (26 Main St., Apt. #4)
Otego, New York 13825

PROJECT TITLE: "OPERANT BEHAVIOR IN PERSONS RECOVERING FROM TRAUMATIC BRAIN-INJURY: EXPLORATORY STUDIES"

SUBMISSION DATE: 2-4-87 PROPOSED PROJECT DATES 2-28-87 TO 3-27-87

Note: The principal investigator should not initiate the research project until the protocol has been reviewed and approved by the Human Subjects Institutional Review Board.

APPLICATION IS: XX New __ Renewal __ Continuation __ Supplement

SOURCE OF FUNDING:
(IF APPLICABLE) __

SIGNATURE OF INVESTIGATOR

STUDENT RESEARCH (Fill out if applicable.)

Name of Student Robert_E. Obrecht Phone see above Address see above

The research is: ______ Undergraduate Level XXXXX Graduate Level

Faculty Advisor Chris Krolczek Phone 3:15 PM

VULNERABLE SUBJECT INVOLVEMENT (Fill out if applicable.)

Research involves medically stabilized individuals (ages 18 to 35) who are recovering from traumatic brain-injury, and are residents at a transitional living center called Ashby House (78 Springhurst, Toronto, Ontario, Canada M6K 1B8, Ms. Hedy Chandler: Executive Director, Phone: (416) 533-6759).
Protocol #: __________
Received: __________

VEL OF REVIEW: Please indicate here if you think that the research project is exempt from review, subject to expedited review, or subject to full review.

___ Exempt (Forward 1 application to IRB Chair)
Which category of exemption applies? 

XXXX Expedited (Forward 3 applications to IRB Chair)

___ Subject to full IRB review (Forward 8 applications to IRB Chair)

Comments:

Your application was reviewed and the Human Subject Institutional Review Board (HSIRB) has determined that:

___ 1. The proposed activities, subject to any conditions and/or restrictions indicated in Remarks below, have (a) provided adequate safeguards to protect the rights and welfare of human subjects involved, (b) established appropriate procedures and/or documents to obtain informed consent, and (c) demonstrated that the potential benefits of the research substantially out-weigh the risks.

___ 2. The proposed activities, for reasons indicated in Remarks below do not provide adequate protection for the rights and welfare of the human subjects.

At its meeting on 2/4/87, the HSIRB (approved) (provisionally approved... see remarks) this application with regard to the treatment of human subjects. The HSIRB categorized this application as:

___ Involving subjects at no more than minimal risk.

___ 2. Involving subjects at more than minimal risk.

REMARKS:

Need consent form rewritten.

___
Signature HSIRB Chair

Date
Protocol #: ____________

DIRECTIONS: Please type the requested information - except signatures. 
You may attach additional sheets as necessary and reference the appropriate page.

PRINCIPAL INVESTIGATOR: Robert Edward Obrecht. Date 2-4-87

TITLE OF PROJECT: "OPERANT BEHAVIOR IN PERSONS RECOVERING FROM TRAUMATIC BRAIN-INJURY: EXPLORATORY STUDIES"

ABSTRACT: Briefly describe the purpose, research design, and site of the proposed research activity.

Please see both the page entitled, "ABSTRACT," and the letter of official approval from the Board of Directors of Ashby House, regarding permission to conduct this research study at Ashby House. Both are attached to this application.

CHARACTERISTICS OF SUBJECTS: Briefly describe the subject population (e.g., age, sex, prisoners, people in mental institutions, etc.). Also indicate the source of subjects.

Subjects will consist of persons recovering from traumatic brain damage (males, ages 18-35, residents of Ashby House: transitional living centre for medically stabilized individuals whose goal it is to improve their daily living and vocational skills), and of persons who have no history of traumatic brain damage (Ashby House staff members). Participation in this study is strictly voluntary.

SUBJECT SELECTION: How will the subjects be selected? Approximately how many subjects will be involved in the research?

Approximately three Ashby House residents, and three Ashby House staff members, will participate in this study. Selection of staff members is based on their having no history of brain damage or other neurologic deficits. Other selection criteria for all subjects, regardless of history of TBI, are: (1) functional use of at least one upper extremity, e.g., left or right arm, hand, and fingers; (2) medically stabilized condition (a prerequisite for admission into Ashby House's program); (3) no history of seizure activity, or no current seizure activity because it is under pharmacological control, and well monitored by trained Ashby House staff members; (4) corrected visual acuity of at least 20/30; (5) no evidence of visual field deficits that would prevent subject from viewing the stimuli presented on the monitor; (6) no evidence of inability to recognize/name visually presented stimuli such as triangles, circles, or squares; and (7) no evidence of other sensory deficits that would preclude participation.
CONFIDENTIALITY OF DATA: Briefly describe the precautions that will be taken to ensure the privacy of subjects and confidentiality of information. Be explicit if data is sensitive.

Audio-video tapes used to record the sessions will be erased after the tapes have been analyzed. The performance of each subject will be confidential and records will be stored in a locked file. The names of the subjects will never be used on written documents describing the study, nor will they be provided during oral reports. Also, the performances of subjects will not be discussed with other subjects.

BENEFITS OF RESEARCH: Briefly describe the expected benefits of the research. Please see the attached form entitled "BENEFITS OF RESEARCH."

RISKS TO SUBJECTS: Briefly describe the nature and likelihood of possible risks (e.g., physical, psychological, social) as a result of participation in the research.

From a review of the nature and design of this study, and the presence of well trained Ashby House staff members to monitor the well being of participating residents, there appears to be no apparent risks to the subjects participating in the research.

PROTECTION FOR SUBJECTS: Briefly describe measures taken to protect subjects from possible risks, if any.

As mentioned above, the performances of the subjects will be kept strictly confidential.

INFORMED CONSENT: Please attach a copy of the informed consent form. If oral consent will be obtained, describe procedures for obtaining and documenting such consent. (Subject should be given a copy of the consent form).

Please see the attached informed consent forms. The copy of the form printed on Ashby House stationary, was developed by this researcher and approved by Hedy Chandler who is the executive director of Ashby House. An additional statement of informed consent was provided to give a general explanation of the nature of the research; this statement is attached to the other informed consent form.

QUESTIONNAIRES OR INTERVIEW SCHEDULES: If questionnaires, interview schedules or data collection instruments are used, please identify them and attach a copy of what will be used in the project.

An audio-video recorder will be used to record all sessions. Subject's responses will then be analyzed through the use of the attached data sheet, entitled, "AUDIO-VIDEO DATA RECORDING SHEET." An IBM compatible personal computer will be used to record, for each session: (1) the number of correct, and incorrect responses per unit time; (2) the amount of time that elapsed from the presentation of a given stimulus or stimuli, to the response emitted in the presence of the presented stimulus or stimuli; and (3) the number of reinforcements per unit time.
All participating subjects will receive daily (Mon - Fri) exposure to a IBM compatible personal computer which would help reduce "computer phobia." Daily interaction with the computer would prepare the participating residents for possible future assessment, treatment, or recreational oriented computer involvement (Ashby House has no computer, yet one of its goals is to acquire a computer for both administrative and "therapeutic" purposes). Participants would gain a beginning-level working knowledge of computer terminology, and computer software/hardware usage. (This researcher makes no guarantees that any participant will necessarily improve his or her cognitive abilities as a result of exposure to the software used in the study). Participants will be able to see a record of only their own performances; this may prove to be helpful to them to discover how their performance may or may not fluctuate over time.

Other benefits: since not all traumatic brain injuries are alike, a method of observing and recording idiosyncratic behavioral sequelae of tbi should prove to be invaluable to future research and clinical endeavors. The proposed assessment methodology will have enough flexibility so that many different variables can be altered; such flexibility will allow for future systematic analysis of the properties of stimuli that control the idiosyncratic responses of humans recovering from tbi. Finally, the future development and modification of computer software, as well as determining the efficacy of such software as treatment tools, should benefit from the observing and recording methods this researcher has developed.
For all documentation attach an "ADDITIONAL RECORDING SHEET" when necessary.

A. TRANSCRIPT OF ALL VERBAL BEHAVIOR (BOTH SUBJECT'S AND RESEARCHER'S):

   (for each verbal passage, include the time during the session when each
   passage/phrase began. Also include the duration of any pauses within a
   passage/phrase, or between passages/phrases)

B. DOCUMENT THE NUMBER OF TIMES A SUBJECT LEFT HIS/HER SEAT DURING THE
   SESSION:

C. DOCUMENT THE DURATION OF TIME SUBJECT SPENT OUT OF HIS/HER SEAT, ON EACH
   OCCASION:

D. DOCUMENT WHERE THE SUBJECT WENT, AND WHAT THE SUBJECT DID FOR EACH TIME
   THE SUBJECT LEFT HIS/HER SEAT:

E. DOCUMENT THE NUMBER OF TIMES, AND THE DURATION FOR EACH TIME, THAT A
   SUBJECT'S EYES WERE NOT TRAINED AT THE SCREEN OR THE KEYBOARD, ALSO
   INCLUDE THE DIRECTION IN WHICH SUBJECT'S EYES WERE TRAINED:

F. DOCUMENT WITH WHAT FINGER DID THE SUBJECT USE TO MAKE HIS/HER RESPONSES:

G. DOCUMENT THE MANNER IN WHICH THE SUBJECT SAT BEFORE THE COMPUTER
   HARDWARE, AND THE MANNER IN WHICH S/HE MADE THE RESPONSES. NOTE AND
   DESCRIBE ANY CHANGES IN POSTURE THROUGHOUT THE SESSION:

H. DOCUMENT THE DURATION THAT THE SUBJECT SAT BEFORE THE COMPUTER EQUIPMENT
   WITHOUT INTERACTING WITH THE COMPUTER AT THE APPROPRIATE TIMES:

I. DOCUMENT THE VARIOUS FACIAL EXPRESSIONS, AND UNUSUAL BODY MOVEMENTS
   (STOMPING THE FEET, TAPPING THE FOOT, SHAKING OF ARMS/HANDS):

J. IN GENERAL, DOCUMENT ANY BEHAVIOR THAT IS COMPATIBLE WITH THE SUBJECT
   OPERATING THE NECESSARY KEYBOARD KEY AT THE APPROPRIATE MOMENT TO RECEIVE
   CREDIT TOWARD MONETARY REINFORCEMENT:

K. IN GENERAL, DOCUMENT ANY BEHAVIOR THAT IS INCOMPATIBLE WITH THE SUBJECT
   OPERATING THE NECESSARY KEYBOARD KEY AT THE APPROPRIATE MOMENT TO RECEIVE
   CREDIT TOWARD MONETARY REINFORCEMENT:
TO: Robert E. Obrecht
Chris Koronakos

FROM: Ellen Page-Robin, Chair

RE: Research Protocol # 87-02-05

DATE: February 4, 1987

This letter will serve as confirmation that your research protocol, "Operant Behavior in Persons Recovering From Traumatic Brain-Injury: Exploratory Studies," has been approved by the HSIRB. The Board was concerned, however, about the change of person in the final paragraph of the consent form. Please rewrite the consent form so that the information about the research is separated from the consent portion, and send a revised copy for your file.

If you have any questions, please contact me at 383-4917.

Dear Robert – How nice to hear from you and that you’re finishing your degree. Good luck! Let me hear from you from time to time.

Ellen Page-Robin
October 15, 1986

Mr. Robert Edward Obrecht,
P.O. Box 235,
Otego, New York,
13825, U.S.A.

Dear Mr. Obrecht:

The Board of Directors of Ashby House has reviewed your proposal of a research project which you hope to carry out in connection with your Master's Degree.

The Board moved that you be permitted to proceed with your study, using the residents of Ashby House, subject, of course, to their being agreeable. Please consider this letter as formal agreement to your so doing.

Arrangements, as necessary, can be made through our Executive Director, Mrs. Hedy Chandler, Ashby House, 78 Springhurst Avenue, Toronto, Ontario M6K 1B8, telephone number 416-533-6759.

Yours truly,

[Signature]

NAE:cvh

per Nancy Elgie
Chairman of the Board,
Ashby House
Appendix D

IRT and MTS State Diagrams
Shown below is a state diagram of an interresponse time greater than an interval \( t \) (\( IRT > t \)), with a delay of \( t \) seconds.

\[ \text{Rwk} = \text{any white key press} \quad \text{M1} = \text{"1-cent credit" message} \]

\[ \text{Start} \rightarrow 1 \quad \text{Rwk} \]

\[ 1 \rightarrow 2 \quad \text{Rwk:On M1} \quad 3 \quad \text{t}'' \quad 3''\text{:Off M1} \]

---

Shown below is a state diagram for the matching-to-sample procedure with a 5 second delay, 1 second time limit, and with warning stimulus on 50% of the trials (see Baron & Menich, 1970). This state diagram was modified for other values of delay, time limit, and no warning stimulus.

<table>
<thead>
<tr>
<th>Rsbp = space bar press</th>
<th>Ss = sample stimulus</th>
<th>M1 = &quot;too soon&quot; message</th>
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<tbody>
<tr>
<td>RL = left key press</td>
<td>Sw = warning stimulus</td>
<td>M2 = &quot;1-cent credit&quot; message</td>
</tr>
<tr>
<td>Rr = right key press</td>
<td>Sc = comparison stimulus</td>
<td>M3 = &quot;wrong&quot; message</td>
</tr>
<tr>
<td>R^+ = correct key press</td>
<td>T = time the messages were left on the screen</td>
<td>M4 = &quot;too late&quot; message</td>
</tr>
<tr>
<td>R^- = incorrect key press</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \text{Start} \rightarrow 1 \quad \text{Rsbp, RL & Rr:On Ss} \]

\[ 1 \rightarrow 2 \quad 2''\text{:Off Sw:On Sc} \quad P = 0.5 \quad 5''\text{:On Sc} \]

\[ 2 \rightarrow 3 \quad \text{R^+:On M1} \]

\[ 3 \rightarrow 4 \quad 3''\text{:On Sw} \]

\[ 4 \rightarrow 5 \quad 1''\text{:On M4} \]

\[ 5 \rightarrow 6 \quad 6\text{:Off M2} \]

\[ 6 \rightarrow 7 \quad T\text{:Off M2} \]

\[ 7 \rightarrow 8 \quad 1\text{:On M4} \]

\[ 8 \rightarrow 9 \quad \text{T\text{:Off M4}} \]

\[ 9 \rightarrow 10 \quad \text{R^+:On M2} \]

\[ 10 \rightarrow 11 \quad \text{T\text{:Off M3}} \]
Appendix E

Example of Lotus 123 Spread Sheet
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</tbody>
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Appendix F

Experiment One: R1's Cumulative Response Records
R1, Day 1. Cumulative response record of an unsignalled IRT > t session, with t = 0-seconds.

Note

The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 14/177.19 or .0790. A 1-cent credit message followed a key press only if a certain amount of time (0-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
RI, Day 1. Cumulative response record of an unsignalled IRT > t session with t = 3-seconds.

Note

The subject, RI, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 7/591.04 or .0118. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R1, Day 1. Cumulative response record of an unsignalled IRT > t session with t = 6-seconds.

Note

The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 3/482.73, or .0062. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R1, Day 1. Cumulative response record of an unsignalled IRT > t session with t = 12-seconds.

Note

The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 2/555.7 or .0036. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Day 1, R1. Cumulative response record of an unsignalled IRT > t session with t = 18-seconds.

Note

The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 1/380.15, or .0026. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R1, Day 2. Cumulative response record of an unsignalled IRT > t session with t = 0-seconds.

Note

The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 11/135.08 or .0814. A 1-cent credit message followed a key press only if a certain amount of time (0-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Cumulative response record of an unsignalled IRT > t session with t = 3-seconds.

The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was $6/469.01$ or $0.0127$. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Cumulative response record of an unsignalled IRT > t session with t = 6-seconds.

The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 3/510.45 or .0059. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
The subject, Rl, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 1/466.99 or .0021. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R1, Day 2. Cumulative response record of an unsignalled IRT > t session with t = 18-seconds.

Note

The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 0/687 or .0000. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R1, Day 3. Cumulative response record of a signalled IRT > t session with t = 0-seconds.

Note

The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 11/129.95, or .0846. A 1-cent credit message followed a key press only if a certain amount of time (0-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Rl, Day 3. Cumulative response record of a signalled IRT > t session with t = 3-seconds.

Note

The subject, Rl, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 19/299.06, or .0635. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Rl, Day 3. Cumulative response record of a signalled IRT > t session with t = 6-seconds.

Note

The subject, Rl, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 11/194.14, or .0567. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Cumulative response record of a signalled IRT > t session with t = 12-seconds.

The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 9/271.07, or .0332. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R1, Day 3. Cumulative response record of a signalled IRT > t session with t = 18-seconds.

Note

The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 7/190.76, or .0367. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Cumulative response record of a signalled IRT > t session with t = 6-seconds.

The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 18/337.61, or .0533. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Cumulative response record of a signalled IRT > t session with t = 12-seconds.

The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 9/211.66, or .0425. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.

Note
Rl, Day 4.  Cumulative response record of a signalled IRT > t session with $t = 18$-seconds.

Note

The subject, Rl, was a male adult with a history of traumatic brain injury. IRT > $t$ means interresponse time greater than some value of $t$, where $t$ = a given time period. The rate of correct white key presses per total number of seconds, was $8/261.60$, or $.0306$. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R1, Day 4. Cumulative response record of an unsignalled IRT > t session with t = 3-seconds.

Note

The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 5/306.45 or .0163. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R1, Day 4. Cumulative response record of an unsignalled IRT > t session with t = 6-seconds.

Note

The subject, R1, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 0/70.59 or .0000. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Cumulative response record of an unsignalled IRT > t session with $t = 12$-seconds.

The subject, Rl, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was $2/325.62$ or $0.0061$. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Rl, Day 4. Cumulative response record of an unsignalled IRT > t session with t = 18-seconds.

Note

The subject, Rl, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 0/310.61 or .0000. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Appendix G

Experiment One: R2’s Cumulative Response Records
R2, Day 1. Cumulative response record of an unsignalled IRT > t session with t = 0-seconds.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. IRT means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key pressing per total number of seconds was 18/233.21 or .0772. A 1-cent credit message followed a key press only if a certain amount of time (0-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R2, Day 1. Cumulative response record of an unsignalled IRT > t session with t = 3-seconds.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 18/527.74 or .0341. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R2, Day 1. Cumulative response record of an unsignalled IRT > t session with t = 6-seconds.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 10/553.24 or .0181. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
CUMULATIVE RESPONSE RECORD

Cumulative response record of an unsignalled IRT > t session with t = 12-seconds.

The subject, R2, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 6/548.49 or .0109. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Cumulative response record of an unsignalled IRT > t session with t = 18-seconds.

The subject, R2, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 2/533.05 or 0.0038. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R2, Day 2. Cumulative response record of an unsignalled IRT > t session with t = 0-seconds.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 10/123.49 or .0810. A 1-cent credit message followed a key press only if a certain amount of time (0-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R2, Day 2. Cumulative response record of an unsignalled IRT > t session with t = 3-seconds.

The subject, R2, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 22/979.84 or .0225. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Cumulative response record of an unsignalled IRT > t session with t = 6-seconds.

The subject, R2, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 4/691.27 or .0058. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R2, Day 2. Cumulative response record of an unsignalled IRT > t session with t = 12-seconds.

Note
The subject, R2, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 1/219.86 or .0045. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R2, Day 3. Cumulative response record of a signalled IRT > t session with t = 0-seconds.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 11/132.66, or 0.0829. A 1-cent credit message followed a key press only if a certain amount of time (0-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R2, Day 3. Cumulative response record of a signalled IRT > t session with t = 3-seconds.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 19/286.31, or .0664. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
CUMULATIVE RESPONSE RECORD

R2, Day 3. Cumulative response record of a signalled IRT > t session with t = 6-seconds.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 5/408.21, or .0122. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
CUMULATIVE RESPONSE RECORD

The subject, R2, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 14/253.19, or .0553. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R2, Day 4. Cumulative response record of a signalled IRT > t session with t = 12-seconds.

The subject, R2, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 11/250.03, or .0440. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R2, Day 4.  Cumulative response record of a signalled IRT $> t$
session with $t = 18$-seconds.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. IRT $> t$ means interresponse
time greater than some value of $t$, where $t$ = a given
time period. The rate of correct white key presses
per total number of seconds, was 9/246.97, or .0364.
A 1-cent credit message followed a key press only if a
certain amount of time (18-seconds) elapsed since the
preceding press. If the key was pressed before the
programmed time interval was over, no message was
delivered, and the time was reset for the same full
interval. A tone indicated when the interval was
over. The recording pen was reset after 100
responses; diamond-shaped pips on the ascending line
indicate that the subject made a response. Short
vertical lines rising above the -10 horizontal axis
line indicate that the subject waited to make a key
press at least the minimum amount of time necessary to
receive a 1-cent credit message.
Cumulative response record of an unsignalled IRT > t session with t = 3-seconds.

The subject, R2, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 13/235.82 or .0551. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses: the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R2, Day 4. Cumulative response record of an unsignalled IRT > t session with t = 6-seconds.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 8/146.11 or .0548. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
CUMULATIVE RESPONSE RECORD

R2, Day 4. Cumulative response record of an unsignalled IRT > t session with t = 12-seconds.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 0/46.02 or .0000. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R2, Day 4. Cumulative response record of an unsignalled IRT > t session with t = 18-seconds.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 0/30.68 or .0000. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Appendix H

Experiment One: R3's Cumulative Response Records
Cumulative response record of an unsignalled IRT > t session with t = 3-seconds.

The subject, R3, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 3/112.29 or .0267. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
CUMULATIVE RESPONSE RECORD

Cumulative response record of an unsignalled IRT > t session with t = 6-seconds.

Note

The subject, R3, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 3/369.84 or .0081. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R3, Day 2. Cumulative response record of an unsignalled IRT > t session with t = 12-seconds.

Note

The subject, R3, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 2/419.78 or .0048. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R3, Day 2. Cumulative response record of an unsignalled IRT > t session with t = 18-seconds.

The subject, R3, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 4/419.78 or .0095. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R3, Day 3. Cumulative response record of a signalled IRT > t session with t = 0-seconds.

Note

The subject, R3, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 11/125.44, or .0877. A 1-cent credit message followed a key press only if a certain amount of time (0-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R3, Day 3. Cumulative response record of a signalled IRT > t session with t = 3-seconds.

Note

The subject, R3, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 25/380.03 or .0658. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R3, Day 3.  Cumulative response record of a signalled IRT > t session with t = 6-seconds.

Note

The subject, R3, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct of white key presses per total number of seconds, was 12/206.16, or .0582. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R3, Day 3. Cumulative response record of a signalled IRT > t session with t = 12-seconds.

Note

The subject, R3, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 11/262.87 or .0418. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R3, Day 3. Cumulative response record of a signalled IRT > t session with t = 18-seconds.

Note

The subject, R3, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 7/183.4 or .0382. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Cumulative response record of a signalled $\text{IRT} > t$ session with $t = 6$-seconds.

The subject, R3, was a male adult with a history of traumatic brain injury. IRT > $t$ means interresponse time greater than some value of $t$, where $t$ = a given time period. The rate of correct white key presses per total number of seconds, was 13/223.82, or .0581. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R3, Day 4. Cumulative response record of a signalled IRT > t session with t = 12-seconds.

The subject, R3, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 13/296.21, or .0439. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R3, Day 4.  Cumulative response record of a signalled IRT > t session with t = 18-seconds.

Note

The subject, R3, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 7/205.62, or .0340. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
The subject, R3, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 6/311.75 or .0192. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
R3, Day 4. Cumulative response record of an unsignalled IRT > t session with t = 6-seconds.

Note

The subject, R3, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 2/255.47 or .0078. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Cumulative response record of an unsignalled IRT > t session with t = 12-seconds.

The subject, R3, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 0/206.20 or .0000. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
CUMULATIVE RESPONSE RECORD

R3, Day 4. Cumulative response record of an unsignalled IRT > t session with t = 18-seconds.

Note

The subject, R3, was a male adult with a history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 1/347.95 or .0029. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Appendix I

Experiment One: S1's Cumulative Response Records
Cumulative response record of an unsignalled IRT > t session with \( t = 0 \) seconds.

The subject, S1, was a female adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of \( t \), where \( t = \) a given time period. The rate of correct white key presses per total number of seconds was 13/150.11 or .0866. A 1-cent credit message followed a key press only if a certain amount of time (0-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
**Cumulative Response Record**

*S1, Day 1.* Cumulative response record of an unsignalled IRT > t session with t = 3-seconds.

**Note**

The subject, S1, was a female adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 0/557.28 or .0000. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Cumulative response record of an unsignalled IRT > t session with t = 6-seconds.

The subject, S1, was a female adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 0/585.71 or .0000. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
**CUMULATIVE RESPONSE RECORD**

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**S1, Day 1.** Cumulative response record of an unsignalled IRT > t session with t = 12-seconds.

**Note**

The subject, S1, was a female adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 0/544.63 or 0.0000. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit.
S1, Day 1. Cumulative response record of an unsignalled IRT > t session with t = 18-seconds.

Note

The subject, S1, was a female adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 0/207.21 or .0000. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit.
S1, Day 2. Cumulative response record of an unsignalled IRT > t session with t = 3-seconds.

Note

The subject, S1, was a female adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 30/625.91 or .0479. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
S1, Day 2. Cumulative response record of an unsignalled $\text{IRT} > t$ session with $t = 6$-seconds.

Note

The subject, S1, was a female adult with no history of traumatic brain injury. $\text{IRT} > t$ means interresponse time greater than some value of $t$, where $t$ = a given time period. The rate of correct white key presses per total number of seconds was $14/500.79$ or $0.0280$. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Cumulative response record of an unsignalled IRT > t session with t = 12-seconds.

The subject, S1, was a female adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was \(\frac{4}{520.00}\) or .0077. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
S1, Day 2. Cumulative response record of an unsignalled IRT > t session with t = 18-seconds.

Note

The subject, S1, was a female adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 0/377.10 or .0000. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Appendix J

Experiment One: S2's Cumulative Response Records
S2, Day 1. Cumulative response record of an unsignalled IRT > t session, with t = 0-seconds.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 7/83.91 or .0834. A 1-cent credit message followed a key press only if a certain amount of time (0-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
S2, Day 1. Cumulative response record of an unsignalled IRT > t session, with t = 3-seconds.

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 1/38.04 or .3680. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
CUMULATIVE RESPONSE RECORD

S2, Day 1. Cumulative response record of an unsignalled IRT > t session, with t = 6-seconds.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means inter-response time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 3/98.82 or .0304. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
S2, Day 2. Cumulative response record of an unsignalled IRT > t session with t = 3-seconds.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 27/509.97 or .0529. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
S2, Day 2. Cumulative response record of an unsignalled IRT > t
session with t = 6-seconds.

Note

The subject, S2, was a male adult with no history of
traumatic brain injury. IRT > t means interresponse
time greater than some value of t, where t = a given
time period. The rate of correct white key presses
per total number of seconds, was 15/466.81 or .0321.
A 1-cent credit message followed a key press only if a
certain amount of time (6-seconds) elapsed since the
preceding press. If the key was pressed before the
programmed time interval was over, no message was
delivered, and the time was reset for the same full
interval. The recording pen was reset after 100
responses; diamond-shaped pips on the ascending line
indicate that the subject made a response. Short
vertical lines rising above the -10 horizontal axis
line indicate that the subject waited to make a key
press at least the minimum amount of time necessary to
receive a 1-cent credit message.
S2, Day 2. Cumulative response record of an unsignalled IRT > t session with t = 12-seconds.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 8/433.09 or .0185. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Cumulative response record of an unsignalled IRT > t session with t = 18-seconds.

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds was 4/359.48 or .0111. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
S2, Day 3. Cumulative response record of a signalled IRT > t session with t = 0-seconds.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 17/208.82, or .0814. A 1-cent credit message followed a key press only if a certain amount of time (0-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
S2, Day 3. Cumulative response record of a signalled IRT > t session with t = 3-seconds.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 9/163.96, or .0549. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
S2, Day 3. Cumulative response record of a signalled IRT > t session with t = 6-seconds.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 13/228.97, or .0568. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
S2, Day 3. Cumulative response record of a signalled IRT > t session with t = 12-seconds.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 7/174.53, or .0401. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
CUMULATIVE RESPONSE RECORD

S2, Day 3. Cumulative response record of a signalled IRT > t session with \( t = 18 \) seconds.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of \( t \), where \( t \) = a given time period. The rate of correct white key presses per total number of seconds, was 9/247.90, or .0363. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
S2, Day 4. Cumulative response record of a signalled IRT > t session with t = 6-seconds.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 16/280.40, or .0571. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
S2, Day 4. Cumulative response record of a signalled IRT > t session with t = 12-seconds.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 27/329.50, or .0819. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
S2, Day 4. Cumulative response record of a signalled IRT > t session with t = 18-seconds.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was $11/310.45$, or $0.0354$. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the time was reset for the same full interval. A tone indicated when the interval was over. The recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicate that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
S2, Day 4. #082

Cumulative response record of an unsignalled IRT > t session with t = 3-seconds.

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 14/234.83 or .0596. A 1-cent credit message followed a key press only if a certain amount of time (3-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
S2, Day 4. #083

Cumulative response record of an unsignalled IRT > t session with t = 6-seconds.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 12/250.91 or .0478. A 1-cent credit message followed a key press only if a certain amount of time (6-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
S2, Day 4. Cumulative response record of an unsignalled IRT > t session with t = 12-seconds.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 6/194.61 or .0308. A 1-cent credit message followed a key press only if a certain amount of time (12-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Cumulative response record of an unsignalled IRT > t session with t = 18-seconds.

The subject, S2, was a male adult with no history of traumatic brain injury. IRT > t means interresponse time greater than some value of t, where t = a given time period. The rate of correct white key presses per total number of seconds, was 10/467.33 or .0214. A 1-cent credit message followed a key press only if a certain amount of time (18-seconds) elapsed since the preceding press. If the key was pressed before the programmed time interval was over, no message was delivered, and the timer was reset for the same full interval. The ascending line represents cumulative responses; the recording pen was reset after 100 responses; diamond-shaped pips on the ascending line indicated that the subject made a response. Short vertical lines rising above the -10 horizontal axis line indicate that the subject waited to make a key press at least the minimum amount of time necessary to receive a 1-cent credit message.
Appendix K

MTS Schematics
The following pages of contain examples of MTS response sequences and credit/error messages. Each schematic representation consists of four or five "screens" set between rows of asterisks. The schematics are based on those of Mostofsky in *Stimulus Generalization*, where in chapter 19, Cumming and Berryman discuss "The Complex Discriminated Operant: Studies of Matching-To-Sample and Related Problems (1965)."
Note Shown here are schematic monitor representations of the Simultaneous Matching-to-Sample (S-MTS) procedure. S- = negative stimulus (stimulus correlated with the extinction of responses), S+ = positive stimulus (stimulus correlated with the reinforcement of responses).
Note: Shown here are schematic monitor representations of the Zero-Delay Matching-to-Sample (ZD-MTS) procedure. S- = negative stimulus (stimulus correlated with the extinction of responses), S+ = positive stimulus (stimulus correlated with reinforcement of responses).
Note Shown here are schematic monitor representations of the Zero-Delay Matching-to-Sample (ZD-MTS) procedure. Error Message. S- = negative stimulus (stimulus correlated with the extinction of responses), S+ = positive stimulus (stimulus correlated with reinforcement of responses).
Note Shown here are schematic monitor representations of the Zero-Delay Matching-to-Sample (ZD-MTS) procedure. Error Message. S- = negative stimulus (stimulus correlated with the extinction of responses), S+ = positive stimulus (stimulus correlated with reinforcement of responses).
Note  Shown here are schematic monitor representations of the Zero-Delay Matching-to-Sample (ZD-MTS) procedure. Error Message. $S^-$ = negative stimulus (stimulus correlated with the extinction of responses), $S^+$ = positive stimulus (stimulus correlated with reinforcement of responses).
PLEASE PRESS
THE
SPACEBAR
ONCE

(ANY ONE OF THE FOUR POSSIBLE ERROR MESSAGES
OR THE CORRECT MESSAGE)

Note Shown here are schematic monitor representations of the Variable-Delay Matching-to-Sample (VD-MTS) procedure. Error or Credit Message. S- = negative stimulus (stimulus correlated with the extinction of responses), S+ = positive stimulus (stimulus correlated with reinforcement of responses).
Appendix L

Experiment Two: Rl’s Cumulative Response Latency Records
The subject, R1, was a male adult with a history of traumatic brain injury. S-MTS = simultaneous matching-to-sample. There was no off-set of the sample stimulus when the comparison stimuli were presented on the screen. The reinforcement rate, number of reinforced responses per total number of seconds, was 61/1719.51, or .0355. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Latency of response was measured in seconds from the onset of the sample stimulus to the pressing of a key which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, RL, was a male adult with a history of traumatic brain injury. S-MTS = simultaneous matching-to-sample. There was no off-set of the sample stimulus when the comparison stimuli were presented on the screen. The reinforcement rate, number of reinforced responses per total number of seconds, was 95/2650.04 or .0358. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Latency of response was measured in seconds from the onset of the sample stimulus to the pressing of a key which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.
**R1, Day 7.** Response latency record of a S-MTS session phase.

#088

**Note**

The subject, R1, was a male adult with a history of traumatic brain injury. S-MTS = simultaneous matching-to-sample. There was no off-set of the sample stimulus when the comparison stimuli were presented on the screen. The reinforcement rate, number of reinforced responses per total number of seconds, was 98/2689.08 or .0364. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Latency of response was measured in seconds from the onset of the sample stimulus to the pressing of a key which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
R1, Day 8. Response latency record of a ZD-MTS session phase.

Note

The subject, R1, was a male adult with a history of traumatic brain injury. ZD = zero delay interval between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The reinforcement rate, number of reinforced responses per total number of seconds, was 69/2659.14 or .0259. Diamond-shaped pips on the ascending and descending lines along the S-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from the onset of the sample stimulus to the key press which corresponded to comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
R1, Day 9. Response latency record of a ZD-MTS session phase.

Note

The subject, R1, was a male adult with a history of traumatic brain injury. ZD = zero delay interval between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The reinforcement rate, number of reinforced responses per total number of seconds, was 81/2667.14 or .0304. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from the onset of the sample stimulus to the key press which corresponded to comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
The subject, Ri, was a male adult with a history of traumatic brain injury. ZD = zero delay interval between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The reinforcement rate, number of reinforced responses per total number of seconds, was 80/2717.08 or .0294. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from the onset of the sample stimulus to the key press which corresponded to comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
Response latency record of a VD-MTS-150s session phase.

The subject, R1, was a male adult with a history of traumatic brain injury. VD = variable delay interval between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The average delay interval was 150 seconds. The reinforcement rate, number of reinforced responses per total number of seconds, was 24/2648.37 or .0091. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of the sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.
Response latency record of a VD-MTS-200s session phase.

The subject, R1, was a male adult with a history of traumatic brain injury. VD = variable delay interval between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The average delay interval was 200 seconds. The reinforcement rate, number of reinforced responses per total number of seconds, was 21/2571.01 or .0082. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of the sample stimulus to the key press which corresponded to comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

The subject, Rl, was a male adult with a history of traumatic brain injury. VD = variable delay interval between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The average delay interval was 250 seconds. The reinforcement rate, number of reinforced responses per total number of seconds, was 18/2720.33 or .0066. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of the sample stimulus to the key press which corresponded to comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
Response latency record of a ZD-MTS-RL-VP session phase.

The subject, R1, was a male adult with a history of traumatic brain injury. ZD = zero delay interval between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. The reinforcement rate, number of reinforced responses per total number of seconds, was 80/2770.33 or .0289. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, Rl, was a male adult with a history of traumatic brain injury. ZD = zero delay interval between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. The reinforcement rate, number of reinforced responses per total number of seconds, was 50/2674.98 or .0187. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
RESPONSE LATENCY RECORD


Note

The subject, Rl, was a male adult with a history of traumatic brain injury. ZD = zero delay interval between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. The reinforcement rate, number of reinforced responses per total number of seconds, was 55/2638.87 or .0208. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, R1, was a male adult with a history of traumatic brain injury. ZD = zero delay between onset of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. TC = temporal contingencies of reinforcement. The reinforcement rate, number of reinforced responses per total number of seconds, was 58/2777.5 or .0209. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, RL, was a male adult with a history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. TC = temporal contingencies of reinforcement. The reinforcement rate, number of reinforced responses per total number of seconds, was 52/2688.24 or .0193. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
R1, Day 19.

Response latency record of a ZD-MTS-RT-VP-TC session phase.

The subject, R1, was a male adult with a history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. TC = temporal contingencies of reinforcement. The rate of correct key presses per total number of seconds was 65/3258.92 or .0199. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
Appendix M

Experiment Two: R2's Cumulative Response Latency Records
R2, Day 5. Response latency record of a S-MTS session phase.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. S-MTS = simultaneous matching-to-sample. There was no off-set of the sample stimulus when the comparison stimuli were presented on the screen. The rate of correct key presses per total number of seconds was 55/1653.86 or .0333. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
Response latency record of a S-MTS session phase.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. S-MTS = simultaneous matching-to-sample. There was no off-set of the sample stimulus when the comparison stimuli were presented on the screen. The rate of correct key presses per total number of seconds was 19/480.28 or .0396. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.
R2, Day 7. Response latency record of a S-MTS session phase.

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Note

The subject, R2, was a male adult with a history of traumatic brain injury. S-MTS = simultaneous matching-to-sample. There was no off-set of the sample stimulus when the comparison stimuli were presented on the screen. The rate of correct key presses per total number of seconds was 18/459.21 or .0392. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The rate of correct key presses per total number of seconds was 17/591.02 or .0288. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The rate of correct key presses per total number of seconds was 18/565.59 or .0318. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

The subject, R2, was a male adult with a history of traumatic brain injury. ZD = zero delay between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The rate of correct key presses per total number of seconds was 18/561.819 or .0320. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.
R2, Day 11. Response latency record of a VD-MTS-150s session phase.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. VD = variable delay interval between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The average delay interval was 150-seconds. The rate of correct key presses per total number of seconds was 18/1794.09 or .0100. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.
R2, Day 12. Response latency record of a VD-MTS-200s session phase.

The subject, R2, was a male adult with a history of traumatic brain injury. VD = variable delay between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The average delay interval was 200 seconds. The rate of correct key presses per total number of seconds was $11/1836.98$ or $.0060$. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

The subject, R2, was a male adult with a history of traumatic brain injury. VD = variable delay between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The average delay interval was 250 seconds. The rate of correct key presses per total number of seconds was 12/2139.98 or .0056. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note
R2, Day 14.  

Response latency record of a ZD-MTS-RL-VP session phase.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. The rate of correct key presses per total number of seconds was 16/524.61 or .0305. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. The rate of correct key presses per total number of seconds was 10/572.02 or .0175. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.
Response latency record of a ZD-MTS-RL-VP session phase.

The subject, R2, was a male adult with a history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. The rate of correct key presses per total number of seconds was 9/608.01 or .0148. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
The subject, R2, was a male adult with a history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. TC = temporal contingencies of reinforcement. The rate of correct key presses per total number of seconds was 11/533.25 or .0206. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. TC = temporal contingencies of reinforcement. The rate of correct key presses per total number of seconds was 11/566.76 or .0194. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, R2, was a male adult with a history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. TC = temporal contingencies of reinforcement. The rate of correct key presses per total number of seconds was 12/566.29 or .0212. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
Appendix N

Experiment Two: R3's Cumulative Response Latency Records

Note:
The subject, R3, was a male adult with a history of traumatic brain injury. S-MTS = simultaneous matching-to-sample. There was no off-set of the sample stimulus when the comparison stimuli were presented on the screen. The rate of correct key presses per total number of seconds was 58/2204.28 or .0263. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.
The subject, R3, was a male adult with a history of traumatic brain injury. S-MTS = simultaneous matching-to-sample. There was no off-set of the sample stimulus when the comparison stimuli were presented on the screen. The rate of correct key presses per total number of seconds was 72/2220.95 or .0324. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, R3, was a male adult with a history of traumatic brain injury. ZD = zero delay between off-set of sample stimulus and on-set of comparison stimuli. MTS = simultaneous matching-to-sample. The rate of correct key presses per total number of seconds was 65/2642.08 or .0246. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, R3, was a male adult with a history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = simultaneous matching-to-sample. The rate of correct key presses per total number of seconds was 80/2647.62 or .0302. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
R3, Day 10.

Response latency record of a ZD-MTS session phase.

Note

The subject, R3, was a male adult with a history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = simultaneous matching-to-sample. The rate of correct key presses per total number of seconds was 82/2739.00 or .0299. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, R3, was a male adult with a history of traumatic brain injury. VD = variable delay between off-set of sample stimulus and on-set of comparison stimuli. MTS = simultaneous matching-to sample. The average delay interval was 150 seconds. The rate of correct key presses per total number of seconds was 21/2547.81 or .0082. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, R3, was a male adult with a history of traumatic brain injury. VD = variable delay between off-set of sample stimulus and on-set of comparison stimuli. MTS = simultaneous matching-to-sample. The average delay interval was 200 seconds. The rate of correct key presses per total number of seconds was $1/211.74$ or $0.0047$. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, R3, was a male adult with a history of traumatic brain injury. VD = variable delay between off-set of sample stimulus and on-set of comparison stimuli. MTS = simultaneous matching-to-sample. The average delay interval was 250 seconds. The rate of correct key presses per total number of seconds was 15/2681.03 or .0056. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, R3, was a male adult with a history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = simultaneous matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. The rate of correct key presses per total number of seconds was 75/2678.08 or .0280. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, R3, was a male adult with a history of traumatic brain injury. ZD = zero delay between off-set of sample stimulus and on-set of comparison stimuli. MTS = simultaneous matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. The rate of correct key presses per total number of seconds was 46/2670.81 or .0172. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.
Appendix O

Experiment Two: S1's Cumulative Response Latency Records

The subject, S1, was a female adult with no history of traumatic brain injury. ZD = zero delay between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. The rate of correct key presses per total number of seconds was 59/2683.12 or .0220. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.
**RESPONSE LATENCY RECORD**

The subject, S1, was a female adult with no history of traumatic brain injury. ZD = zero delay between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. TC = temporal contingencies of reinforcement. The rate of correct key presses per total number of seconds was 74/2691.39 or .0275. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, S1, was a female adult with no history of traumatic brain injury. ZD = zero delay between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. TC = temporal contingencies of reinforcement. The rate of correct key presses per total number of seconds was 59/2699.49 or .0219. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
Appendix P

Experiment Two: S2’s Cumulative Response Latency Records
S2, Day 5. Response latency record of a S-MTS session phase.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. S-MTS = simultaneous matching-to-sample. There was no off-set of the sample stimulus when the comparison stimuli were presented on the screen. The rate of correct key presses per total number of seconds was 65/1819.49 or .0358. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note
The subject, S2, was a male adult with no history of traumatic brain injury. S-MTS = simultaneous matching-to-sample. There was no off-set of the sample stimulus when the comparison stimuli were presented on the screen. The rate of correct key presses per total number of seconds was 98/2686.90 or .0365. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
S2, Day 7. Response latency record of a S-MTS session phase.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. S-MTS = simultaneous matching-to-sample. There was no off-set of the sample stimulus when the comparison stimuli were presented on the screen. The rate of correct key presses per total number of seconds was 93/2721.97 or .0342. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

The subject, S2, was a male adult with no history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The rate of correct key presses per total number of seconds was 71/2705.28 or .0262. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. ZD = zero delay between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The rate of correct key presses per total number of seconds was 87/2660.65 or .0327. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

The subject, S2, was a male adult with no history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The rate of correct key presses per total number of seconds was 91/2680.57 or .0340. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note
The subject, S2, was a male adult with no history of traumatic brain injury. VD = variable delay interval between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The average delay interval was 150-seconds. The rate of correct key presses per total number of seconds was 21/2680.13 or .0078. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
Response latency record of a VD-MTS-200s session phase.

The subject, S2, was a male adult with no history of traumatic brain injury. VD = variable delay interval between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The average delay interval was 200-seconds. The rate of correct key presses per total number of seconds was 19/2747.44 or .0069. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.
RESPONSE LATENCY RECORD


Note

The subject, S2, was a male adult with no history of traumatic brain injury. VD = variable delay interval between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. The average delay interval was 250-seconds. The rate of correct key presses per total number of seconds was 19/2576.58 or .0074. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. ZD = zero delay between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. The rate of correct key presses per total number of seconds was 70/2708.95 or .0258. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. ZD = zero delay between off-set of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. The rate of correct key presses per total number of seconds was 44/376.99 or .1167. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. The rate of correct key presses per total number of seconds was 46/2688.33 or .0171. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. TC = temporal contingencies of reinforcement. The rate of correct key presses per total number of seconds was 39/2713.90 or .0144. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject's key press that corresponded to the comparison stimulus that matched the sample stimulus.

Note

The subject, S2, was a male adult with no history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and on-set of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. TC = temporal contingencies of reinforcement. The rate of correct key presses per total number of seconds was 56/2712.41 or .0240. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from on-set of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.
RESPONSE LATENCY RECORD


Note

The subject, S2, was a male adult with no history of traumatic brain injury. ZD = zero delay between offset of sample stimulus and onset of comparison stimuli. MTS = matching-to-sample. RL = response latency. VP = verbal prompt, i.e., subject was verbally prompted to make the matching response as quickly as possible. TC = temporal contingencies of reinforcement. The rate of correct key presses per total number of seconds was 49/2702.43 or .0181. Diamond-shaped pips on the ascending and descending lines along the X-Y quadrant indicate that a subject made a response of a given latency during the phase. Response latency was measured in seconds from onset of sample stimulus to the key press which corresponded to the comparison stimulus that matched the sample stimulus. Short vertical lines rising above the -1 horizontal axis line indicate that a 1-cent credit message followed the subject’s key press that corresponded to the comparison stimulus that matched the sample stimulus.


