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THE INFLUENCE OF RATE OF BEHAVIOR AND PREDICTABILITY OF RATE CONDITIONS ON OBSERVER ACCURACY, RATE OF OBSERVING RESPONSES, AND ALLOCATION OF OBSERVING TIME

by

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The rate and predictability of a subject's behavior are related to observer accuracy. Since those factors often change during the course of applied research, the accuracy of observational data may inadvertently be influenced. The present study explored the relationship between rate and predictability of the subject's behavior and observers' accuracy and two other measures of observing behavior.

Two assistants each presented a behavior at a rate of 3 or 1.1 behaviors/minute. Each assistant presented one behavior at one target, observed by two other assistants. The pairs of assistants alternated between these two roles. Each pair observed for four phases, each having six 20-minute sessions. The four phases differed in the rates of behavior at each target and in the predictability of the rates from session to session. The occurrence of the behaviors, the observers' indications of these occurrences, and the observers' electrooculograms were simultaneously recorded. These recordings permitted assessment of observer accuracy of the rate of observing responses, and of the observing time allocated to each target.

The results revealed an inverse relationship between the rate of the behaviors and observer accuracy. This relationship obtained across sessions and when the two rates were observed either simultaneously or sequentially. The observers showed individual differences in their abilities to observe accurately when the rate conditions were changed between sessions. A direct relationship was found between the rate of the observing responses and the rate of the behaviors. The relationship between the observers' allocation of observing time to the targets and the distribution of the behaviors to the targets approached matching.

Possible problems in the use of observation for gathering data are discussed. A facet of generalizability theory, the methodology of data analysis, is proposed to eliminate problems associated with comparing the results of investigations of observation, vigilance, and observing responses and facilitate research in these areas.

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CHAPTER I

INTRODUCTION

Observation procedures are used in many of the behavioral sciences. One major feature common to all observation procedures is the interpolation of the behavior of a human observer between the behavior of interest and the permanent, quantitative record of the event (Repp, Deitz, Boles, Deitz, & Repp, 1976). In the observation procedures that are often used in the field of applied behavior analysis, one or more observers watch the behavior of a subject, assign the behavior to one or more explicitly defined catagories, and make a permanent record of their decisions.

A major problem with this indirect route of data collection stems from the inability of the experimenter to attribute all changes in the recordings of the subject's behavior to actual changes in the subject's behavior. The experimenter must deal with the possibility that the obtained changes instead reflect changes in the behavior of the observer (Baer, Wolf, & Risley, 1968; Johnson & Bolstad, 1973; Jones, Reid, & Patterson, 1975). That is, the observer's behavior may be controlled by stimuli other than the behavior of the subject whom the observer is directed to monitor. This additional control of the observer's behavior may alter the obtained data in undesirable ways, such as increasing error variance or biasing the data toward or against experimental hypotheses.

It is possible to determine the extent to which these additional stimuli control the observer's behavior by measuring the accuracy of the observer's measurements as the variables of interest are experimentally manipulated (Foster & Cone, 1980; Kazdin, 1977). This type of determination has been carried out for a number of variables, such as knowledge by observers of experimental hypotheses (e.g., Kass & O'Leary, 1970; O'Leary, Kent, & Kanowitz, 1975). The results of these investigations have permitted experimenters to reduce the influence of these variables by modifying the procedures used in training of observers and in the acquisition of data.

It has recently been shown that a class of variables exists which exerts control over observer accuracy but which, unlike the above variables, is inseparable from the behavior being observed (Kapust, 1976, Mash & McElwee, 1974; Kapust & Nelson, Note 1). These variables are dimensions of behavior such as rate or intensity. In some experiments, the dimensions may be irrelevant to the experiment while in others they may be the major variable being studied. As an example of the former case, the content of a subject's speech may be of experimental interest, yet an irrelevant dimension such as the intensity of the speech may control the observers' behavior.

Rate of behavior is a common dependent variable in many areas of psychological investigation. Many experimenters systematically alter the rate of one or more categories of behavior during the course of an experiment. If the rate of a category being observed influences the behavior of the observer, studies that alter the rate of behavior may also inadvertently produce changes in the accuracy of the data produced by the observers.

The current experiment follows two previous experiments by Kapust (1976; Note 1) in which changes in observer accuracy were produced by changes in dimensions of the behavior being observed. This experiment increases the generalizability to typical observation settings of the results of the previous laboratory experiments and describes the data in terms of observing responses (the responses that observers must make in order to perceive the behavior of the subjects). Such description may permit experimenters to arrange the conditions of observation or of observer training to reduce or eliminate the undesired changes in observer accuracy. Aside from the experiments by Kapust (1976; Note 1) which are presented below, two related areas of research provide support for this investigation of observer accuracy. One area has been described by the term "vigilance" (Jerison, 1970; McGrath, Harabedian, & Buckner, 1968). A second area of research involves experiments that measure and control a type of response called the "observing response" (e.g., Holland, 1958; Jerison, Pickett & Stenson, 1965). These areas are discussed in subsequent sections.

Control of Observation by the Rate of a Response

Methodological considerations in the measurement of accuracy. The measurement of observer accuracy was mentioned above as a way by which variables controlling the behavior of an observer could be examined. Accuracy of observation has been defined as the extent to which an observer's recordings are concordant with previously established criterion recordings (Johnson & Bolstad, 1973) or standards (Kazdin, 1977).

The essential element of any measure of accuracy is a criterion recording that reflects the subject's behavior as it occurs. The recordings made by the observers are compared with the criterion recordings to establish the accuracy of observation. Several methods exist for constructing criterion recordings.

In one method (e.g., O'Leary et al., 1975; Taplin & Reid, 1972), a sample of the behavior to be observed is videotaped. The videotapes are then observed by several well trained observers whose consensual recordings are designated as the criterion recordings. These criterion recordings are then compared to other observers' recordings. Observer accuracy is inferred from the agreement between the observer and criterion recordings. Several problems result from using this type of procedure. Observations of videotapes may not generalize to the natural "live" setting. More importantly, the observers who make the criterion recordings are themselves instruments of unknown accuracy. One cannot assume that even experienced observers are accurate when they show high agreement. Interobserver agreement, the extent of concordance between the independent recordings of two observers, has been widely used as a substitute for a measure of observer accuracy (e.g., Preparation of Manuscripts, 1969; Reid, 1970). It does not, however, qualify as a measure of accuracy because there is no exact standard to which either observer's recordings can be compared.

The second method for preparing a criterion was used by Mash and McElwee (1974). These experimenters recorded audio tapes of two people engaged in conversation. The conversations were read from scripts that were prepared by the experimenter. Use of this method eliminates the latter problem described above but leaves unresolved the question of generalization to the natural environment.

A third method, although methologically more difficult than the second, eliminates both problems. This method involves defining the behavior that is to be observed in such a way that it can be measured precisely (Foster & Cone, 1980). These precise measurements are compared to the observers' recordings. Transducers of various types can be used to provide the desired precision. For example, O'Leary and Becker (1967) present an observation code with a number of categories to which this method may be applied. "Out-of-seat" is a category that is defined by the child's weight being supported by his or her chair. A suitably placed switch could also record this information. Comparison could then be made between the criterion (switch) and the observers' recordings of the out-of-seat category. Experimental manipulations could be effected by having the observee follow a predetermined behavioral script of sitting. Although this methodology is not suited to all behavior, such as content of speech, many routinely monitored categories of behavior could thus be investigated.

Kapust (1976; Note 1) selected this third method in his investigations of observer accuracy. A category of behavior, finger movement, was selected that permitted electromechanical recording of its presence and absence. This category was topographically similar to categories of behavior that have been observed in previous research (e.g., Lipinski, Black, & Nelson, 1975; Patterson, Ray, Shaw, & Cobb, 1969). Assistants were trained to produce finger movements according to prerecorded signals. These movements were restricted to specific locations and topographies and were recorded electromechanically. The actual subjects of the experiments, the observers, recorded their observations of these finger movements on electromechanical devices. The types of electromechanically recorded data, one directly reflecting occurrences of the behavior that was observed and one reflecting both these occurrences and the behavior of the observer, were then compared to determine observer accuracy in the various experimental conditions.

Experiment I. In this experiment (Kapust, 1976), four variables were investigated: the rate at which two categories of behavior, or targets, were presented, the distance between the targets, the particular assistant whose behavior was observed, and the duration of observation.

The two categories of behavior consisted of the movements of the assistants' index fingers to specified locations on or above the table in front of them. These two categories of finger movement were designated as signal stimuli (the behavior to be recorded). Other finger movements were nonsignal stimuli (behavior not to be recorded). Stimuli from both categories were presented continuously. A signal or nonsignal stimulus occurred at an average rate of 8/min. Signal stimuli were presented at rates of 3/min. or 1.1/min. That is, eight stimuli were presented each minute. Depending on the experimental conditions, either 3 or 1.1 of the eight stimuli presented each minute were signal stimuli. The rest were nonsignal stimuli. The assistant presented stimuli with each index finger. In two experimental conditions, each finger presented the same rate: 1.1/min. or 3/min. A third condition involved the presentation of the higher signal rate by one finger and the lower rate by the other.

The experiment utilized two assistants, each of whom presented one target of observation with each index finger to one half of the subjects. For one half of the subjects in each of the three rate conditions, the assistant's index fingers were separated by a distance of 1 in. (e.5 cm); for the other half, their fingers were separated by 13 in. (33 cm). The subjects, seated 20 ft. (6 m) away, were required to observe both sets of finger movements simultaneously for one 60-min. session. For purposes of analysis, each session was divided into six 10-min. intervals.

Statistical analysis of the subjects' accuracy revealed a significant effect of the rate conditions. Observer accuracy was greater in the conditions in which the lower signal rate was presented than in the conditions in which the higher signal rate was presented. The mixed condition produced the same results: greater accuracy for the fingers moving at the lower rate than for the fingers moving at the higher rate.

A significant effect was found for the assistant who presented the stimuli. The accuracy of observers who observed one assistant was greater than that of the subjects who observed the other assistant. This effect occurred despite extensive visual and electromechanical monitoring by the experimenter of the stimuli that were presented by the assistants. No major differences in topography of the stimuli, errors in presenting stimuli, or latency to respond to the signal cues were detected. This significant effect for assistants and a significant interaction between rate, assistant, and the separation of the two sets of finger movements was apparently due to some consistent difference in the signal (or nonsignal) stimuli that were presented by the two assistants. The accuracy of the subjects' observations was influenced by these variables as well as by the experimental variables. These findings further support the author's assertion that the behavior of the observer may be controlled by nonsignal stimuli presented by the observee. Other significant results of this experiment further support this position but are not directly relevant to the present research and hence will not be included here.

Experiment II. In Experiment I, the separation factor produced greater accuracy when the distance between the assistants' fingers was small, but the effect was found to be significant only in interactions with other variables. It was hypothesized that increasing the distance between fingers would increase the extent to which this variable would produce decrements in accuracy (Kapust & Nelson, Note 1). The larger level of the separation factor was increased from 13 in. (33 cm) to

43 in. (1.1m). In order to effect this change, two assistants were needed to present the finger movements; each assistant presented one target of observation by moving one index finger. Other changes included increasing the length of each observation session from 60 minutes to 70 minutes and making explicit the time remaining in a session.

The results of this experiment replicated the major findings of Experiment I, with a larger effect for separation. The observers were more accurate when the distance between the targets was small. The mean accuracy of subjects who observed the lower signal rate was greater than that of the subjects who observed the higher signal rate. The mixed condition means were again split, with greater observer accuracy of the lower signal rate than the higher signal rate.

The influence of characteristics of the target behavior on observer accuracy is, thus, a strong and replicable phenomenon. These two experiments do not, however, completely generalize to the typical situation in which observation is used. Experiments I and II utilized naive observers who participated as a course requirement. None were volunteers and none had any committment to the experimenter for their performance. The typical observer is a volunteer and is highly committed to perform well for the experimenter. In Experiments I and II, the experimental observers viewed only one rate condition for one 60- or 70-min. session. The typical experiment often requires the observer to monitor several changing rates of behavior over the course of many observation sessions.

The present experiment replicated these results and increased their generalizability to the typical use of observation procedures in the applied analysis of behavior. It also examined the relationship between these and other apparently similar phenomena.

Observation, Vigilance and Observing Response Experiments

As discussed above, investigations of the behavior of an observer have been conducted by many researchers. These investigations can be grouped into three slightly overlapping areas according to the questions that the experiment is designed to answer and the universe to which the research generalizes. The experimental paradigms, dependent variables, and methods of data analysis that are used do differ among the three areas but these factors are not discriminating (e.g., Baum, 1975; Holland, 1963). The three areas are labeled "observation research", "vigilance research" and "observing response research" by investigators in each respective area.

Observation research is most often conducted by experimenters within the field of applied behavior analysis. The experiments are designed to solve problems that are inherent in the use of observers to gather data in an applied setting. The results of this area of research are assumed to generalize to uses of observation procedures in clinical practice as well as to applied research. The extent of generalization is restricted, however, by the lack of standardization of procedures and by the catch-as-catch-can approach to subject selection.

The experimental paradigm involves the use of paid or volunteer observers who most often are unaware that they are serving as experimental subjects. The characteristics of the subjects often vary greatly within and between experiments because the subjects are usually recruited as they are available. Similarly, the observees and the categories of behavior to be observed are usually selected by availability. The procedures of observation are determined more often by the limits of the applied setting or by the experimenter's familiarity than by their suitability to address a particular question or to extend an established line of research. This lack of standardization limits the experimenter's ability to systematize existing results.

Vigilance research is most often conducted by experimenters within the fields of human factors and psychophysics. The research was originally designed to determine the optimal conditions for performing monitoring tasks, such as observing a radar screen, but the area has evolved toward examining the nature of perceptual processes in a controlled monitoring situation. The results of vigilance research originally were felt to generalize to military and industrial applications of monitoring tasks. Recent research relates its results to the typical human observer within the specific experimental paradigm. The research typically uses paid subjects who are aware that they are subjects of an experiment but unaware of the specific manipulations. An attempt is often made to secure subjects who are typical of the universe of generalization, e.g., factory workers or radar operators. Vigilance research originally confined itself to a few basic experimental paradigms, such as the Mackworth Clock Test. Recent research has applied the results of the earlier studies to a variety of tasks to enlarge the universe of generalization.

Observing response research is most often conducted within the field of the experimental analysis of behavior. This research typically seeks to explain monitoring behavior according to established laws and principles. The experimental paradigms are rigorously controlled and vary little across investigations. Subjects are often primates, rats or pigeons although humans are also used. External validity of these experiments is usually quite high but the range of generalizability is restricted.

Observation procedures have many elements in common with the procedures used in vigilance experiments. Observation procedures require the observer to monitor the behavior of one or more organisms (most often human). Vigilance tasks require the observer to monitor a mechanical or electronic display. Jerison (1970b) presents characteristics of vigilance tasks which apply equally to observation tasks. In both types of task, stimuli are presented to the observer. Some of these stimuli are defined by the experimenter as signal stimuli which are to be reported in some manner to the experimenter. Other stimuli are defined as nonsignal stimuli and are usually not actively reported. The signal stimuli are presented infrequently and with no warning. They are usually strong in a psychophysical sense (i.e., they are rarely missed when the trials are cued), but are not attention demanding.

The task continues for one half hour or more, during which time the observer must be continuously alert in order to detect and report all signal stimuli.

These characteristics define monitoring tasks without reference to a particular type of signal stimulus, such as human or mechanical. It is, however, the particulars of the signal stimuli and other aspects of the experimental procedures, such as the manner in which the observer reports the occurrence of the signal stimuli, which define the boundaries of vigilance, observation, and observing response research. The particular details are determined by the questions that the experimenter seeks to answer and the phenomena to which the results are intended to generalize.

An additional similarity between the observation and vigilance tasks is seen in the control of observer accuracy by signal rate. For example, in vigilance tasks, very low signal rates (less than 30/hr.) produce a decrement in the number of signal stimuli that are detected as the monitoring session continues (Loeb & Alluisi, 1970). This performance decrement within the session is not found when greater signal rates are used or when several targets are monitored simultaneously, as in Experiments I and II.

It is apparent that in certain situations observer accuracy is sensitive to the rate at which the signal stimulus occurs. This relationship can be addressed by analyzing common elements of the tasks that are required of observers in vigilance and observation paradigms. The first element basic to both tasks is the establishment of a discrimination between two types of stimuli. One type is called the "positive stimulus," "signal," or "S^D," or "target of observation". The observer is instructed to monitor and record all presentations of this stimulus. The other type of stimulus is called the "negative stimulus", "nonsignal stimulus," or "S " and usually requires no overt response.

The response by which the observer records presentations of the signal stimulus, i.e., the recording response, is a second element common to both tasks. This response may be made verbally or motorically using various means of making a permanent record. Before the observer can correctly make the recording response, however, he or she must observe the signal and nonsignal stimuli (Browne & Dinsmoor, 1974). That is, the observer must make a response so that he or she can observe the experimental stimuli.

Wyckoff (1952, 1969) has defined an observing response as a response which results in exposure to discriminative stimuli. Within this definition, observing behavior includes such naturally occurring responses as orienting toward a display, fixating on the display, and scanning it (Holland, 1963). For example, when a man rotates his head toward a clock, fixates his eyes on the clock's face, and scans to locate the hands, he has emitted observing behavior, that is, a series of observing responses. The occurrence of observing behavior can be inferred when the observer makes a recording response immediately following the presentation of a signal stimulus (Kelleher, 1958). Thus, the occurrence of observing behavior may be inferred in the example above when the individual reports the correct time. The observing response may also be an experimenter-imposed response which is added to the observer's natural repertoire of observing behavior (Browne & Dinsmoor, 1974). An experimenter-imposed observing response could be the operation of a switch to illuminate an otherwise dark clock face. The use of this type of observing response places an experimentally defined correspondence between observing behavior and the recording response. The monitoring tasks found in vigilance and observation paradigms are characterized by the lack of an experimentally defined correspondence of this type (Guralnick. 1972).

Use of an experimenter-imposed or operationally defined observing response permits the analysis of observer accuracy using a measure separate from the recording response. It will be shown below that there may be a functional relationship between the frequency and pattern of the observing response and the observer's accuracy.

One concern of investigators who use an operationally defined observing response or measure a naturally occurring observing response is the degree to which their findings correspond to those of experiments that require only naturally occurring observing responses. The results of a number of experiments, some using observing responses imposed by the experiment and others using naturally occurring observing responses, have demonstrated that measuring observing responses does not alter the phenomena that are typical of the vigilance task. That is, experiments that utilize an experimenter-imposed observing response in addition to observing responses that exist in the natural environment produce findings that are equivalent to the results of experiments that utilize only naturally occurring observing responses. The results of these experiments may thus be viewed as representative of similar vigilance experiments in which observing responses are not measured. For example, using a schedule of signal presentation equivalent to that used in many vigilance experiments (e.g., Loeb & Alluisi, 1970), Holland (1958, 1963) replicated the performance decrement found in vigilance tasks. He found that the decrease in accuracy with the session was accompanied by a decrease in the rate of observing responses, which were presses of a lever. Increasing the rate at which signal stimuli were presented increased both the rate of observing responses and the accuracy with which the signals were detected. The finding of improved detection performance as the rate at which signals were presented was increased is consonant with the results of this manipulation in many other vigilance experiments (e.g., Baddeley & Colquhoun, 1969).

Holland also incorporated the measurement of observing responses into experiments using the schedules of signal stimuli which had been used by Mackworth (1948) in his early studies of vigilance. The results paralleled those of Mackworth for the mean percentage of signals detected over time (within session) and also showed approximately the same proportion of individuals whose performance contributed to the overall decrease. By recording the observing response, Holland was able to show that the observing response rates increased over time in those individuals whose performance remained high for the entire session while the observing response rate decreased over time in those individuals whose performance deteriorated. That is, the decrease in accuracy of the group of observers was due to some observers whose accuracy declined sharply rather than to moderate declines shown by all observers.

Schroeder and Holland (1968) extended the generalizability of the use of an operationally defined observing response to a different behavior, eye movements through a device that permitted them to continuously monitor a display of four dials arranged at the corners of a square. Signal stimuli (pointer deflections) occurred infrequently on these dials. The subjects' detection performance and rate of eye movements decreased as the signal stimulus rate decreased. These measures also showed decreases within the sessions. The individuals who showed higher observing response (eye movement) rates tended to detect more signals. These results parallel the findings that were presented above.

The results of these and other experiments (e.g., Dardano, 1965; Guralnick, 1972, 1973; Krasnegor & Brady, 1972) clearly show that a number of phenomena found in vigilance experiments are accompanied by lawful changes in the rate of observing responses. In addition, a large number of experiments (e.g., Frazier & Bittetto, 1969; Holland, 1958, 1963; Rosenberger, 1973; Schroeder & Holland, 1969) have demonstrated that observing behavior, both that imposed by the experimenter and that which is naturally occurring, conforms to the basic principles of operant behavior.

<u>Statement of Purpose</u>

It is the purpose of the present study to extend Kapust's previous research to explore common elements of the vigilance, observation and observing response areas. The previous studies by Kapust show the influence of rate and separation of the target behaviors on observer accuracy. The original paradigm was selected to be similar to that used in observation research and applied uses of observation.

The two studies did, however, differ in important ways from the desired universe of generalization. For example, subjects observed for only one session. In the typical uses of observation, observers are used for many sessions over an extended period of time. In order to determine if the results of the previous two studies obtain within the paradigm of typical observation research, and to improve the generalizability of the results to this research, the present study was designed to eliminate many of the deficiencies of the previous two experiments.

To accomplish this replication and extension, the experiment utilized the same rates of signal presentation and total event presentation (signal stimuli and nonsignal stimuli), the same target behaviors, and the same experimental apparatus that were used in the previous Kapust experiments. To increase generalizability, the design and procedure were modified in the following ways: the distance between the targets was increased to 162 cm, the observers were volunteers interested in and graded for their overall performance in the experiment (not only for their levels of accuracy), the session length was decreased to 20 min., the observers observed during many (24) sessions, the signal rate at one or both targets was varied during the experiment, and the possibility of the observers' predicting the rate conditions of one session from those of the previous session was manipulated.

The second purpose of the present experiment is to explore the process of observing by determining relationships between observer accuracy and measures of observing responses. Although research within the observing response area suggests that the lawful relationships of this area generalize to the observation area there is some indication from Kapust (1976) and Holland (1963) that characteristics of the observer interact with and modify these relationships. The present experiment is thus necessary both to confirm the applicability of the relationships and to determine the extent of any interaction.

In order to accomplish this second purpose, an observing response was experimentally defined as eye movements between the two targets of observation. The eye movements were assessed by recording the observers' electroculograms. The large distance between the two targets of observation (162 cm) forced the observers to move their eyes to observe the targets, making eye movements an observing response. The observers' naturally occuring observing behavior was measured in two ways: the rate of observing responses and the proportional allocation of observing time. he rate of observing responses was the actual rate at which the experimentally defined observing response was emitted by the observer (i.e., the rate of eye movements back and forth between the two targets of observation). The proportional allocation of observing time was the amount of time that the observer looked at one target relative to the total amount of time spent observing.

The experiment was divided into four phases. Each phase consisted of six sessions for each of two pairs of observers. The phases differed in the rates of signal stimuli that were presented to the observers. In Phases I, II, and III, the rate of signal stimuli remained constant within the phase (across sessions). The rates differed between phases. In Phase IV, the rate of signal stimuli was changed between sessions within the phase. This design permits assessment of the stability of the subjects' accuracy and observing behavior during multiple sessions of one rate condition (within Phases I, II, and III), when the rate conditions are altered between phases, and when the rate conditions are altered within a phase (between the sessions of Phase IV). The four phases are briefly described below.

In Phases I and II, the two pairs of observers were presented with rates of signal stimuli in a counterbalanced manner. In each phase, one pair received signal stimuli at a rate of 3/min. (high rate) while the other received the stimuli at a rate of 1.1/min. (low rate). The rates of signal stimuli were identical at each target of observation. Thus, in Phases I and II all observers were exposed to the high rate of signal stimuli at both targets and the low rate at both targets but in a counterbalanced order. In Phase III, the pairs of observers were split and re-paired so that one member of each original pair was placed in each new pair. Each new pair was presented with a high signal rate at the other. The rates were counterbalanced for left-right position. Phases I, II, and III in effect replicated the rate conditions of the previous experiments by Kapust (Note 1, 1976). Phase IV was designed to determine the influence of two factors on accuracy, rapidly changing rate conditions and the predictability of the rate conditions.

The rate conditions for all sessions for Phase IV and for Phases I, II, and III are presented in Table 1. (Table 1 and all subsequent tables are located in Appendix A). In the first three phases, the observers could predict the rate conditions of one session from the conditions of the previous session (except for the first session of each phase). In Phase IV, this predictability was manipulated. In designing this phase, the intent was to create a predictable sequence of rate conditions in Sessions 1 to 5 for two observers and to create an unpredictable sequence in these sessions for the other two observers. The last session was intended to be unpredictable for all observers. During the analysis of the data from this phase, another interpretation of predictability than that intended in the designing of the experiment became evident. These two alternative interpretations will be discussed below in the presentation of the results of Phase IV.

Given the purposes and design presented above, the following predictions were made for the results of this experiment:

1. The results of Kapust's previous experiments (Note 1, 1976) would be replicated, that is, observers would be more accurate when observing the low rate conditions than when observing the high rate conditions. These results would occur when the high rate conditions were presented in one phase (or to one pair of observers) and the low rate conditions were presented in another phase (or to the other pair of observers) and also when the high and low rate conditions were both presented simultaneously within a session. The results of Holland and other investigators (i.e., accuracy is a function of the rate of signal presentation when other factors are held constant) indicate that these predicted relationships between observer accuracy and signal rate should hold in all sessions of Phase, I, II, and III. It is likely, however, that in transition from one phase to the next (i.e., the first session of each phase), when the observers are learning the new conditions of that phase, the accuracy of observation may decrease or increase before a constant level is reached.

2. The results of Mash and McElwee (1974) suggest that the observers who receive a predictable sequence of rate conditions would show greater accuracy than observers who receive an unpredictable seqeunce of rate conditions when all observers are given the same rate conditions in Session 5 of Phase IV. When the predictable sequence of rate conditions is terminated in Session 6 of Phase IV, the observers who receive the unpredictable sequence for all sessions should show greater accuracy than the observers who receive the predictable sequence for Session 1 to 5.

3. There is no previous research from which predictions can be made regarding the effect on accuracy of changing rate conditions within a phase. Experiments with very controlled conditions (e.g., Baum, 1975; Holland, 1963) report that responding is ultimately controlled by the rate of signal presentation. This control, however, appears to develop after numerous sessions.

4. Previous research by Schroeder and Holland (1968, 1969), and by Jerison (1970a), indicates that the rate and allocation of observing responses are under the control of the rate and spatial distribution of signal stimuli. This body of research supports a prediction that the rate of observing responses would vary directly with the rate of signal presentation. Many experiments (e.g., Baum, 1975) have found, however, that when two responses are available, the subject rapidly alternates between responses if there is little effort or cost involved in this response style. When effort or cost is made contingent on changing from one response to the other, the subjects display response patterns that reflect the rates of signal stimuli.

The present experiment does not include an explicit or experimenter-defined cost for changing from one response to another, and the effect of possible naturally occurring costs of this type of changeover on the dependent variables is not known. Because each changeover in this experiment is defined as one observing response, rapid alternation would produce a high rate of observing responses and equal observing time to each target. If, on the other hand, this response pattern does not emerge and the rate of observing responses and the proportional allocation of observing time are not influenced by these cost factors, the direct relationship between the rates of signal presentation and observing responses that was presented above should be found. In addition, the results of Baum (1975) suggest that observing time will be allocated to the targets according to the relative rates of signal stimuli at the targets. That is, the distribution of observing time to the targets will match the distribution of signal stimuli at the targets.

Specifically, in Phases I and II, when the signal stimuli are distributed equally between the targets, there should be no significant differences between observers' observing time at each target. In Phase III, the signal stimuli are distributed either 75% to the right target or 75% to the left target (depending on the pair of observers). The allocation of observing time in Phase III should conform to these distributions either immediately (within the first session) or progressively across sessions within the phase. During Phase IV, the observers receiving the predictable sequence of signal stimuli should be better able to allocate their observing time than the observers receiving the unpredictable sequence. The increased accuracy predicted above for the observers receiving the predictable sequence of rate conditions will be due, in part, to this more efficient allocation of observing time, as will the predicted decrement in accuracy be due to less efficient distribution of observing time during the unpredictable rate conditions.

5. Several researchers (e.g., Holland, 1963; Mackworth, 1948) have reported large individual differences in the accuracy and observing responses of observers. The differences in accuracy are presumed to be produced by individual differences in factors that influence the observing responses, such as history of reinforcement, differing perception of the stimulus rates, and effectiveness of reinforcement in the observing situation. These characteristics were found to be consistent for any individual but were modifiable by application of contingent feedback or reward. The individual differences, if found in the results of the present study, should be consistent, despite changes in rate conditions.

CHAPTER II

METHOD

Observers and Assistants

Four female undergraduates served as subjects. All four were of average height and appearance. Their visual acuity was 20/25 or better, as measured by the Armed Forces Visual Acuity Test, Form 3. For three of the subjects, participation in this experiment served as a portion of an independent study project. The fourth was a volunteer. All four subjects participated simultaneously in every observation period of the experiment: two served as assistants and presented the stimuli, and two were observers. Each subject served as an assistant in one half of the observation periods, and as an observer in the other half.

Experimental Setting

The experiment was conducted in a portion of a large room that was used to house laboratory equipment (Figure 1; Figure 1 and all subsequent figures are located in Appendix B). The experimental area was 12 ft. (3.6 m) wide and 23 ft. (7 m) long and was surrounded by wall cabinets containing various types of equipment. Two large laboratory tables (A & B in Figure 1) were located in the center of the room, with their long dimension across the width of the experimental area. An additional table (O in Figure 1) was placed so that this table and the more distant laboratory table (Table A) were 15 ft. (4.5 m) apart at their outside edges. The top surface of each laboratory table was 30 in. (76 cm) above the floor; the top surface of Table O was 32 in. (81 cm) above the floor.

The undergraduate observers were seated at Table O. They were seated 3 ft. (91 cm) from each other and faced the more distant laboratory table (Table A). A partition was placed between the observers to ensure independence of recording. The undergraduate assistants were seated at Table A and faced the observers. The assistants sat five feet (1.5 m) from each other. The midpoints of the distance between the assistants and the observers corresponded to the middle of the width of the experimental area.

All recording and programming equipment was located in an adjacent area of the same room. During sessions the experimenter remained in this area.

Definition of Stimuli

The stimuli which were presented by the assistants consisted of positions of their index fingers on and above small metal touchplates placed on laboratory table A. Two touchplates were placed in front of each assistant (see Figure 2). Each pair of touchplates was oriented in a plane perpendicular to the assistant's body. Each assistant presented the experimental stimuli using the index finger on the hand that was closer to the assistant seated next to her.

Four positions of the assistants' index fingers comprised the experimental stimuli. One of the positions, the finger touching the front touchplate (i.e., the touchplate that was closest to the observers and furthest from the assistant), was designated the signal stimulus. The other three positions, designated nonsignal stimuli, were the finger touching the back touchplate (i.e., the touchplate that was closest to the assistants and furthest from the observers) and the finger held .75 in. (1.9 cm) above either of the touchplates. All movements of the assistants' index fingers were from one of the above positions to another. Each assistant moved her finger among the positions associated with her pair of touchplates according to schedules of commands which were presented by earphones. The schedules differed in the number of signals that were presented each minute. All schedules produced a mean rate of 7.7 movements of each assistant's finger per minute. These movements included both signal and nonsignal stimuli. That is, the total rate of movements (the event rate) was constant while the signal rate was varied.

Each assistant was required to keep in her lap the hand that was not to be used to present stimuli. The other fingers of the hand that was used to present stimuli were spread away from the index finger. Each assistant's forearm and the heel of her palm rested against the table top during experimental sessions and were moved only as the index finger was moved forward and backward.

Observation Task

The observers were required to observe simultaneously the movements of each assistant's finger and to record occurrences of the signal stimulus by pressing pushbuttons. The observers pressed one pushbutton when the index finger of the assistant seated on their left side displayed the signal stimulus. A second pushbutton was used in the same manner when the index finger of the assistant seated on the observers' right side displayed the signal stimulus. The observers released the appropriate pushbutton when an assistant's index finger moved from the signal position to one of the three nonsignal positions.

Design

The experiment consisted of four phases (Table 1). The phases differed primarily in the rates at which the signal stimuli were presented to the subjects. When serving as observers in Phase I, two subjects, M and R monitored signal stimuli which were presented at a rate of 1.1/min. by each of the assistants. When the other two subjects, T and D, served as observers in Phase I, they monitored signal stimuli which were presented at a rate of 3/min. These rates of signal presentation were selected because they had produced the greatest differences in accuracy of observation in prior studies (Kapust, 1976; Note 1). During this phase, observer M was paired with Observer R and Observer T with Observer D. The members of each pair observed simultaneously. Thus, Phase I consisted of six 20-min. observation periods of each pair.

During Phase II, Observers M and R monitored signal stimuli which were presented at a rate of 3/min. by each of the assistants. Observers T and D observed signal stimuli that were presented at rates of 1.1/min. All other aspects of Phase II were identical to Phase I.

During Phase III, Observers M and T served together and Observers R and D served together. Observers M and T monitored signal stimuli that were presented at a rate of 3/min. by the assistant on the observers' left side and at a rate of 1.1/min. by the assistant on the observers' right side. Observers R and D were presented with a signal rate of 3/min. on their right and a signal rate of 1.1/min. on their left. All other aspects of Phase III were identical to the preceding phases.

During Phase IV, Observers M and T again observed together, as did Observers R and D. The rate conditions at which the experimental stimuli were presented to the observers during this phase are presented in Table 1. Excluding each observer's last session in Phase IV, the stimuli presented to observers R and D alternated between rates of 1.1/min. on both sides and 1.1/min. on their left side and 3/min. on the right. The order in which signal rates were presented to Observers M and T was selected to present no predictable pattern to the observers. In their last session, all observers were presented with a signal rate of 3/min. by the assistant on the observers' left side and with a signal rate of 1.1/min. by the assistant on the observer's right side. All other aspects of this phase were identical to previous phases.

Apparatus

Each observer recorded her observations of the signal stimuli using a modified Lafayette 632AS Visual Choice Reaction Time Apparatus. The basic device consisted of a horizontal row of four lights of different colors that was parallel to a row of four pushbuttons. Each pushbutton was adjacent to a light. For this experiment, the two center pushbuttons and lights were nonfunctional. The pushbutton that was located toward each observer's left side was used to record observations of the assistant's index finger that was toward the observer's left side. The pushbutton located toward the observer's right side was used to monitor the assistant's index finger that was toward the observer's right side. Depression of a pushbutton illuminated the light adjacent to that pushbutton and activated recording equipment.

Each assistant was seated at a laboratory table on which 14-in. (36 cm) by 23-in. (58 cm) rectangular boards were placed (Figure 2). These boards, like the table top, were painted flat black. Two 1.5-in. (3.8 cm) square metal touchplates were nailed to each board so that the outside edges of the two pairs of touchplates defined the corners of a rectangle that was 67 in. (170 cm) long and 4 in. (10 cm) wide. The long dimension of this rectangle was parallel to and 9.5 in. (24 cm) from the edge of the laboratory table at which the assistants sat. Thus, the two touchplates that were located directly in front of each assistant were separated from each other by 1 in. (2.5 cm) while the two pairs of touchplates were separated by 64 in. (162 cm). Each pair of touchplates was illuminated by a 15-W lamp located 8 in. (20 cm) above and to the side of the board. The lamp did not interfere with the vision of either observer.

The assistants wore earphones and listened to audio tapes on which commands had been prerecorded by the experimenter. These commands informed each assistant of the position to which she was to move her finger and gave a signal when the movement was to occur. There was a separate tape for each of the four signal rate conditions: 1.1/min. presented by both assistants, 1.1/min. presented by the assistant seated toward the observers' left and 3/min. by the assistant seated toward the observers' right, 3/min. by the assistant seated to the left and 1.1/min. by the assistant seated to the right, and 3/min. by both assistants. Each tape was 20 min. in length and consisted of two identical 10-min. sequences of commands. To produce the four signal rate conditions, only two sequences of commands were needed: one that produced a signal rate of 1.1/min. and one that produced a signal rate of 3/min. These two sequences of commands were then combined or duplicated to produce tapes of each of the above signal-rate conditions.

The two sequences of commands had been used in a prior experiment (Kapust, 1976, Note 1). They were prepared using the following procedure. A distribution of 20 intervals of six durations (4-, 6-, 8-, 10-, 18-, and 20-sec) was constructed so that the total duration of the 20 intervals would be 2.5 min. These 20 intervals were placed in random order four times to create 80 intervals of 10 minutes' total duration. To create the sequence of events in which the signal stimulus occurred at an average rate of 1.1/min., 10 signal positions were assigned to the 80 intervals of the 10-min. sequence of events. To create the 3/min. sequence, 30 signal positions were assigned to the 80 intervals of the

10-min. sequence of events. The remaining intervals in each sequence were randomly assigned one of the nonsignal positions so that each nonsignal position occurred with approximately equal frequence. Thus, at this point, two sequences of signal and nonsignal events had been produced: one for each rate of signal presentation.

In order to equalize length of signal presentation, the signal stimuli were assigned to intervals of particular lengths to produce the following parameters. The maximum, mean, and minimum signal durations for both of the 10-min. sequences of signal and nonsignal stimuli were 10 sec, 5.6 sec, and 4 sec, respectively. The particular interval of specified length to which a signal stimulus was assigned was determined randomly. Thus, in the 1.1/min. sequence of stimuli, the maximum, mean, and minimum duration between signal stimuli were 112 sec, 54.4 sec, and 4 sec, respectively. The corresponding parameters of the 3/min. sequence were 34 sec, 11.1 sec, and 4 sec.

These two sequences of events were then paired and duplicated to produce the four rate conditions described above. The paired sequences were translated into commands to the assistants, which were recorded on tape. To ensure that the patterns of events presented by the assistants were comparable but not identical, the sequence of commands for one assistant was recorded as the reverse of that for the other assistant.

In order to compare the occurrence of stimuli to the observers' recordings of those occurrences and to assess the extent to which the assistants reliably followed the schedules of stimulus presentation, the four touchplates were individually wired to programming equipment to produce a permanent record of touches to the touchplates. Metal thimbles were placed on the end of the assistants' index fingers (white cotton gloves were worn to prevent shock) and were connected to the electrical ground of the programming equipment.

A Grass polygraph (Model 73), equipped with two low-level DC pre-amplifiers (Model 7P1A) and two DC driver amplifiers (Model 7DAC), was used to monitor simultaneously the electrooculograms (EOG) of both observers. Gold electrodes were placed on both observers' left and right temples and on their right hands, as a ground. The polygraph pre-amplifiers were set for AC recording (time constant = .1) and were adjusted for each observer so that any left-to-right or right-to-left eye movement between the pairs of touchplates caused a pen excursion of 1 cm. Eye position, per se, was not monitored. An automatic time base permitted the syncronization of the EOG recordings with the observers' accuracy of monitoring.

The programming equipment was wired in such a way that the logical "AND" between the occurrence of a stimulus event and an observer's recording of that event was recorded. For each observer in a session the following information was recorded: the occasions on which the observer recorded that a signal stimulus was being presented by the assistant on the observer's left side (i.e., the observer pressed the left pushbutton) and on which a signal stimulus was actually being presented by that assistant (the "AND" in which the signal was in an

ON condition); the occasions on which the observer recorded that any nonsignal stimulus was being presented by this assistant (i.e., did not press the pushbutton) and on which the assistant was actually presenting a nonsignal stimulus (the "AND" in which the signal was in an OFF condition); and the equivalent two logical "AND's" for the assistant on the observer's right side. Thus, eight logical "AND's" were recorded: one ON condition "AND" and one OFF condition "AND" for each of the two observers for each of the two sets of signal stimuli presented by the assistants. In addition, the presentation of a signal stimulus by each assistant was also recorded.

The above information was recorded on two types of equipment. It was recorded in analogue form on an Esterline-Angus Operation Recorder (Model 620A) and in digital form on digital counters. The information was transformed into a digital representation of the duration of the "TRUE" state of each logical "AND" in the following way. The logical states of the eight logical "AND's" and the two states (presented = "TRUE"; not presented = "FALSE") of the signal stimuli presented by the assistants were electromechanically tested four times per second. Any of these 10 logical states that were true when the test occurred caused a count of one to be added to the appropriate one of 10 counters. An additional counter recorded each four per second test pulse. All 11 counters were read every 2.5 min. by the experimenter and the data recorded.

Procedure

Assistant Training. Prior to the first session of Phase I, all assistants were trained to obey the commands that were given through the earphones. Each assistant was trained to present the stimuli at all signal rate conditions. During training and during all phases of the experiment, the assistants were given feedback about their accuracy in following commands immediately after each session. Training continued until the performance of all assistants agreed with the programmed sequence of stimuli at a level of 85% or better. (All agreement scores were calculated by dividing the smaller of the criterion score or the obtained score by the larger of the two.) No observers were present during training sessions nor was any assistant told prior to Phase I which finger position was the signal stimulus. The assistants were uninformed as to all experimental hypotheses.

Phase I. Once the training criterion was met, two subjects were randomly assigned to each of the signal rate conditions of Phase I (M and R to the 1.1 1 min. condition; T and D to the 3/min. condition). Recall that Phase I consisted of six 20-min. sessions. Three 20-min. periods of observation were conducted on each of three days per week. The pairs of observers alternated periods of observation. On each successive day the first pair of subjects that served as observers was alternated. There was a 10-min. rest period between periods of observation. The observers were instructed to be as accurate as possible but received no feedback. Before all sessions, electrodes were placed on the observers, and ten minutes were permitted to elapse so that the electrodes could polarize. Prior to each pair of observers' first period of observation in Phase I, the following instructions were read and a 5-min. practice period was given. The instructions were thus read twice. During this practice period, stimuli were presented to the observers at the rate they were scheduled to receive in their first session. The observation procedure was identical so that followed during the four experimental phases. The actual stimuli which were presented were taken from the last 5 min. of the appropriate program so that the observers received a novel sequence of stimuli at the beginning of the experimental session, yet the rate was the same as that they would receive in Phase I. The instructions explained the nature of the monitoring task and presented the definition of the signal and nonsignal stimuli.

> Your task while you are observing will be to watch the assistants' hands and to continuously record the following two events. The first occurs when (give name of assistant sitting on observers' right) touches the front touchplate on her side like this (assistant demonstrates). The second event occurs when (give name of other assistant) touches the front touchplate on her side, like this (assistant demonstrates). When (give name of assistant on right) finger is touching the front touchplate on your right side, you should press the button on the right side of your recording set and keep it pressed until her finger leaves the plate. When you press this button the red light will turn on. When (give name of assistant on left) finger touches the front touchplate on your left side, you should press the button on the left side of your recording set and keep it pressed until her finger leaves the plate. Pressing this button will turn on the white light. Remember you will only press the left hand button when (name of assistant on observer's left side) touches the front touchplate on your left side and you will only press the right hand button when (name of assistant on observer's right side) touches the front touchplate on your

> right side. Only press the button when you are sure that the assistant's finger is actually touching the front touchplate. Record only what is happening when you see it. Don't record what happened in the past and don't try to guess where they will move their fingers. Are there any questions? (Answer questions) We will begin with a five minute practice period in which I will give you feedback. Ready. Begin. (Start equipment).

After these instructions were read, the tape by which the experimental stimuli were presented was started and the observers were instructed to begin monitoring the assistant's hands. During the practice period prior to each pair of subjects' first period of observation, the experimenter constantly monitored the accuracy of the observers and verbally shaped correct observation and recording behavior. After the practice period, the stimulus tape was rewound to the beginning and the following instructions were read:

> We will now begin the first session of the experiment. Please continue to observe as you were and try to be as accurate as possible. Do you have any questions? Ready. Begin. (Start equipment)

The observation period was then started. During all observation periods, the experimenter remained in the adjacent area to monitor the programming and recording equipment. Each subsequent observation period began with the following events: The electrodes were attached and permitted to polarize for 10 min., the appropriate stimulus tape was started, and the observers were given the command, "Begin observing". In each of the remaining observation periods, the observers changed places with each other.

Phase II. The procedure of Phase II did not differ from that of Phase I. The rate conditions were reversed (as per the design) so that Observers M and R monitored signal stimuli at the 3/min. rate and Observers T and D monitored signal stimuli at the 1.1/min. rate. No additional instructions were given at the beginning of the observation periods in the first session of Phase II; the observers were not informed of the changes from phase to phase.

Phase III. The procedure of Phase III was identical to that of Phase II with the following exceptions. Observer pairs were changed so that Observers M and T monitored during the same observation period, as did Observers R and D. In this phase, the signal tapes that were played when Observers M and T were scheduled to observe presented a signal rate of 1.1/min. to the assistant sitting on the observers' right side and a signal rate of 3/min. to the assistant sitting on the observers' left side. The signal tapes that were played when Observers R and D were scheduled to observe were opposite: 1.1/min. on the left and 3/min. on the right.

Phase IV. The procedure of Phase IV was identical to that of Phase III in all ways but one. The signal tapes that were played in each session were selected according to Table 1. Thus, the rate conditions for a particular subject changed from session to session.

Accuracy of Stimulus Presentation by Assistants

In order to assess the rate of signals actually presented by the assistants (i.e., their accuracy in following the auditory cues to present signal and nonsignal stimuli), the analogue data recorded on the operation recorder was analyzed by counting the number of signals presented by each assistant in each interval of each session.

The rates at which the four assistants presented signal stimuli and the rates that these stimuli were scheduled to be presented are displayed in Table 2 for all sessions. Comparison of the scheduled rates to the actual rates shows only minor deviation from the scheduled rates.

Dependent Variables

Three types of dependent variables were measured during this experiment: observer accuracy, rate of observing responses, and the proportional allocation of observing time to the right-hand target. Observer accuracy is a proportion (range: 0.0 - 1.0) reflecting the concordance between the observer's indication that the targeted behavior occurred (pressing a pushbutton) and the occurrence of that behavior (the assistant's finger touching the touchplate. Rate of observing responses is the number of observing responses per minute of observation. An observing response is a movement of the observer's eyes from the target on the right to the target on the left or vice versa. This measure can range from a response rate of zero (a fixed gaze on one target) to a maximum rate determined by the ability of the observer to move her eyes rapidly back and forth for an extended period. Tests by several volunteers indicated that response rates of about 80/min. became painful after several minutes but that rates of about 40/min. could be maintained in comfort. Proportional allocation of observing time is the proportion of time that anobserver fixated on the right-hand target. The numerical value of this measurement can range from zero (fixating exclusively on the left-hand target) to .5 (fixating on both targets equally) to 1.0 (fixating exclusively on the right-hand target).

Accuracy data. The data from the digital counters were combined in the following manner to determine the accuracy of each observer's recordings for each of the two targets of observation during each 2.5-min. portion of a session or interval (there were eight intervals in each session). The elapsed time recorded on the counter that measured the ON condition for a particular observer and stimulus (target) was added to the elapsed time recorded on the counter that measured the OFF condition for this observer and stimulus. This total was then divided by the total length of the interval (2.5 min.) to yield the proportion of time that the observer had observed accurately.

Rate of observing responses. Both this measure and the third dependent variable, relative allocation of observing time, were obtained by examination of the polygraph chart paper. During the first few sessions of the experiment, a disturbance in the polygraph recordings was noted. This disturbance appeared to be an electrical artifact unrelated to the present experiment and was uncorrectable. It occurred throughout the experiment and made portions of the polygraph record uninterpretable. For that reason, data were obtained from only half of the intervals of each session. The first, fourth, fifth, and eighth intervals were used when possible. When the artifact prevented the use of these intervals, the preceding or following interval was used. This procedure was possible in all but two sessions. In these two sessions, only three intervals were scorable. Table 3 presents the intervals from which data were utilized for all sessions. The rate of the observing responses was calculated by counting the number of deflections of the polygraph pen in each of the intervals that were utilized and dividing by length of the interval (2.5 min.). Each movement of the polygraph pen represented a movement of the observer's eyes from one target to the other, or one observing response.

Proportional allocation of observing time. This measure was obtained from the same intervals used in the calculation of rate of observing responses by use of the following procedure. The duration of each successive observing response in an interval was determined (i.e., the interobserving response time). That is, the distance between each successive pen movement and the next on the polygraph chart paper was measured. These times were obtained separately for observing responses which represented movements from the right-hand target to the left-hand target and for those from the left-hand target to the right-hand target. A total interobserving response time was then determined for responses toward each target. These two totals were calculated by adding the individual interobserving response times for each of the two directions of observing response. The proportional allocation of observing time was calculated by dividing each total time by the length of the interval

(2.5 min.). Since the proportion of observing time allocated to the left is the complement of that allocated to the right, only the proportion allocated to the right is presented and discussed.

CHAPTER III

RESULTS

Overview

There are two basic purposes of this experiment: (a) the replication of previous experiments by Kapust with increased generalizability to the typical observation situation; and (b) the delineation of relationships between observer accuracy and measures of observing behavior.

The results generally replicate the results of the previous studies. The observers were more accurate when they observed at the lower rate (1.1/min.) than when they observed at the higher rate (3/min.). The results were obtained when the two conditions were observed sequentially as well as simultaneously. The influence of signal rate on observer accuracy is found both within the sessions of each phase and across the rate changes from phase to phase. The relationship does not, however, hold uniformly for the rate conditions presented in Phase IV. The manipulation of predictability of rate conditions in Phase IV produced results that suggest individual differences in the observers' ability to observe accurately when rate conditions were changed from session to session. The results from Phase IV differ among observers.

A direct relationship between the rate of observing responses and changes in the rate of signal presentation was found. In general, the proportional allocation of observing time matched the distribution of the signal stimuli to the two targets. The relationship was not, however, consistently found for all observers, especially in Phase IV. In Phase IV, the observers whose accuracy responded to changes in rate of signal presentation also showed concomitant changes of proportional allocation of observing time in the predicted direction.

A consistent finding for all three measures (accuracy, rate, allocation) is that there were individual differences among observers. In several cases, these differences were of greater magnitude than the effects of the experimental manipulations of rate. In most cases, the individual differences were temporally consistent and continued throughout the experiment. The individual differences and the other results summarized above are presented in detail in the remainder of this chapter.

Observer Accuracy

The observer accuracy data were analyzed in the following manner. The data from Phases I and II for all observers were included in two analyses of variance: one for the accuracy of observations of the left-hand target and one for the accuracy of observations of the right-hand target. The data of Phases III and IV could not be included in these analyses because the observer pairs were rearranged for these phases. The data from Phase III were compared to the data from Phases I and II using the t-test for dependent or paired data. The data of Phase IV were analyzed with t-tests according to the experimental predictions.

Phases I and II. The accuracy data of Phases I and II were transformed using an arcsin transformation because of their proportional nature. These transformed data were analyzed using two 3-way analyses of variance, one for each target of observation. The factors of the analyses were rate of signal presentation (two levels: 1.1/min. and 3/min.), session (six levels: six sessions per phase), and order in which the two rates were presented (two levels: 1.1 then 3, and 3 then 1.1). Two observers were nested within each level of the order factor. The rate and session factors were repeated measures.

Tables 4 and 5 present the summary tables for these analyses. Only one factor, rate of signal presentation, is significant in each analysis of variance (right-hand target: F (1,2) = 73.85, p .05; left-hand target: F (1,2) = 38.90, p .05). Observer accuracy for both targets was greater when the observers were presented with signal rates of 1.1/min. at both targets than when they were presented with rates of 3/min. at both targets. When presented with the 1.1/min. rates, the observers achieved accuracies of 93.9% and 95.7% for the right- and left-hand targets respectively. When presented with the 3/min. rates they achieved accuracies of 89.1% and 90.4% respectively. These results replicate the significant between-group rate factor of

Kapust's earlier work. (The mean and standard deviation of each observer's accuracy for the left- and right-hand targets in Phases I, II, and III are presented in Table 6.)

The left- and right-hand accuracy data for all sessions of Phases I through IV are presented in Figures 3 to 6 for observers M,R,T, and D, respectively. (The data presented in Figures 3-6 are presented in tabular form in Table 7.) These figures illustrate the greater accuracy exhibited by all observers in Phases I and II when they were presented with the 1.1/min. rate condition and the lesser accuracy when they were presented with the 3/min. rate condition. It should be noted that each observer's levels of accuracy were relatively constant throughout these two phases.

Figures 3-6 also present one type of individual difference. In Phases I and II, Observers M and R (Figures 3 and 4, respectively) show approximately equal levels of accuracy to the right- and left-hand targets. Observers T and D (Figures 5 and 6) show, however, consistently greater accuracy for observations of the left-hand target than for observations of the right-hand target (see also Table 6). For substantiation, the dependent t-test of the data of Observer T shows significantly greater accuracy for observations of the left-hand target than of the right: Phase I, t (5) = 6.79, p .005; Phase II, t (5) = 2.16, p .10. The data of observer D show similar results. (Appendix C presents the results of all t tests, both significant and non-significant.) These individual differences in accuracy for each target behavior are further discussed below.

Phase III. Figures 3 to 6 and Table 7 present the left- and right-hand accuracy data for all phases. The phase means and standard deviations for Phase I through III are presented in Table 6. Visual examination of these figures and tables reveals three major findings.

First, observer accuracy in Phase III is greater for the target at which the 1.1/min. rate was presented than for the target at which the 3/min. rate was presented.

Second, each observer's level of accuracy to the low signal rate in Phase III is consistent with her level of accuracy to the low signal rate in Phases I and II and is different from her level of accuracy to the high signal rate in these two phases. Observer M's data provide one exception: Her level of accuracy for the right-hand target in Phase I (at which the signal was presented at the lower rate) is significantly greater than her accuracy in Phase III at this target (with the same signal rate) with dependent t (5) = 3.54, p .02. Each observer's level of accuracy to the high signal rate in Phase III is consistent with her level of accuracy to the high signal rate in Phases I and II and is different from her level of accuracy to the low signal rate in these two phases. (Consistency and difference are based on visual inspection of the data and the use of dependent t-tests when inspection proved equivocal. The results of the t-tests are found in Appendix C.)

Third, the above two findings show little fluctuation across the sessions within the phases.

Phase IV. As was noted in the Introduction, the predictability of the rate conditions of Phase IV can be viewed in two ways, each interpretation predicting slightly different results. The two interpretations apply to the sequence of rate conditions presented to Observers R and D only. This sequence of rate conditions was designed to be predictable. (The rate conditions of Phase IV are presented in Table 1.) The rate conditions presented to Observers M and T were designed to be unpredictable and for the first four sessions of Phase IV were selected randomly.

One interpretation, referred to as "combined", considers the rate conditions at the two targets as a single or combined stimulus that controls the observers' behavior. The alternate interpretation, referred to as "separate", views the rate condition presented at each target as a single stimulus. The behavior of the observer is controlled by each of these two separate stimuli.

The combined interpretation was implicit in the design of Phase IV. It was thought that during Sessions 1 to 5 the combined stimulus alternated predictably between the 1.1-1.1 pair of rates and the 3-1.1 pair. This interpretation led to the conclusion that for Observers R and D the 1.1-1.1 rate condition in Phase IV was discriminable from the 3-1.1 rate condition of Phase III and to a prediction that alteration of the rate condition at either target would influence the accuracy of observation at both targets. Thus, the combined interpretation suggests that in Session 1 of Phase IV, Observers R and D received a stimulus (the 1.1-1.1 rate condition) that was discriminable from the stimulus (the 3-1.1 rate condition) presented in Sessions 1 through 6 of Phase III. In Sessions 2 through 5 of Phase IV the stimulus alternated between these two pairs of rate conditions each of which was discriminable from the other.

The separate interpretation views the rate conditions of Session 6, Phase III and Sessions 1 through 5 of Phase IV in the following manner: The signal rate at the left-hand target remained unchanged (1.1/min.) during these six sessions. The signal rate at the right-hand target alternated between rates of 3/min. and 1.1/min. This interpretation implies that in Phase IV only the rate condition at the right-hand target was discriminable from that in the previous session. The separate interpretation predicts altered observer accuracy to the changing (right-hand) stimulus, only. The data will be discussed in light of both interpretations.

For both interpretations of the design, Session 5 of Phase IV served to test the hypothesis that predictability of rate conditions facilitates observation, i.e., produces increased levels of accuracy. The combined interpretation predicts that, in this session, Observers R and D (who received the predictable sequence) would show greater accuracy at both targets than Observers M and T. These data were analyzed by performing t-tests on the right- and left-hand accuracy of Observers M and T and Observers R and D. The results of the t-test do not support the prediction (left-hand: $t\ (1) = 1.21$, ns; right-hand: $t\ (1) = .127$, ns).

The separate interpretation predicts that the left-hand data of Observers R and D would be more accurate than their right-hand data because the rate conditions at this target were more predictable than at the right-hand target. This interpretation similarly predicts that the left-hand data of Observers R and D would be greater than the left-hand data of Observers M and T. Neither of these predictions is supported by the results of t-tests (Observers R and D, left-hand versus right-hand: t (1) = 1.515, ns; left-hand data, Observers R and D versus Observers M and T: t (1) = 1.21, ns).

The second hypothesis for the data of Phase IV predicts decreased accuracy to the unpredicted rate condition in Session 6 following predictable conditions in Sessions 1 through 5 and unchanged accuracy to this rate condition following unpredictable conditions in the previous sessions. The combined interpretation predicts that Observers M and T, who received the unpredictable sequence of rate conditions in Sessions 1 through 5, would show greater accuracy than Observers R and D, who received the predictable sequence. The data (in Table 7) do not reveal this relationship when the data are compared with t-tests between pairs of observers in Session 6 (left-hand data: t (1) = -2.13, ns; right-hand data: t (1) = -.868, ns). These results are in the opposite direction of the predicted relationship.

The separate interpretation makes different predictions for this second hypothesis. It suggests that the rate conditions that were presented at the left-hand target for Observers M and D show a change from predictable in Sessions 1 through 5 to unpredictable in Session 6 and thus predicts that the left-hand data of these two observers should show a large decrement in Session 6. The rate conditions presented to the right-hand target for all observers and the left-hand target for Observers M and T show less of a change in predictability fromessions 1 through 5 to Session 6, thus the data of these targets and observers are predicted to show little difference in Session 6 or when compared to previous sessions of Phase IV, as above. Examination of Table 7 does not reveal these relationships.

Thus, the results of Phase IV do not unequivocally support any experimental prediction from either interpretation of the design. Several other findings, however, may be seen in this phase. These findings consist of comparisons of the observers' performance in Phase IV with their performance in the previous three phases.

In the first five sessions of Phase IV, Observers R and D received the same rate condition (1.1/min.) at the left-hand target (Table 1). Inspection of Figures 4 and 6 reveals that the accuracy of these observers' observations of this target in Phase IV differs little from their levels of accuracy when this rate was presented in previous phases (Observer R received this rate condition at both targets in Phase I and at the left-hand target in Phase III; Observer D received this rate condition at both targets in Phase II and also at the left-hand target in Phase III). These data indicate that despite changing conditions at the right-hand target (between sessions in Phase IV) the two observers responded independently to the rate conditions presented at the left-hand target. These data provide support for the separate interpretation of the rate conditions presented at the targets.

With the above exception, there were individual differences in the observers in the extent that their levels of accuracy in Phase IV were consistent with their performance across the previous phases in which similar rate conditions were presented. On one hand, Observer M's accuracy for the left- and right-hand targets in Session 5, Phase IV (96.5% and 96.6%, respectively) are higher than any that she obtained in Phase I with the same rate condition (1.1 for both targets). On the other hand, Observer T's accuracy for the right-hand target in Session 5, Phase IV (87.1%) is lower than any score that she obtained in Phase II, with the same rate condition (1.1/min.).

These individual differences are seen to varying degrees for all four observers. Observers D and T show the greatest consistency when their performance in all sessions of Phase IV is compared to that of previous phases with identical rate conditions. Observer M shows the least consistency in such a comparison. Observer M's relative inconsistency, however, does not imply reduced accuracy; unlike the other three observers, she shows a slight overall improvement in accuracy in Phase IV in comparison to the first three phases.

It is important to note that in Session 6 of Phase IV, two observers, M and R (one from each predictability condition), displayed greater accuracy to the left-hand target (at which was presented the 3/min. signal rate) than to the right-hand target (at which was presented the 1.1/min. rate), which is not what would be predicted from past data and from their performance in Phase III. Observers T and D displayed lower levels of accuracy to the left-hand target (at which was presented the 3/min. rate) than to the right-hand target (at which the 1.1/min. rate was presented) which is what would be predicted from past data and from their performance in Phase III. This finding will be related below to the proportional allocation of observing time data.

Rate of Observing Responses

The data on rate of observing responses (observing responses per minute) were analyzed in the following manner. The data from Phases I and II were included in an analysis of variance. This analysis was performed only on the data of Phases I and II because the observer pairs were rearranged following these phases. The data of all phases were analyzed with Pearson Product Moment Correlations for each observer and across all observers. A relationship between accuracy and rate of observing responses is described.

Phases I and II. The data on rate of observing responses were analyzed using a 3-way analysis of variance. The factors of the analysis were rate of signal presentation (two levels: 1.1/min. and 3/min.), session (six levels: six sessions per phase) and order in which the two rate conditions were presented (two levels: 1.1 then 3 and 3 then 1.1). Two observers were nested within each level of the order factor. The rate and session factors were repeated measures. Table 8 presents the summary table for this analysis. The rate factor is the only factor nearing conventional significance, F (,2) = 15.997, p .10, but this finding falls short of demonstrating that there is a direct relationship between rate of signal presentation and the rate of the observing responses. The mean rate of observing responses for the sessions in which the 1.1/min. rate condition was presented to both targets is 47/min. The mean rate of observing responses for the sessions in which the 3/min. rate condition was presented to both targets is 53.5/min.

Phases I through IV. The relationship between rates of signal presentation and rate of observing responses was also tested by Pearson Product Moment Correlations on the rate of observing responses and the average rate of signals in each condition. The correlation coefficient for all observers across Phases I, II, and III is r (70) = .314, p .005, across Phase IV is r (22) = .298, p .05, and across Phases I, II, III, and IV is r (94) = .319, p .005. These correlations, although statistically significant, account for only approximately 10% of the variance in the data.

When correlations are performed on the rates of observing responses and of signal presentation for each observer's data for all sessions of all phases, the following four correlation coefficients are obtained: Observer M - r (22) = .560, p .005; Observer R - r (22) = .641, p .005; Observer T - r (22) = .152, p .10; Observer D - r (22) = .637, p .005.

These calculations indicate a very strong direct relationship between signal rate and rate of observing responses for Observers M, R, and D. This relationship accounts for between 30% and 40% of the variance in their data. Observer T, however, displays no direct relationship between signal rate and rate of observing responses.

Inspection of Figures 7 to 10 and Tables 9 and 10 provides visual confirmation of these strong relationships and the difference between Observer T's data and that of the other observers. It is important to note that observer T's accuracy data is not distinctly different from that of the other observers.

Visually comparing the mean accuracy data of Phases I, II, and III (Table 6) with the mean rate of observing responses (Table 9) suggests a relationship between these two variables. These data are presented together in Figure 11. Observer M, who shows a mean rate of observing responses consistently lower than the other three observers also displays the lowest mean accuracy for observations of the low signal rate condition, the high signal rate condition, and the mixed rate conditions in Phase III. No consistent relationships of this type can be found at the upper extremes of these two variables, i.e., for the data of Observers R, T, and D. This relationship between rate of observing responses and observer accuracy does not obtain in Phase IV. These data are not included in Figure 11 due to the changing rate conditions within Phase IV.

Allocation of Observing Time to the Right-Hand Target

The allocation of observing time data were analyzed in the following manner. The data from Phases I and II were included in an analysis of variance. This analysis was performed on the data of Phases I and II only because the observer pairs were rearranged following these phases. The data of Phases III and IV were compared to the data of Phases I and II using z-scores, as described below. The data are also discussed in relation to the rate of observing responses data and accuracy data, already described.

Phases I and II. The allocations of observing time of Phases I and II were transformed using an arcsin transformation because of their proportional nature. hese transformed data were analyzed using a 3-way analysis of variance. The factors of this analysis were rate of signal presentation (two levels: 1.1/min. and 3/min.), sessions (six levels: six sessions per phase), and order in which the two rates were presented (two levels: 1.1 then 3, and 3 then 1.1). Two observers were nested within each level of the order factor. The rate and session factors were repeated measures.

Table 11 presents the summary table for this analysis. The allocation of observing time was not influenced by rate, session, or order: no factors or interactions are significant at $p = .05$. This lack of significant change within the first two phases may be seen in Figures 12 through 15. The data presented in these figures show the allocation of observing time for Phases I through IV for Observers M, R, T, and D, respectively.

In these figures, the percent of observing time that was allocated to the right-hand target is presented for each session, for each observer. The dashed lines represent the proportional distribution of signal stimuli to the right-hand target and were determined by dividing the rate of stimuli presented to the right-hand target by the sum of the rates presented to both targets. Each dash represents the proportional distribution of signal stimuli for one session. If an observer's data coincided exactly with the dashed lines, the observer would have distributed her observing time to the targets in exactly the same proportions as the distribution of the signal stimuli at the targets. That is, the observer would be showing perfect matching of observing time to the distribution of signal stimuli.

The phase means and the standard deviations of the proportional allocation of observing time to the right-hand target for each observer in Phases I, II, and III are presented in Table 12. The allocation of observing time data for each session of each phase for each observer are presented in Table 13.

Since the signal stimuli were distributed equally between the two targets, it was predicted for all sessions of Phase I and II that the allocation of the observers' observing time to one target would not be significantly different from their allocation to the other target. The nonsignificant results of the analysis of variance conducted on these data support this prediction as does visual inspection of the data.

It should be noted that this approximation of matching of the allocation of observing time to the distribution of signal stimuli appears to be independent of the signal rates (at the magnitudes used in this experiment). That is, this approximation of matching remained relatively constant throughout Phases I and II even though the rate of signal presentation was altered between the phases.

Inspection of the four observers' data reveals a difference between Observer M's performance and that of Observers R, T and D. The latter three observers show mean allocation of observing time in Phases I and II that range from 50.22 to 54.1%. Observer M, however, shows means of 60.8% and 60.6% for these phases, respectively. The reader should note that, in Phases I and II, Observer M also showed a distinctly low rate of observing responses and slightly lower accuracy. These relationships are also seen in Phase III (discussed below) and, though of small magnitude, suggest that Observer M was performing inefficiently as an observer. That is, she produced fewer observing responses than the other observers and distributed them in a less efficient manner. The inefficient observing style may have produced her slightly lower levels of accuracy.

Phase III. During this phase, all four observers received 73% of the signal stimuli from one target and 27% from the other. Figures 12 through 15 present these distributions as dashed lines. Inspection of these figures reveals that each observer's proportional allocation of observing time changes in the same direction as the change in distribution of signal stimuli. For example, Observer R's mean allocation in Phases I and II is 50.2% and 52.7%. In Phase III, the signal stimuli were distributed to Observer R with 73% at the right-hand target and 27% at the left-hand target. For the first three sessions of Phase III, her allocation is similar to Phases I and II (Session 1 = 53.5, Session 2 = 51.0, Session 3 = 52.6), but in the last three sessions she allocated a progressively greater proportion of her observing time to the right-hand target (Session 4 = 56.3%, Session 5 = 57.2%, Session 6 = 61.0%).

These changes from Phases I and II to Phase III are further illustrated in Table 14. This table presents each observer's proportional allocation in Phases III and IV as a standard score (*z*-score) of her allocation in Phases I and II. The *z*-score was used to make this comparison because dependent *t*-tests were obviated by the unequal number of data points (12 from Phases I and II, together; 6 each from Phases III and IV) for each observer. The *z*-scores were calculated for each observer by grouping together the mean allocation for all sessions of Phases I and II and obtaining the mean and standard deviation. A *z*-score was determined for each session of Phases III and IV for each observer in order to describe the observers' allocation in these phases in terms of their performance in the preceeding two phases. A positive *z*-score indicates more allocation of observing time to the right-hand target in comparison to the allocation in Phases I and II; a negative *z*-score indicates less allocation to the right-hand target (i.e., more to the left-hand target). A significant *z*-score, regardless of the direction, suggests that the indicated session mean is not likely to be obtained by chance from the distribution of session means of Phases I and II. The greater the significance, the less the likelihood that the score may be obtained from this distribution.

In Session 6 of Phase III, all observers display a significant difference in their performance compared with Phases I and II. The directions of the differences are toward the target at which were presented the greater proportion of signal stimuli. Thus, Observers R and D received more signals at the right-hand target and show positive *z*-scores; Observers M and T received fewer signals at the right-hand target and show negative *z*-scores. Significant *z*-scores are seen prior to Session 6. Observers M and D show significant *z*-scores in Session 5 and Observer T in Sessions 2 through 6. Of interest, is Observer D's *z*-score in Session 1 of Phase III, in which she showed a significant change away from the predicted direction but then in subsequent sessions reversed her direction of change in allocation toward the right-hand target.

Thus, in Phase III, when each observer received more signal stimuli at one target than the other, all observers began to allocate more observing time to the target at which were presented the greater number of signals. It should be noted that unlike the changes in levels of accuracy and rate of observing responses presented above, the changes in allocation of observing time do not occur in the first session of the changed rate conditions. The changes in allocation appear only after several sessions, the number of which varies for individual observers. Also, the observers do not appear to reach stable (asymptotic) levels of allocation by the last session of Phase III.

Phase IV. It was predicted that the allocation of observing time by observers who received the predictable sequence of rate conditions would better approximate the distribution of the signal stimuli to the two targets than would the allocation by the observers who received the unpredictable sequence. This prediction is not supported by the results (Table 14; Figures 12 through 15). Of the two observers who received the predictable sequence of rate conditions, Observers R and D, only one, Observer D, showed this relationship to a significant degree; and she did so in one session, only: Session 6.

Observer R shows no significant *z*-scores, indicating that her allocation did not significantly differ from her allocation in Phases I and II, even though in Sessions 2,4, and 6, 73% of the signal stimuli were distributed to one side or the other (see Table 1) and only Sessions 1, 3, and 5 had the same distribution of signal stimuli that was presented in Phases I and II. Observer D showed significant *z*-scores in Sessions 5 and 6. These significant *z*-scores reflect an increase in allocation to the right hand target in Session 5 from that of Phases I and II and a decrease in allocation in Session 6 from that of these two phases. Only the latter change was predicted. Thus, predictability did not systematically influence the allocation of observing time.

Observers M and T, who received the unpredictable sequence of rate conditions show, in Phase IV, patterns of allocation that differ from each other and also from those of Observers R and D. In all six sessions, Observer M's allocation to the right-hand target is less than that shown by her in Phases I and II (all sessions but Session 4 are significantly lower; Table 14). These data indicate an overall reduction of Observer M's allocation of observing time to the right-hand target during Phase IV. Her performance does not closely correspond to the distribution of signal stimuli in Phase IV (which was equal to each target in Sessions 1, 2, 4, and 5 and 27% to the right-hand target in Sessions 3 and 6). Observer T showed greater allocation to the right-hand target in Phases I, II, and III than the other observers. This reduction in her overall level of allocation appears to be inversed related to her overall levels of accuracy.

Observer T's data shows significant decreases in allocation in Sessions 3, 5, and 6. In Phase IV, Observer T received signal stimuli that were distributed equally to the two targets in Sessions 1, 2, 4, and 5, and signals that were distributed predominantly (73%) to the left-hand target in Sessions 3 and 6. Thus, of all the observers, allocation of Observer T's observing time best approximates the distribution of signal stimuli at the targets. It should be noted that Observer T also showed this correspondence to a greater extent and earlier in Phase III than did the other three observers. In Session 6 of Phase IV, two observers, D and T, showed greater accuracy to the right-hand target, at which the 1.1/min. signal rate condition was presented, than to the left-hand target, at which the 3/min. rate condition was presented. These two observers also exhibited more observing time to the left-hand target than to the right-hand target. In this session, the other two observers, M and R, both show greater accuracy to the higher signal rate and approximately equal allocation of observing time to each target.

In summary, allocation of observing time does not appear to be directly influenced by the predictability of the signal rate. Allocation appears to be less sensitive to changes in signal rate than are observer accuracy and rate of observing responses, to be more sensitive to the distribution of signal stimuli at the targets than are the other two variables, to be slower to respond to changes in distribution of signal stimuli than are accuracy and rate of observing responses, and, as are both other variables to be controlled by variables that differ among observers.

CHAPTER IV

DISCUSSION

Discussion of Findings

Influence of signal rate on observer accuracy. In the present study, as in Kapust (1976) and Kapust and Nelson (Note 1), the observers were more accurate when the lower (1.1/min.) signal rate was presented than when the higher (3/min.) signal rate was presented. As was predicted, this effect was found when the two rate conditions were presented in the same phase (Phase III) and when they were presented in successive phases (Phases I and II). The respective levels of accuracy for the two rates obtained in Phases I and II, when the rate conditions were presented separately, were equivalent to those obtained in Phase III when the two rate conditions were presented simultaneously. Thus, the simultaneous presentation of the differing rate conditions (Phase III) did not alter the general levels of accuracy that were obtained during every session.

This inverse effect of signal rate on observer accuracy (higher accuracy at lower rates) is discrepant with related findings in the vigilance and observation literatures. Many vigilance experiments (e.g., Baddeley & Colquhoun, 1969) have found that observer accuracy increases as the signal rate increases; observation studies (e.g., Johnson & Bolstad, 1973) commonly report that reliability or inter-observer agreement is generally lower when "low-rate" behavior is monitored. There are several possible explanations for this discrepancy.

First, these may be differences in parametric values in event and signal rates. The "low" rates reported in the vigilance experiments are usually in the order of magnitude of .1 signals per minute and the "high" rates are usually in the range of 1 to 10 signals per minute. Thus, both rate conditions of the present experiment are comparable to the "high" rates of the vigilance experiments. The event rate of the present experiment, 8/min., is lower than the 30/min. or 60/min. event rates often used in vigilance experiments. It is not known in what manner these parametric differences influence the accuracy of observation. Vigilance experiments (e.g., Taub & Osborne, 1968) that do, however, use signal rates that approximate those of the present experiment do not yield the traditional vigilance relationships of a decrement in accuracy across time or a direct relationship between accuracy and signal rate.

The parameters of event and signal rate that were used in the present study were originally selected to approximate those found in the natural environment or imposed by observation procedures. For example, Johnson and Lobitz (1974) used an observation system (Patterson et al., 1969) that recorded behavioral interactions as they occurred (the event rate was subject-determined and occurred at a maximum rate of 12/min.). The rates of the four variables that were reported ranged from approximately .67/min. to 3/min. Thus, the parameters of the present experiment reflect the constraints of observation procedures within the natural environment rather than the values selected in experimental analogues of vigilance and observing response experiments.

Second, the discrepancy between the results of the present experiment and those of the vigilance and observation literature may result from the use of different measures to evaluate the fidelity of the observers' recordings. As discussed in the Introduction, observation studies most often use inter-observer agreement to evaluate the observers' performance. The present experiment, however, uses observer accuracy. In the observation studies, the variable that is found to decrease when "low-rate" behaviors are monitored is inter-observer agreement, not observer accuracy. Kapust and Nelson (Note 1) found a non-linear relationship between inter-observer agreement and observer accuracy. This non-linearity cautions against generalization from effects of independent variables on observer agreement to their effects on observer accuracy.

Unlike either the present study or other observation studies, vigilance studies (e.g., Baddeley & Colquhoun, 1969; Loeb & Alluisi, 1970) often use the methodology of signal detection theory to examine their data. The detection of signals (hits) is often measured and reported separately from the correct nonreport of no signals (correct rejections); errors of omission (misses) are often differentiated from errors of commission (false alarms). Baddeley and Colquhoun (1969), for example, report that as signal rate was increased, signal detection improved; but errors of comission became more frequent. The present study, however, incorporates hits, correct rejections, misses, and false alarms into a composite calculation of observer accuracy. The effects of a wider range of a signal rates or these four variables could be examined in future studies.

The influence of signal rate on the rate of observing responses. The research of Holland and Schroeder (Holland, 1958, 1963; Schroeder & Holland, 1968, 1969) and other researchers (e.g., Frazier & Bittetto 1969; Laties & Weiss, 1960, 1963) demonstrates that observing responses are operants that appear to be reinforced by the act of detecting a signal or by the information acquired by such a detection (D'Amato, Etkin, & Fazzaro, 1968). These investigators find that the rate and pattern of observing responses are controlled as an operant by the schedule of the signal stimuli. Thus, it was predicted in the present experiment that the rate of observing responses would vary directly with the rate of the signal stimuli.

This prediction is supported by the performance of three observers, M, R, and D. The rates of their observing responses when the lower signal rate was presented were about 15% lower than that when the higher signal rate was presented. This relationship is relatively strong; it accounts for approximately 30-40% of the variance in these observers' observing response data. It is of interest that the changes in rate appear to occur within the first or second sessions of Phase II, after the rate conditions at both targets were altered (either upward or downward) but the changes appear to develop slowly in Phase III when only the rate condition at one target was changed. One would expect that the alteration of rate conditions at both targets (from Session 6 of Phase I to Session 1 of Phase II) would be more discriminable than the alteration of the rate condition at one target (from Session 6 of Phase II to Session 1 of Phase III), and the data appear to support this supposition. Observer T's performance, however, did not support this prediction that the rate of observing responses would vary directly with the rate of signal stimuli. Her data showed a weak relationship between signal rate and rate of observing responses. She displayed approximately equal rates of observing responses in Phases I and II and showed a 37% decrease in rate of observing responses during Phase III. *Her data will be discussed further below, with the data on proportional allocation of observing time.*

The relationship between rate of observing responses and observer accuracy. The observing response is a necessary component of monitoring or observing behavior. If observing responses are not emitted, no signals can be detected (except by chance) and accuracy is zero. The rate at which observing responses are emitted is thus a determinant of observer accuracy. The levels of accuracy obtained in this experiment are all above 80%; 75% of the accuracy scores are greater than 90%, and 30% are greater than 95%. These levels of accuracy suggest that the task was relatively easy.

Observer M displayed the lowest mean levels of accuracy in Phases I, II and III and also consistently showed a mean rate of observing responses which was lower than those of the other three observers. A possible explanation for the data is that Observer M's lower rate of observing responses was relatively inefficient when compared with the other observers' rates. That is, she did not emit enough observing responses to detect the same number of signals as did the other observers. This inefficiency produced lower levels of accuracy. The explanation is further supported by Observer M's performance in Phase IV. In this phase she showed an increased rate of observing responses and also achieved higher levels of accuracy (when her performance to the rate conditions presented in Phase IV is compared to her performance to the same rate conditions in previous phases). The concept of observer efficiency will be discussed further below.

The rates of observers' observing responses may have been influenced by an additional variable: the cost of emitting the observing response. Baum (1975) reports that with no cost for making an observing response, subjects would rapidly alternate their observing responses from one target to another. When a cost was defined by the experimenter and made contingent on the observing response, this rapid alternation was eliminated. Increasing the response cost increases the extent to which the allocation of observing responses matches the distribution of the reinforcers (or signal stimuli). These experimenter-defined response costs can be a monetary penalty for making an observing response or the occurrence of a short period after the observing response during which reinforcement is made unavailable.

The present experiment did not impose an experimenter-defined response cost on the observing response. It is possible, however, that a naturally-occurring response cost, fatigue, did exist. In several pilot tests, volunteers were asked to emit observing responses at varying rates. When asked to do so as quickly as possible, they were able to emit 80 observing responses per minute for several minutes, but were not able to or did not elect to continue this high rate due to pain or fatigue. When asked to respond at a comfortable rate, they emitted about 40 observing responses per minute and reported no pain or fatigue.

In the present study, there were no explicit experimental controls over the observers' rates of observing responses. Each observer was permitted to assume a rate according to the naturally occurring response costs and the constraints of the experimental task. Inasmuch as no observer at any time during the experiment complained about her eyes, it may be assumed that each observer emitted a rate that was less than the painful or fatiguing maximum of which she was capable. Their rates reflect the interaction of variables idiosyncratic to each observer and the experimental demands. This point will be discussed further below.

<u>The relationship of signal rate and signal distribution to proportional allocation of observing time</u>. The results of experiments by many investigators (e.g., Baum, 1975; Wyckoff, 1969) demonstrate that the matching law (see Herrnstein, 1974) describes the relationship between observers' allocation of their observing responses to

targets of observation and the rates at which the signal stimuli are presented at these targets. With discrete observing responses, such as the depression of a pushbutton to produce a single flash of light of fixed duration (e.g., Frazier & Bitetto, 1969), the rate of the observing responses can differ at the various targets of observation. That is, the observer allocates more of his or her observing responses to one pushbutton than to another and is able to observe more frequently at the target illuminated by the preferred pushbutton. In the present experiment, however, the observing responses were restricted to two targets. Since the observing response was defined as a movement of the observer's eyes from one target to the other, the number of observing responses made to one target per unit of time was always equal to or differed by one response from the number of observing responses made by that observer to the other target in that unit of time. Thus, the rate of observing responses to one target was almost identical to that of the other.

Instead of varying the rates of observing responses to each target, the observer is able to vary the amount of time that he or she views one target or the other between observing responses. That is, the observer can choose to fixate or gaze at one target for greater periods of time than the other target or can choose to gaze at both for the same amount of time. The variable, proportional allocation of observing time reflects the observers' choices in observing the targets.

It was predicted that when the rates of signal presentation at the two targets were equal (in Phases I and II) the proportional allocation of observing time would be half to each target or .50. The data of three observers, T, D, and R, support this prediction. Observer M consistently allocated more observing time to the right-hand target (with a proportion of about .60). This discrepant pattern of responding will be discussed below.

It was also predicted that when the rates of signal presentation at the two targets were unequal (in Phase III) the proportional allocation o observing time would conform to the distribution of signal stimuli. No prediction was made regarding whether this correspondence would occur immediately or develop over several sessions. The data of all four observers support this prediction with the correspondence developing across several sessions, the number of which and the extent of the correspondence differing among the four observers. None of the observers appeared to achieve actual matching or stable asymptotic levels of allocation in the six sessions of Phase III.

Thus, the observers were able to discriminate among the various distributions of signal stimuli and to modify their observing behavior accordingly. Their apparent use of this matching strategy further supports the explanation of observer accuracy in terms of the efficiency of the observer.

On one hand, Observer T, who showed the closest approximation to matching of observing time to signal distribution in Phase III, also showed a precipitous decline in rate of observing responses during this phase. That is, as she matched her observing time to the signal stimuli, she looked from target to target less frequently. This dual change was accompanied by constant levels of accuracy through Phase III until Session 6 when her left-hand accuracy decreased. These events may represent an attempt by this observer to minimize the effort or cost of observing while maximizing her performance, i.e., being very efficient. She was able to increase her efficiency until Session 6, when she may have reduced her rate of observing responses to below the optimal level. With no feedback for her performance, as in the present study, it is likely that she was not aware of her change from efficient observing in Session 5 to inefficient observing in Session 6.

On the other hand, Observer M displayed a less efficient pattern of allocation of observing time during Phases I and II and the beginning of Phase III. That is, she allocated more observing time to the right-hand target than to the left. She was thus less able than the other observers to detect signals at the left-hand target. The explanation, as it stands, does not, however, explain Observer M's low accuracy to the right-hand target during Phases I and II. The greater proportion of allocation to this side should have produced, if only slightly greater accuracy to this target. It appears that the accuracy of the observer is influenced by factors in addition to rate of the observing response, the allocation of observing time, and the distribution of signal stimuli.

These factors and the efficiency of the observer will be discussed further below.

The influence of altered signal rate conditions between phases on accuracy. Phase IV was designed to manipulate the predictability of signal rate conditions. As presented above, the nature of the predictable conditions is subject to two interpretations, but, regardless of the interpretation, predictability per se had no consistent effect on the three dependent variables. The data appear to be influenced more by characteristics of the individual observers than by this experimental manipulation.

The data of Phase IV are not, however, without interest. Many experiments in the field of applied behavior analysis vary the experimental conditions from session to session. The designs of these small group or single subject experiments are referred to as "alternating treatments", "multiple schedule", and randomization design" (Barlow & Hayes, 1979). The effects of rapidly changing experimental conditions on measures of the observers' behavior have not been systematically investigated. The following section discusses the results of Phase IV as they relate to this topic.

In Sessions 1 through 5 of Phase IV two observers, R and D, received the same rate of signal stimuli at the left-hand target. The rates of signal stimuli were changed between sessions at the right-hand target for these two observers, at both targets for them in Session 6, and at both targets throughout the phase for Observers M and T. The accuracy of Observer's R and D to the unchanging left-hand target in Phase IV was quite similar to their performance in the same signal rate condition for the left-hand target in Phase III. This consistency of accuracy is seen even though the rate conditions at the right-hand target (the other target) were altered between each session. Thus, these two observers appear to have responded to the constant signal rate at the left-hand target independently of the changing conditions at the right-hand target. The two observers show levels of accuracy to the right-hand target that are similar to their performance in previous phases in which the same rate conditions were presented. Thus, there appears to be no major effect of the changing rate conditions at the right-hand target. Observer T's data also show no clear detrimental effect of the changing rate conditions. In Session 5, however, she does display very low accuracy (87.1%) to the right-hand target at which was presented the 1.1 signal per minute rate. This level of accuracy is not consistent with her performance in Phase I through III, but as discussed above she showed a slight overall increase in accuracy which may be unrelated to the conditions of Phase IV. Thus, the between-session changes in experimental conditions (i.e., signal rate) appear to have no major effect on observer accuracy.

The results discussed thus far indicate that there are definite and complex relationships between observer accuracy and measurements of observing behavior. The construct, observer efficiency, has been presented above to describe these relationships.

This construct may have use in evaluating patterns of observing behavior with a goal of producing high levels of accuracy for an entire period of observation. For example, one one hand, Observer M appeared to show inefficient observing behavior from the first session of the experiment. Observer T, on the other hand, was an efficient observer at first but then became inefficient in Phase III. Each observer showed a different pattern of observing behavior, yet they were both inefficient. This use of "observer efficiency" is discussed further below.

Individual differences in performance. On the basis of the findings of Holland (1963) and Mackworth (1948), it was predicted that the observers might show individual patterns of responding in accuracy or in observing behavior. These individual differences, if found, were predicted to be consistent across rate conditions, i.e., refractive to the experimental manipulation. A number of these differences have been presented and discussed above. One example is Observer M's inefficient pattern of observing behavior in Phases I, II, and III, with the resulting lower levels of accuracy, which differed from the other observers' patterns of observing behavior. Her pattern was stable across these three phases but became like those of the others in Phase IV. A second example of an individual pattern of responding is displayed by Observer T and to a lesser extent by Observer D. In Phases I and II, these observers consistently show greater accuracy to the left-hand target than to the right-hand even though the signal stimuli at these two targets were presented with equal rate. Observers M and R do not display this type of pattern. In Phase III, this pattern is not seen in Observer T's data but is accentuated in Observer D's data. In this phase, each observer responded as was predicted: better performance to the lower rate condition. Thus, the individual pattern of responding shown by Observers T and D in Phases I and II was modified by the experimental manipulation of Phase III.

Several other individual patterns of responding could be described in the present experiment. At this point, the specific patterns are not as important as the existence of the patterns. Further research would be needed to determine the form and stability of these individual differences in performance, the influence of the differences on accuracy in various tasks, and the characteristics of the observers that predict, or possibly produce them.

Summary of results. It is useful, at this point, to summarize the major results of this experiment. First, the accuracy of observation was influenced by rate of signal presentation. An inverse relationship of higher accuracy at lower rates was found across multiple sessions of observing through which the rates at which the signals were presented were altered. Second, observers differed in their ability to maintain their levels of accuracy when the signal rates were altered in every session. Third, measurements of the observers' observing behavior (observing time and rate of observing responses) were related to the rates at which signals were presented, and to a lesser degree, to the observers' levels of accuracy. Fourth, the manner by which the measured observing behavior was related to the rate of signal presentation was not the same for each observer. Fifth, the observers displayed individual patterns of observing behavior and accuracy that appeared not directly related to the experimental manipulations.

These results replicate the inverse relationship between signal rate and accuracy that was obtained in the previous two studies and, furthermore indicate that this relationship obtains under conditions quite similar to those of observation procedures used in the applied settings. The relationship is seen in the results of each observer throughout the multiple sessions of all phases. That is, it is a substantial effect and is not spontaneously corrected by the observers after many sessions. he results thus fulfill the first purpose of the study.

The results also demonstrate the existence of observers' individual patterns of observing behavior and of accuracy, both related to and unrelated to the experimental manipulations. These individual differences have not been demonstrated by previous research in the observation area, although their existence has been noted in vigilance and observing response research.

The second purpose of the present experiment was to determine lawful relationships between observers' accuracy and their observing behavior. The obtained relationships were suggestive of those predicted from the observing response area. The discrepancies are most likely due to the present study's limited experimental control over possible extraneous variables. Since this relative lack of control (especially over observer variables) is typical of research in the observation area, the results of the present study have important implications for the use of observation procedures by researchers in the applied analysis of behavior. Because of limitations inherent in the experiment, discussed below, specific conclusions like "observer accuracy decreases as the rate of a target behavior increases" are not warranted. More general conclusions like "observer accuracy is influenced by specific properties of the observer, the observee, and the observation procedures" are warranted.

The present study's finding of an inverse relationship between rate of signal presentation and accuracy that appeared throughout the experiment suggests that observer accuracy is influenced by i.e., is under the control of, certain aspects of the subject's behavior. This situation adds error to obtained data; and the extent of the error may not be measurable independent of the rate of the actual target behavior. The addition of a constant error to one's data is tolerable. The addition of variable error is not. The present study suggests that the source of error, rate of the behavior, may be inseparable from the behavior being observed and that its magnitude may covary with the behavior of interest. Thus, an experimenter who desires to test the efficiency of a certain theraputic technique may inadvertently alter the accuracy of his or her data as he or she alters the rate of the target behavior. The specific individual patterns that were obtained are not of as much value to investigators as the existence of any such patterns. Further research must determine the conditions for the occurrences of the specific patterns, the frequency of their occurrence, their impact on the obtained data, and techniques for identifying observers who observe in these fashions as well as methods of training them to observe correctly. Overall, experimenters must be aware of the possibility that their observers may respond in an idiosyncratic manner to the properties of target behaviors.

The relationships between the observers' accuracy and observing behavior have value in providing an explanatory link between the conditions of observation and the observer's accuracy. They can be used to determine faulty procedures or conditions that are conducive to low accuracy and to suggest corrective modifications for these procedures and conditions.

Limitations of the Present Study

This experiment, as well as the line of research of which this study is a portion, contains several characteristics that may limit the generalizability of the results to other areas.

First, following Phase II, the observer pairings were changed. This change in the observer pairs was done to counterbalance the influence of the order of the rate conditions in the first two phases. The two assistants who were not observing were used to present the signal stimuli to the observers who were observing, thus, the change in observer pairs may have confounded the effects of the rate changes in Phase III when compared to Phases I and II. In Kapust's (1971) Experiment I, the assistant was included as a factor in the design and was found to influence significantly the observers' levels of accuracy. In Phases III and IV of the present study, all four observers were presented signals by one different assistant than in Phases I and II. In both Kapust (1976) and the present study, no differences in the manner of signal presentation were noted by the experimenter. The exist nce, however, of slight differences between the observers cannot be ruled out in the exact topography of their finger movements, in the discriminability of their fingers against the background of their clothes a factor (which was not controlled), or other factors such as unintentional coincidental facial or postural changes that predictably accompanied signal or nonsignal stimuli.

This change in observer pairs also limited the statistical analysis of the data. It precluded the use of analysis of variance to analyze the results of Phases I, II, and III together. The statistical analysis was also hampered by the small number of subjects in each experimental condition, by the relatively few number of sessions per phase, and by the marked differences of the design of Phase IV from that of the first three phases. For example, time series analysis may have been a useful tool, but this technique requires more data points in each experimental condition for each subject than were available.

A third limitation is found in the design of Phase IV. This design, which was intended to manipulate the predictability of rate conditions, permits dual interpretations of predictability. The major flaw in the design of this phase lies in the nature of the redundancy that determined predictability. In Mash and McElwee's (1974) study of the influence of predictability on accuracy of observation, signals occurred 20 times per minute for each 6.5-min. trial. Each trial was repeated six times in each phase of the experiment. The observers thus received many presentations of the redundancy within each trial and received six such trials of training all in the same temporally contiguous session.

In the present study, the redundancy occurred twice within the combined interpretation, or twice for the right-hand target and up to sixteen times for the left-hand target (for Observer D) within the separate interpretation. It is likely that the observers in the present study had difficulty in perceiving the redundancies that were presented because relatively few redundant sequences were presented, because the redundancy required comparison of the conditions of one session to those of the previous session, and because between sessions of observing the observers served as assistants.

In hindsight, the present study would have benefitted from the following modifications, some of which were considered in the original design but were discarded due to time considerations. First, each observer should have observed alone, a procedure which would have eliminated the need for changing observer pairs and would have eased the statistical analysis. Second, because the present study was exploratory in nature, the counterbalancing in Phases I, II, and III should have been delayed until future experiments; instead, all four subjects should have been given identical rate conditions in each session. This change would have further eased the difficulties of statistical analysis and permitted better determination of individual patterns of responding. The manipulation of predictability in Phase IV also should have awaited future experiments, and the sessions allocated to Phase IV should have been used to lengthen the first three phases. This modification would have better permitted the assessment of the stability of observing across time.

Other aspects of the present study that may limit generalizability include the lack of extensive training of the observers in the monitoring task, the nature of the analogue behavior being observed, and the specific limited parameters of the rate of signal presentation and visual angle. Limitations of this type may be eliminated relatively easily through future studies that replicate and extend the findings. Additional suggestions for future research are presented below.

The impact on generalizability of the above mentioned factory is, at present, not known. The present experiment is exploratory, that is, it draws together elements of otherwise disparate areas. The literature of these areas is of marginal value in elucidating the influence of these factors on the present results. Only additional research will suffice.

There is, however, an additional and possibly limiting aspect of the study for which literature exists. This aspect is the method used to calculate accuracy. A number of studies have been conducted and articles written on this topic, most often centering on the computation of interobserver agreement (Foster & Cone, 1980). A review and analysis of this literature is beyond the scope of this study. The reader is referred to Hartmann (1977), Light (1971), and Repp et al. (1976) for discussion of this topic. For purposes of comparison, the present experiment used the Exact Agreement, All Intervals Method (Repp et al., 1976) or Percentage Agreement, Trial Reliability Method (Hartmann, 1977). These studies, unfortunately, provide few specific conclusions. The researchers do, however, emphasize that the specific method selected limits the generalizability of the results to studies utilizing the same methodology. Hartmann (Note 2) expressed concern that there is not sufficient systematic use of the various measures, especially those that are more complex but statistically supported, and that at this time the impact of selecting one method or another cannot be predicted. He suggested that the calculation of the results of observation studies using several methods might be a means of resolving these questions.

This concern about the specific statistic that should be used to calculate observer accuracy is but one facet of a greater issue: the differing methodologies of data analysis and interpretation that are used in experiments dealing with questions related to the validity of observations. The results of experiments in the vigilance, observation, and observing responses literature are not easily generalizable from one area to another although the studies seek to answer related, and often virtually identical, questions. This lack of generalizability results from the different methods of data analysis and interpretation used in each area.

The generalizability model of Cronbach, Gleser, Nanda, and Rajaratnum (1972), as presented by Foster and Cone (1980) and Jones et al. (1975), is a possible tool for better relating these areas. The types of generalizability suggested by Foster and Cone (1980) and Jones et al. (1975) include the context of observation, the behaviors observed, and the method of observation. An additional type of generalizability, methodology of data analysis, is needed to reconcile the various methods of evaluating observer accuracy. An investigation of the generalizability of the methodology of data analysis would be designed to yield data that could be analyzed by the different methods of each field of study. (The reader should note that the data of the present study was recorded in a manner that permits analysis by any of the above mentioned methodologies.)

Observer Efficiency

As discussed above, the results of the present study and of the previous two experiments by Kapust (1976, Note 1) are limited in their generalizability to the literature of the areas of vigilance, observation, and observing behavior. The results do, however, point out the need for future research in this area. A qualitative, inuitive construct, "observer efficiency" is presented below. This construct may facilitate future research by focusing attention on the process of observation rather than on the outcome of observation, by illustrating the complex and synamic nature of this process, and by defining possible areas for investigation. Efficiency is the comparison of production and cost. Observer efficiency is the amount of accuracy (production) produced by a given pattern or amount of observing behavior (cost). A very efficient operation maximizes production while minimizing cost. Both production and cost must be considered in evaluating observer efficiency.

If observation is viewed by its outcome, data that accurately reflect the behavior being observed, little information is gained from data that are inaccurate. When the process of observation is examined, inaccurate data may reveal the causes of inaccuracy and spur the development of procedures that eliminate these causes. The heuristic value of this construct is illustrated below in the results of the present experiment and of experiments by Mackworth (1948) and Holland (1963).

Mackworth (1948) and many other investigators in the vigilance area reported that, under certain conditions, observers showed a great decrement in accuracy as the observation session progressed. Holland (1963), through the measurement of observing behavior, was able to show that this decrement was the result of the decreasing rate of observing responses of some observers. The other observers, who showed constant rates of observing responses, produced constant levels of accuracy. Thus, the former group of observers produced less than maximal results and were very inefficient in their observing. The latter group was more efficient.

In the present study, the results of Observers T and M illustrate the range of observer efficiency. Observer M observed inefficiently by distributing more observing time to one target and emitting relatively few observing responses. Her accuracy was subsequently lower than that of the other three observers. Observer T appeared to show greater efficiency of observation as Phase III progressed. That is, her accuracy (production) remained relatively constant as her rate of observing responses (cost) decreased. This reduction in cost ultimately became inefficient: as she reduced her observing rate in Session 6, her accuracy decreased substantially.

It is as important for an observer to minimize the costs of observing as it is for him or her to maximize accuracy. High accuracy that is obtained only with high costs poses a number of potential problems. First, the observer may not be able or willing to continue observing for the desired length of time, and the volunteer observer is the mainstay of most applied research. Second, research on concurrent schedules (e.g., Baum, 1975) demonstrates that as the cost of observing is increased even slightly, the rate of observing behavior decreases and matching to the signal stimuli increases. When the costs of observing become very high it is likely that matching will decrease as the aversive effects of observing become greater than the rewarding effects of making detections. Third, in many experiments the rate of a behavior is increased as a result of some experimental manipulation.

If high accuracy necessitates maximal effort, the observer might not be able to maintain the level of accuracy as the rate of the behavior increases, thus threatening internal validity. Fourth, and conversely, many experiments attempt to reduce the rate of a behavior. If the observer must use much effort to detect the (higher) baseline rate of behavior, the subsequent reduced rate of detections may be insufficient to maintain the observer's observing behavior when the rate of the behavior is reduced. (This explanation is given by Baddeley & Colquhoun (1969), Holland (1958; 1963), Jerison (1970a; 1970b), Jerison & Pickett (1963), Jerison, Pickett & Stenson (1965) to explain the performance decrement found in certain vigilance paradigms.)

In all of these cases, it would be incumbent on the experimenter to ensure that the observers were not observing with maximal effort even though they are accurate. The experimenter should arrange the conditions of observation to prevent this type of situation. He or she should monitor the observers' observing behavior and modify any inefficient patterns of observing.

Research upon vigilance and observing responses provides some indications of variables that influence observation performance. These findings and possible corrective actions are listed below:

1. Requiring observers to make discriminations by comparing a signal to an internalized (previously learned) criterion produces decreasing performance across time (Loeb & Alluisi, 1970). Most observation procedures, including the present experiment, require that the observer

learn the criterion (observation code or definition of behavior) and make discriminations during the monitoring task using this internalized criterion rather than using external criteria such as written definitions or pictures of the target behavior. The use of external criteria is extremely cumbersome for most situations. Loeb and Alluisi (1970) report that if the criteria are not available externally or if the internal criteria are not frequently recalibrated (through retraining), performance decreases over time, presumably because the internal criteria became distorted. This finding is similar to the phenomenon of observer drift reported by O'Leary and Kent (1972).

2. Environmental variables such as heat, cold, noise, and physical discomfort decrease performance especially in combination (Loeb & Alluisi, 1970). Noise alone appears to interfere only with very complex tasks. These types of variables should be kept to minimal levels.

3. As would be expected, stimulants improve performance; depressants and sleep loss decrease performance (Loeb & Alluisi, 1970). The provision of caffeinated beverages and the solicitation of observers' feelings of well-being before observation sessions could reduce the effects of these organismic variables.

4. Knowledge of results, in terms of detection performance, improves performance. Simulated knowledge of results, while not as powerful as true knowledge, also improves performance but can reward poor performance (Loeb & Alluisi, 1970), as simulated knowledge of results does

not provide a true contingency between correct detections and the feedback.

5. If information regarding the signal rates (Baddeley & Colquhoun, 1969) or schedules (Frazier & Bitetto, 1969) of the behavior to be observed is provided during training, performance during data collection is improved. The observers may use thistype of information to adopt an efficient pattern of observing behavior quickly when data collection is begun. If training is given with the same rates or schedules of behavior that will be encountered in data collection, the observers can learn these efficient response patterns before they are asked to collect data.

6. Many investigators (e.g., Jerison, 1970a) have noted that as the rate of the events to be observed (signal and non-signal stimuli) increased, the latency of the recording response decreased. In general, poor detection performance was accompanied by short latencies and good performance by longer latencies. The experimenter can control this event rate by pacing the observers according to a time schedule (e.g., Hamilton, 1969; O'Leary & Becker, 1967; Patterson et al., 1969) and thus give the observer sufficient time to make his or her decision.

7. The signal-to-noise ratio has a powerful effect on performance (Loeb & Alluisi, 1970); as the signal becomes less discriminable from the non-signal stimuli, performance decreases. The experimenter should attempt to define the target behavior and arrange the conditions of observation to maximize this ratio. That is, if the target behavior is difficult to discriminate, the observers should be given a better

viewing position or be given magnifying glasses. Alternatively, the experimenter could broaden the topography of the target behavior. For example if out-of-seat is the behavior being observed, the category could be altered to include gross movements of the students' torso rather than the extent of support by the chair (O'Leary & Becker, 1967).

8. Multiple sources of signal stimuli and spatial uncertainty of the signal stimuli reduce performance (Loeb & Alluisi, 1970). Modifications of observation procedures to direct the observers' observing responses to targets in specific sequences or at specific locations would serve to reduce thistype of problem.

9. Laties and Weiss (1960) reported that observers often check to see if their recording response actually recorded the datum. That is, they would give an additional observing response to the display to see if the signal was reset by their recording response. In observation settings, the recording response does not reset the target behavior, but observers may nonetheless spend time checking their recording. When paper-and-pencil recording methods are used, time for checking should be allocated; when electronic or electromechanical methods are used, an auditory stimulus that denotes the recording response would decrease these extraneous observing responses.

10. McGrath et al. (1968) reports that interpolating frequent and brief rest periods into a long observation watch improves the detection

of infrequent true signals (McGrath et al. (1968). This manipulation may be useful in certain situations especially when an experimental assistant can be included in the group of individuals to be observed. This assistant can produce the artificial signals. These signals can also be used to calibrate the observers. It is, of course, important that the artificial signals be indistinguishable from the true signals.

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APPENDIX A

TABLE 1

Order of Presentation of the Four Rate Conditions (1.1-1.1, 1.1-3, 3-1.1, 3-3)[a] to the Four Observers (M,R,T,D)[b]

Phase	Sessions	Rate Condition Presented to: Observer M	Observer R	Observer T	Observer D
I	1-6	1.1-1.1	1.1-1.1	3-3	3-3
II	1-6	3-3	3-3	1.1-1.1	1.1-1.1
III	1-6	1.1-3	3-1.1	1.1-3	3-1.1
IV	1	1.1-1.1	1.1-1.1	1.1-1.1	1.1-1.1
	2	3-3	3-1.1	3-3	3-1.1
	3	1.1-3	1.1-1.1	1.1-3	1.1-1.1
	4	3-3	3-1.1	3-3	3-1.1
	5	1.1-1.1	1.1-1.1	1.1-1.1	1.1-1.1
	6	1.1-3	1.1-3	1.1-3	1.1-3

[a]Rate Conditions: The numbers indicate the rate per minute at which the signal stimuli were presented at the targets on the observers' right and left sides, respectively.

[b]Observer Pairs: In Phases I and II, Observer M was paired with Observer R and Observer T with Observer D. In Phases III and IV, Observer M and T were paired and Observers R and D were paired.

TABLE 2

Actual and Scheduled Rates of Signal Presentation per minute by Assistants and Targets

PHASE I

Session	Assistants T&D Targets Right	Assistants T&D Targets Left	Assistants M&R Targets Right	Assistants M&R Targets Left
1	1.00(1.1)[a]	1.05(1.1)	3.10(3)	3.05(3)
2	1.00	1.10	3.05	3.00
3	1.05	1.10	3.05	3.30
4	.90	1.05	3.00	3.10
5	.85	1.10	3.00	3.15
6	.95	1.10	3.05	3.05

[a]The scheduled rate is given in parentheses. In Phases I, II, and III, the scheduled rate remained constant throughout the six sessions.

(Table 2 continued below.)

TABLE 2 (cont.)

Actual and Scheduled Rates of Signal Presentation per minute by Assistants and Targets

PHASE II

	Assistants T&D		Assistants M&R	
	Targets		Targets	
Session	Right	Left	Right	Left
1	3.05(3)	3.20(3)	1.05(1.1)	1.05(1.1)
2	3.05	3.00	1.05	1.05
3	3.00	3.25	1.05	1.05
4	3.00	3.05	1.05	1.05
5	3.00	3.10	1.00	1.15
6	3.05	3.05	1.00	1.15

[a]The scheduled rate is given in parentheses. In Phases I, II, and III, the scheduled rate remained constant throughout the six sessions.

(Table 2 continued below.)

TABLE 2 (cont.)

Actual and Scheduled Rates of Signal Presentation per minute by Assistants and Targets

PHASE III

	Assistants R&D		Assistants M&T	
	Targets		Targets	
Session	Right	Left	Right	Left
1	2.95(3)	1.00(1.1)	1.00(1.1)	3.00(3)
2	3.10	1.00	1.00	3.00
3	3.05	1.05	1.00	3.00
4	3.05	1.00	1.00	3.00
5	3.05	1.00	1.05	3.10
6	3.20	1.00	.95	2.85

[a]The scheduled rate is given in parentheses. In Phases I, II, and III, the scheduled rate remained constant throughout the six sessions.

(Table 2 continued below.)

TABLE 2 (cont.)

Actual and Scheduled Rates of Signal Presentation per minute by Assistants and Targets

PHASE IV

	Assistants R&D		Assistants M&T	
	Targets		Targets	
Session	Right	Left	Right	Left
1	1.05(1.1)	.95(1.1)	1.00(1.1)	1.05(1.1)
2	3.00(3)	3.00(3)	3.05(3)	1.00(1.1)
3	1.05(1.1)	3.05(3)	1.20(1.1)	1.10(1.1)
4	3.10(3)	3.05(3)	2.95(3)	1.00(1.1)
5	1.05(1.1)	1.10(1.1)	1.00(1.1)	1.20(1.1)
6	1.00(1.1)	2.80(3)	1.00(1.1)	3.05(3)

[a]The scheduled rate is given in parentheses. In Phases I, II, and III, the scheduled rate remained constant throughout the six sessions.

TABLE 3

Intervals used in Calculating Rate of Observing Responses and Proportional Allocation of Observing Time to the Right-Hand Target for all Sessions and Observers

	Session	Observer T	D	R	M
Phase I	1	*[a]	2,4,5,8	1,3,5,8	*
	2	1,5,6,8	*	*	*
	3	1,3,4,8	*	*	*
	4	*	*	*	*
	5	*	*	*	*
	6	*	*	2,4,5,8	2,4,5,8
Phase II	1	1,4,5,7	1,4,5,7	*	*
	2	*	*	*	*
	3	*	*	*	*
	4	1,3,6,8	1,3,6,8	*	*
	5	*	*	*	*
	6	2,4,5,8	2,4,5,8	1,4,5,7	1,4,5,7

[a]In each session marked by an asterisk, intervals 1,4,5, and 8 were used.

(Table 3 continued below.)

TABLE 3 (cont.)

Intervals used in Calculating Rate of Observing Responses and Proportional Allocation of Observing Time to the Right-Hand Target for all Sessions and Observers

	Session	Observer T	D	R	M
Phase III	1	*[a]	*	*	*
	2	1,4,5,7	*	*	*
	3	*	1,5,6,8	1,5,6,8	*
	4	2,4,5,8	*	*	2,4,5,8
	5	*	*	*	*
	6	4,5,8	*	2,4,5,8	2,4,5,8
Phase IV	1	*	1,4,5	*	*
	2	*	2,4,5,8	2,4,5,8	*
	3	*	*	*	*
	4	*	*	*	*
	5	*	*	*	*
	6	*	*	*	*

[a]In each session marked by an asterisk, intervals 1,4,5, and 8 were used.

TABLE 4

Summary of Analysis of Variance of Observer Accuracy for Observations of the Right-Hand Target in Phases I and II

Source	*SS*	*df*	*MS*	*F*	*p*
Order (Ord)	0.1697	1	0.1697	4.9196	NS[a]
Observers Within Order (Obs w/in Ord)	0.06899	2	0.03455		
Rate (Rte)	0.56532	1	0.56532	73.8498	$<.05$
Rte x Ord	0.005210	1	0.005210	0.6806	NS
Rte x Obs w/in Ord	0.01531	2	0.007655		
Session (Ses)	0.01454	5	0.002908	1.9375	NS
Ses x Ord	0.001820	5	0.000364	0.2425	NS
Ses x Obs w/in Ord	0.01501	10	0.001501		
Rte x Ses	0.02111	5	0.004222	0.1981	NS
Rte x Ses x Ord	0.01002	5	0.002006	.09413	NS
Rte x Ses x Obs w/in Ord	0.2131	10	0.021311		

[a]NS = not significant at $p \leq .05$.

TABLE 5

Summary of Analysis of Variance of Observer Accuracy for Observations of the Left-Hand Target in Phases I and II

Source	SS	df	MS	F	p
Order (Ord)	0.09537	1	0.09537	3.0451	NS[a]
Observers Within Order (Obs w/in Ord)	0.06264	2	0.03132		
Rate (Rte)	0.5600	1	0.5600	38.90	$p < .05$
Rte x Ord	0.004876	1	0.004876	0.3387	NS
Rte x Obs w/in Ord	0.02879	2	0.01440		
Sessions (Ses)	0.000494	5	0.0000988	0.02287	NS
Ses x Ord	0.039056	5	0.007811	1.8077	NS
Ses x Obs w/in Ord	0.04321	10	0.004321		
Rte x Ses	0.1070	5	0.02140	0.4822	NS
Rte x Ses x Ord	0.046304	5	0.009261	0.2087	NS
Rte x Ses x Obs w/in Ord	0.4437	10	0.04437		

[a]NS = not significant at $p \leq .05$.

TABLE 6

Mean and Standard Deviation (SD) of Percent Accuracy of Observation of the Left and Right Targets for Phases I, II, and III for each Observer

		Observer							
		M		R		T		D	
Phase	Target	Mean	SD	Mean	SD	Mean	SD	Mean	SD
I	Right	93.1	2.7	95.2	1.9	90.1	1.2	88.3	1.6
	Left	94.2	0.8	95.0	3.1	92.8	0.4	90.2	1.5
II	Right	87.1	3.5	91.0	2.6	93.3	3.4	94.1	3.2
	Left	87.2	3.4	91.6	1.4	96.7	1.2	97.0	0.6
III	Right	90.8	2.8	91.5	2.7	95.3	1.4	89.3	2.8
	Left	88.3	1.4	96.6	0.7	91.3	2.7	95.9	1.3

TABLE 7

Percent Observer Accuracy of Observation by Sessions and Phases for both Targets of Observation and for all Observers

Phase	Session	Observer M Target		Observer R Target		Observer T Target		Observer D Target	
		Right	Left	Right	Left	Right	Left	Right	Left
I	1	94.5	95.0	93.2	89.0	91.2	93.2	90.1	90.9
	2	90.3	92.9	96.5	97.5	90.4	92.6	86.3	89.7
	3	95.5	93.9	93.8	96.2	88.6	92.1	86.6	89.2
	4	96.0	94.2	93.4	94.4	91.0	93.3	88.0	89.8
	5	92.4	95.1	97.2	97.0	88.5	92.8	88.6	88.9
	6	89.7	94.0	96.9	95.9	90.9	92.8	90.0	93.0
	Mean	93.1	94.2	95.2	95.0	90.1	92.8	88.3	90.2

(Table 7 continued below.)

TABLE 7 (Cont.)

Percent Observer Accuracy of Observation by Sessions and Phases for both Targets of Observation and for all Observers

Phase	Session	Observer M Target Right	Observer M Target Left	Observer R Target Right	Observer R Target Left	Observer T Target Right	Observer T Target Left	Observer D Target Right	Observer D Target Left
II	1	85.4	84.4	94.3	92.1	96.4	97.1	92.0	97.4
	2	91.7	88.9	88.6	92.5	91.2	96.8	97.0	97.3
	3	86.2	81.8	87.4	89.3	96.4	97.9	89.9	97.2
	4	86.9	88.6	91.1	91.5	88.9	97.3	97.3	97.4
	5	81.9	90.6	93.2	90.9	90.7	96.8	96.7	95.8
	6	90.4	88.9	91.2	93.2	96.2	94.5	91.6	97.1
	Mean	87.1	87.2	91.0	91.6	93.3	96.7	94.1	97.0

(Table 7 continued below.)

TABLE 7 (Cont.)

Percent Observer Accuracy of Observation by Sessions and Phases for both Targets of Observation and for all Observers

Phase	Session	Observer M Target Right	Observer M Target Left	Observer R Target Right	Observer R Target Left	Observer T Target Right	Observer T Target Left	Observer D Target Right	Observer D Target Left
III	1	89.7	90.0	89.4	97.4	96.8	93.7	92.4	94.7
	2	89.0	87.9	87.6	97.0	97.0	90.1	89.6	95.0
	3	94.9	89.0	93.7	97.3	95.4	92.9	84.9	96.4
	4	92.7	89.4	94.3	96.5	94.1	92.8	88.8	97.3
	5	91.3	87.2	93.3	95.9	93.8	91.9	87.9	97.3
	6	87.0	86.5	90.6	95.6	94.7	86.5	92.1	94.4
	Mean	90.8	88.3	91.5	96.6	95.3	91.3	89.3	95.9

(Table 7 continued below.)

TABLE 7 (cont.)

Percent Observer Accuracy of Observation by Sessions and Phases for both Targets of Observation and for all Observers

		Observer							
		M		R		T		D	
Phase	Session	Target		Target		Target		Target	
		Right	Left	Right	Left	Right	Left	Right	Left
IV [a]	1	94.7	93.7	97.9	96.7	93.1	97.7	93.2	96.8
	2	90.2	93.1	92.9	96.2	90.9	91.5	89.7	97.8
	3	92.3	94.0	91.9	97.7	96.3	93.0	93.8	95.2
	4	86.6	92.5	88.0	96.0	89.3	93.0	91.0	95.3
	5	96.5	96.6	94.6	97.0	87.1	96.2	90.0	96.6
	6	87.5	91.4	89.6	93.6	93.9	91.0	95.3	92.1

[a]Because Phase IV consisted of changing rate conditions, no mean was calculated.

TABLE 8

Summary of Analysis of Variance of Rate of Observing Responses in Phases I and II

Source	SS	df	MS	F	P
Order (Ord)	1075.41	1	1075.45	1.335	NS[a]
Observers within Order (Obs w/in Ord)	1611.37	2	805.68		
Rate (Rte)	444.08	1	444.08	15.997	$p < .10$
Rte x Ord	.91	1	0.91	.0328	NS
Rte x Obs w/in Ord	55.52	2	27.76		
Sessions (Ses)	62.80	5	12.56	0.633	NS
Ses x Ord	28.16	5	5.64	0.284	NS
Ses x Obs w/in Ord	198.38	10	19.84		
Rte x Ses	15.41	5	3.082	0.0024	NS
Rte x Ses x Ord	6531.78	5	1306.36	1.040	NS
Rte x Ses x Obs w/in Ord	12555.59	10	1255.56		

[a]NS = not significant at $p \leq .05$.

TABLE 9

Mean and Standard Deviation (SD) of Rate (per minute) of Observing Responses for Phases I, II, and III for each Observer

Phase	Observer M		Observer R		Observer T		Observer D	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
I	34.2	3.0	49.9	3.1	58.5	2.9	56.7	3.5
II	40.6	2.4	58.2	2.5	55.8	4.5	47.8	5.4
III	38.0	3.3	53.5	3.2	50.1	8.3	48.5	2.9

TABLE 10

Rate (per minute) of Observing Responses by Sessions and Phases for all Observers

Phase	Session	M	R	T	D
		Observer			
I	1	32.0	45.5	59.0	52.8
	2	31.0	53.0	58.0	58.2
	3	32.0	52.8	56.0	58.0
	4	35.0	48.0	61.0	54.5
	5	37.8	52.0	62.5	54.2
	6	37.5	48.0	54.8	62.2
	Mean	34.2	49.9	58.6	56.7
II	1	42.0	63.0	54.2	56.2
	2	43.0	59.0	62.2	49.2
	3	40.0	57.2	54.0	50.5
	4	40.5	56.2	54.5	46.2
	5	42.0	56.8	60.0	41.2
	6	36.2	57.0	49.8	43.5
	Mean	40.6	58.2	55.8	47.8

(Table 10 continued below.)

TABLE 10 (cont.)

Rate (per minute) of Observing Responses by Sessions and Phases for all Observers

		Observer			
Phase	Session	M	R	T	D
III	1	40.0	58.2	60.2	48.2
	2	43.2	53.2	55.8	53.2
	3	35.2	54.5	52.0	48.5
	4	38.0	51.8	51.8	49.5
	5	37.5	48.5	43.0	47.4
	6	34.0	54.2	37.8	44.3
	Mean	38.0	53.5	50.1	48.5
IV [a]	1	41.2	53.7	55.4	48.0
	2	42.4	49.4	60.6	51.4
	3	46.8	48.7	61.6	46.4
	4	44.6	45.2	58.4	44.8
	5	39.6	44.0	42.6	38.6
	6	39.7	45.3	50.0	41.6

[a]Because Phase IV consisted of changing rate conditions, no mean was calculated.

TABLE 11

Summary of Analysis of Variance of Proportional Allocation of Observing Time to the Right Hand Target in Phases I and II

Source	SS	df	MS	F	p
Order (Ord)	.0462	1	.0462	4.33	NS[a]
Observers within Order					
(Obs w/in Ord)	.02145	2	.01072		
Rate (Rte)	.000008	1	.000008	.00338	NS
Rte x Ord	.00617	1	.00617	2.609	NS
Rte x Obs w/in Ord	.00473	2	.002365		
Sessions (Ses)	.02545	5	.00509	2.530	NS
Ses x Ord	.02867	5	.005734	2.850	NS
Ses x Obs w/in Ord	.02012	10	.002012		
Rte x Ses	.01748	5	.003496	.0626	NS
Rte x Ses x Ord	.01661	5	.003322	.0595	NS
Rte x Ses x Obs w/in Ord	.5583	10	.05583		

[a]NS - not significant at $p < .05$

TABLE 12

Mean and Standard Deviation (SD) of Proportional Allocation of Observing Time to the Right-Hand Target for Phases I, II and III for each Observer

Phase	M		R		T		D	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
I	0.608	0.021	0.502	0.038	0.520	0.035	0.534	0.020
II	0.606	0.031	0.527	0.026	0.530	0.009	0.541	0.027
III	0.558	0.042	0.553	0.036	0.419	0.049	0.552	0.057

TABLE 13

Proportional Allocation of Observing Time to the Right-Hand Target by Sessions and Phases for each Observer

Phase	Session	Observer M	R	T	D
I	1	.622	.494	.544	.554
	2	.611	.455	.505	.534
	3	.569	.468	.521	.523
	4	.602	.512	.472	.509
	5	.626	.562	.504	.523
	6	.618	.518	.572	.561
	Mean	.608	.502	.520	.534
II	1	.560	.504	.524	.578
	2	.603	.507	.519	.559
	3	.586	.504	.530	.521
	4	.608	.567	.538	.549
	5	.642	.542	.544	.534
	6	.636	.538	.525	.504
	Mean	.606	.527	.530	.541

(Table 13 continued below.)

TABLE 13 (cont.)

Proportional Allocation of Observing Time to the Right-Hand Target by Sessions and Phases for each Observer

Phase	Session	Observer M	R	T	D
III	1	58.3	53.5	49.9	48.0
	2	58.2	51.0	40.9	51.1
	3	59.5	52.6	44.6	56.4
	4	58.0	56.3	41.6	52.5
	5	51.4	57.2	38.0	60.8
	6	49.6	61.0	36.2	62.4
	Mean	55.8	55.3	41.9	55.2
IV[a]	1	44.8	56.3	49.8	56.5
	2	54.4	52.2	49.1	55.8
	3	55.8	51.1	42.7	55.4
	4	57.4	52.4	50.1	55.8
	5	51.4	51.4	47.0	58.4
	6	54.7	53.5	37.9	41.6

[a]Because Phase IV consisted of changing rate conditions, no mean was calculated.

TABLE 14

The Proportional Allocation of Observing Time to the Right-Hand Target of Phases III and IV, by Sessions, Expressed as *Z*-Scores of each Observer's Mean Allocation in Phases I and II [a]

Observer	Mean of Phases I and II	Sessions of Phase III 1	2	3	4	5	6
M	.607	- .96	- 1.00	- .48	-1.08	-3.72**	-4.44**
		(-)[b]	(-)	(-)	(-)	(-)	(-)
R	.514	.62	- .12	.35	1.44	1.70	2.82**
		(+)	(+)	(+)	(+)	(+)	(+)
T	.525	-1.04	- 4.64**	-3.16**	-4.36**	-5.80**	-6.52**
		(-)	(-)	(-)	(-)	(-)	(-)
D	.537	- .25*	1.13	1.17	- .52	3.09**	3.78**
		(+)	(+)	(+)	(+)	(+)	(+)

[a]Positive numbers indicate that the observer's allocation in Phase III or IV exceeded her mean allocation of Phases I and II (i.e., was directed more toward the right-hand target.

[b]The sign indicates the predicted direction of change in allocation from Phases I and II to Phases III and IV.

* = $p < .05$
** = $p < .01$

(Table 14 continued below.)

TABLE 14 (cont.)

The Proportional Allocation of Observing Time to the Right-Hand Target of Phases III and IV, by Sessions, Expressed as Z-Scores of each Observer's Mean Allocation in Phases I and II [a]

Observer	Mean of Phases I and II	Sessions of Phase IV 1	2	3	4	5	6
M	.607	-6.36**	-2.54**	-1.96*	-1.32	-3.72**	-2.40*
		(=)	(=)	(=)	(=)	(=)	(-)
R	.514	1.44	.24	.09	.29	0.00	.62
		(=)	(+)	(=)	(+)	(=)	(=)
T	.525	-1.08	-1.36	-3.92**	- .96	-2.20*	-5.84**
		(=)	(=)	(=)	(=)	(=)	(-)
D	.537	1.22	.91	.74	.91	2.04*	-5.26**
		(=)	(+)	(=)	(+)	(=)	(=)

[a]Positive numbers indicate that the observer's allocation in Phase III or IV exceeded her mean allocation of Phases I and II (i.e., was directed more toward the right-hand target).

[b]The sign indicates the predicted direction of change in allocation from Phases I and II to Phases III and IV.

* = $p < .05$
** = $p < .01$

APPENDIX B

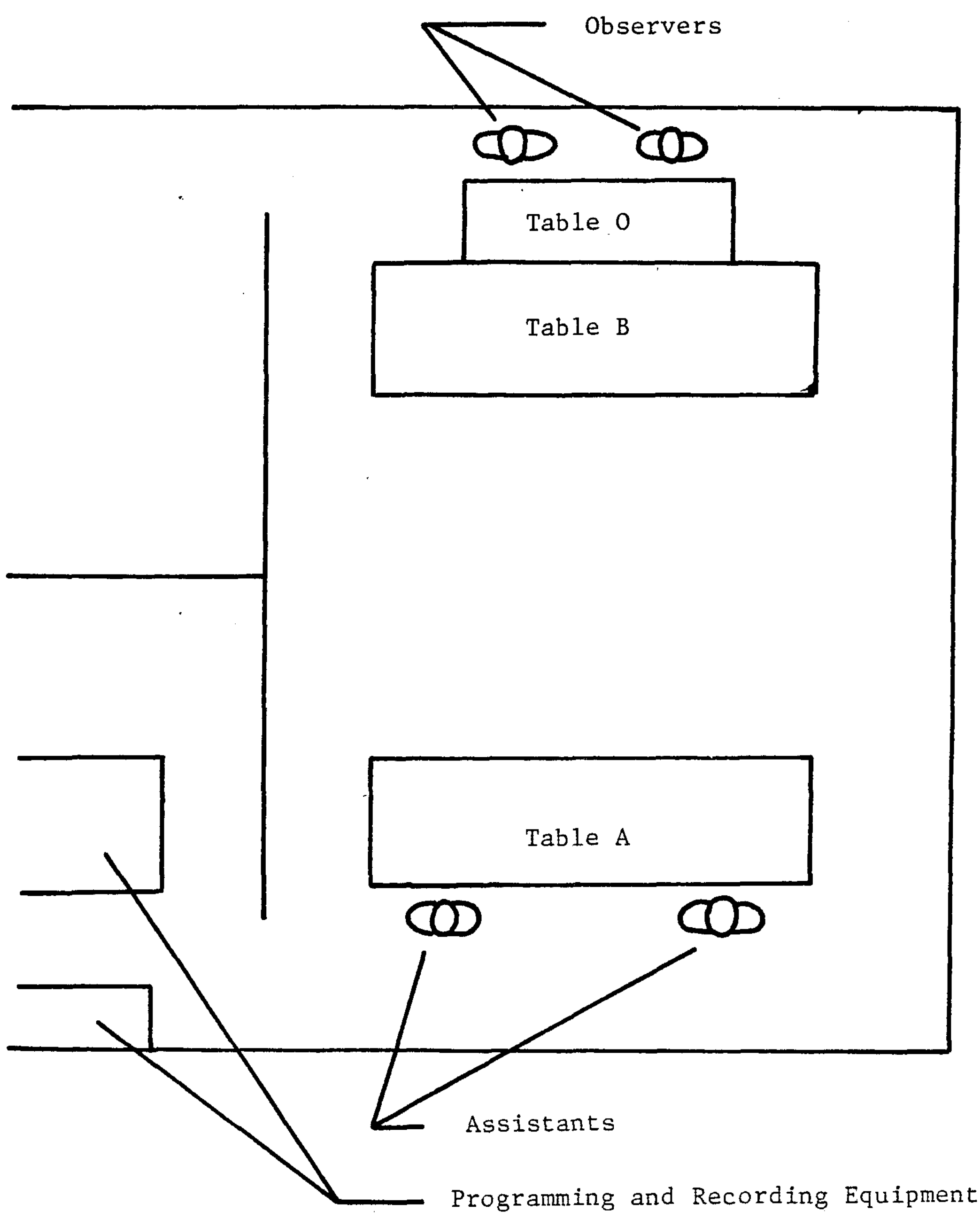

Figure 1. Plan View of the Experimental Setting (Not drawn to scale).

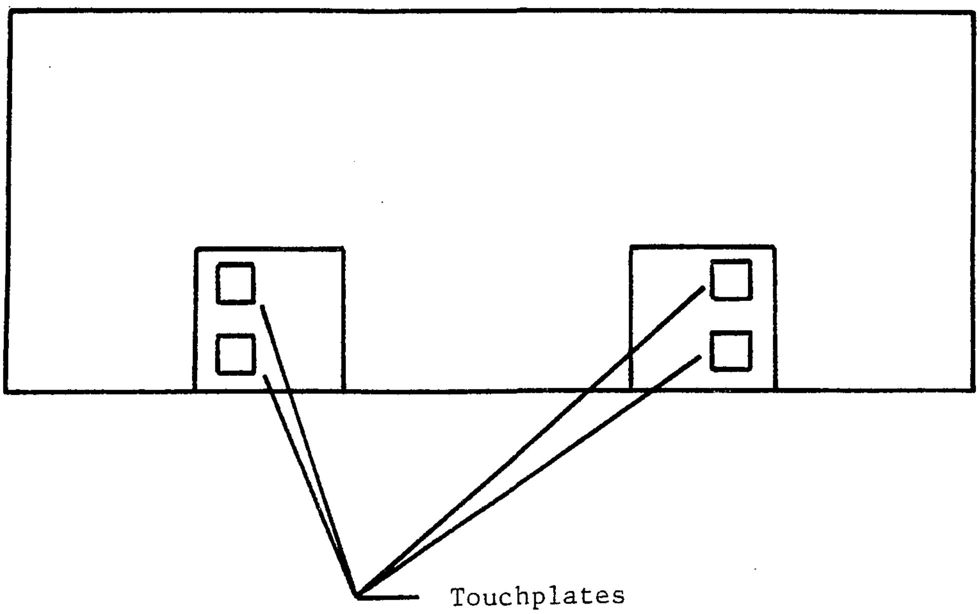

Figure 2. Plan View of Table A (Not drawn to scale).

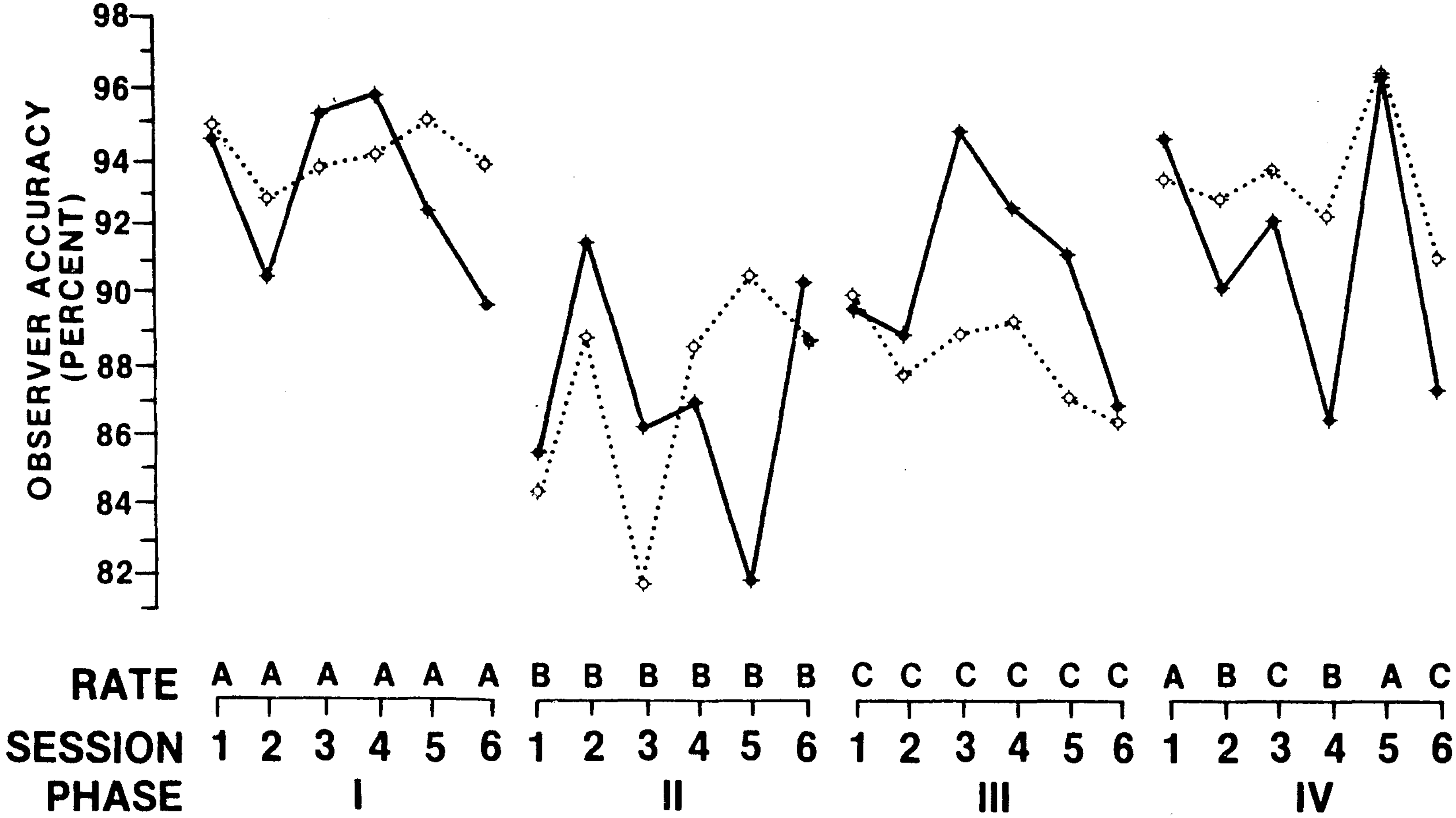

Figure 3. Observer accuracy to the left- and right-hand targets for observer M for all sessions. (Left-hand data: ◇·······◇ , right-hand data: ◆———◆ ; Rate conditions (right-hand, left-hand): A = 1.1-1.1, B = 3-3, C = 1.1-3, D = 3-1.1).

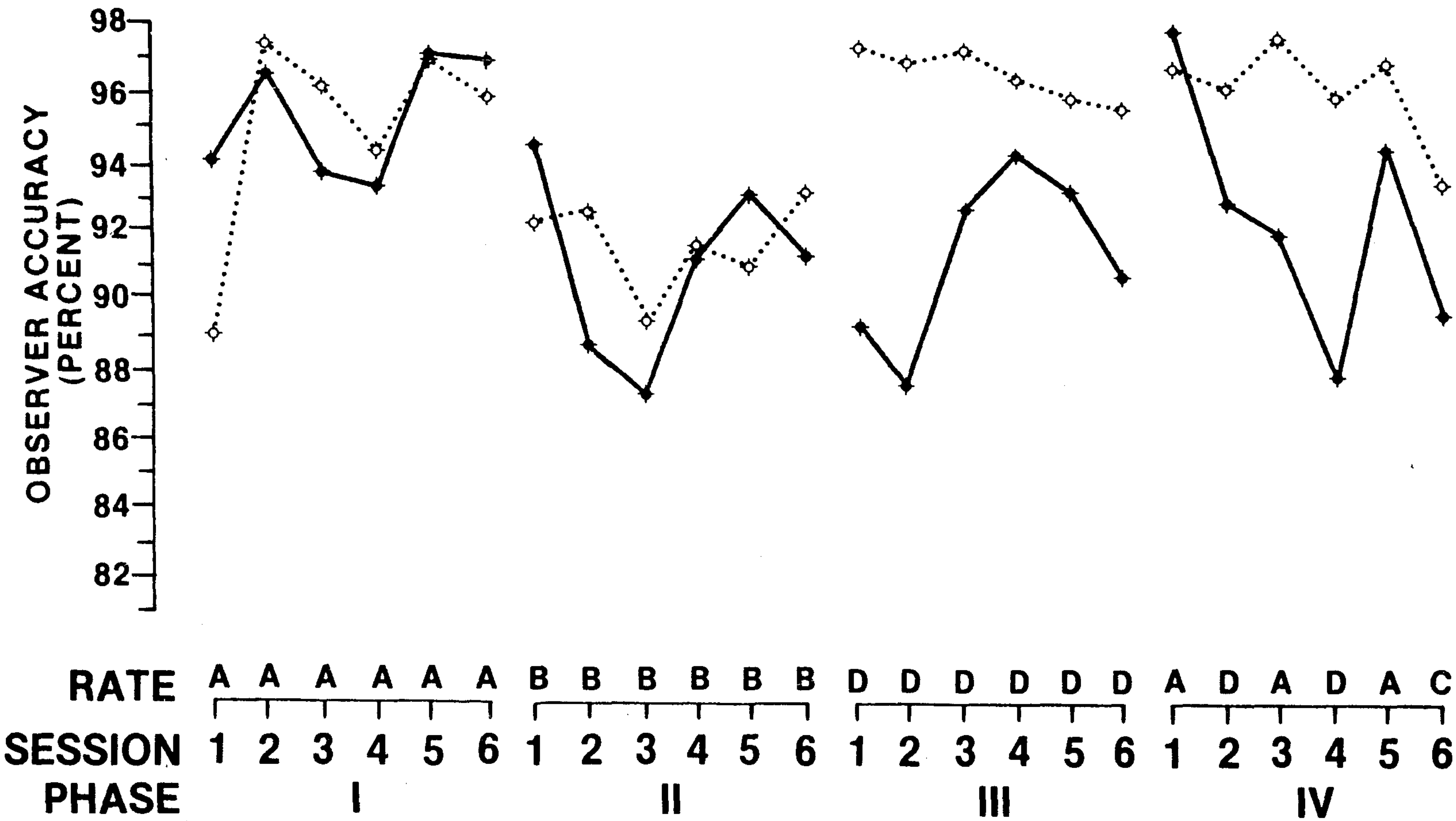

Figure 4. Observer accuracy to the left- and right-hand targets for observer R for all sessions. (Left-hand data: ◇·········◇ , right-hand data: ◆━━━◆; Rate conditions (right-hand, left-hand): A = 1.1-1.1, B = 3-3, C = 1.1-3, D = 3-1.1).

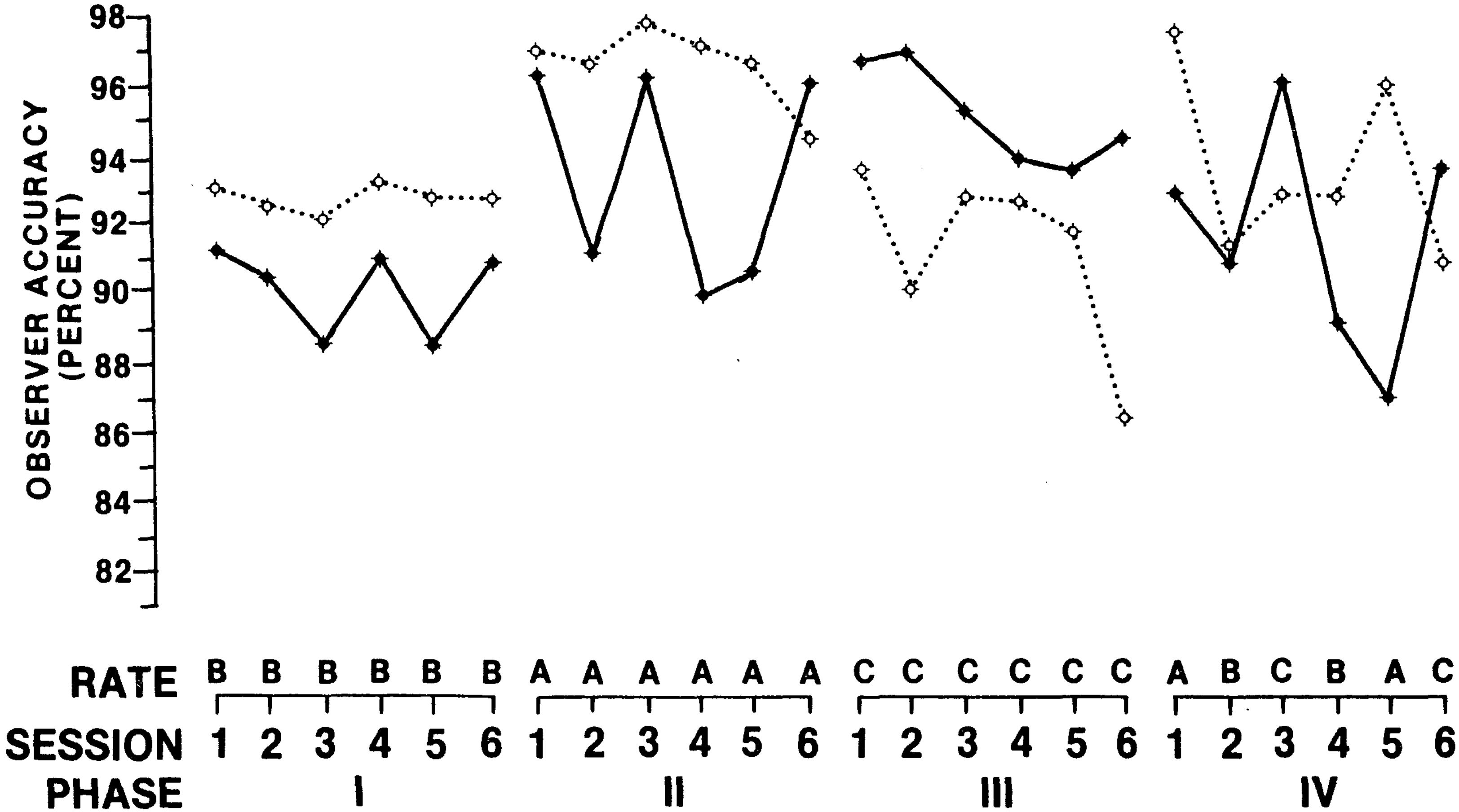

Figure 5. Observer accuracy to the left- and right-hand targets for observer T for all sessions. (Left-hand data: ◇·········◇ , right-hand data: ◆———◆ ; Rate conditions (right-hand, left-hand): A = 1.1-1.1, B = 3-3, C = 1.1-3, D = 3-1.1).

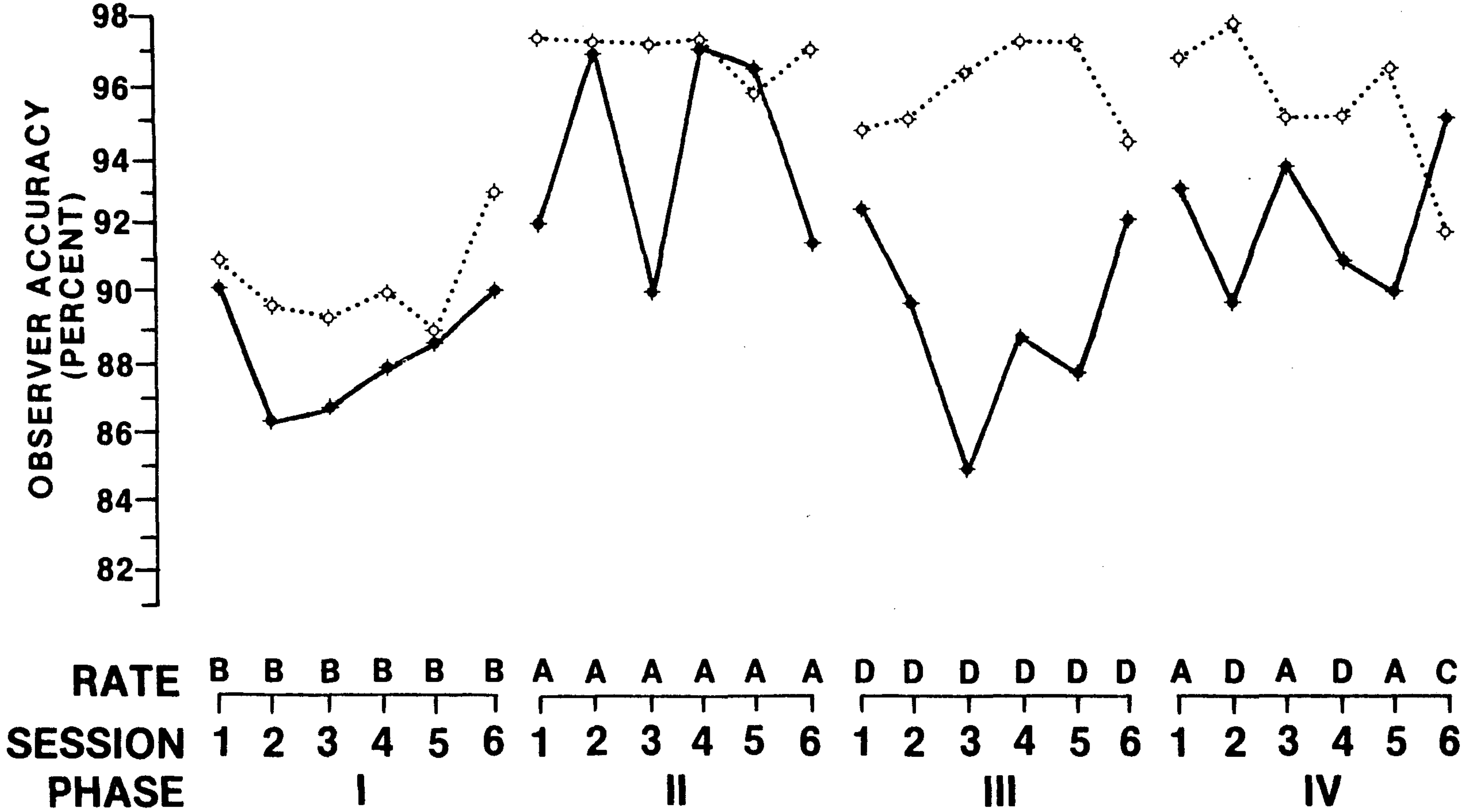

Figure 6. Observer accuracy to the left- and right-hand targets for observer D for all sessions. (Left-hand data: ◇········◇ , right-hand data: ◆———◆ ; Rate conditions (right-hand, left-hand): A = 1.1-1.1, B = 3-3, C = 1.1-3, D = 3-1.1).

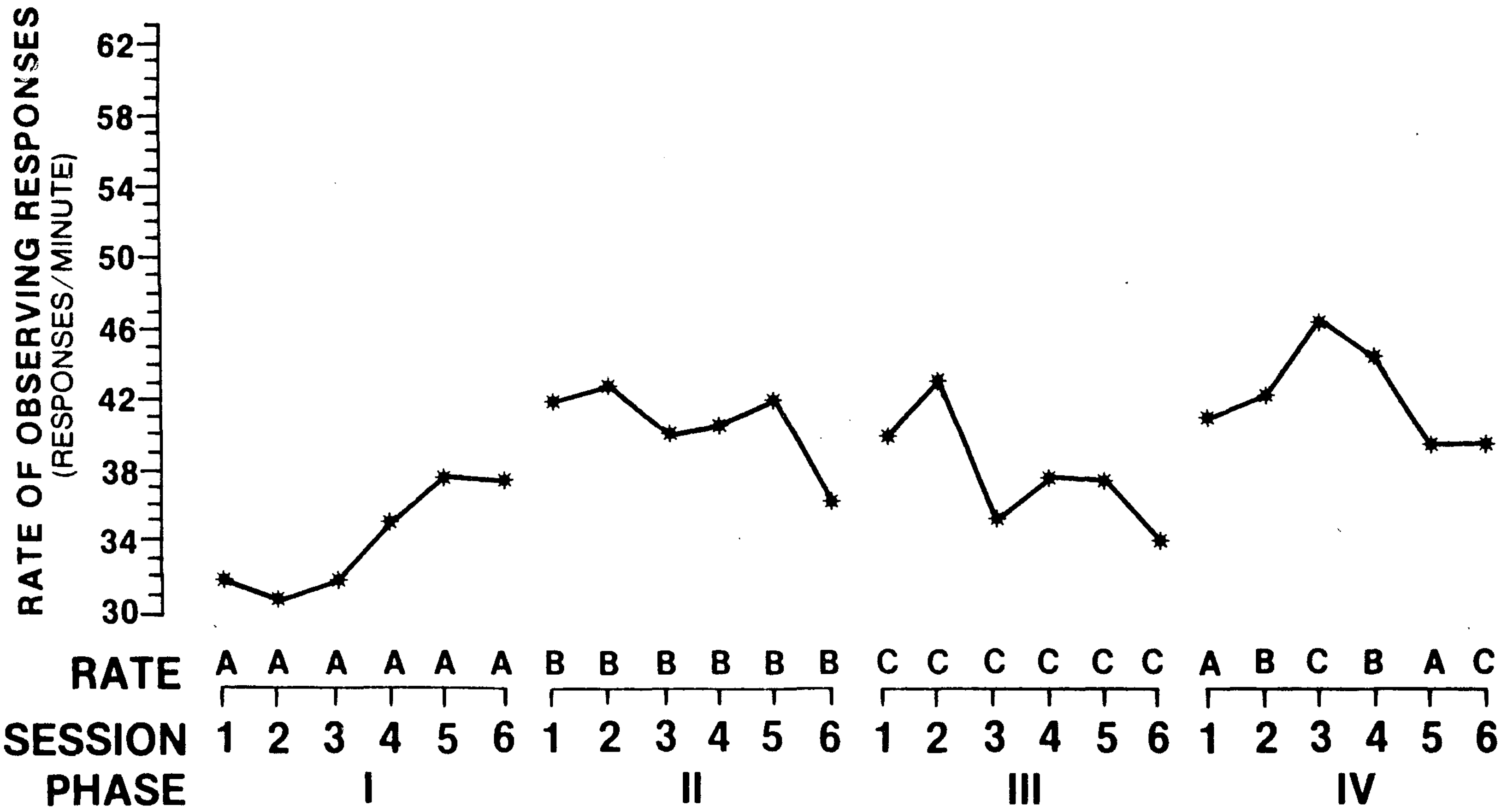

Figure 7. Rate of observing responses for Observer M for all sessions. (Rate conditions (right-hand, left-hand): A = 1.1-1.1, B = 3-3, C = 1.1-3, D = 3-1.1).

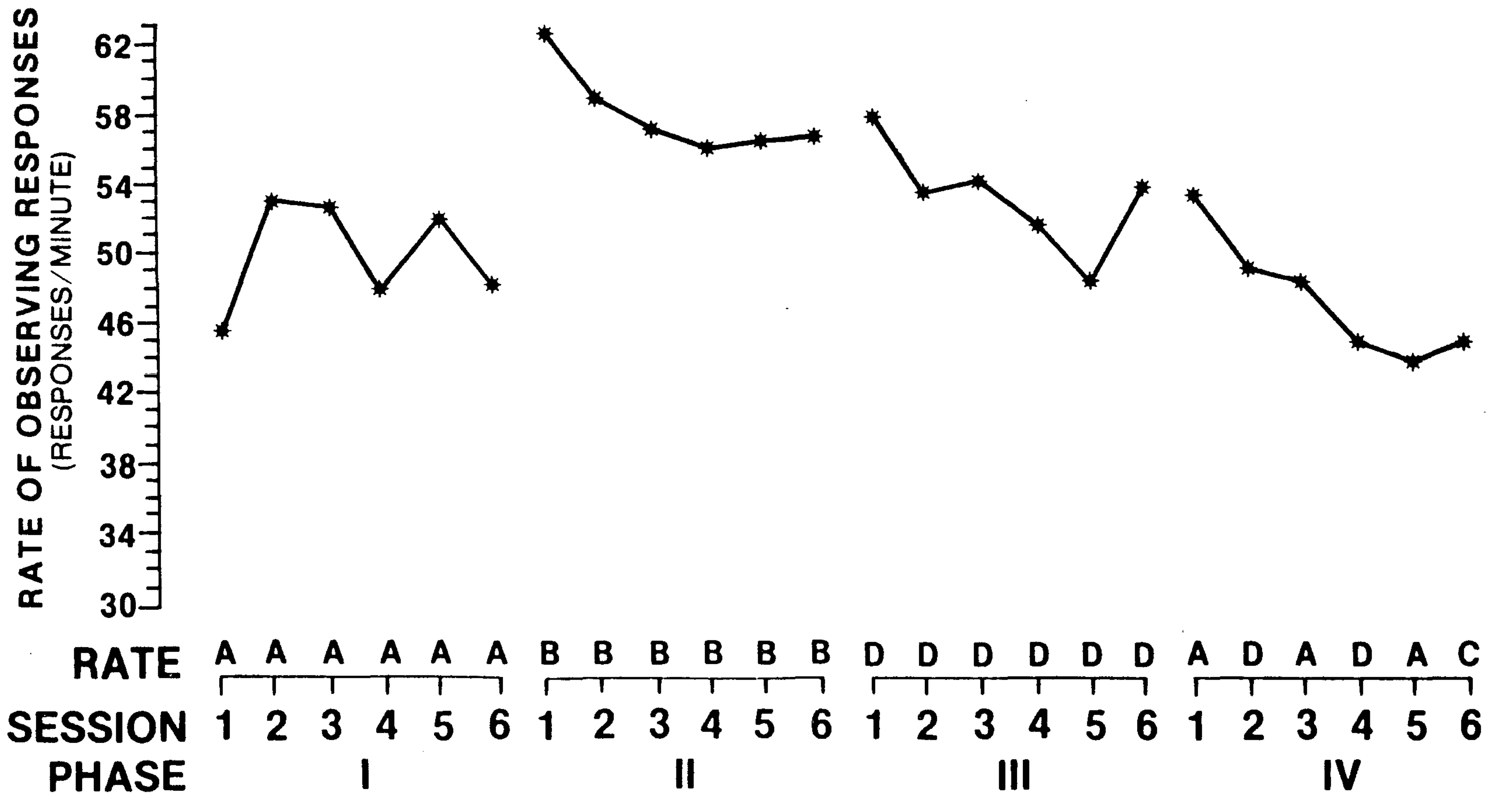

Figure 8. Rate of observing responses for observer R for all sessions. (Rate conditions (right-hand, left-hand): A = 1.1-1.1, B = 3-3, C = 1.1-3, D = 3-1.1).

Figure 9. Rate of observing responses for observer T for all sessions. (Rate conditions (right-hand, left-hand): A = 1.1-1.1, B = 3-3, C = 1.1-3, D = 3-1.1).

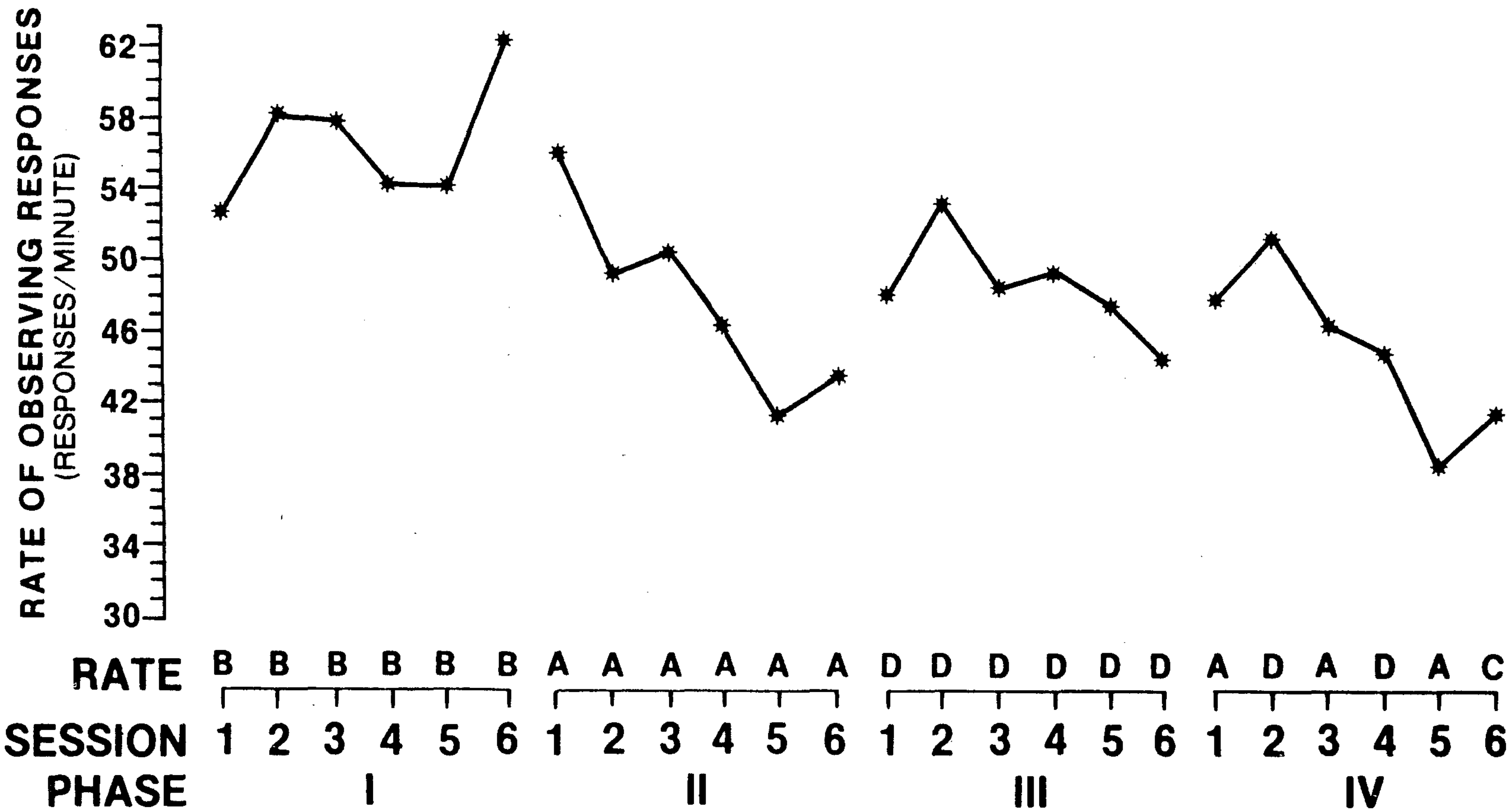

Figure 10. Rate of observing responses for observer D for all sessions. (Rate conditions (right-hand, left-hand): A = 1.1-1.1, B = 3-3, C = 1.1-3, D = 3-1.1).

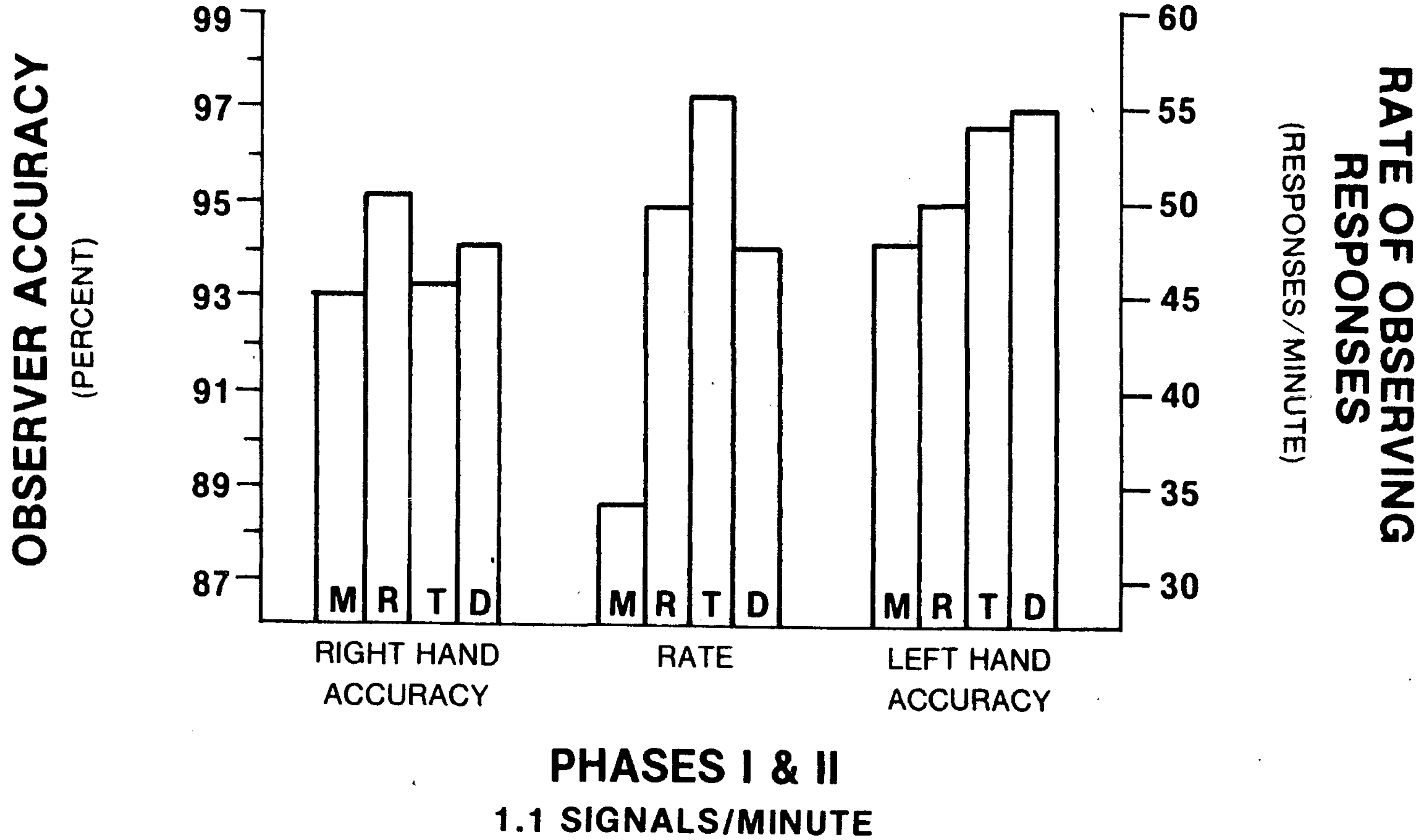

Figure 11. Observer accuracy and rate of observing responses for all observers for Phases I, II, and III by rate conditions and target of observation.

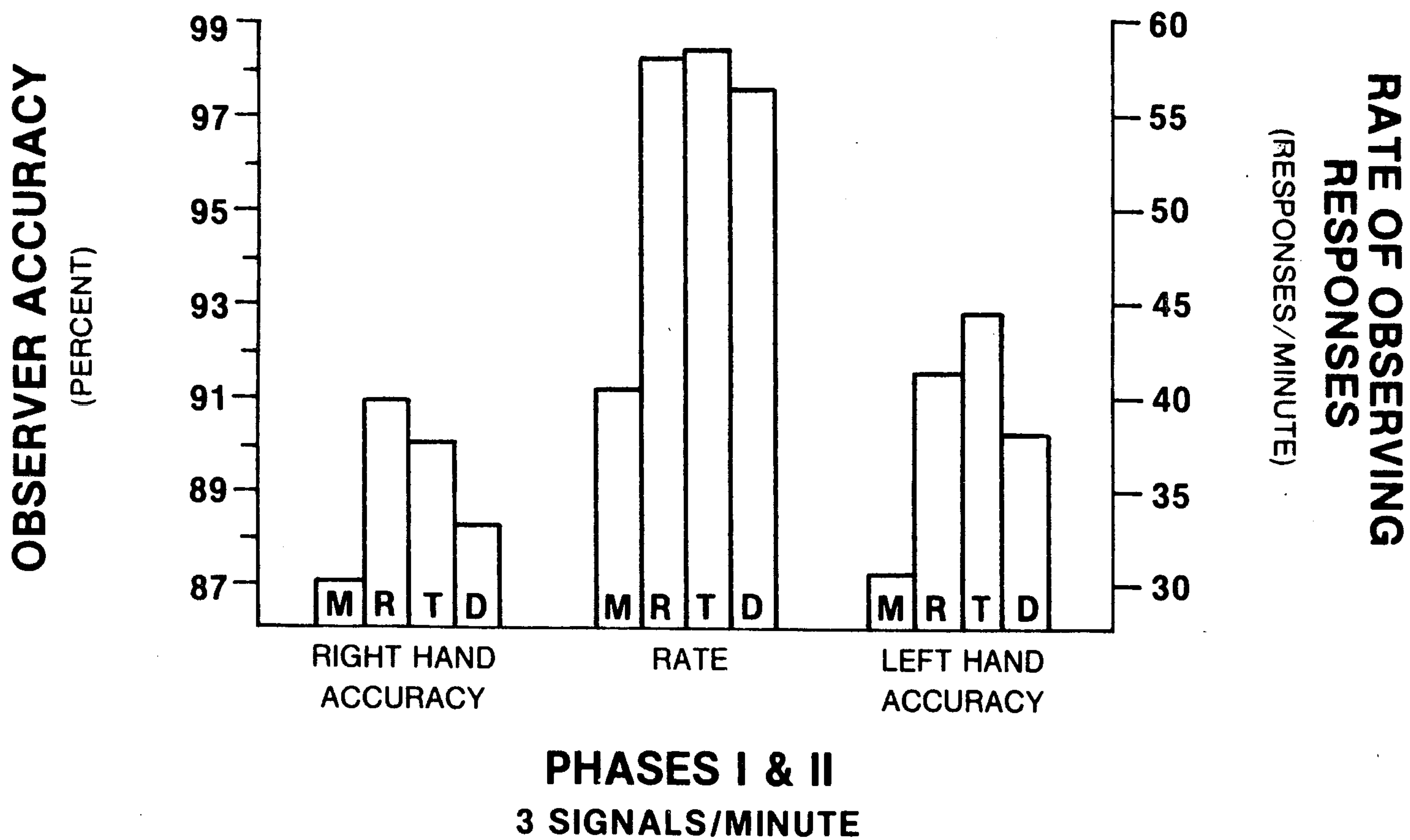

Figure 11. (cont.) Observer accuracy and rate of observing responses for all observers for Phases I, II, and III by rate conditions and target of observation.

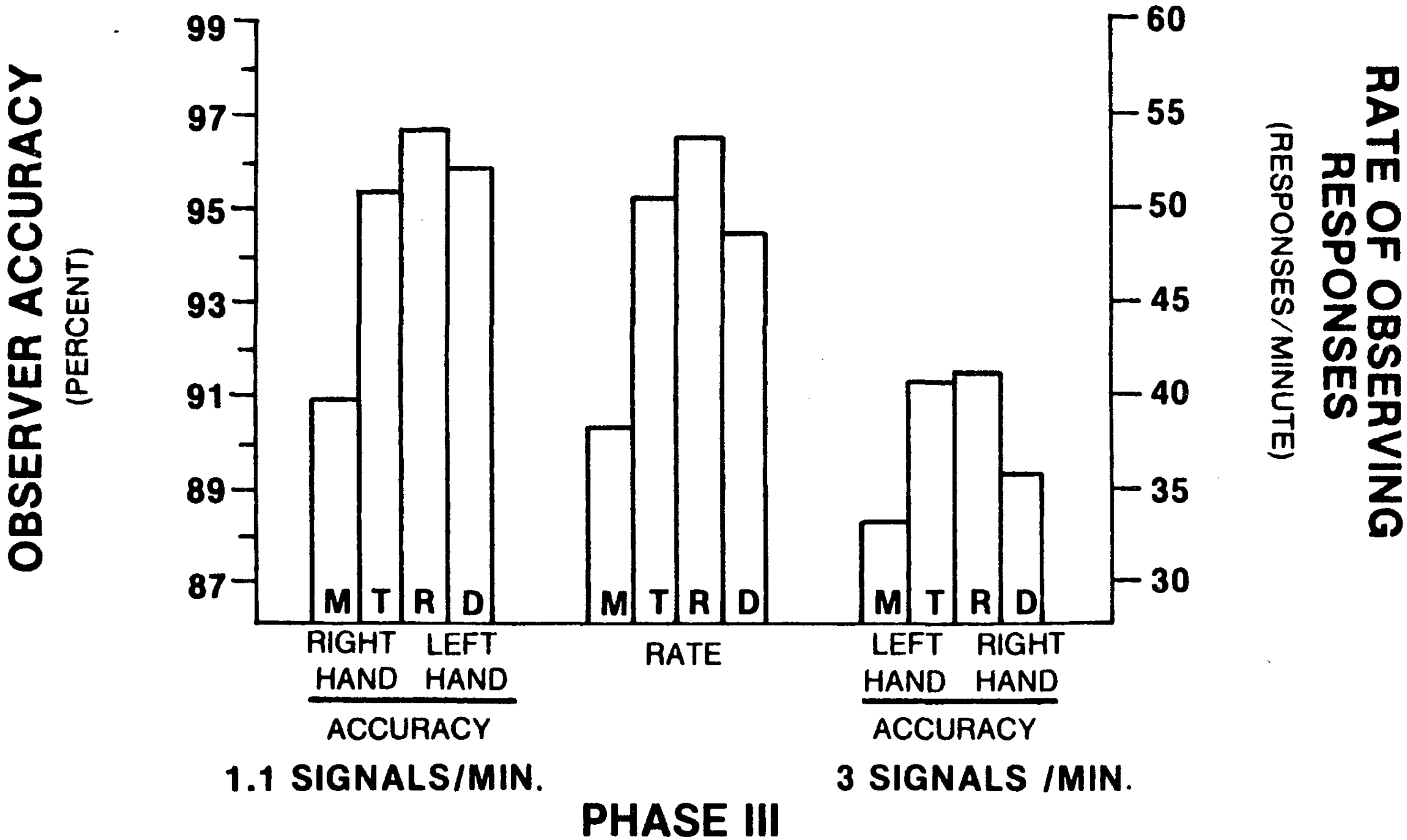

Figure 11. (cont.) Observer accuracy and rate of observing responses for all observers for Phases I, II, and III by rate conditions and target of observation.

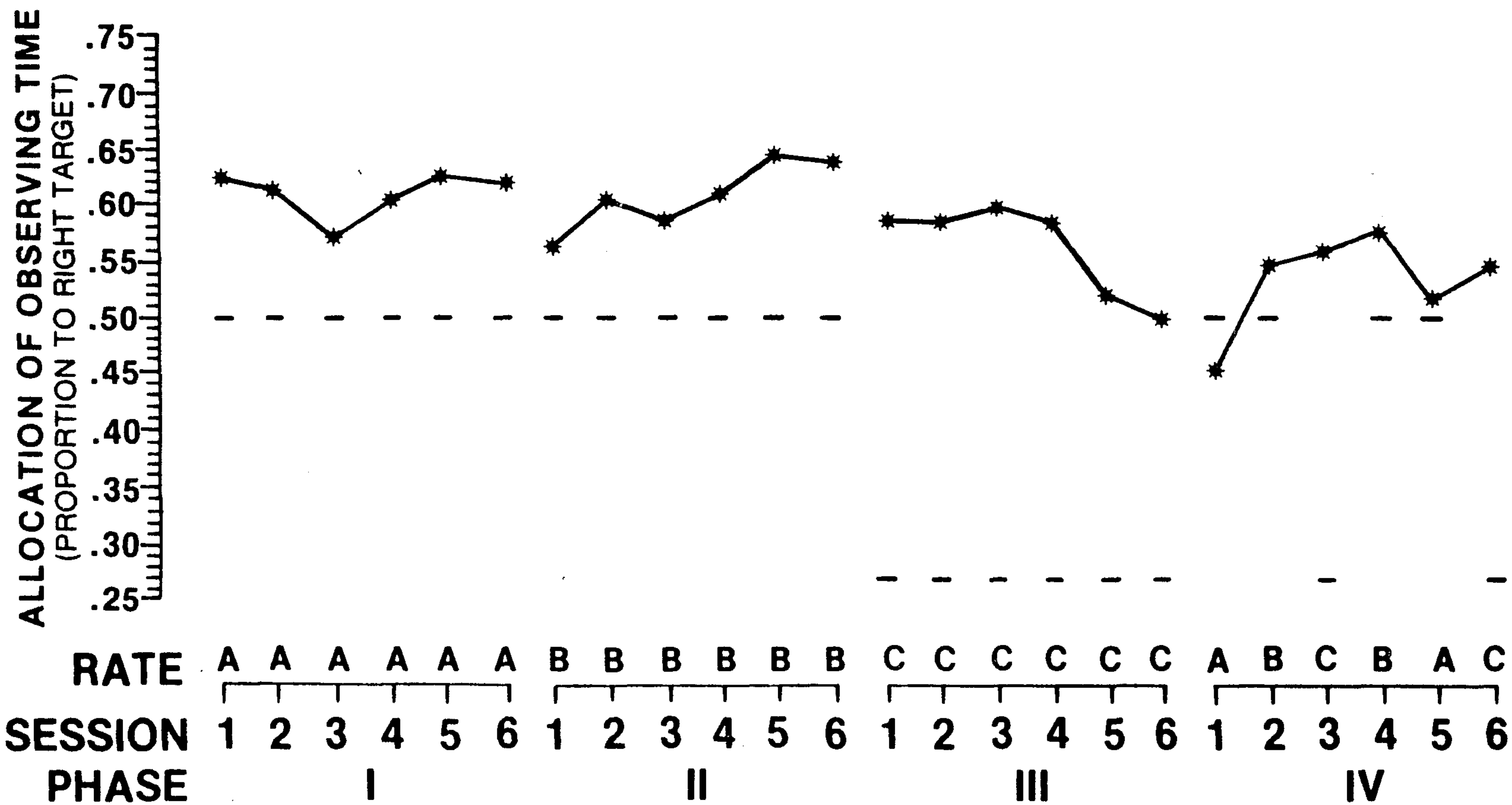

Figure 12. Proportional allocation of observing time to the right-hand target and the proportional distribution of signal stimuli to the right-hand target for observer M for all sessions. (The proportional distribution of signal stimuli to the right-hand target is indicated by a dash. Rate conditions (right-hand, left-hand): A = 1.1-1.1, B = 3-3, C = 1.1-3, D = 3-1.1).

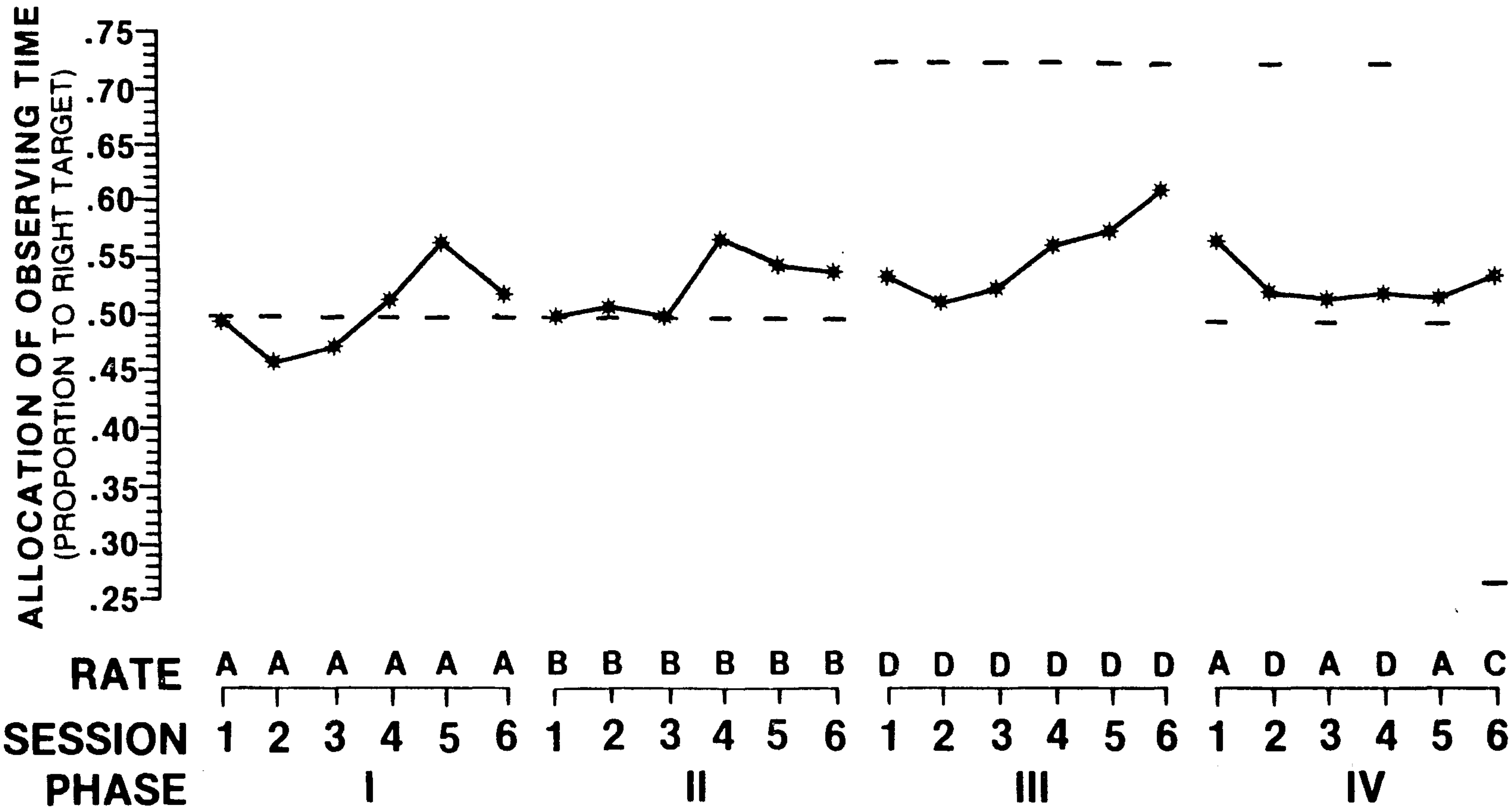

Figure 13. Proportional allocation of observing time to the right-hand target and the proportional distribution of signal stimuli to the right-hand target for observer R for all sessions. (The proportional distribution of signal stimuli to the right-hand target is indicated by a dash. Rate conditions (right-hand, left-hand): A = 1.1-1.1, B = 3-3, C = 1.1-3, D = 3-1.1).

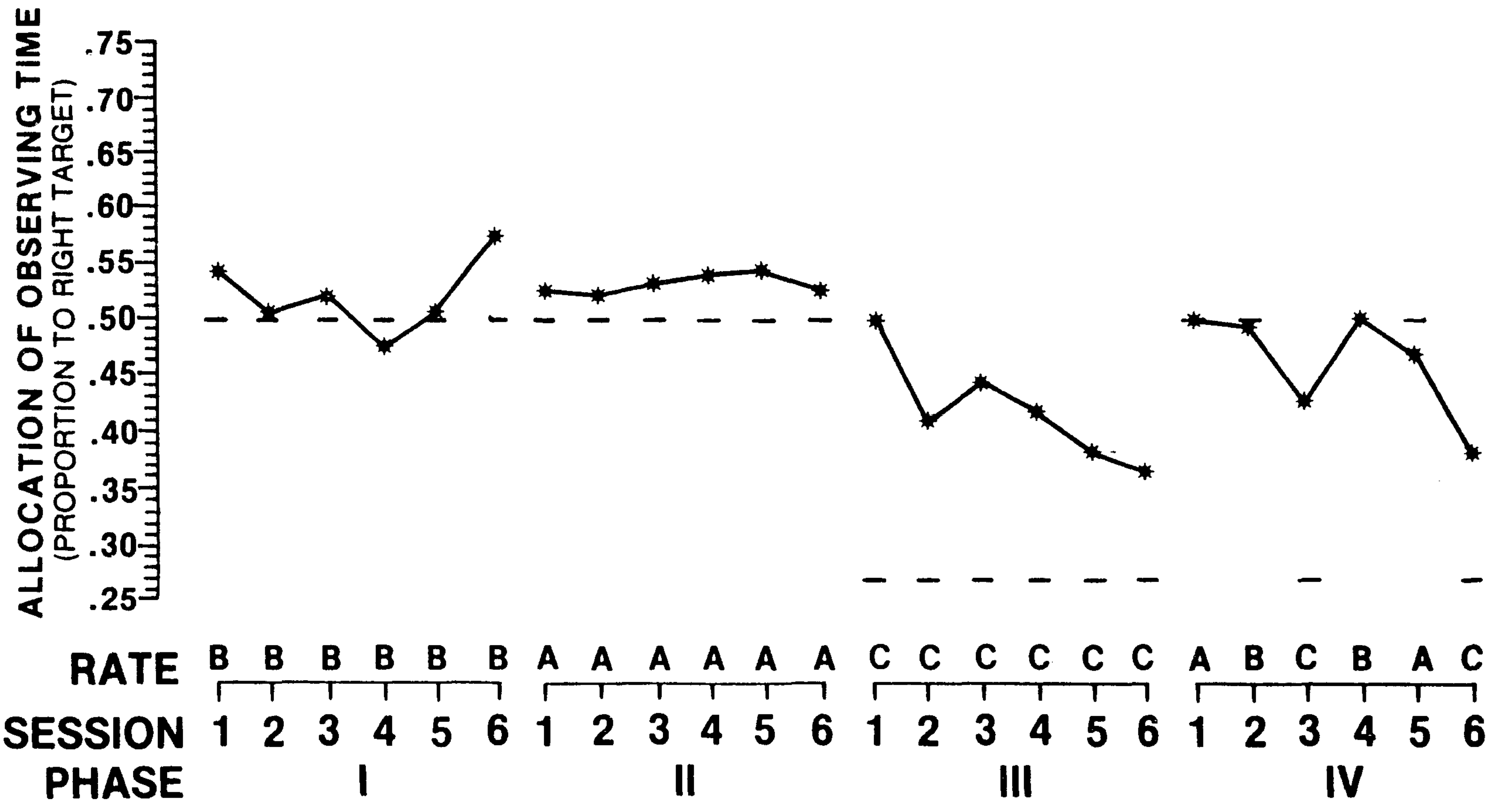

Figure 14. Proportional allocation of observing time to the right-hand target and the proportional distribution of signal stimuli to the right-hand target for observer T for all sessions. (The proportional distribution of signal stimuli to the right-hand target is indicated by a dash. Rate conditions (right-hand, left-hand): A = 1.1-1.1, B = 3-3, C = 1.1-3, D = 3-1.1).

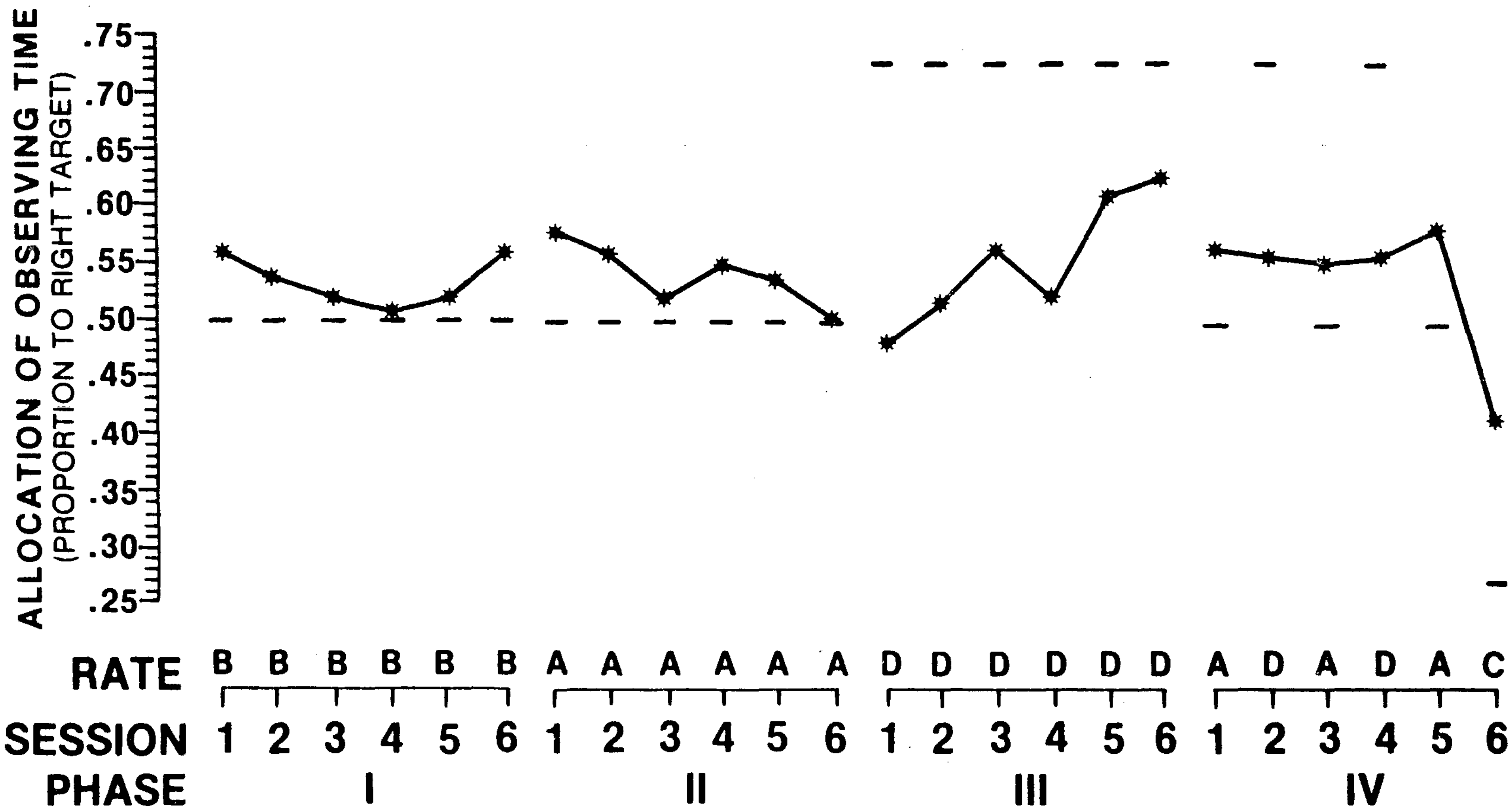

Figure 15. Proportional allocation of observing time to the right-hand target and the proportional distribution of signal stimuli to the right-hand target for observer D for all sessions. (The proportional distribution of signal stimuli to the right-hand target is indicated by a dash. Rate conditions (right-hand, left-hand): A = 1.1-1.1, B = 3-3, C = 1.1-3, D = 3-1.1).

APPENDIX C

RESULTS OF t-Tests

(Accuracy Data)

Comparisons of Phases I and II with III

Observer	Phases	Target	t	df	p
M	I & III	Left	10.03	5	$< .005$
M	I & III	Right	3.50	5	$< .02$
M	II & III	Left	- .64	5	NS[a]
M	II & III	Right	- 1.63	5	NS
R	I & III	Left	- 1.11	5	NS
R	I & III	Right	2.47	5	$< .05$
R	II & III	Left	- 6.83	5	$< .005$
R	II & III	Right	- .32	5	NS
T	I & III	Left	1.36	5	NS
T	I & III	Right	- 8.56	5	$< .005$
T	II & III	Left	8.00	5	$< .005$
T	II & III	Right	- 1.55	5	NS
D	I & III	Left	- 5.28	5	$< .005$
D	I & III	Right	- 1.10	5	NS
D	II & III	Left	1.59	5	NS
D	II & III	Right	2.74	5	$< .025$

[a]NS = Not significant at $p < .10$.

RESULTS OF t-Tests

(Accuracy Data)

Comparisons of Right-Hand with Left-Hand

Observer	Phase	t	df	p
M	I	-1.07	5	NS[a]
M	II	- .05	5	NS
R	I	.21	5	NS
R	II	- .59	5	NS
T	I	- 6.79	5	$<.005$
T	II	- 2.16	5	$<.10$
D	I	- 3.75	5	$<.02$
D	II	- 2.03	5	$<.10$

[a]NS = Not significant at $p < .10$.

RESULTS OF *t*-Tests

Phase IV

Comparisons of the accuracy of observers receiving the predictable sequence of rate conditions (Observers R and D) with that of observers receiving the unpredictable sequence (observers M and T)

Session	Target	*t*	df	*p*
5	Left	1.21	1	NS[a]
5	Right	.13	1	NS
6	Left	-2.13	1	NS
6	Left	- .87	1	NS

[a]NS = not significant at $p \leq .05$.

RESULTS OF *t*-TESTS

(Accuracy Data)

Phase IV

Comparison of the accuracy of observations of the left-hand target with those of the right-hand target for observers R and D

Session	*t*	df	p
5	2.14	1	NS[a]

[a]not significant at $p \leq .05$.