THE EFFECT OF SET AND KNOWLEDGE OF RESULTS ON REACTION TIME IN A VIGILANCE TASK

by

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CHAPTER I

INTRODUCTION

The present investigation was undertaken to determine the effects of set and prearranged knowledge of results on a vigilance task. There has been no research on the effect of set, while the effect of prearranged knowledge of results has only recently been studied. With research being conducted on the training of individuals for vigilance work, it is surprising that the effect of these two variables has not been more thoroughly examined.

The exact meaning of the word, vigilance, varies from study to study. In general a vigilance situation is one in which an individual monitors for infrequent, often weak, signals in an isolated environment over extended periods of time. The task is to detect this signal. A radar operator is a prime example of an individual in a vigilance situation. This example can easily be generalized to display monitors of early warning systems in our national defense and to automated equipment monitors in industry. The study of vigilance is receiving more attention, as indicated by the variety of reporting publications.

Knowledge of results (KR) informs an individual of his performance during a vigilance task. This information can simply be an indication that a signal has been presented or an indication on the quality of his performance. Generally, KR improves performance in a vigilance task. The recent exploration on the effect of prearranged KR indicates that it also improves performance although the results are not entirely consistent. Prearranged KR refers to information that is given to the individual regardless of his true performance.

The popular theoretical models dealing with vigilance all handle the effect of KR effectively. However, the results of prearranged KR studies, although few, have proven difficult to explain. More work in this area is needed in order to give the various models an opportunity to incorporate these findings.

Knowledge of results schedules and the S's set will be varied in the present study. The results will be interpreted using current vigilance models in an attempt to give a better explanation of these effects. Also, brief suggestions for application of these results to field situations will be mentioned.

CHAPTER II

REVIEW OF THE LITERATURE

The primary interest in vigilance can be traced to Mackworth's study (1950) which has been called the classic vigilance study. Presently, the applied areas are very much interested in vigilance, and theoretical researchers have attempted to formulate a model to explain the data.

The term, vigilance, usually implies the maintenance of attention over extended periods of time. The experimental conditions used to test vigilance vary considerably, however, as illustrated by the wide range of tasks reported in the literature. For instance, one study reported by Kibler (1965) used a signal rate of 960 per hour, while another study presented only an average of 7.5 signals per hour (Jenkins, 1958). Both were labeled vigilance studies. The intensity of the signal will also vary considerably from study to study, as will the type of signal used.

Kibler (1965) reported one study that required the S to remain in the experimental situation for 9 hours, while others (McCormack, 1959; McCormack & McElheran, 1963) required the S to remain only forty minutes. Moreover, McCormack (1959, 1960) kept presenting the signal until the S responded. Adams and Boulter (1962) used a 5 sec. signal presentation, but the usual signal duration is only 100 to 500 millisec.

The use of the term, vigilance, is somewhat ambiguous. One reason for this is the vast number of studies reported by Es who were interested only in an extremely specific situation. The wide range of conditions reported comes from both the applied areas and theoretical researchers.

The studies of vigilance are normally one of four types; (a) the classical task, where single, infrequent signals are presented and performance measured; (b) multiple display tasks, a complex generalization of the classical task; (c) threshold measurement, wherein a series of signals is presented to the S, starting with a subthreshold level and gradually increasing it until the S detects the signal; and (d) observing response experiments, where attention is indirectly measured by some other response that implies attending to the signal (Frankman & Adams, 1962). Most vigilance studies are based either on the classical task or the multiple display task.

There are two major measurements used in vigilance studies, per cent of signals detected and latency of response. Traditionally, the most popular of these two is per cent of signals detected, although latency of response has been used more frequently in recent years.

The major factor studied in vigilance studies is the decrement in performance by the S over extended periods of time. This decrement is seen using either type of response measure. Typically, the decrement is well advanced by the end of thirty minutes (Chinn & Alluisi, 1964; Church & Camp, 1965) after which performance levels off to a fairly constant plateau. Studies taking observation over durations of 30 to 60 minutes usually yield results comparable to those using much longer trial sessions.

Theoretical Models

There are three popular models offered to explain vigilance results. These models are based on inhibition, expectancy, and attention or arousal. These models presently have little predictive power and are mostly general explanations for the data.

Mackworth (1950) advanced the first comprehensive interpretation of vigilance using the principles of Pavlovian classical conditioning. The Clock Test, since used by many other Es, had a blank circular face with a hand that moved one step per second. According to a prearranged schedule the hand would occasionally jump two steps per second. This jump was the critical signal whose detection was reported by pressing a response key. The decrement in the per cent of signals detected over time was explained as an illustration of the extinction period in classical conditioning. The US was the E's informing comment, "Now", during training when the clock jumped two steps per second, which was the CS. The CR was the pressing of the key switch during the session. Over the two hour session extinction, fewer signals detected, took place since the US was no longer present. The internal inhibition that built up resulted in the lowering of performance, thus explaining the decrement.

The expectancy model was first set forth by Deese (1955). Performance in a vigilance task was said to be in part a function of the individual's expectation of when the signal was going to occur. Other factors, such as motivation and individual differences, would also have an effect, however. Deese's model has the individual taking into account the signal rate of all signals presented up to the present and mentally computing an average intersignal interval. Performance would be directly related to this value. The probability of detecting a signal before this average value would be lower than the probability of detection after this average value had been passed without perceiving a signal. Response time would also vary around this value.

Baker (1958, 1959a, 1959b, 1960) has elaborated Deese's original model to include five major variables that help determine performance. These are (a) average signal rate, (b) regularity and range of signal interval, (c) knowledge of results, (d) knowledge of signal location, and (e) signal intensity. These variables purportedly influence the S's actual perception of the series of signals. For example, an unperceived signal about which the S receives no knowledge from E alters the S's interpretation of the signal situation by increasing his value for the intersignal interval. The more signals missed, the higher would be the S's average intersignal value and the lower his performance. Conversely, the more signals perceived the higher would be his performance. Any decrement seen in performance would be the result of an increasingly higher intersignal interval value being formed.

Broadbent (1953) explained performance decrement by using attention. Any individual is subjected to many more stimuli at one time than his central nervous system can handle. Consequently, he will respond to certain stimuli only. Which stimuli he will respond to is a function of (a) the intensity of the stimulus, (b) the biological importance of the stimulus, and (c) the novelty of the stimulus. Intensity and biological importance will remain constant in a vigilance situation, but the critical signal will lose its novelty over repeated presentation, causing a decrease in performance. Other parts of the situation have gained in priority resulting in less attention to the critical signal.

Adams and Boulter (1962) report that some authors attribute performance level to a stimulus arousal effect. Any stimulus has certain arousal or motivational properties. A drop in performance is the result of the critical stimulus losing these properties due to the lack of stimulus variation in a vigilance task. The more uniform the environment, the quicker the individual becomes adapted leading to less attention being paid to the critical signal. This leads to a decrement in performance.

This model which has been called the activationist model is closely related to known physiological facts on the ascending reticular activating system (ARAS). The basis for this hypothesis stems from Hebb's (1955) comments on the dual role, cue and motivational, of a stimulus.

Each model has its limitations, however. The inhibition model would predict complete extinction which has not been observed in a vigilance task. A high signal rate results in little decrement, although the Pavlovian approach would predict quicker extinction from massed trials.

The expectancy model has not primarily concentrated on the decrement, but has attempted to explain the data over short time intervals. Over extended periods of time intersignal interval seems to have proven irrelevant (Buckner, Harabedian, & McGrath, 1965; Hardesty & Bevan, 1964; McCormack, 1960). The model is well stated and can be readily tested.

The attention model and the arousal model are loosely stated and difficult to test by contrast. Many of Broadbent's explanations seem post hoc, while Adams and Boulter (1962) did not produce any support for the activationist model. At the present time these models have not stated the parameters of their model specifically enough.

Frankman and Adams (1962) conclude that the main shortcoming of the present models seems to be a casualness of formulation that makes the definitive testing of their implications difficult.

Knowledge of Results

One variable that seems to eliminate the decrement is knowledge of results (KR). This is not surprising since KR has been shown to improve performance in most situations. Ammons (1956) in reviewing the literature on KR stated that KR will usually result in a higher level of proficiency. The facilitating effect of KR in vigilance tasks has not been overlooked. Mackworth (1950) was the first to report that KR eliminated the decrement, and since then many others have reported similar results. In all cases reported so far KR will increase performance under both types of dependent variables. Knowledge of results will eliminate the decrement when per cent of signals detected is the dependent variable, but if latency of response is the measure used, a decrement may still appear (McCormack, 1959). The type of KR given affects the amount of performance improvement. Knowledge of results given by the E in the same room with the S produces better results than KR given by a machine or lights alone (Hardesty, Trumbo, & Bevan, 1963). The KR must also be meaningful to the S in the situation (Weidenfeller, Baker, & Ware, 1962).

The effect of KR is clear-cut, but the reason behind it is not. Mackworth (1964) stated that KR seems to do two things, provide information about the task and increase motivation. Adams and Humes (1964) suggested that perhaps KR improves performance because of one or more of the following reasons: (a) the stimulation properties of the signal, (b) the habit formed if KR is reinforcing, and/or (c) the improved temporal expectancies.

The effect of KR in a vigilance task was the chief reason Baker (1959) chose to use Deese's expectancy model in explaining performance. Baker felt that KR served to inform the S on the temporal interval between signals along with a more specific identification of the critical signal. No motivational properties were assigned to KR by Baker.

The other models explain KR equally well. The inhibition model would interpret KR simply to be a reinforcer. Broadbent (1953) concluded that KR maintains the novelty of the critical stimulus. The arousal or activationist view would hold that KR is another source of stimulation that makes the vigilance situation more varied. The more stimulation, the easier it is for the S to maintain attention for the critical signal.

A recent development in the use of KR is not handled as well by these models. What has been labeled "false" knowledge of results (FKR) has recently been used (Loeb & Schmidt, 1960; Weidenfeller et al., 1962; Mackworth, 1964). In these studies part or all of the KR given is not a true representation of the S's performance. Preplanned KR signals were presented to the S, indicating that he has missed a signal or generally indicating inaccurate information. The results of these experiments are generally consistent with those studies using normal KR in that performance improves.

Loeb and Schmidt (1960) measured latency of response to an auditory signal in a 50 min. session. They found that initially both KR and FKR increased performance equally but that the FKR group showed a significant decrement over the experiment.

Weidenfeller et al. (1962) studied FKR in a classical situation, measuring per cent of signals missed. The S's task was to detect aperiodic interruptions of a continuous light. Knowledge of results was given by a pilot lamp located above the signal source with an illuminated lamp indicating a missed signal. For the FKR group the pilot lamp was flashed at prearranged times during the experiment. These false indications were presented in addition to the true KR. Both the KR and the FKR groups performed significantly above the control group with neither KR group showing a decrement. No difference between the two KR groups was detected.

Mackworth (1964) studied FKR using the classical Mackworth Clock task. The KR and the FKR were given in a manner similar to Weidenfeller et al. (1962). The results from this experiment showed that both the KR groups exhibited an increase in the per cent of signals detected. The FKR group, however, exhibited a decrement similar to the no-KR group.

Comparing the two studies using per cent of signals missed as a measure of performance, it is seen that they differ on whether a decrement was observed in the performance of the FKR group. Several major differences in their procedures complicate any such comparison, however. Mackworth (1964) informed her Ss of their false responses, responses given when no signal had been presented, whereas Weidenfeller et al. (1962) did not. The signal rate also differed, Mackworth presenting thirty signals every ten minutes and Weidenfeller et al. presenting only 24 signals per hour. The Ss were Army trainees for Weidenfeller et al., but Mackworth used both males and females ranging in age from 16 to 45 years of age. These differences make any comparisons questionable. Trying to compare these two studies with the Loeb and Schmidt (1960) study also is difficult since it used a different response measure and a different signal, an auditory tone. The fact that FKR improves performance is clear, but the effect of FKR on performance decrement is inconsistent.

The theoretical models have not explained the results of the few FKR studies reported. In both the Weidenfeller et al. (1962) and Mackworth (1964) studies the FKR groups received more total signals. As a result the attention and arousal models would predict higher performance than the group receiving regular KR. Higher performance would also be predicted by the expectancy model. Due to the manner in which FKR was given, a lower intersignal value would result. Conversely, the inhibition model would predict lower performance, quicker extinction. The low amount of FKR employed, 12-17%, in these studies may not have provided an adequate test of FKR, however.

Set

Of the studies reviewed none controlled or reported control of the mental set of the Ss. As a result there is no information on whether or not the attitude of the S can affect performance. None of the current models include a variable for this factor, evidently assuming that it is not a major influence. The Ss used were either college students or military trainees in most of the studies, and these studies do not report what the S's attitude was coming into the experiment, particularly concerning the effect of KR. Therefore, the reported increase in performance due to KR could possibly be the result of a particular set.

Relation to Applied Areas

Vigilance study started in an applied area, the military, and interest has remained high in these areas. Radar operators in World War II first showed the decrement in performance over time. Since that time researchers have investigated specific tasks in which they were interested which has helped produce such a wide range of studies reported. Monitoring early warning systems, quality control inspection, and monitoring semi-automated machinery are all examples of vigilance situations in applied areas. Training for vigilance tasks is also a popular area of research for it has been shown that performance in laboratory experiments will carry over to field performance, especially the effect of KR (Adams & Humes, 1963; Wiener, 1963).

One criticism of present laboratory studies by the applied researchers is that laboratory studies rarely have a relation to field conditions as they presently exist (Kibler, 1965). Modern technology has produced semi-automated systems that control themselves, leaving only reaction to emergency signals as the major task. The basic characteristic that has changed in the last twenty years is the signal intensity. Brief, weak signals are rarely seen in field systems now. The signals used are relatively strong, continuous, and frequently bimodal such as visual and audible. In aerospace monitoring tasks, for instance, an emergency signal will be both illuminated and sounded. Both sources of stimulation will remain until action is taken to acknowledge them. In this case speed of response is critical, since detection of the signals will eventually be accomplished. Laboratory studies, however, still use weak, brief signals and mostly measure per cent of missed signals.

Summary and Pertinent Questions

Vigilance covers a wide range of applied and theoretical research. Duration of task, type of critical signal, signal intensity, signal frequency, signal regularity, type of response, and response measure are all variables frequently manipulated by Es. As a result the use of the term, vigilance, is somewhat ambiguous.

Vigilance studies are normally one of four basic types. The two most frequently used are the classical, single signal task and a complex generalization of it, the multiple display task. The two popular performance measures are per cent of signals detected and latency of response.

The most frequently examined portion of a vigilance task is the decrement in performance over time. This decrement is rapid during the initial thirty minutes and then levels off.

There are three popular models that attempt to explain behavior in a vigilance task. The inhibition model is based on Pavlovian classical conditioning. A vigilance task is viewed as an extinction period, accounting for the decrement. The expectancy model has as its major point the average intersignal interval value a S computes. Performance is centered on this value. However, the expectancy model does not specifically explain the decrement although it is the most specific of the models. The attention/arousal models are based on the stimulus itself. Attention for the critical signal decreases as this signal loses its novelty, or as the individual becomes adapted to the uniform environment. Of the two the arousal model is closely related to known physiological facts. The main criticism of all the models is that there is a casualness of formulation that makes specific testing difficult.

Set, the S's attitude toward KR coming into the experiment, has never been directly controlled. Although none of the models would predict an influence due to set, it is surprising that this has never been investigated since in other areas the appropriate set will influence behavior.

Knowledge of results has been shown to increase performance in all vigilance tasks thus far reported. In studies measuring per cent of signals missed KR also eliminated the decrement. Some studies using latency of response as a measure have reported no elimination of the decrement, however. All three models handle the result of KR effectively.

Recently, false knowledge of results has been employed in vigilance tasks. False knowledge of results, not an accurate indicator of the S's performance, increases performance in a fashion similar to normal KR. The effect of FKR on performance decrement is not clear, however. The differences in the experimental conditions in studies using FKR makes any direct comparison questionable. The present models have had difficulty explaining this data.

One question that is important to the whole area of FKR concerns the use of the word, false, to describe the particular KR given. In these studies the S never has any reason to believe that the KR was anything but accurate. The FKR used informed the S of an erroneous reaction time (RT) or that he had missed a signal. The effect of this could possibly produce different motivational attitudes. Weidenfeller et al. (1962), for instance, stated that Ss reported that the signals indicating they had missed a signal were "annoying".

As an example, two individuals coming into the experiment with similar attitudes might be affected differently. Both would have a similar idea of what their performance should be. If one is given FKR informing him that his performance is below this level, he might be motivated to improve his performance. The normal KR S on the other hand would not be motivated to increase his performance.

The different performance levels that might result represent a source of investigation. If different KR schedules could be shown to produce varying performanse, the present theoretical models would need to undergo revision. Also, such a result might have application to vigilance training.

In order to test FKR vs. KR one criticism of past studies must be overcome. In the Weidenfeller et al. (1962) and Mackworth (1964) studies FKR groups received both FKR and more total signals. Some method of equating the total stimulation received by the two groups must be developed.

Statement of the Problem

This study will investigate the effects of set and KR in a classical vigilance task employing latency of response, as the dependent measure. Three levels of set, (a) no set, (b) a KR facilitates performance set, and (c) a KR impairs performance set, will be tested. Prearranged KR will also be tested over three levels, (a) no KR, (b) a high positive ratio KR, and (c) a high negative ratio KR. Due to the nature of this task two additional effects, intersignal interval and time in task will be measured.

From a review of the literature and the current vigilance models the following hypotheses are set forth.

There will be no significant effect due to manipulating the levels of the S's set concerning the effect of KR.

The groups receiving KR, regardless of schedule, will have lower reaction times than the group receiving no KR.

Comparing the high positive ratio KR group with the high negative KR group will yield no significant difference, however.

The effect of using several intersignal intervals will also be negligible.

In the no-KR group alone time in task will exert a significant effect on performance.

CHAPTER III

METHOD

Apparatus

The primary apparatus was a specially designed relay circuit, a Kodak Model 1 Carousel Programmer, and a standard Wollensak monaural tape recorder. A recorded signal on the tape would trigger the programmer. In turn, the programmer would send its signal through the special circuit which simultaneously turned on the critical signal, a standard $7\frac{1}{2}$ watt light bulb, and started a Lafayette Standard timer capable of recording reaction time (RT) in hundredths of a second. The S's pressing a response switch terminated the signal and the timer, allowing measurement of the S's RT.

Also contained in the circuit were a reset switch, a select switch, and a present switch. Depressing the reset switch was necessary to reset the circuit after each signal presentation. Depressing the present switch would illuminate either a red or a green KR indicator depending on the position of the select switch. The KR indicators were 12 watt clear bulbs with colored lens, located on a flat black panel positioned 7 ft. in front of the S at approximately eye level.

The panel which measured 21 in. by 21 in. contained both the KR indicator lights and on the same level a $\frac{1}{2}$ in. hole midway between the two lights. The critical signal was positioned behind the panel so that it would shine through the hole when illuminated.

A second Wollensak tape recorder presented instructions and a masking tone to the S over a pair of standard earphones. The S's response switch was a Kodak remote cord switch.

In the room with the S were the panel, table, remote cord switch, earphones, and a student desk. The wires from this equipment led to an adjacent room where the remaining equipment was located.

Experimental Design

A 3 x 3 x 5 x 8 factorial arrangement of treatments was employed using repeated measures on each S. Factors A and B, set and KR, were between Ss variables, and factors C and D, intersignal interval and time in task were within Ss variables. Forty observations were taken on each of the 36 Ss used.

The experimental session was based on a series of experiments conducted primarily by McCormack (McCormack, 1959; McCormack, 1960; McCormack, Binding, & Chylinski, 1962; McCormack, Binding, & McElheran, 1963; McCormack & McElheran, 1963). These studies consisted of 40 min. sessions and used intersignal intervals of 30, 45, 60, 75, and 90 sec., averaging one signal per minute. These five intersignal intervals constituted a factor in this study with an interval being measured from onset of signal to onset of signal. The time factor consisted of light five minute periods which defined the forty minute session. Each intersignal interval was used in each five minute time period with a separate randomization assigning the five intervals to positions within each five minute period. Because of the limitations of the apparatus, all Ss received the intersignal intervals in the same order during any one five minute period.

The KR factor was presented at three levels, a control level and two different schedules of indicators. One of the two KR groups received 75% green indicators with a green indicator informing the S that his RT was faster than the average RT of Ss not receiving KR. The remaining 25% KR consisted of red indicators which informed the S that his RT was slower than the average RT of no-KR Ss. The second group receiving KR was given 75% red (negative) indicators to 25% green (positive) indicators. The choice of these ratios centered around finding one ratio that would adequately inform the S that his RT was above average and that would, by inverting the ratio, inform him that his RT was below average according to the established criterion. The high positive ratio KR schedule was considered equal to the normal KR used in previous studies, and the high negative KR schedule was considered equal to the FKR previously used. The decision to use completely prearranged KR schedules was based on a criticism of earlier work in which the number of KR signals varied from S to S.

For the KR groups the indicators were randomly assigned on a twenty minute basis. In each half of the session each of the five intersignal intervals was paired with the 25% indicator. Conversely, the 75% indicator was paired with each interval three times per half session.

Set was also presented at three levels, a control, a "KR facilitates performance" set, and a "KR impairs performance" set. The particular portion of the instructions forming the set was written so that each S under either the facilitary or impairment sets received essentially the same instructions. Certain interchangeable words, such as increase/decrease, were used to form the applicable set desired. The appropriate content word was used throughout these instructions given below.

Interest in vigilance started primarily during the Second World War. Mackworth's classical study in 1950 initiated a period of intense study of vigilance in situations where signals are presented at irregular intervals over a period of time. The study of vigilance is still a popular one by the military, industry, and theoretical researchers. Wright-Patterson Air Force Base and the University of Illinois are both locations where the study of vigilance is actively pursued. One portion of a vigilance situation that has been concentrated on is the (detremental/facilitating) effect on performance caused by telling the individual how he is doing during the experiment. This (increase/decrease) in performance after informing the individual of his prior performance is not clearly understood, but is of interest to researchers. This experiment will attempt to repeat the results reported by Adams in 1965 in which performance was (lowered/increased) after the subject had been informed of his results during the session.

The group receiving no-KR received the above instructions plus the following.

You, however, will be part of a control group and will receive no information.

Procedure

The Ss consisted of 36 volunteer male students from basic psychology sections. The Ss who volunteered received minor course credit for participating in the study. Their ages ranged from 17 to 23 years with a mean of 18.97 years. Subjects were randomly assigned to nine treatment groups, making a total of four Ss per group.

One major modification was made in the present study, compared to previous work. An attempt was made to control the effect of the E on each S, a source of variation in a vigilance study reported by Fraser (1953). Any such effect was removed by never having the E and the S come into direct contact. Further, Ss were told that the entire experiment was controlled and presented automatically from an adjacent room and that the E would not be present while the experiment was being run. Actually, the E's presence in the other room was necessary to record RT, present the KR, and control the apparatus. However, the Ss seemed to be unaware of the E's presence in the adjoining room. This fact was confirmed by conversations with other Ss used in a pilot study conducted by the author shortly before the main study.

In order to better simulate a true vigilance situation a low frequency tone, 150 cps, was fed into the S's ear during the experimental session. This frequency has been shown to have a low annoyance value (Berrien, 1946). The tone was presented at 75 db $\pm$ 5, as rated by a recently calibrated Bruel - Kjar Decibel Meter, model 2203. This level is considered to be quiet (Jerison, 1959; Church & Camp, 1965). The auditory input served to mask external sounds but not to block the sounds of the apparatus from the adjacent room since these sounds helped to create the atmosphere of automation.

Preliminary instructions (Appendix A) were distributed to the Ss without their coming into contact with the E. The S was instructed to enter the experimental room and sit at the desk. He was then instructed to position the earphones over his ears, pick up the switch, and look at the panel.

Upon looking at the panel the S found that the signal light was shining through the $\frac{1}{2}$ in. hole. Having the light on served to familiarize the S with the critical signal and to further the notion that the experiment was automated from an adjacent room. The preliminary instructions directed the S to press the switch which extinguished the light and automatically started the apparatus in the other room. The E was in the adjoining room, controlling the equipment.

When the S pressed the switch, the E started one tape recorder which gave further instruction to the S. All Ss received the basic instructions listed in Appendix B. The S's task, to push the switch upon detection of a signal, was explained. No set instructions were given to the appropriate groups, while the remaining groups received the set instruction given earlier on pages 18 and 19.

The applicable KR instructions (Appendix C) were inserted in the basic instructions. The appropriate groups were told that each stimulus presentation had an average RT associated with it. The average RT was supposedly computed, on a trial basis, from a group of S who had not received KR. A positive indicator, the green light, indicated a faster response while a negative indicator, the red light, indicated a slower RT. In order to keep the S from suspecting the situation, careful emphasis was placed on the fact that each signal presentation had a different average RT associated with it. The no-KR groups were instructed to disregard the indicators.

At the termination of the instructions, the masking tone began. Also at this point the E started the second tape recorder which automatically presented the signal during the session. The signal was presented forty times for measurement and once at the start for further familiarization. This initial signal presentation was inserted after completion of the pilot study in which it was noticed that the RT to the first signal was much longer than the RTs that followed.

During the session the S responded to each signal after which the E recorded the RT. If the S was in one of the KR groups, he received a KR indicator for 3 sec. after his response. This procedure was followed for the entire session. At its termination the S was told of any erroneous information given and of the use of a prearranged KR schedule, if applied to him.

CHAPTER IV

RESULTS

The statistical design used was a 3 x 3 x 5 x 8 factorial arrangement of treatment combinations with repeated measures. The first two factors, set and KR, were between subjects effects, and the last two factors, intersignal interval and time in task, were within subjects effects. Mean RTs in seconds are presented for the above factors in Tables II, III, and IV. All Ss tested are included in the overall analysis given in Table I.

Factor A, set, yielded no significant results, having an F ratio of less than one. Thus one of the stated hypothesis, that the S's set would not influence his performance, was confirmed.

The Mean Square for KR was insignificant. Mean RTs associated with the high positive ratio and high negative ratio groups were nearly identical, while the mean RT for the no-KR group was much higher. As was previously indicated, a priori orthogonal comparisons were planned. These comparisons do not depend on a significant overall F test for a particular effect, therefore the appropriate Mean Square estimates were analyzed out of the overall Mean Square associated with KR effects. As predicted, the two KR groups were significantly different from the no-KR group at the .05 level as illustrated in Table I. The second contrast also confirmed the hypothesis that no significant difference would exist between the two KR groups. Therefore it would appear that the two KR schedules did not

TABLE I

SUMMARY OF THE ANALYSIS OF VARIANCE AND ORTHOGONAL COMPARISONS OF THE EFFECTS OF SET, KR, INTERVAL, AND TIME ON RT IN A VIGILANCE TASK

Source	df	SS	MS	F
Betw. Ss	35	3.4444		
Set	2	0.0084	0.0042	<1
KR	2	0.4572	0.2286	2.48
KR_0 vs. $KR_1 + KR_2$ /2	1	0.4552	0.4552	4.94*
KR_1 vs. KR_2	1	0.0020	0.0020	<1
Set x KR	4	0.4908	0.1227	1.33
Subj. w. gp.	27	2.4880	0.0921	
Within Ss	1404	17.0995		
Interval	4	0.1669	0.0417	3.35*
Set x Int.	8	0.0226	0.0028	<1
KR x Int.	8	0.1155	0.0144	1.16
Set x KR x Int.	16	0.2559	0.0159	1.28
Int. x Subj. w. gp.	108	1.3446	0.0125	
Time	7	0.1861	0.0266	1.89
Set x Time	14	0.1566	0.0119	<1
KR x Time	14	0.1041	0.0074	<1
Set x KR x Time	28	0.2326	0.0083	<1
Time x Subj. w. gp.	189	2.6553	0.0141	
Int. x Time	28	0.2378	0.0085	<1
Set x Int. x Time	56	1.3646	0.0244	2.04*
KR x Int. x Time	56	0.5599	0.0099	<1
Set x KR x Int. x Time	112	0.7951	0.0079	<1
Int. x Time x Subj. w. gp.	756	9.0244	0.0119	

* = significant at the .05 level

affect differentially the Ss' motivation to the point of influencing performance.

TABLE II

SET X KR MEAN RT (SEC.) SUMMARY

		Set 0	1	2	Total
	0	0.262	0.315	0.279	0.285
KR	1	0.259	0.240	0.248	0.249
	2	0.265	0.215	0.259	0.246
Total		0.262	0.257	0.262	0.260

The overall results of KR were somewhat disappointing, since a pilot study run a short time before the main study had produced much greater differences between KR and no-KR groups. In the earlier study the overall effect of KR was significant using only nine Ss vs. the 36 Ss used in the present study.

The set x KR interaction term was insignificant, as would be assumed from the hypotheses on set and KR effects.

An examination of the within subjects portion of the Analysis reveals only two differences that are significant at the .05 level, intersignal interval and the set x interval x time in task interaction. Hence the hypothesis that RT would increase over time in the no-KR group was not confirmed. In general, RT did increase over time for all groups as seen in Table III. The increase in RT for the no-KR group was rapid, whereas the

TABLE III

KR X TIME IN TASK MEAN RT (SEC.) SUMMARY

		KR			
		0	1	2	Total
	0	0.271	0.269	0.243	0.261
	1	0.280	0.244	0.246	0.257
Time	2	0.261	0.230	0.231	0.240
in	3	0.290	0.237	0.228	0.252
Task	4	0.290	0.247	0.228	0.255
	5	0.291	0.256	0.273	0.273
	6	0.290	0.255	0.251	0.261
	7	0.310	0.256	0.270	0.279
Total		0.285	0.249	0.246	0.260

two KR groups exhibited an initial decrease in RT before gradually increasing to a higher level.

The Sum of Squares for intersignal interval was further analyzed using the Student-Newman-Kuel test. The results of these comparisons are presented below in Table IV and show that the only significant difference is between the 75 sec. interval and the 30 and 45 sec. intervals. In Table IV any two means not underscored by the same line are significantly different at the .05 level. Therefore the hypothesis was not confirmed since no interval differences were predicted.

TABLE IV

INTERSIGNAL INTERVAL COMPARISONS USING STUDENT-NEWMAN-KUEL VALUES

Interval:	30 sec.	45 sec.	60 sec.	90 sec.	75 sec.
Mean:	0.2738	0.2715	0.2579	0.2510	0.2468

The significant set x intersignal interval x time in task interaction was not predicted, and no further analysis was performed on this result. Additional comments on this result will be made later.

Overall three of the five hypotheses were confirmed. No set effect was detected with the three groups yielding nearly identical scores. A difference did exist comparing the two KR groups with their scores also being almost equal.

Two hypotheses were not confirmed. The increase in RT over time in task for the no-KR group was not significant, rejecting an hypothesis. Also, the hypothesis that there would be no interval effects was rejected since a significant difference did occur.

CHAPTER V

DISCUSSION

The present study investigated the effects of set, KR, intersignal interval, and time in task on RT in a vigilance task. As hypothesized there were no set effects demonstrated although the "KR facilitates performance" group did have the shortest RT. Therefore it would appear that KR is not dependent on the S's attitude. The lack of set x KR interaction supports this conclusion. Since the current vigilance models do not specifically mention set, no direct prediction on this effect could be made. Evidently these models have assumed set to be irrelevant, a fact which this study confirms.

The effect attributable to KR was significant when the two KR groups were compared with the no-KR group. Knowledge of results exerts its effect regardless of the per cent of positive vs. negative indications. The group yielding the shortest total RT, however, was the facilitating set, high negative KR schedule group. The models reviewed would predict that the two schedules would have a similar effect on performance, since none of them have included a cognitive variable. The results of the present study confirm this prediction.

The method used in this study answered one criticism of previous FKR studies. In these studies groups receiving FKR also received more total signals than the regular KR groups. In the present study all groups received an equal number. This study, then, yielded a more accurate picture of the effect of FKR, yielding results that indicate FKR and KR operate in a similar fashion.

Several differences prevent an adequate comparison of the present study with the previous FKR studies (Weidenfeller et al., 1962; Mackworth, 1964). The signal lasted only 300 millisec. in the Weidenfeller et al. study, while the Mackworth Clock Test was used by Mackworth. In order to measure RT the signal in the present study remained until the S responded. This measure of performance also differed from the previous studies, as mentioned.

The different performance measures resulted in two KR types. The previous studies merely informed the S that he had missed a signal. The present study's KR confirmed that a signal has been presented and evaluated the S's response. As seen, the evaluation of his response did not affect the S's performance over two levels of KR schedules. The mean RTs given in Table II show the similar performance of the two KR groups.

Although not statistically significant, the general decrement in RT exhibited by all KR groups was somewhat surprising, but not totally unexpected. Others (Adams & Humes, 1963; McCormack, 1959; McCormack et al., 1962) also reported this RT decrement even when KR was used. The main difference between the no-KR and the KR groups was in the onset of the decrement. The no-KR group showed an immediate increase, while the KR groups initially decreased their RT then gradually increased it.

The general decrement seen in RT studies is difficult to explain using the various models. These results indicate that a decrement is going to occur regardless of the methods used. The models were constructed primarily from studies using per cent of signals detected as the performance measure. However, in studies using per cent of signals detected, a cutoff point beyond which a S's response is not counted has to be established. Five seconds past the signal is a frequently used point, if such a cutoff is reported. Performance, therefore, could decrease greatly before being detected. The RT measure, however, would detect a decrease in performance immediately.

The surprising result in the present study was the significant difference between the intersignal intervals which is strong support for the expectancy model. A S computes an average intersignal interval value, according to this model. Before this value expectancy, and therefore performance, is low. As this interval value approaches, expectancy and performance increase. Once this interval is passed expectancy continues to increase. The comparisons in Table IV partially confirm this model with only the 90 sec. and 75 sec. intervals reversed. By contrast, the series of studies underlying the present study (McCormack, 1959; McCormack, 1960; McCormack et al., 1962; McCormack et al., 1963; McCormack & McElheran, 1963) produced no consistent interval effects.

The intersignal interval effect could be the result of the attempt made in this study to convince each S that he was unobserved during the experiment. The Ss believed the experiment to be completely automated and that no other persons would be present when the test was run. Fraser (1953), however, has shown that the E's presence increases the S's performance. The Ss in the previous studies were perhaps aware of the E's presence and were more motivated than Ss in the present study. Baker (1959) stated that motivational levels should not change the fact that intersignal intervals determine performance, but the forty minute session used by these studies could be too short to accurately measure interval effect under different motivational levels. In the present study the effect of the E's presence, actual or implied, was removed, allowing detection of an interval effect in the forty minute session.

Intersignal interval can not be interpreted alone due to the significant set x interval x time interaction. This interaction probably reflects the influence of the two smaller intersignal intervals, 30 and 45 sec., which vary considerably from set to set in the last three time periods. During the same time the other intervals, 60, 75, and 90 sec., were consistent. The significance of this interaction is not known.

The expectancy model is the only model that specifically attributes performance to intersignal interval. The results of this study clearly support intersignal interval as being a major determinant of performance. Other factors, such as stated in the inhibition, attention, and activationist models, were not manipulated in this study but also could affect performance. The other models, however, do not state that interval is a major factor.

Application for Applied Research

Field tasks are usually quite different from the task used in the present study. In many instances signals in field situations are very infrequent, no more than one or two per day. However, the implications of this study can be utilized. Performance could be increased through the use of prearranged signals built into the monitoring system. Reaction time to these preplanned signals could be measured, and KR given. The average interval would be lowered, resulting in increased performance.

CHAPTER VI

SUMMARY

The purpose of this investigation was to determine the effects of set and prearranged KR on performance in a vigilance task. Due to the nature of the vigilance task used, two additional effects were also measured, intersignal interval and time in task.

A review of the literature revealed a general lack of control of the S's set coming into the experiment. Recent studies reviewed showed an interest in what was labeled false knowledge of results. In these studies prearranged information was given as a performance indication regardless of the S's actual performance. The three popular models on vigilance, based on inhibition, expectancy, and attention/arousal, had been unable to explain the results of the few studies on false knowledge. This factor was further studied in an attempt to gain additional information for both the theoretical models and the applied areas interested in vigilance. The hypotheses were (a) no set effect, (b) an overall effect due to KR, (c) no difference between groups receiving KR, (d) a decrement in performance in the no-KR groups over time, and (e) no intersignal interval effect.

A total of 36 Ss were used to test these hypotheses in a classical vigilance task. The performance measure was latency of response. The effect of the E's presence, actual or implied, was removed by telling the Ss that the entire experiment was automated. This also created a situation more closely resembling a true vigilance situation. Two completely prearranged KR schedules were used which resulted in all the appropriate Ss receiving an equal number of signals. Subjects were tested for forty minutes, each S receiving forty signal presentations.

Three of the five hypotheses were confirmed. No set effect was detected, KR did exert an effect compared to no KR, and no difference existed between groups receiving KR. However, all groups exhibited a decrement in performance over time, and a significant interval effect was found. An unexpected interaction, set x interval x time, was also found.

The results of the set effect and KR effect were expected, based on the review of the popular models. Prearranged KR seems to act in a manner similar to normal KR. No significant increase in RT was detected over time in the no-KR group. The general decrement in all groups was attributed to the response measure used, RT, which is more sensitive than other measures in detecting such a decrement. The significant interval difference was interpreted as support for the expectancy model. Other factors stated in the inhibition and attention/arousal models were not measured, however, and their effects were not completely discounted. A general application of the results to applied areas was briefly discussed.

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APPENDIX A

PRELIMINARY INSTRUCTIONS

Read these instructions carefully before going to the experiment. Bring this sheet with you.

Report to Room 206 in Old Central at _____. Please be on time, but do not arrive more than 5 minutes before your scheduled time. You will not need to bring any material with you. The door to Room 206 will be open, and a sign saying "Psychology Experiment" will be on the inside of the door. Enter the room, closing the door all the way. Do not turn on the overhead light.

Sit down in the student desk facing the panel on the table with the lights on it. Do not move the desk from its position during the experiment. There will be (a) a hand pushbutton switch on the desk and (b) a pair of earphones on the back of the desk.

Place the earphones over your ears in a comfortable position. Once you have become situated in the chair with the earphones on, pick up the hand pushbutton switch in your hand. Looking at the panel, you will notice that a light is shining through the small hole in the middle.

Pressing the pushbutton will extinguish the light and start the experiment. A programmer in the adjacent room will give you your instructions over the earphones, present the experiment, and notify you when it is over.

When you have been notified that the experiment is over, you may leave. Please place the earphones and hand switch back on the desk. Leave the door open as you depart. To insure that you receive credit for participating in this experiment, leave this instruction sheet with your name on it on the desk.

APPENDIX B

BASIC TAPED INSTRUCTIONS

The purpose of this experiment is to measure performance in a vigilance situation. This situation is similar to situations found in the military where individuals scan radar scopes for meaningful signals and in industry where constant checks on emergency signals are required to insure proper equipment operation.

(The applicable set instructions were inserted here.)

Your task will be to press the pushbutton switch you have in your hand as soon as you detect a light shining through the small hole located in the middle of the panel. In other words, to repeat the action you took to start this experiment. The light will appear at irregular intervals during the experiment and will remain lit until you press the button. A firm, quick pressure on the button should extinguish the light; however if the light should remain on, press the button again.

Your reaction time to the onset of the light will be measured, so press the button as soon as you see the light. Do not, however, press the button when the light is not lit. To insure fast reaction, keep the switch in your hand. Do not try to time the light, as this will only slow your reaction time. To familiarize you with the light, it will be presented as soon as the experiment starts. You will not be timed on this first trial, although you will have to respond.

(The applicable KR instructions were inserted here.)

No smoking will be permitted. Please remain in the chair and do not move the chair from its position. To create a situation more like a true vigilance task, a low volume noise will be heard over these earphones. The purpose of this noise is to isolate you as much as possible from external sounds.

You will be notified at the termination of this session. The experiment will now begin.

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This concludes the experiment. Please leave your instruction sheet with your name on it on the desk. You are free to leave. However, do not discuss this experiment with anyone. Thank you for your time.

(At the termination of the session, the S was also told of the prearranged KR schedules and that KR improved performance in a vigilance task, if this was applicable.)

APPENDIX C

KR INSTRUCTIONS INSERT

No KR Group

The two colored lights on either side of the small hole in the panel are not part of this particular experiment, so pay no attention to them. They will not be lit during this session.

KR Groups

The two colored lights on either side of the small hole in the panel will inform you on how your reaction time compares with the average reaction time of groups not receiving any comparison information. This average reaction time you are being compared with was computed on a trial by trial basis. That is, each light presentation has a different average reaction time associated with it. These average times will naturally vary, as will your reaction time.

After each response one of the two lights will appear for a period of 3 sec. If the green light is illuminated, it will indicate that your reaction time was faster than the average for that trial of the group not receiving this information. If the red light is illuminated, it will indicate that your reaction time was slower on that particular trial. So, a green light indicates a faster response and a red light a slower response.

VITA

Stanley Doane Stephenson

Candidate for the Degree of

Master of Science

Thesis: THE EFFECT OF SET AND KNOWLEDGE OF RESULTS ON REACTION TIME IN A VIGILANCE TASK

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