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The Effects of a Monetary Bonus and Penalty on the Performance of a Simple Monitoring Task

Gordon Henry
Western Michigan University

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THE EFFECTS OF A MONETARY BONUS AND PENALTY ON THE PERFORMANCE OF A SIMPLE MONITORING TASK

by

Gordon Henry

A Dissertation
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
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The effects of a monetary bonus and penalty on the performance of a simple monitoring task

Gordon Henry, Ph.D.
Western Michigan University, 1994

The purpose of the present study was to compare the effects of three different pay systems on human monitoring performance. With increasing automation, monitoring tasks are becoming increasingly common, but methods of compensation that will promote good performance remain unexamined. Although hourly pay is typically used, data suggest that contingent pay may be more effective in motivating high levels of performance.

In the current study, six undergraduate students, four females and two males ranging in age from 19 to 21 years, performed a monitoring task analogous to one performed by a security guard. Specifically, subjects observed a television screen and detected the presence of signals that were superimposed on video tapes. Using a within subject withdrawal design, subjects were exposed to three pay conditions: (1) hourly pay, (2) hourly pay plus a performance-contingent monetary bonus, and (3) hourly pay in combination with the bonus and a financial penalty contingent upon poor performance.

The two contingent-pay conditions resulted in only inconsistent improvements in monitoring performance over the hourly pay condition. Implications of the task, subjects, setting, and experimental procedures employed in the present study for researchers and practitioners are discussed.
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Henry, Gordon O., Ph.D.
Western Michigan University, 1994
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CHAPTER I

INTRODUCTION

Over the past decades, American businesses and industries have become increasingly aware that, to survive, they must make extensive efforts to improve the quality of their products and services. The need to meet rising consumer expectations, reduce production costs, and compete in increasingly international markets has made it imperative that quality issues be addressed immediately and successfully to avoid economic ruin. As early as 1975, Deming (1975) emphasized that American industry's neglect of quality issues had already resulted in a substantial decline of the American economy. Later, Crosby (1984) also noted that the American economy was being adversely affected by organizations having to expend significant portions of their operating costs redoing things that had initially been done incorrectly.

Some authors (see Craig, 1984 or Warm, 1984 for examples) have maintained that technological advances, which would reduce the need for fallible human quality inspectors, would be a great aid in improving the quality of American goods and services. However, much research has shown that advances in automated technology merely alter the nature of inspectors' tasks rather than eliminate the need for inspectors altogether. Harris (1969) outlined three types of tasks typically performed by quality inspectors; two of which do not make use of highly automated mechanical or electronic equipment and one which does.

The most common of the former tasks, at least in past years, are scanning tasks. Scanning consists of an inspector searching for defects by making a point-by-point examination of an item. Such examination is typically visual but other senses may be
employed from time to time. For example, machinists may visually inspect finished parts to detect imperfections or they may rub their fingers over certain areas of metal parts to detect the presence of nicks or burrs. Other examples of scanning tasks include the inspection of fruits and vegetables for mold and bruises, the examination of electronic hardware for improper connections and wiring, and the inspection of automobile body surfaces for blemishes in the paint.

Like scanning tasks, measuring tasks do not require the presence of automated equipment. Measuring tasks are performed in situations in which an inspector uses some instrument to determine whether or not a particular dimension of the product is within specified tolerances. These tasks may be fairly simple, such as placing a ring around a cylindrical part to assure proper diameter of the part, or may involve extensive calculations and preparation for performing a measurement using a complex measuring instrument. Often, measurements obtained in this way are plotted on process control charts in organizations that are using a statistical process control (SPC) program to track the quality of their outputs. Note that neither scanning nor measurement tasks require the presence or use of automated technology.

The final category of inspection tasks described by Harris (1969) is typically associated with the control of some type of automatic or semiautomatic equipment. The job of the inspector is to observe monitors or displays for evidence of out-of-tolerance or abnormal conditions. When engaged in monitoring the inspector does not observe the object of the inspection directly. A nuclear reactor operator who watches a gauge that displays the temperature of the reactor core is engaging in a monitoring task. Similarly, a member of the flight crew of an aircraft may observe the condition of the jet engines by monitoring a panel of indicators.
Harris (1969) predicted that many people who at that time performed manipulative type tasks such as assembling products or manually scanning or measuring finished products would be replaced by people who carried out monitoring tasks similar to those described above. In Harris' words, "With the trend toward increased automation, it is likely that this type of inspection task will become increasingly common" (p. 142).

More recent findings by Weiner (1987) show that Harris' prediction was accurate. Weiner argued for abandonment of the "myth" that automation of job functions eliminates or even diminishes the need for human inspectors by citing several case studies. In one instance, the mass transit system of Dade County, Florida installed a device called an ATO (Automatic Train Operation) in their trains that was designed to automatically regulate a train's speed and bring it to a precise stop at station platforms. However, at about every 10 stations the ATO failed to receive the electrical signal to stop, forcing the human driver of the train to depress a red button that engaged the train's brakes. Typically, the train had overshot the station and the driver would have to backtrack to let the passengers out.

Weiner (1987) also reported the results of task analyses performed by the U. S. Army. The ever-increasing use of computers and other electronic and mechanical automations in military equipment was supposed to decrease the amount of subjective decision making required of Army personnel. However, over 100 of the 1500 jobs analyzed required at least some human monitoring activity, which represented a substantial increase when compared to previous Army records.

Possibly the most convincing evidence of the increased frequency of monitoring tasks necessitated by automation provided by Weiner (1987) consists of the results of questionnaires and interviews he conducted with commercial airline pilots. The pilots
showed a high degree of ambivalence toward automation, especially as to whether it enhanced safety and reduced workload. In face-to-face interviews, a panel of pilots continually stressed that, "...automation meant more monitoring activity and that the safety of automated flight depended not on the reliability of the equipment, but on the pilots' ability to maintain watch over the equipment and the progress of the flight" (p. 732). Recently, increases in the amount of monitoring necessitated by technological advances have also been noted in such diverse areas as highway driving (Drory, 1985), railroad operations (Wilde & Stinson, 1983), and security (Miller & Mackie, 1980).

It is commonly acknowledged that advances in automated technology have aided in reducing some of the quality-related problems in American business and industry (Craig, 1984; Warm, 1984; Weiner, 1987). However, as is apparent from the previous discussion, the vast majority of organizations continue to rely, at least in part, on humans to implement their quality control programs. Although these employees now more often engage in monitoring rather than scanning or measuring, it continues to be the performance of human quality inspectors that ensures that goods produced and services rendered are of high quality. It remains vitally important to our economic survival then that we employ the most effective methods known to motivate and encourage high levels of performance on the part of these human quality inspectors.

An understanding of signal detection theory (SDT) and an examination of signal detection research may aid in this endeavor. In the typical signal detection study, a discrete event, such as a particular numerical digit or a tone of a specific frequency, is displayed against a background of "noise." In the vast majority of studies, these events have been visual in nature, but several studies have introduced auditory signals superimposed on a background of auditory noise. Regardless of the type of event
presented, an observer is typically required to make differential responses in the presence and absence of a predetermined event, commonly referred to as the signal. Nevin (1991) noted that there are four possible combinations of stimulus presentations and response alternatives during any one experimental trial. The subject may respond "yes" (there is a signal present) or "no" (there is not a signal present), and either of these responses may occur whether a signal has actually been presented or not. These four combinations are commonly presented in a 2 x 2 matrix, well known as either the Yes-No signal detection matrix or the payoff matrix, which is exemplified in Figure 1.

<table>
<thead>
<tr>
<th>RESPONSE</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIT</td>
<td>MISS</td>
<td></td>
</tr>
<tr>
<td>FALSE ALARM</td>
<td>CORRECT REJECTION</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. The Matrix of Stimulus Presentations and Response Alternatives in the Yes-No Signal Detection Paradigm.

Researchers in the area of signal detection have shown that by manipulating various characteristics of the task setting, such as amount of background noise or
number of displays; characteristics of the signal itself, such as signal duration, density, or salience; and subject characteristics such as amount of sleep or type of training received, they are able to differentially affect the number of correct and incorrect responses made by a subject (see Commons, Nevin, & Davison, 1991, for an extensive review of interventions used in signal detection). In addition, signal detection researchers often have introduced different types of consequences following correct and incorrect responses of subjects. Correct responses have been followed by feedback or payoffs, while errors have been followed by different feedback, penalties or no consequence (Commons et al., 1991). However, even though it has been shown that correct and incorrect responses can be differentially affected in the typical signal detection paradigm, there is not universal agreement concerning the exact mechanism by which these environmental manipulations come to affect signal detection performance.

Signal detection theory holds that the detection of signals can be assumed to involve two distinct processes: discrimination and decision (Davies & Tune, 1969). The first process, discrimination, refers to the ability of an observer to accurately discriminate between signal and nonsignal events (Craig, 1987). The second process represents the observer's decision criterion, his or her bias toward one or the other response alternative (Swets, 1977). Reports of signal occurrence that are correct (hits) and those that are incorrect (false alarms) are jointly determined by the observer's capacity for discriminating between signal and nonsignal and by his or her bias toward reporting signal occurrences. Signal detection theorists subscribe to standard methods of measuring the extent to which each of these processes is present in a particular case.

Of the four stimulus-response combinations presented in the 2 x 2 signal detection matrix, only two provide independent information about the subject's
performance that is used in calculating a subject's discrimination capacity and decision criterion bias. These two are the number of hits and the number of false alarms. MacMillan and Creelman (1991) noted that, if the number of hits and false alarms are known, the other two quadrants in the matrix may be filled in, assuming that the total number of signals presented and the total number of experimental trials are also known. The matrix is then typically summarized by two numbers: the hit rate (typically denoted as "H"), or proportion of experimental trials in which signals were correctly detected, and the false-alarm rate (denoted as "F"), or proportion of experimental trials in which the observer incorrectly reported that a signal had been presented. The hit and false-alarm rates can also be interpreted as probabilities. The hit rate is the probability that an observer will respond "yes" given that a signal has been presented, and the false-alarm rate is the probability that an observer will respond "yes" given that no signal has been presented.

It is necessary then to use these probabilities in a way that characterizes the observer's sensitivity to signals. A function of H and F that attempts to capture this ability of the observer is called a sensitivity measure. A perfectly sensitive subject would have a hit rate of 1 and a false-alarm rate of 0. A completely insensitive subject is unable to distinguish between signal and nonsignal events at all and, in fact, could perform equally well without attending to them. For this observer, the probability of responding "yes" does not depend on the stimulus presented, so the hit and false-alarm rates are the same. Most often, sensitivity falls between these extremes in that H is greater than F, but performance is not perfect.

The most important and commonly used measure of sensitivity in SDT is \(d'\), defined in terms of the inverse of the normal distribution function (MacMillan & Creelman, 1991, p. 9):
\[ d' = z(H) - z(F). \]

The sensitivity measure which represents the decision criterion bias of the observer, \( B \), is defined in terms of the ordinates of the normal curve corresponding to \( H \) and \( F \) (Swets, 1977, p. 707):

\[ B = \frac{f(H)}{f(F)}. \]

Different types of experimental manipulations have been thought to affect these two sensitivity measures. The effects of changes in the signal presentation itself on \( d' \) have been studied by varying such things as signal intensity, signal duration, intensity of background noise, the number of signal components, the interval in which a signal of fixed duration is presented, and the number of signal repetitions (Swets, 1964). The decision process, \( B \), has been examined by introducing variables thought to affect the decision criterion of the observer such as performance feedback, instructions to subjects, the use of multiple observers, and the reported probability of certain signals occurring (Swets, 1964).

Even though the seeming ability of SDT to quantify internal human processes is attractive, some authors (e.g. Mackie, 1987) have debated whether the statistical analyses used in SDT are especially applicable to the types of tasks which involve monitoring as defined by Harris (1969). The crux of this argument is that signal detection tasks typically involve discrete trials, between which observers may rest or engage in other nontask-related activities. These tasks may be likened to Harris' (1969) scanning or measuring tasks. Monitoring tasks, on the other hand, require the observer to continuously attend to some display in the search for abnormal conditions. This
basic difference in the two types of tasks has led to the question of whether statistics used in SDT are valid in analyzing monitoring tasks (Mackie, 1987).

Numerous other authors, however, have no doubt of the contribution that signal detection theory can make in analyzing performance on monitoring tasks due to the long history of SDT being used in the interpretation of results from vigilance research. The tasks employed by vigilance researchers are more like contemporary monitoring tasks in that continuous observing of some display is required. McNicol (1972) argued that SDT analyses were applicable to the results of vigilance research because signal detection theory is simply "a theory about the ways in which choices are made" (p. 10), and, in this respect, vigilance and signal detection tasks are similar. Broadbent and Gregory (1963) had advocated earlier for the use of statistics from signal detection theory (SDT) in the analysis of results from vigilance studies, thereby rendering the results applicable not only to actual monitoring tasks but to a wide range of real-world situations in which humans are required to make choices.

Since Broadbent and Gregory's (1963) assertion that signal detection theory is useful in analyzing many human problems, researchers have applied SDT analyses to a wide variety of situations ranging from identification of sane versus insane patients (Rosenhan, 1973) to an analysis of why so few people work to prevent nuclear war (Fuld & Nevin, 1988). In almost all cases, SDT analyses have proven successful in providing a better understanding of human behavior in choice situations. It seems, then, that ample evidence exists showing that an analysis of vigilance, and hence, monitoring, performance using components of SDT such as the payoff matrix and the statistics d' and β may be both logical and helpful. However, to understand the relationship between these two lines of research, it is now necessary to more fully examine the experimental designs and manipulations used in vigilance research.
During World War II, Mackworth performed much of the early work that formed the basis for subsequent studies on vigilance. He was hired by the governments of the United States and Great Britain to determine the optimum length of watch for radar operators on anti-submarine patrol. These operators were required to monitor a display in search of critical, but infrequent, signals. Research in this area indicated a drop in the percentage of signals detected as time progressed which Mackworth came to refer to as a vigilance decrement (Mackworth, 1948). Mackworth noted that this decrement occurred even though the radar operators reported high levels of motivation to perform their job well and though the consequences of errors during performance of this task were serious, perhaps even fatal.

In an attempt to replicate his findings in a more controlled environment, Mackworth designed what is perhaps the classic study on human vigilance in 1950. In this study, a pointer rotated around a dial in successive small jumps, one every second. At irregular intervals the pointer made a double jump, and observers were required to indicate that they had noticed each of these double jumps by depressing a key. After approximately 30 minutes, subjects began to miss the double jumps, and the number of double jumps missed increased throughout a two-hour observation period (Broadbent, 1953).

Mackworth's research led to a great deal of debate concerning exactly what behaviors or cognitive states were involved in human vigilance. Buckner and McGrath (1963) noted that vigilance had been described variously as simply the accuracy of performance on monitoring tasks, as attention over extended periods of time, and as a state of the organism—a readiness to respond to infrequent signals occurring at unpredictable temporal intervals. Despite this lack of agreement regarding the specific overt and/or covert behaviors involved in human vigilance, vigilance research
conducted subsequent to that of Mackworth was remarkably consistent in showing the presence of a vigilance decrement even when other aspects of the experimental setting were varied.

Mackworth himself developed an auditory, as opposed to visual, vigilance task and quickly confirmed that detection of "signals" declined to a considerable extent simply as a function of time on task. Replications of Mackworth's studies conducted by Broadbent (1953), Adams (1956), and Whittenburg, Ross, and Andrews (1956) confirmed the existence of a vigilance decrement. Recently Mackie (1987) estimated that over a thousand laboratory studies had been conducted showing the presence of the decrement. As Wiener (1987) put it, "...the vigilance decrement was about as dependable a result as one will ever see in human experimentation, especially considering the wide variety of tasks and conditions reported in the vigilance literature" (p. 729-730).

One additional consistency that has been shown in the vigilance literature is that the vigilance decrement does not occur in a linear fashion over time. Colquhoun (1959, 1960), Wilkinson (1961, 1964), Baddeley (1969), and countless other researchers have shown that vigilance seems to drop off sharply after 20 to 30 minutes if no signal is detected in that time. Subjects' vigilance then seems to decrease in a more moderate, linear fashion over the remainder of the experimental session. However, each time a signal is detected this pattern of vigilance performance recurs with vigilance remaining high for 20 to 30 minutes after a signal presentation and then dropping sharply.

Over the years, several theories have been proposed in an attempt to account for this consistent pattern of performance by humans engaged in tasks requiring vigilance. In a comprehensive review of the vigilance literature, Craig and Colquhoun (1975)
wrote that much of the vigilance research was based respectively on the notions of arousal, extinction, orienting response habituation, filtering, and expectancy.

According to arousal theory, the central nervous system requires some minimal level of activity in order to maintain a reasonable level of efficiency (Hebb, 1955). Since it is stimulation from the external environment which is thought to maintain this activation level, nervous system activity will be low when a human is involved in a monotonous, unstimulating environment. As Zuercher (1965) pointed out, most tasks that require vigilance take place in such an environment, especially in laboratory settings. It is not surprising then that the efficiency of performance will be low in such a setting and will deteriorate as exposure to the monotonous environment continues.

According to inhibition theory, the vigilance process is similar to experiments with nonhumans in which the subject is deprived of any reward or reinforcement following a particular response. In such an experimental situation, it can be expected that the response would be extinguished. It can be argued that in the typical vigilance task, responses following the almost continuous display of normal or non-signal events are extinguished because they are not followed by any environmental change which could be considered reinforcing. Then, this "inhibitory state" (Craig & Colquhoun, 1975) generalizes to whatever response is required following events which are defined as signals. This theory becomes more applicable to vigilance tasks as the number of features shared by responses following signal and non-signal events increases.

The orienting response habituation theory, summarized by Jerison (1966), holds that humans produce a short-lived neurophysiological response in the presence of a discrete stimulus, especially a novel stimulus. It is this response which gradually habituates when that previously novel stimulus is presented repeatedly. This theory is attractive to some researchers because it is thought that some internal response is
necessary to provide the subject or worker with "evidence" (Jerison, 1966) which aids in deciding whether a signal has been presented or not. This evidence then declines as the orienting response habituates, thus decreasing vigilance efficiency.

This same reduction in stimulus novelty as a consequence of the large number of repetitions involved is also critical to understanding the filtering explanation of vigilance performance. Broadbent (1958) proposed the existence of a cognitive "filter" through which all information to be processed must pass, and which has a constant bias in favor of novel events. The decline in novelty from input associated with the vigilance task itself would lead the observer to attend less and less to the task at hand and become more easily distracted by other, now more novel, sources of stimulation.

It is apparent that these four explanations of what leads to the typical pattern of vigilance performance depend on the repetitive, monotonous pattern of stimulation which is an essential feature of vigilance tasks. This is true despite the differences in the proposed mechanisms by which this monotony leads to a decrease in vigilance performance over time. In addition, the notion that performance declines because of the boring nature of the task situation or the task itself has some intuitive appeal, especially for those who have been required to engage in such tasks either on the job or in a laboratory simulation. However, the final proposed explanation of the vigilance decrement suggests that performance may actually benefit if the structure of the typical vigilance task was made even less varied.

The expectancy theory holds that a major reason for the reduced efficiency during a vigilance task is the uncertainty concerning signal arrival times which typically exists when very few signals occur over a lengthy period of time. Baker (1960) suggested that, "the low response rate is merely a reflection of the estimate of the low signal rate, an estimate which is based on past experience" (p. 674). So, if an observer
failed to detect a signal or two early in the vigil, he or she would be even less certain about arrival times of signals later in the vigil. This would lead to a revision of the observer's opinion of the overall signal probability and a bias on the part of the observer to become less likely to report any subsequent signals.

Although the proponents of these various theories reached quite different conclusions regarding what had caused observed changes in vigilance performance, the primary goal of each of their studies was the same - to identify those environmental variables which, when manipulated, resulted in behavior which varied from typical vigilance performance. Mackworth himself began this process by systematically introducing such variables as increased familiarity of the subjects with the task involved, low signal rates, and adverse environmental conditions such as a high ambient temperature (Craig & Colquhoun, 1975). Mackworth's work began a long tradition of examining the effects of antecedent variables (variables which occur prior to actual vigilance performance) on the typical pattern of vigilance.

One class of antecedent variables examined were those associated with the signals themselves. In an attempt to support the expectancy theory of vigilance, Baker (1960), using the same clock task developed by Mackworth, reduced the variability in the times between signal presentations. He was careful, however, to retain the same average interval between signals that had been used in the previous Mackworth studies. Baker's results showed that this manipulation produced a marked reduction in the vigilance decrements of subjects. Later, Baker (1963) was able to complement these findings by showing that subjects who had been trained with a particular distribution of signal presentation times were more likely to detect subsequent signals when they were presented at these times, but less likely to detect signals which were presented either relatively early or late. Baker (1963) maintained that his results supported the
expectancy theory of vigilance. Note that Baker's manipulation had, in effect, increased the repetitive nature of the experimental task, and only the expectancy theory would account for an increase in vigilance performance under these conditions. However, it seems that the vast majority of studies in which the vigilance decrement was reduced or eliminated have been based on one (or more) of the theories that hold that some decrease in the monotony and fatigue brought about by typical vigilance tasks is necessary to improve performance.

One method of reducing this monotony is to increase the rate of signals presented. Jenkins (1958) showed that lower rates (averaging 6 signals per 1-hour experimental session) of signal presentations did produce lower levels of detection efficiency than higher rates (averaging 21 signals per experimental session). Similar results regarding signal rate have been reported by Kappauf and Powe (1958), Colquhoun (1961), and Aitmeyer (1989). In fact, in a comprehensive review of vigilance research, Craig and Colquhoun (1975) reported that the importance of signal rate in influencing vigilance performance is probably the most accepted finding in the vigilance literature. Craig and Colquhoun (1975) did note, however, that the rate of signal presentation is now more commonly interpreted in terms of the probability of a signal occurring given some time period rather than simply the actual frequency of signal presentations over time.

Colquhoun (1961) and Colquhoun and Baddeley (1964) have argued that, possibly, it is not the actual probability of a signal occurring which influences vigilance performance, but whether the subjects expected a high or low rate of signals. These researchers were able to show that if subjects were told that a high rate of signals would be forthcoming, a low rate of signal presentations resulted in a more severe vigilance decrement than if subjects were told to expect a low rate of signals. Colquhoun and
Baddeley (1964) concluded that the divergence between the expected rate of signals and the actual rate adversely affected vigilance performance in their studies and that, at least, the effects of signal rate or probability on the vigilance decrement were moderated by subject expectancies.

Other subject characteristics have also been shown to moderate the effects of signal probability on vigilance performance. In a review, Mackie (1987) reported that signal probability effects also seem to be moderated by amount of sleep, mood and morale levels, amount of regular exercise, and even circadian rhythm patterns. In general, those characteristics which are thought to reduce one's susceptibility to fatigue, such as more sleep, elevated mood, regular exercise, and a faster circadian rhythm cycle, have been consistently associated with a decrease in the amount of vigilance decrement observed due to relatively low signal probabilities.

Rather than manipulate the signal rate, some researchers have altered the complexity of the task in attempts to reduce the vigilance decrement. One of the earliest studies to examine task complexity was performed by Bakan (1959) who was interested in auditory vigilance. Half of the volunteer undergraduate psychology students who served as subjects in this study had to listen to a stream of digits and report when three identical digits occurred consecutively. In a more complex condition, the other subjects were to report when an odd-even-odd sequence occurred. Each subject participated in one 45-minute experimental session and ten signals were presented during each 15-minute period to all subjects. Although Bakan (1959) hypothesized that increased complexity would offset any vigilance decrement produced by this task, his results showed that decrements in performance over the period of the vigil were found only in the more complex form of auditory vigilance. Since vigilance decrements were clearly present in numerous previous studies employing very simple
tasks, Bakan (1959) then suggested that there may be a window of optimal task complexity that results in enhanced vigilance performance. Tasks which were either too simple or too complex would thus produce a vigilance pattern containing a decrement over the period of the vigil.

It has been suggested (Loeb, Noonan, Ash, & Holding, 1987) that Bakan (1959) did not find a vigilance decrement in the simple condition due to the relatively short (45 minute) length of the vigil his study entailed. In a replication of Bakan's (1959) study, Montague, Webber, and Adams (1965) were able to show that a vigilance decrement did occur under the simple task condition when a vigil of eighteen hours was employed. Further, the decrement was not present for those subjects performing the more complex task. It seems then that the use of a relatively complex task can abolish the usual decrement under certain conditions, one of which is a sufficiently lengthy exposure to the task.

In addition, it appears that vigilance performance may actually improve rather than decline over time under certain conditions. Warm (1984) reported the results of several studies in which vigilance performance during simple, often referred to as sensory, tasks was compared to vigilance during more complex or cognitive tasks. The assumption made in these studies was that in sensory vigilance the detection of critical signals required only the discrimination of physical changes in the stimuli. In what was described as cognitive vigilance the observer was required to respond to symbolic changes in task stimuli the physical detection of which presented no difficulty. Warm (1984) reported that, quite often, a vigilance increment was observed when the vigilance task was of the cognitive variety.

One such result was obtained from an experiment in which successive pairs of digits were presented for visual monitoring. The same digit pairs were used in two
types of experimental conditions that differed only in the symbolic operations the subjects were required to perform. In a simple condition the critical items for detection were pairs of digits whose value differed by one or less. A complex condition added the further requirement that the total formed by the two digits had to lie between 4 and 14. A further manipulation imposed either slow or fast event presentation rates, at 6 or 21 digit pairs per minute, in both conditions of complexity.

When the decision that a signal had occurred was simple, the results followed the typical vigilance pattern with the probability of detecting a signal falling as the watch period continued, and, as expected, this decrement effect was greater at the faster event rate. In contrast, the complex criterion resulted in a steady improvement over a one-hour session, with no differential effect due to event rate. Warm (1984) stated that this relatively novel effect was reproduced in a follow up study using the same task.

Two possible explanations for the existence of a vigilance increment under complex conditions have been proposed (Warm, 1984). One explanation suggests that subjects may learn more efficient strategies for dealing with complex tasks. For example, in the study reported by Warm (1984) above, subjects may have been able to memorize all of the critical digit pairs or may have discovered a simplified rule for identifying critical signals which would reduce the task to a relatively simple matching problem. Note, however, that this explanation of the increment may not be satisfactory because it is unclear that it predicts a steady improvement over the course of a vigil. It may be argued that the vigilance of subjects who have learned to simplify the task should eventually decline as it does in other simple conditions.

Another possible explanation for the vigilance improvement involves the concept of enhanced motivation. In this case the assumption would be that the complexity of the task provided sufficient intrinsic motivation to maintain or possibly
improve performance as the interest generated by the task increased over time. Unfortunately, subsequent studies have been unable to rule out one or the other of these possible explanations of the vigilance increment. In fact, in the vast majority of follow-up studies, which make use of a wide variety of experimental tasks and conditions, researchers have been unable to reproduce the increment at all.

For example, Loeb, Noonan, Ash, and Holding (1987) conducted a study in which 60 students from an introductory psychology class were randomly assigned to six groups of 10 subjects each. All subjects were presented with pairs of single digit Arabic numerals displayed on a computer screen at the rate of 20 per minute (each digit pair remained on the screen for three seconds), and the single experimental session conducted with each subject lasted for 50 minutes. In any 10-minute period of each experimental session, five signals, as defined below, were presented.

Although all subjects were instructed to press a button on a hand-held plunger when a signal was presented, the definition of what constituted a signal was varied across groups. For Group 1, which was the simplest condition, any digit pair containing the numeral 7 was defined as a signal. Group 2 was to respond when a digit pair totaling nine was presented. For Group 3 the digit total which constituted a signal ranged from 1 to 18 depending on a target value displayed elsewhere on the computer screen for an average of 60 seconds. Subjects in Group 4 performed the same task as those in Group 3 but were also was presented with a brief (200 milliseconds) tone when the target value changed. The definition of signals for Groups 5 and 6 were identical to those for Groups 3 and 4, respectively, except that the target value was replaced by "HH" after the first three seconds of display.

Results from this study showed that the simplest condition gave the largest number of signals detected. In addition, there were no significant differences in the
number of signals detected among any of the remaining, cognitive, experimental conditions although in each of these conditions there was a general trend toward a decline in performance over time. Loeb et al. (1987) maintained that these results did not support the claim that cognitive vigilance tasks could actually produce increments in performance over time. However, these authors did acknowledge that measures of subject performance other than number of hits, such as response latencies, may be more sensitive in detecting the possible existence of vigilance increments.

It is fairly obvious that the great body of literature which examines the effects of antecedent events, such as signal rate and task complexity, on vigilance performance have produced markedly mixed results. As a reading of Warm and Jerison (1984) would suggest, the vast effort directed toward understanding the parameters of the stimuli that mediate the vigilance decrement has been unable to identify a unitary factor of sustained attention.

It may be that the effort to explain the data of the vigilance studies has been difficult due to the reliance upon some inherently unobservable cognitive construct being present and active in the observers. The use of these constructs give the appearance of explaining the data, when in fact they merely add to the number of phenomena that require explanation. For example, a subject is said to make a detection because some environmental parameter associated with the stimulus, the task, or the subject himself causes him to be vigilant, attentive, or expecting a signal at that moment. The problem then becomes one of directly measuring this vigilance, attention or expectancy. Badalamente and Ayoub (1969) noted that one cannot simply compare the number of signals detected to the actual number of signals presented and refer to this ratio as a measure of a subject's vigilance, because it is simply a measure of his efficiency as a result of his vigilant behavior. As Holland (1958) put it, "It is
unsatisfactory to say that the percentage of signals detected is the vigilance rather than a result of vigilance, attention, or expectancy, just as the learning theorist is unsatisfied in saying that decrease in errors is learning" (p. 62). Only after the behavior of interest itself, and its controlling variables, have been described do terms such as "vigilance" or "expectancy" develop descriptive value. Holland (1958) went on to suggest that researchers should concentrate on the actual behaviors which make signal detection possible, which he called "observing responses," and that these responses follow the principles of operant behavior in that they are primarily controlled through their environmental consequences.

To demonstrate this type of analysis, Holland (1958) used the clock task, with its pointer that made irregular double jumps, developed by Mackworth in 1948. Holland (1958) used Navy enlisted men in his study and added the condition that subjects were completely in the dark during their vigils. In order to see the dial, subjects had to press a key which illuminated the dial for .07 of a second. Holland then introduced various schedules of dial deflections (double jumps) and found that the rate of observing responses (pressing the key for the light) varied directly with the schedule employed. Further, Holland (1958) found that the vigilance decrement was accompanied by a parallel decrement in observing response rate. He concluded that the detection of a signal can serve as reinforcement for an observing response and that the detection data of vigilance studies may reflect the observing response rates generated by the particular schedules employed. It should be noted that Holland did not theorize regarding exactly what experience a subject must have for signal detection to serve as an effective reinforcer, but the effect did seem quite consistent across his subjects. The fact that Holland (1958) was able to exert fairly precise control over his subjects' observing responses by varying the schedule of reinforcement does suggest that
vigilance behavior may be analyzed in a way which does not appeal to a non-behavioral level.

In an effort to apply Holland's analysis to a more complex, realistic task, Badalamente and Ayoub (1969) designed a simulation of an assembly-line inspection task. Their assembly line was represented by a rotating disk in which items to be inspected could be placed in slots. The items to be inspected were simulated electronic circuits, and the observing response decided upon was the pressing of a button which stopped the rotating disk for one second only. Subjects, four undergraduate male college students, were carefully briefed on the criteria for a defective circuit and were told that the object of the study was to detect as many defective circuits as possible. The stop button was placed on a stand at the subject's left and a container was situated to the right of the subject into which defective circuits were to be placed. The subject was instructed to press the button, thus stopping the disk, if he wished to inspect a particular circuit more carefully. Subjects were only able to see a wedge-shaped area of the disk and the experimenter sat behind a screen on the subject's left.

The experimenter, out of the view of the subjects, was able to place defective and correctly made circuits in the disk slots in such a way as to maintain a prearranged schedule of defectives. The eight schedules which Badalamente and Ayoub (1969) examined were both high and low values of fixed-interval, variable-interval, fixed-ratio, and variable-ratio schedules. The low value of the interval schedules was two, or an average of two, defective circuits per minute. The high value of the interval schedules was seven. The low value for the ratio schedules was 20 while the high value for these schedules was 75.

Each subject participated in one 60-minute experimental session, and an event-recorder was used to record the number of observing responses (button presses) made
by each subject throughout each session. By plotting the cumulative response records over time it was seen that, in general, subjects' pattern of responding conformed to that which would be expected in a simple operant conditioning procedure, as Holland (1958) had hypothesized.

The fixed-ratio schedules were characterized by a pause after a signal detection, which was small for the fixed ratio 20 and larger for the fixed ratio 75. On the other hand, the overall rate of responding was sustained on the variable-ratio schedules and the response curves obtained were very nearly straight lines. The fixed-interval schedules were characterized by a pause in responding after a detection and then an increase in responding to a high rate just prior to the next detection. Again, the variable-interval schedules produced a consistent high rate of responding with no detectable pauses after a signal detection. Further, Badalamente and Ayoub (1969) argued that these patterns of behavior resulted from signal detection serving as the reinforcer for observing responses.

Although there has been much debate over exactly what environmental stimuli may serve as reinforcement for observing responses (see Craig & Colquhoun, 1975, for a treatment of this topic), these studies have apparently been successful in showing that vigilance may be interpreted as consisting of the strength (the frequency or relative frequency) of some observing response, and that this relationship was subject to operant learning principles. This realization led many researchers to shift their focus to identifying the exact consequences of observing responses which would serve as reinforcers, thus decreasing or eliminating the vigilance decrement. This shift in focus was also necessitated due to the limited practical value of improving vigilance performance through manipulation of signal characteristics. Grunzke, Kirk, and
Fischer (1974) noted that most display characteristics (those having to do with the signal and its presentation) cannot be manipulated outside of the laboratory.

These authors also suggested that it may be of practical significance, and be in keeping with the theory that vigilance consists of operantly-controlled behavior, to attempt improvements in vigilance performance using interventions commonly found in organizations wishing to improve other work-related behaviors. Such an intervention, actually suggested as early as 1948 by Mackworth (Craig & Colquhoun, 1975) but virtually ignored for over 20 years, was the use of performance feedback. Craig & Colquhoun (1975) also called for the use of feedback, often referred to as knowledge of results in the vigilance literature, to improve the performance of quality inspection tasks having the characteristics of vigilance or monitoring. They defended this suggestion by noting the power of feedback in improving performance during the Hawthorne studies. Craig & Colquhoun (1975) concluded by acknowledging that providing meaningful performance feedback may not be easy for some tasks, but insisting that good feedback be provided for other jobs where it is less difficult. This argument seemed to generate much interest in the relationship between feedback and vigilance performance. However, over the next five to six years several studies were conducted which produced only mixed results in the attempt to show that the use of performance feedback could significantly reduce vigilance decrements (see Davies & Parasuraman, 1982, for a review of this research).

Later experiments proved to be more successful in this attempt. Mackie (1987) described a study in which subjects, sonar operators, were provided with feedback regarding both correct detections and false alarms. The signal display in the study consisted of a simulated sonar screen upon which signals, made to resemble signals with which sonar operators would come into contact during performance of their jobs,
were presented. The signals were presented at a rate of either 4 or 16 per hour and the length of the watches lasted from two to four hours.

Results of this study showed that feedback improved performance as measured by increased signal detection rates and significantly reduced detection latencies. These results were consistent across both signal presentation rates and all lengths of watches. Interestingly, the use of feedback in this study did not seem to increase the false alarm rate as Craig (1984) had predicted. However, this experiment did seem to show a strong relationship between the introduction of performance feedback and reductions in the vigilance decrement, and it precipitated the design of numerous other experiments that examined this relationship.

Unfortunately, most of these studies, although successful in showing improvements in vigilance performance, used a combination of feedback and some other intervention, thus obscuring the effects of the feedback itself. For example, Mason (1992) studied how the interaction of knowledge of results and signal density affected vigilance performance and Chadda (1991) examined the correlation between age and whether feedback was introduced or not when she attempted to improve the detection of signals during a vigilance task.

Although there is a large body of literature documenting the relationship between feedback and vigilance performance, the effects of another consequence commonly used in work settings, monetary incentives, have not received as much attention. In addition, the research that does exist examining the relationship between monetary incentives and vigilance performance often suffers from the same confounds as the feedback studies. That is, incentives have most often been used in combination with other interventions, thus obscuring the effects of the incentive itself on vigilance. In the field of organizational behavior management, however, it has been shown that
monetary incentives, when properly implemented, can be effective in improving performance on a wide variety of tasks in both laboratory and applied settings.

In a laboratory simulation of a simple assembly task, Frisch and Dickinson (1990) were able to show that significant productivity increases could be realized when as little as 3% of a subject's total compensation was made up of monetary incentives. It is interesting to note that the performance of subjects in this study who received a greater percentage of their total pay in incentives was not significantly better than that of those who received only small percentages of incentive pay. However, all groups of subjects who received incentives did, on the average, produce more parts of acceptable quality than subjects who received straight hourly pay (0% incentives).

Several aspects of the Frisch and Dickinson (1990) study which may have influenced the pattern of results obtained are noteworthy. First, the authors noted that subjects were exposed to incentive conditions for only fifteen 45-minute experimental sessions, resulting in total exposure to incentives for somewhat less than two work days. They hypothesized that more prolonged exposure to incentive conditions may yield a different pattern of results. This is consistent with Mackie's (1987) suggestion that vigilance studies should make use of more prolonged experimental sessions in an effort to more realistically simulate actual working conditions.

Frisch and Dickinson (1990) also noted that their subjects worked in isolation, free from the normal disturbances and interruptions commonly found in the work place. In addition, subjects in this study were volunteers who earned only discretionary income for their participation. These factors may have also resulted in the incentives affecting performance differently than would have been the case in an actual work setting. The authors suggested that future laboratory studies using monetary incentives address these issues to more accurately assess the effects of incentives on performance.
Other authors have also shown that contingent compensation in the form of monetary incentives can be generally effective in improving performance on laboratory tasks (e.g., Berger, Cummings & Heneman, 1975; Farr, 1976; London & Oldham, 1977; Pritchard, Hollenback & DeLeo, 1980; Pritchard, Leonard, Von Bergen & Kirk, 1976; Riedel, Nebeker, & Cooper, 1988; Terborg, 1976; Terborg & Miller, 1978; Vecchio, 1982; Weinstein, 1981). For example, Farr (1976) and London and Oldham (1977) showed that incentives can be effective in improving performance when made contingent upon a measure of group productivity. Vecchio (1982) found that the use of monetary incentives resulted in improvements on quantity measures related to the performance of a simulated part-time interviewing task, although no differences in quality measures of the task were found. Earlier, Weinstein (1981) had reported that monetary incentives had been used to improve the reaction time of subjects in his study. Although each of these studies supports the notion that monetary incentives can be effective in improving performance on work-like tasks, each of them suffers in some degree from the lack of realism noted by Frisch and Dickinson (1990). Therefore, the most powerful evidence of the effectiveness of incentives may come from applied settings.

Dierks and McNally (1987) have reported increases in productivity of 200-300% at Union National Bank in Little Rock, Arkansas. Cleveland-based Lincoln Electric's employees became three times more productive than workers in comparable industries when a contingent compensation system consisting of piece-work pay and a merit-based profit sharing plan was implemented (Perry, 1988). LaMere, Dickinson, Henry and Henry (1993) reported dramatic increases in the performance of truck drivers that resulted from an individual monetary incentive system, increases that netted the organization $76,000.00 in labor cost savings over a 15-month period of time.
And, Nebeker and Neuberger (1985) were able to improve the performance of employees in a purchasing division by implementing a performance contingent reward system which included monetary incentives. Similar improvements have been reported by several others (e.g., Bushhouse, Feeney, Dickinson, & O'Brien, 1982; Dale, 1959; Gaetani, Hoxeng, & Austin, 1985; George & Hopkins, 1989; Latham & Dossett, 1978; Yukl & Latham, 1975; Yukl, Latham & Pursell, 1976).

In addition to these specific applications, other authors (Henderson, 1985; Lawler, 1971, 1990; Locke, 1982; McAdams & Hawk, 1992; O'Dell & McAdams, 1987) have noted the increasingly more widespread use of performance contingent monetary incentives to improve performance in a wide variety of business and organizational settings. However, even though the use of monetary incentives has been shown to improve task performance in such a wide range of settings, they have been used only occasionally when the task involved was one of vigilance.

In one study, Cruse (1991) introduced monetary rewards following increases in hit rates during the performance of vigilance tasks which required either simultaneous or successive discriminations to be made. The results of this study were mixed in that when discriminations were required for two tasks being performed simultaneously, monetary rewards contingent on hit rate increases did tend to decrease the vigilance decrement. However, no such effect of the reward was present during the performance of two vigilance tasks conducted successively. Cruse (1991) suggested that manipulations other than introducing simultaneous or successive tasks may enhance the ability of monetary rewards to combat the vigilance decrement.

Perryman, Halcomb, and Landers (1981) used an intervention package consisting of training, knowledge of results, and incentives in the form of tokens to improve the performance of retardates engaged in a visual monitoring task. The
subjects in this study participated in four 25-minute training sessions during which the signal presentation rate was gradually decreased by varying the mean inter-signal interval from 2.0 seconds in the first training session to 3.5 seconds in the fourth training session. During these training sessions, lights which provided the subjects with knowledge of correct detections and false alarms were continuously operative. In addition, each subject was praised following hits and given a number of tokens corresponding to her score (hits minus false alarms) during each training session. The subjects were also reminded about the prizes for which tokens could be exchanged following each training session.

The subjects' performance during a 68-minute post-training session was then compared to that from a baseline session of the same length. During the baseline and post-training sessions, the feedback lights were inoperative, but subjects did receive praise and tokens. Following the post-training session, subjects were allowed to exchange their tokens for prizes of their choice. Although Perryman et al. (1981) were successful in improving vigilance performance through the use of this training intervention, they did acknowledge that it was not possible, on the basis of their data collected, to identify the aspect of the training which led to the improved performance.

This same drawback is true of a study conducted by Grunzke, Kirk, and Fischer (1974) which combined both visual and auditory knowledge of results with monetary incentives to improve vigilance. The 72 volunteer male undergraduates who served as subjects in this study were required to monitor a computer screen for one 3-hour session. Constantly present on the screen during the session was a simulation of a cathode-ray tube, 3 inches in diameter. The signal in the study was a spot of light 3/8 inches in diameter, which appeared aperiodically at one of 12 positions on the simulated tube for a duration of 250 milliseconds. One hundred forty-four signals were presented
at the rate of 12 signals during each 15-minute monitoring period - one signal at each of
the 12 positions on the display. Subjects responded to the signal by pressing a hand-
held push-button switch. Twelve inter-signal intervals (20, 30, 40,..., 130 seconds)
were used resulting in a mean inter-signal interval of 75 seconds. Each inter-signal
interval was used once during each 15-minute monitoring period. The inter-signal
interval and the position of the signal on the display were randomized.

Grunzke et al. (1974) then compared the effects on vigilance of three
combinations of consequences: (1) visual knowledge of results with a partial record of
performance, (2) auditory knowledge of results without a record of performance, and
(3) performance-contingent monetary incentives with a partial record of performance.
Visual knowledge of results was provided by a row of 25 lamps located above the
vigilance display. The lamp on the subjects' extreme left was lighted at the beginning
of the experiment and the light shifted one position to the right each time the subject
responded within three seconds of a signal being presented. Missed signals resulted in
the light shifting back one position to the left. No change in lighting occurred when
subjects responded without a signal having been presented. When the light reached the
extreme right of the display, it automatically reset to the left, thus providing immediate
knowledge of the results of any one response and a partial record of overall
performance.

Auditory knowledge of results was given by means of two tones differing in
frequency. A high-pitched tone was presented for 500 milliseconds when a subject
responded to a signal within three seconds. A low-pitched tone was presented
following a missed signal. If a response occurred in the absence of a signal, no tone
was presented. No overall record of performance accompanied this auditory feedback.
In the incentive condition, subjects were credited with five cents for each detected signal and penalized five cents for each missed signal. When the credit balance reached $1.25 a marble was dispensed into a cup at the lower right corner of the display, and the marbles were redeemed at the end of the experiment for $1.25 each. Subjects were advised that the deductions would not reduce their earnings to less than $1.00 per hour, but the signal rates employed limited subjects' maximum earnings to $2.40 per hour. Subjects in this condition also were provided with the visual feedback and partial record of performance.

A control group of subjects was formed to correspond with each of the three experimental groups. These groups performed the task without any knowledge of results or performance-contingent monetary rewards. Subjects in these groups and all other groups except contingent monetary reward were paid $1.45 per hour for their participation. The performance of subjects in each of the three experimental conditions was compared to the performance of subjects in each of the control conditions, respectively.

Both methods of providing feedback resulted in higher signal detection probabilities than their respective control conditions. However, no statistically significant differences in either detection probability or reaction time were found between the two groups receiving visual or auditory feedback. The performance-contingent monetary incentive condition resulted in the most improvement in probability of signal detection over its corresponding control condition. One interesting note concerning these results is that the number of false alarms did not increase under the monetary reward condition as Grunzke et al. (1974) had expected. Studies conducted by both signal detection and vigilance researchers (see Craig & Colquhoun, 1975, for a
review) had previously indicated that an experimental manipulation which resulted in an increase in hits would also increase the false alarm rate.

There are two additional characteristics of the monetary reward condition in this study which should lead to these results being viewed with caution. Since subjects in this condition also received knowledge of results, Grunzke et al. (1974) acknowledged that the effects of their monetary consequences were possibly obscured. In addition, Grunzke et al. did not address the fact that they had made specific monetary consequences contingent upon two of the four possible stimulus-response combinations used in the signal detection payoff matrix: hits and misses. It is possible that, had monetary consequences been contingent upon only one combination, such as hits, the improvements seen in subjects' vigilance may not have been as pronounced.

Levy (1989) also examined the effects of a reward and a penalty contingent upon two stimulus-response combinations on vigilance performance. However, whereas the reward and financial penalty employed by Grunzke et al. (1974) were contingent upon hits and misses, respectively, those introduced by Levy (1989) were contingent upon hits and false alarms. Note that the penalty used by Grunzke et al. can not be considered a form of response cost since it was contingent upon misses which involved no observable behavior on the part of the subjects. Levy hoped to study the effects of rewards and true response costs by making these consequences contingent upon hits and false alarms, both of which require that the subject has made some predetermined observable response.

Levy's (1989) subjects were 38 male children between the ages of seven and eleven who fit the diagnostic criteria for attention deficit disorder (ADD). So that the differential effects of reward and response cost could be determined, subjects were randomly assigned to one of four groups: reward contingent upon hits, response cost
contingent upon false alarms, reward-plus-response cost, and a control group. In the reward condition subjects received one point for each hit. In the response cost group, subjects were initially given 45 points and lost a point for each incorrect response (false alarm). Subjects in all groups received no feedback regarding their performance during the experimental sessions thus eliminating the possible interaction of knowledge of results and monetary rewards present in the Grunzke et al. (1974) study.

The response cost condition was found to be significantly more effective than the control condition in decreasing false alarms. However, this condition was not significantly different from either the reward or reward-plus-response cost condition in increasing the number of hits recorded. Levy (1989) noted that the use of a more powerful reward, money for instance, may have been more effective than a token such as points in increasing subject vigilance performance. In addition, the results of this study may not be applicable to the general population or to specific groups of employees since the subjects were all diagnosed with ADD which may have limited the effectiveness of the contingencies introduced in improving vigilance performance.

The present study is essentially an expansion of those conducted by Levy (1989) and Grunzke et al. (1974). However, several elements have been introduced in an effort to eliminate threats to the internal and external validity of results present in much of the previous signal detection and vigilance literature. The task employed in the present study was based upon interviews with, and observations of, actual security guards who were engaged in performing their assigned duties. This task development procedure was undertaken in an attempt to address the criticisms of authors such as Harris (1969), Mackie (1987), and Weiner (1987) who have stated that vigilance research that makes use of more realistic work tasks may produce results that are more indicative of the behavior of workers for whom vigilance is a required part of their
actual job. Thus, the task used in the present study, although performed in a laboratory setting, is a fairly realistic simulation of one which is performed by security guards while on the job.

Harris (1969), Mackie (1987), and Weiner (1987) have also criticized the relatively high frequencies of signal presentation used in laboratory studies of vigilance and signal detection. In an extensive review of vigilance research, Mackie (1984) found that in 65% of vigilance studies the signal rates varied from 21 to 60 per hour. Few, if any, real-world tasks could approach this signal rate, and, in fact, this rate does not allow enough time (approximately 20 to 30 minutes) for a vigilance decrement to occur for most tasks. Mackie (1984) also expressed concern regarding the duration of the watches or vigils employed in the signal detection and vigilance research. He found that in 72% of the vigilance studies reviewed, the duration of the vigilance task was unrealistically short, lasting 60 minutes or less per session for only one or a very few sessions. Mackie suggested that the most useful method of increasing the relevance of future studies to the real world would be to have subjects perform a vigilance task day after day even if the time spent in each experimental session remained relatively short.

The closest the literature has ever come to using realistic signal frequencies and lengths of vigil was a study conducted by Warrick, Kibler, and Topmiller (1965). In this study, buzzers were placed at secretaries' desks which produced one or two auditory signals a week for six months. This study was also exceptional in that the secretaries were expected to perform all their customary duties during the course of the experiment.

Although the signal presentation rate, or signal density, in the present study was considerably greater than that employed by Warrick et al. (1965), averaging 2.5 signals per hour, the rate is much more realistic than that used in the vast majority of vigilance
and signal detection studies. In addition, the length of vigils and the total duration of the experiment in the present study were much more realistic than has commonly been the case. Subjects in the present study were asked to observe a display for two-hour experimental sessions, four days a week, for an entire academic semester. This work schedule was very similar to that required of many undergraduate students who have part-time employment.

Monetary consequences were used in the present study for several reasons. First, since money is at least partially under the control of management in most organizations, it was in keeping with the desire to increase the applicability of the results to actual work settings to use money as a consequence following vigilance performance. In addition, it has been shown that contingent pay is effective in improving the performance of a wide variety of tasks in both laboratory and applied settings. Finally, the use of monetary consequences is in keeping with Levy's (1989) recommendation that a more powerful consequence be used to illuminate any differential effects of reward versus reward in combination with response cost in improving vigilance.

Whereas the previous components describe attempts to optimize the external validity of the present study, steps were also taken to protect the internal validity of the experiment. In the past, the effects of some reward on vigilance performance have been obscured by the intentional or unintentional presentation of performance feedback during the experimental sessions (see Grunzke et al., 1974, for example). In the present study, all subjects were provided with performance feedback only at the end of every experimental session. Since the introduction of feedback was standardized across all subjects and all experimental sessions, it would be difficult to argue that the
feedback was responsible for any observed differences in vigilance performance across experimental conditions.

In addition, the present study employed a within-subject experimental design, whereas the vast majority of research in this area has used group designs. This design would tend to eliminate the possibility that failures to observe differences in vigilance performance were due to inherent differences between members of different groups rather than an ineffective independent variable.

In summary, the present study was an attempt to empirically validate the assumption that the manipulation of consequences contingent upon the various stimulus-response combinations contained in the signal detection paradigm could be used to improve vigilance performance. In particular, the present study attempted to determine whether a monetary bonus would, when made contingent upon "hits," counteract the decreases in vigilance performance usually attributed to vigilance decrement. Also, the effect of a monetary bonus contingent upon "hits" combined with a financial penalty contingent upon "misses" was examined. Further, it was noted whether the use of these contingencies resulted in an increase in false alarms. This will be an important finding for those organizations for which a false alarm could result in serious negative consequences (imagine a security guard who activates a sprinkler system when no fire is actually present).

Attempts were also made in the present study to use a realistic vigilance task and more realistic signal densities and "employment" conditions whenever possible in contrast to much of the previous vigilance literature. Finally, the present study also investigated the particular performance strategies that were used by subjects in an attempt to assess whether subjects employed different strategies depending upon the presence or absence of the bonus and financial penalty. This component of the present
study may also reveal exactly what kind of responses are being strengthened through the use of contingent pay when no specific attending behavior is required as part of a vigilance task.
CHAPTER II

METHOD

Subjects

The primary researcher received permission to employ human subjects in the completion of this study from the Human Subjects Institutional Review Board (HSIRB) of Western Michigan University. A copy of the HSIRB's approval form is included as Appendix A.

Subjects were recruited from undergraduate introductory psychology classes at a large midwestern university. In each class, the primary researcher read a recruitment script which informed students of the time commitment required and the nature of the experimental task. Students were also told that subjects would be paid for their participation following each experimental session and that subjects completing the study would receive a fifty dollar bonus. The voluntary nature of participation, the right to withdraw at any time, and the measures taken to protect the privacy of subjects were also stressed. Interested students were then asked to write their name and phone numbers on a sheet of paper and were told to expect a telephone call from the primary researcher to schedule a recruitment interview. The recruitment script is presented in its entirety as Appendix B.

During the recruitment interviews, students were shown the experimental room and allowed to practice the experimental task for two minutes. Students were also asked about their class and work schedules to determine if they were available the required eight hours per week of the study. At the end of the interviews, seven
students who indicated that they were still interested in participating and had the necessary time available were selected as subjects. All seven of these subjects also indicated a need for additional income to help with personal and/or educational expenses. These subjects, five females and two males ranging in age from 19 to 21 years old, then read and signed informed consent forms and scheduled their experimental sessions before leaving the interview. A copy of the informed consent form is included as Appendix C.

No special educational or vocational background was required of the subjects, and there was no attempt to recruit a certain ratio of women to men. In addition, no attempt was made to assess the subjects' financial resources or needs prior to the onset of the study except as they reported them as described above. Subjects were selected based on their reports of interest in participating and their availability during the proposed duration of the study. Even so, one subject, after completing four experimental sessions, withdrew from the study citing time conflicts between experimental sessions and academic and social activities. The remaining six subjects, four females and two males, completed the entirety of the study.

**Task Description and Setting**

The task in the present study was designed to simulate a task that a security guard might perform. Many security guards are required to observe a closed circuit television or some similar display to detect the presence of trespassers, security doors left open, illegal activities on company property, and other abnormal conditions. This part of a security guard's job has been mentioned as a classic example of a monitoring task (Mackie, 1987; Weiner, 1987).
In the present study, subjects were isolated in a room approximately 8 feet by 12 feet in size and were asked to continuously monitor a black-and-white television screen displaying a video-taped group discussion. To increase the realistic nature of the simulation and to avoid possible confounds relating to the subjects' interest in the topics being discussed, the tapes were prepared without sound. Thirteen such tapes were available for each experimental session, and the tape viewed during a session was determined through the use of a random numbers table. However, the same video tape was never viewed by the same subject during two consecutive experimental sessions. This restriction was adopted to guard against the subjects recognizing the content of a tape and subsequently remembering when signals were presented on that tape.

The abnormal condition, or signal, employed in this study was an "x", which was superimposed over the contents of each video tape at irregular intervals. This signal would appear for two seconds in one of the four corners of the television screen. This signal duration was chosen because interviewed security guards had indicated that most abnormal conditions for which they were trained to watch lasted no more than two to three seconds. The "x" was 1/2 inch in height, and the order of appearance of the signal was randomized among the four corners of the television screen. From four to six (with an average of five) signals were presented during each 2-hour session, resulting in a per hour average of 2.5 signals. However, the specific times during sessions at which signals appeared were completely randomized across the two hours. A stopwatch was displayed at the bottom of the television screen, and subjects were asked to record the times at which signals appeared. In signal detection vernacular, the writing of the time was considered the observing response in the present study.

Just as in most settings in which security guards work, subjects were told that they could take breaks during experimental sessions to get a drink of water, use the

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telephone or restroom, or to just stretch their legs. There was also a clock/radio present in each experimental room for the subjects' use. To further simulate an actual work setting, subjects were not allowed to bring "nonwork-related" materials, such as homework or magazines, into the experimental rooms, although they were allowed to take in food and beverages. In addition, since performance on the task did not depend upon detecting audible signals, subjects were allowed to listen to cassette tapes played on their own portable tape players if they wished.

Dependent Variables

The primary dependent variable in the present study was the percentage of signals detected, or "hits" made, by individual subjects in each two-hour experimental session. This was determined by comparing the written times at which subjects indicated that signals appeared to a master list consisting of the times at which signals actually appeared on the video tape used in that session. If a time written by the subject matched a time on the master list, an instance of accurate signal detection or a "hit" was said to have occurred. If the master list contained a time which was not indicated by a subject, a "miss" was said to have occurred. Finally, if a time written by the subject was not on the master list for that session, a "false alarm" was noted. The percentage of signals correctly detected (hits) during each session was computed as follows:

\[
\frac{\# \text{Hits}}{\# \text{Hits} + \# \text{Misses}} \times 100
\]

The reliability of this dependent variable was assessed by an independent observer (a graduate student not otherwise involved in the study) who also compared the times written by subjects to the times on the master list. In this way, agreements,
defined as when both the researcher and the independent observer determined that a signal on the video tape had been either "hit" or "missed," were assessed. Disagreements were said to have occurred when a signal was scored differently by the researcher and the independent observer. Percentage agreement was computed as follows:

\[
\text{Percentage Agreement} = \frac{\# \text{Agreements}}{\# \text{Agreements} + \# \text{Disagreements}} \times 100
\]

At the end of each week during the study, the second observer independently scored all data collection forms obtained from subjects that week. In this way, interobserver agreement was assessed for 100% of experimental sessions conducted.

Other measures of subjects' response patterns that were recorded included: (a) the average percent of signals detected by all subjects under each pay condition, (b) the percentage of sessions under each pay condition in which subjects detected all (100%) of the signals presented, (c) the average amount of pay earned by subjects per session during each experimental phase, and (d) the percentage of signals presented first, second, third, fourth, fifth, and sixth which were detected. These measures were alternative ways of analyzing the one type of response required in this experimental task, namely, detecting signals, and as such should not be considered separate dependent variables. Rather, these measures were recorded in an attempt to detect differences in responding across experimental phases that were not apparent through examination of the graphic results relating to the percentage of signals correctly detected. In addition, the number of false alarms, if any, was noted for each experimental session.
A final dependent variable consisted of the results of short questionnaires that were administered to the subjects at the conclusion of each phase of the study. A copy of the questionnaire is included as Appendix D. Through analysis of subjects' responses on the questionnaire, an attempt was made to determine if the subjects developed any identifiable strategies in an effort to increase signal detection during the experimental sessions. Of particular interest was whether differential strategies were developed across the various pay conditions. It was also hoped that these results may lead to conclusions regarding exactly what behaviors, if any, were being strengthened for those subjects having improved performance under contingent pay conditions.

Upon completion of the final experimental phase, subjects not only completed the questionnaire but were asked by the primary researcher to indicate how they had spent their earnings from the study. It was hoped that responses to this query would aid in the detection of differences in motivational levels between subjects.

Independent Variable

The independent variable was the method of compensation. Three pay systems were examined: (A) hourly pay, (B) hourly pay plus a monetary bonus for detecting 100% of the signals in a session, and (C) hourly pay plus the bonus pay in combination with a financial penalty for missed signals. These three pay conditions will be referred to as Pay A, B, and C, respectively, throughout the remainder of this manuscript. The pay systems are described below and summarized in Table 1.

Hourly Pay (Pay A)

Subjects received $8.00 per two-hour session ($4.00 per hour) regardless of the percentage of signals they detected.
Table 1
Potential Earnings Per Two-Hour Experimental Session

<table>
<thead>
<tr>
<th></th>
<th>Pay A</th>
<th>Pay B</th>
<th>Pay C</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% Signal Detection</td>
<td>$8.00</td>
<td>$8.00</td>
<td>$8.00</td>
</tr>
<tr>
<td>Less than 100% Signal</td>
<td>$8.00</td>
<td>$6.00</td>
<td>$4.00</td>
</tr>
<tr>
<td>Detection</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Hourly Pay Plus Bonus Pay for Detecting Signals (Pay B)**

Subjects received $6.00 per session ($3.00 per hour) in guaranteed pay plus a monetary bonus of $2.00 if 100% of the signals were detected. The total amount of money that subjects earned for detecting 100% of the signals under this pay system was $8.00. Note that if a subject detected 100% of the signals in a session he/she received 25% of their total pay for that session in bonus pay. Although there is no precedent in the signal detection or vigilance literature for using this ratio of bonus pay to base pay, ratios as small as 3% have been shown to be effective in improving the performance of other tasks in both laboratory and applied settings (e.g., Frisch & Dickinson, 1990; LaMere et al., 1993).

The rationale for requiring perfect signal detection to earn incentive pay should also be explained. In many actual work tasks, the goal of monitoring is to detect 100% of the abnormal conditions present. Consider the nuclear reactor operator who misses the illumination of even one light indicating a problem exists within the reactor core. The serious nature of the consequences of such a failure are obvious. During the development of the present study, security guards were asked what percentage of abnormal conditions they were allowed to miss before there were serious consequences...
for themselves and/or the organization. Although the guards acknowledged that different abnormal conditions, if gone undetected, carry consequences of varying seriousness, they admitted that even one miss of a serious abnormal condition, such as an open security door or a robbery which occurred in the parking lot, could have very serious consequences for themselves and/or the organization. These consequences include reprimands, suspensions, or even loss of their jobs or, for the organizations, lawsuits and drastically increased insurance premiums. Considering this input, it was decided that perfect detection would be required to earn monetary incentives to simulate the serious consequences related to less-than-perfect performance in actual work settings. The contingencies in effect for Pay C also reflected this concern.

**Hourly Pay Plus Bonus Pay for Detecting Signals in Combination With a Penalty for Missing Signals (Pay C)**

Subjects received $6.00 in base pay and a $2.00 bonus for perfect signal detection as in the previous condition, but, in addition, were financially penalized for missing even one signal. This penalty was included to emphasize even more the serious consequences noted above that may result if an abnormal condition is not detected in an actual work setting. In the current study, $2.00 was deducted from a subject's pay if he/she failed to detect 100% of the signals during a session. Note that the base pay of $6.00 was no longer "guaranteed" under this system. Rather, due to the penalty, subjects earned only $4.00 if they missed even one signal. As in the previously described pay conditions, subjects received $8.00 for detecting all of the signals presented during any one session.
Experimental Design

A within-subject withdrawal design was employed, with the order of exposure to the pay conditions balanced across two groups of subjects. Prior to their initial two-hour experimental sessions, the six subjects were randomly assigned to one of two groups. Subjects in Group 1 (Subjects 1, 3, and 5) were to be exposed to the three pay conditions in an ABCB order as follows: (A) hourly pay, (B) hourly pay plus bonus pay, (C) hourly pay plus bonus pay in combination with a financial penalty for missing signals, (B) hourly pay plus bonus pay. Subjects in Group 2 (Subjects 2, 4, and 6) were to be exposed to the three pay conditions in an ACBC order. The two groups of subjects were exposed to different orders of the pay systems so that possible sequence effects associated with the different pay conditions could be assessed.

Conditions were to be changed when the performance of subjects met two criteria: a minimum number of sessions and a stability criterion. The minimum number of sessions required for each subject to complete an experimental phase was based on the results of a pilot study using the same task. These results showed that subjects' performance stabilized within six to eight sessions, regardless of the pay condition in effect. So, subjects in the present study were required to complete at least six sessions under each pay condition. In addition, performance was deemed to have stabilized when the absolute number of signals detected by a subject differed by no more than one for three consecutive sessions.

Procedure

Researchers were the author and four senior-level undergraduate psychology majors who had expressed interest in gaining research experience. Although each had served as a research assistant in previous studies, all were required to undergo training
relevant to the present study. One of the four conducted sessions during a pilot study in conjunction with the primary researcher. The remaining three researchers attended a one-hour training session during which they were familiarized with the equipment, the experimental task, subject instructions, and data collection procedures. All four were then required to conduct a simulated session with another of the researchers serving as the subject. All researchers delivered accurate instructions, recorded data correctly, and paid their "subjects" the proper amount of money at the end of the simulated sessions. Based on this performance, it was determined that all researchers were prepared to conduct actual experimental sessions. To further ensure consistency of all procedural details, the primary researcher was present for the first two experimental sessions conducted by each researcher.

Researchers explained the pay systems to subjects just prior to the experimental session in which each system was to take effect. Prior to the initial hourly pay session, subjects were told that they would receive eight dollars for their work that day, regardless of their performance. Before the first Pay B session, subjects were informed that they would receive a base pay of six dollars for their work that day, but that they would receive an additional two dollars if they detected all of the "x's." Prior to the initial Pay C session, subjects were told that their base pay was six dollars and that they would receive an additional two dollars for detecting all the signals. However, it was added that two dollars would be subtracted from their base pay if any signals were missed, resulting in subjects earning either four or eight dollars depending on their performance. In addition, prior to each initial Pay B and Pay C session, subjects were asked to complete the questionnaire regarding their performance while working under the previous pay system.
Before the start of all other experimental sessions, subjects were reminded of the pay system in effect for that session and asked if they had any questions regarding their pay. Prior to all experimental sessions, subjects were informed that they would be paid at the end of the two-hour session. A summary of all instructions given to subjects is included as Appendix E.

When each experimental session was completed, a researcher would enter the experimental room, turn off the television, and collect the data sheet containing times at which, according to the subjects, signals had been presented. After calculating the percentage of signals detected in that session, the researcher informed subjects of their performance and paid the subject accordingly. Subjects were asked to sign a receipt form following each session verifying the amount of money received for participating in that session. Just prior to leaving the experimental room, subjects were thanked for their participation and reminded of their next scheduled session.

At the end of each week in which experimental sessions were conducted, an independent observer reviewed all data collection sheets. At this time, the observer calculated interobserver agreement for each experimental session conducted that week as described above.
CHAPTER III

RESULTS

Planned Versus Actual Intervention Phases

Four of the six subjects completed all planned experimental phases. In Table 2, the planned interventions for each subject are contrasted with the interventions as they were actually implemented.

Table 2
Planned and Actual Interventions for Each Subject
(A=Pay A, B=Pay B, C=Pay C)

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Planned Interventions</th>
<th>Actual Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject #1</td>
<td>ABCB</td>
<td>ABCB</td>
</tr>
<tr>
<td>Subject #3</td>
<td>ABCB</td>
<td>A</td>
</tr>
<tr>
<td>Subject #5</td>
<td>ABCB</td>
<td>ABCB</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group 2</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject #2</td>
<td>ACBC</td>
<td>ACBC</td>
</tr>
<tr>
<td>Subject #4</td>
<td>ACBC</td>
<td>ACB</td>
</tr>
<tr>
<td>Subject #6</td>
<td>ACBC</td>
<td>ACBC</td>
</tr>
</tbody>
</table>
As shown in Table 2, two of the three subjects in each group progressed through all four experimental phases as planned. In Group 1, Subject 3 consistently detected a very high percentage of signals during the initial hourly pay condition and, because of this, subsequent phases were not introduced. One subject in Group 2, Subject 4, also performed at very high rates until approximately half way through the study. Therefore, phases were not changed for this subject until much later in the experiment than had been planned. Although this subject did complete three of the four planned experimental phases, and was exposed to all three pay conditions, she was not exposed to the second Pay C phase (the reversal phase).

Interobserver Agreement

Interobserver agreement was calculated for each experimental session that was completed. One hundred percent agreement was found for all sessions.

Signal Detection Results

The percentage of signals detected by subjects during experimental sessions are presented in Figures 2 and 3 for Groups 1 and 2, respectively. Phase means are also provided. Note again that the pay systems were introduced to subjects in Group 1 in the following order: hourly pay (Pay A), hourly pay + bonus (Pay B), hourly pay + bonus - penalty (Pay C), hourly pay + bonus (Pay B). Subjects in Group 2 received hourly pay (Pay A), hourly pay + bonus - penalty (Pay C), hourly pay + bonus (Pay B), and hourly pay + bonus - penalty (Pay C). Table 3 presents the average percentage of signals detected in each phase by each subject.

Several very different patterns of signal detection are evident. Subject 3 exhibited a high level of detection under the hourly pay condition for 42 sessions.
Figure 2. Percentage of Signals Detected by Subjects in Group 1.
Figure 3. Percentage of Signals Detected by Subjects in Group 2.
Table 3
Average Percentage of Signals Detected Across Pay Conditions by All Subjects

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Pay A</th>
<th>Pay B</th>
<th>Pay C</th>
<th>Pay B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject #1</td>
<td>66.4</td>
<td>48.1</td>
<td>47.2</td>
<td>45.8</td>
</tr>
<tr>
<td>Subject #3</td>
<td>87.9</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Subject #5</td>
<td>78.5</td>
<td>88.1</td>
<td>91.6</td>
<td>79.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group 2</th>
<th>Pay A</th>
<th>Pay C</th>
<th>Pay B</th>
<th>Pay C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject #2</td>
<td>69.0</td>
<td>85.0</td>
<td>89.4</td>
<td>89.3</td>
</tr>
<tr>
<td>Subject #4</td>
<td>89.9</td>
<td>94.0</td>
<td>88.3</td>
<td>N/A</td>
</tr>
<tr>
<td>Subject #6</td>
<td>72.9</td>
<td>83.3</td>
<td>44.8</td>
<td>62.0</td>
</tr>
</tbody>
</table>

As explained earlier, due to this high level of responding, the contingent pay systems were not implemented for this subject.

Subject 4 also displayed a high level of detection that began to deteriorate in Session 20. When Pay C was implemented in Session 23, detection returned to high levels. Detection decreased when Pay B was implemented in Session 30 but increased again toward the end of that phase. Thus, Pay C appears to have generated better performance than either Pay A or B, but exposure to Pay C and B was relatively short, and it is not known how the subject's performance would have been affected by longer exposure.

Subject 1's detection was highly variable throughout the study and showed decreasing trends within both the hourly pay condition and the first Pay B condition. Mean performance during the hourly pay condition was 66.4%, and ranged from
45.8% to 48.1% during the three contingent pay conditions. Her performance appeared to decrease progressively across conditions, however, her highly variable performance precludes any definite conclusion about the relative control of the two contingent pay systems.

The responding of Subjects 2 and 5 seemed to be controlled to a greater extent by the various pay systems. These subjects, in general, detected a higher percentage of signals when the contingent pay conditions (Pay B and C) were in effect. However, Subject 2 detected a slightly higher percentage of signals under Pay B, while Subject 5 detected more signals under Pay C.

Subject 6 exhibited quite a different pattern of detection. Performance increased markedly when Pay C was implemented, then decreased to a very low level in the following two sessions. Following 20% detection in Session 10, performance returned to high levels for the remaining sessions in that phase. The sharp increase in Session 11 may have been due to the monetary penalty experienced by the subject in Session 10. When Pay B was instituted, performance dropped dramatically. Then, when Pay C was reintroduced, performance rose again. However, performance levels observed during the second exposure to Pay C were well below those observed during the first exposure to this pay system and, in addition, below those observed during the hourly pay condition.

Subject 6's response pattern across the phases suggests the possible existence of a sequence effect. It may be that the pay systems, in this case Pay C, influenced performance only when the potential pay for detection errors differed significantly from the potential pay in the previous phase. For example, Subject 6 detected 83.3% of the signals when Pay C followed hourly pay (Pay A), but only 62.0% when Pay C followed hourly pay and bonus (Pay B). In the first situation, if the subject had missed
even one signal, she would have earned only four dollars per session, as contrasted with eight dollars during the hourly pay sessions in the previous phase. In the second situation, a missed signal would have resulted in the subject earning four dollars as well, but this followed a phase in which earnings were a minimum of six dollars per session. Thus, when Pay C followed Pay A, the potential difference in earnings per session was four dollars, while this difference was only two dollars when Pay C followed Pay B.

Consistent improvements in performance were observed for Pay C phases only when Pay C (hourly pay plus bonus minus penalty) followed Pay A (hourly pay) for Subjects 2 and 4 as well. For example, Subject 2's performance increased from 69% to 85% detection when Pay C followed Pay A, the largest improvement observed for this subject. Subject 4's performance also improved when Pay C followed Pay A, however Pay C never followed Pay B for this subject so a relative comparison is not possible. As indicated earlier, the switch from Pay A to Pay C resulted in the greatest difference of potential earnings and, thus, this potential pay contrast may account for some of the observed sequence effects, not only for Subject 6, but also for Subjects 2 and 4. Since subjects in Group 1 (Subjects 1, 3, and 5) were not exposed to Pay C following Pay A, it was impossible to carry out a similar analysis for those subjects.

Due to the 100% performance criterion required by the contingent pay systems, an additional analysis of the signal detection patterns by subjects is warranted. To earn incentives (or avoid financial penalty), subjects were required to detect 100% of the signals presented during an experimental session. If subjects missed or believed that they had missed a signal, they either forfeited the bonus or received the penalty. No additional incentive pay was available for detecting additional signals, nor were further penalties available for missing another signal. This characteristic of the contingent pay
systems was designed to promote 100% detection since, as stated earlier, security guards had indicated that missing even one abnormal condition could have serious consequences for them and/or the organization. However, such a contingency may have depressed detection after a signal had been missed.

No direct data were collected regarding whether subjects ceased responding once they suspected that they had missed a signal. However, if this had occurred, it is likely that fewer signals would have been detected after a signal had already been missed. For instance, if a subject detected fewer subsequent signals during sessions in which the first signal had been missed than when the first signal was detected, it is quite possible that the first missed signal adversely affected subsequent detection. Table 4 presents the percentage of signals detected after the first signal of a session was detected and missed. Subject 3 was never exposed to the contingent pay systems and Subject 4 never missed the first signal in any session, and thus the data for these subjects have been omitted from the table.

Table 4

<table>
<thead>
<tr>
<th>Group 1</th>
<th>After 1st Signal Detected</th>
<th>After 1st Signal Missed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject #1</td>
<td>49.1</td>
<td>40.7</td>
</tr>
<tr>
<td>Subject #5</td>
<td>85.6</td>
<td>70.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject #2</td>
</tr>
<tr>
<td>Subject #6</td>
</tr>
</tbody>
</table>
The first signal was missed 13 times by Subject 1, 6 times by Subject 6, and 2 times by Subjects 2 and 5. Signal detection was lower for all subjects after they had missed the first one, considerably so for Subjects 2 and 5. These data, therefore, suggest that the 100% performance contingency may have depressed the detection of signals after the first one had been missed.

Detection patterns were also examined to assess whether the contingent pay systems reduced any existing vigilance decrement. As noted in the introduction (Baddeley, 1969; Colquhoun, 1960; Craig & Colquhoun, 1975; Wilkinson, 1964), signal detection tends to decrease dramatically after 20 to 30 minutes. If a vigilance decrement occurred in the present study, a greater percentage of signals presented relatively early in experimental sessions would have been detected. Further, if the contingent pay mitigated such a decrement, the decreased detection would be less pronounced during Pay B and Pay C conditions than during the hourly pay condition. Table 5 shows the average percentage of signals detected by all subjects according to their order of presentation for each pay phase.

There is no evidence of a notable vigilance decrement during the hourly pay or the contingent pay systems. Thus, it appears as though the task, unlike tasks in previous studies, did not generate decreased detection over time. Failure to find vigilance decrement in the hourly pay condition makes it impossible to assess whether a contingent pay system might ameliorate such a decrement.

The signal detection data were also examined to determine whether contingent pay increased false alarms in comparison to hourly pay. Because false alarms were not consequated but failure to detect signals were, the contingent pay systems may have caused subjects to report signals that, in fact, were not presented. During the hourly pay condition, at least one false alarm occurred in 2.1% (2 of 94) of the sessions. In
contrast, during Pay B and C, false alarms occurred in 15.4% and 21.4% of the sessions, respectively. These data suggest that the contingent pay systems did increase the incidence of false alarms.

Table 5
Percentage of Signals Detected During Each Phase According to Order of Signal Presentation

<table>
<thead>
<tr>
<th>Signal Presentation Order</th>
<th>Pay A</th>
<th>Pay B</th>
<th>Pay C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>86.2</td>
<td>76.9</td>
<td>80.4</td>
</tr>
<tr>
<td>2nd</td>
<td>89.4</td>
<td>71.2</td>
<td>75.0</td>
</tr>
<tr>
<td>3rd</td>
<td>79.8</td>
<td>71.2</td>
<td>73.2</td>
</tr>
<tr>
<td>4th</td>
<td>85.1</td>
<td>63.5</td>
<td>80.4</td>
</tr>
<tr>
<td>5th</td>
<td>81.5</td>
<td>55.6</td>
<td>71.8</td>
</tr>
<tr>
<td>6th</td>
<td>77.1</td>
<td>73.7</td>
<td>78.3</td>
</tr>
</tbody>
</table>

Table 6 presents the average earnings per session for the pay conditions. All subjects earned more money per session during the hourly pay condition due to the fact that they earned $8.00 per session regardless of performance. No discernible relationship emerged between the amount of money earned and performance.

Questionnaire Results

On the questionnaires administered after each experimental phase, all subjects rated the experimental task as not very enjoyable. On a 5-point scale, with 1 being not enjoyable at all and 5 being very enjoyable, the task received an average rating of 2.0 during Pay A and Pay B and an average rating of 2.1 during Pay C. Subject 5 enjoyed
the task least, rating it a 1 following all three pay plans, while Subject 6 enjoyed the task the most as indicated by consistent ratings of 3 following all pay plans.

Table 6

Average Earnings per Session Across Pay Conditions for All Subjects

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Pay A</th>
<th>Pay B</th>
<th>Pay C</th>
<th>Pay B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject #1</td>
<td>$8.00</td>
<td>$6.00</td>
<td>$4.00</td>
<td>$6.00</td>
</tr>
<tr>
<td>Subject #3</td>
<td>$8.00</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Subject #5</td>
<td>$8.00</td>
<td>$7.00</td>
<td>$7.00</td>
<td>$6.86</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group 2</th>
<th>Pay A</th>
<th>Pay C</th>
<th>Pay B</th>
<th>Pay C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject #2</td>
<td>$8.00</td>
<td>$5.50</td>
<td>$7.50</td>
<td>$6.86</td>
</tr>
<tr>
<td>Subject #4</td>
<td>$8.00</td>
<td>$6.86</td>
<td>$7.00</td>
<td>N/A</td>
</tr>
<tr>
<td>Subject #6</td>
<td>$8.00</td>
<td>$6.29</td>
<td>$6.22</td>
<td>$5.33</td>
</tr>
</tbody>
</table>

In response to the second question, all subjects reported on at least one questionnaire that they had missed signals due to being tired, bored, or fatigued. In addition, 5 of 6 subjects reported that there were times during which they were not paying attention to the monitor and this caused misses.

Two subjects, however, were more explicit in their answers to this question. Subject 6 stated that she may have missed signals because of eating, falling asleep, doodling on the data sheet, and attending to the radio rather than the monitor. This subject's performance was, indeed, quite low during several sessions, particularly toward the end of the study. Further, she expressed disappointment when first exposed to the contingent pay system on the grounds that she needed the full $8.00 per
session to help defray the costs of sorority dues and entertainment expenses. Despite this statement, however, the monetary incentives and penalties did not maintain high detection during the study.

In answer to this question after the third phase of the experiment (Pay C), Subject 1 reported to a research assistant that she had been taking prescription cold medicine for "a while." which made her sleepy. This subject also reported that her medication was making her feel "drowsy" on the questionnaire completed after the final phase of the experiment (Pay B).

In their responses to the third questionnaire item, all subjects reported that they tried to do something to avoid fatigue and improve their monitor-watching such as reading the lips of the people who were talking on the video tapes, singing or humming, drinking coffee, adjusting the radio volume, and doodling on the data collection sheets. However, only Subjects 2 and 5 reported that they developed and used a wide variety of strategies to maximize signal detection. These strategies included attempts to memorize the timing of signals, the delays between signals and the location of signals on particular video tapes, drinking coffee prior to the experimental sessions, attending to only the corners of the monitor (where the signals were presented), and attempts to identify subtle changes on the video tape that may have indicated that a signal was forthcoming. Subjects 2 and 5 were the only two subjects who responded consistently to the different pay systems. No subjects reported using different strategies for the three different pay systems.

Due to the individual differences in responding that were observed, experimenters asked subjects an additional question at the end of the study in an attempt to determine whether financial need might have influenced the extent to which the contingent pay systems influenced performance. Financial need varied across the
subjects. Subject 1 expressed the least financial need, stating that her parents paid for her schooling including tuition, room, board, textbooks, and sorority dues, and thus she spent most of the money on leisure activities such as movies and soft drinks. Subjects 3, 4, and 6 indicated that they used their earnings for a variety of purposes including gasoline, school supplies, and food from convenience stores and restaurants. As indicated previously, Subject 6 also stated, when switched from hourly pay to the contingent pay system, that she needed the full $8.00 per session to defray the costs of sorority dues and entertainment expenses. To varying degrees, the money earned in the study was discretionary income for all of the preceding subjects. This was not the case for Subjects 2 and 5, both of whom reported that they were, to a large extent, supporting themselves while in school and, therefore, spent the money on essential items such as groceries, rent and textbooks. Because these two subjects were the only subjects who responded consistently to the different pay systems and reported developing a wide variety of strategies to maximize signal detection, financial need may well have affected their sensitivity to the contingent pay systems.

Finally, approximately midway through the study, Subjects 3 and 4 indicated that they were good friends, and had set up an informal competition concerning who could detect the most signals. These subjects had the highest detection rate throughout the study. In fact, Subject 3 was never exposed to the contingent pay systems due to her high performance during the hourly pay condition. It is likely that the control exerted by the competitive contingencies was so strong that the pay systems were not functional independent variables for these subjects.
CHAPTER IV

DISCUSSION

The present study provided some data, albeit weak, that contingent pay in the form of a monetary bonus or a bonus plus penalty can improve performance on a monitoring task. Across all subjects, in eight of the fourteen contingent pay phases (57.1%), subjects, on the average, detected a greater percentage of signals than when paid hourly. Two subjects, Subjects 2 and 5, detected a greater percentage of signals during every contingent pay phase. However, only negligible performance differences were found between the bonus pay system and the bonus pay plus penalty system. Of the two subjects whose performances were controlled most by the contingent pay systems, one (Subject 2) detected more signals under the bonus pay condition while the other (Subject 5) detected more under the bonus pay plus penalty system. Further, of the eight contingent pay phases in which performance was higher than in the hourly pay phases, five were bonus pay phases (Pay B), and three were bonus pay plus penalty phases (Pay C), which does not provide compelling evidence for the superiority of either.

As indicated earlier, approximately half way through the study, it was discovered that Subjects 3 and 4 were good friends and had initiated a "race" with respect to which could detect the highest percentage of signals. Given their uniquely high and consistent signal detection throughout the study, it is very probable that their performance was affected by this extra-experimental competitive contingency. Several researchers (for example, see Schmitt, 1987, and Porter, Bird, & Wunder, 1991) have examined the effects of competition on task performance and have generally found that
individual performance is enhanced under such conditions. In addition, Schmitt (1987) has shown that competition can result in improved performance even when other variables that typically suppress responding, such as a decrease in pay, occur. In the present study, time and financial constraints precluded the possibility of recruiting and selecting additional subjects. However, in future studies researchers should assess the interpersonal relationships between subjects, and screen subjects on that basis.

The performance of Subject 1 appeared to progressively decrease throughout the study. And, although the performance of Subject 6 did appear to be controlled by the contingent pay systems, that control was not strong. Part of this lack of control may relate to the motivation level of the subjects. Although these two subjects indicated a desire to earn money for discretionary items, their financial need was not as great as the financial need of Subjects 2 and 5, whose responding was sensitive to the pay systems. This observation is consistent with that of Vecchio's (1982) who noted that individual differences regarding motivational variables probably moderated the relationship between contingent compensation and performance in his study as well. In addition, results from Oah (1989) showed that economic need, measured by the amount of monthly expenses a subject has, can influence responding under performance contingent pay. Thus, future researchers should also assess the financial need of potential subjects, selecting those that express the greatest need.

Finally, the response pattern of three subjects, Subjects 2, 4, and 6 suggested a sequence effect related to the potential pay contrast with the immediately preceding pay condition. The greater the potential pay contrast, the higher the performance in the current pay phase. Thus, the effects of the pay systems may have been partially dependent upon the pay systems experienced by subjects in previous experimental phases. Dickinson and Gillette (1993) noted that sequence effects are commonly
observed in within-subject studies of monetary incentives. Further, and more specifically related to the current study, Weinstein (1981) concluded that the use of monetary incentives resulted in greater improvements on reaction-time tasks when contrasted with a system in which subjects earned very little pay than when contrasted with a system in which earnings were comparable to those earned under incentives. Again, future researchers should consider the possible sequence effects due to potential pay contrast when designing their studies.

The existence of sequence effects is important not only for researchers but also for practitioners in organizational settings who are attempting to improve some aspect of performance by introducing individual monetary incentives. Although many authors (e.g., Dierks and McNally, 1987; Grant, 1988; Killeen, 1985) have noted that, to be effective, incentives should be of sufficient magnitude, practitioners should be aware of the possibility that it may not be the absolute value of the incentives that is critical, but the value of the incentives in relation to the previous pay system.

The analyses of the false alarm data and the number of missed signals after the first signal had been missed provide additional support that the contingent pay systems influenced responding. During the contingent pay systems, significantly more false alarms were reported than during the hourly pay conditions. Karp and Layng (1988) noted the possibility that differential consequences for the various types of signal detection responses (hits, misses, false alarms, and correct rejections) would result in different performances. If, as in the present case, bonuses or penalties are provided for hits and misses, but false alarms are not conseuated, individuals may be more likely to report more signals than are actually presented in order to avoid "misses" or, perhaps more accurately, the consequences for misses. The data from the present study, consistent with previous research (for a review see Craig & Colquhoun, 1975),
confirm this analysis (for a rare exception, see Grunzke et al., 1974). Further, Levy (1989), in his study of signal detection with children diagnosed with Attention Deficit Disorder (ADD), found that a response-cost penalty for false alarms did result in their decrease when compared to a nonreward, nonpenalty control condition. Thus, practitioners should determine the organizational consequences for the various types of signal detection responses, and design a contingent reward system that will produce the desired responses. For example, it may be that in some situations false alarms do not have serious consequences for the organization while misses do. A reward system similar to the current one would be appropriate in that situation. However, if false alarms do result in operational dysfunction, they should be directly consequated.

Security guards who were interviewed prior to the conduct of the study indicated that if they missed even one abnormal condition (a signal) it could have serious consequences for the organization. Thus, as indicated earlier, the present contingent pay systems were designed to promote 100% signal detection. Data from the present study suggest, however, that after the first signal in a vigil was missed, with no further consequences for additional misses and hits, signal detection may have deteriorated. Thus, the overall percentage of signals detected may have been higher if an incentive had been paid for each signal detected and/or a penalty provided for each one missed.

The results from the current study, while generally supporting the notion that monetary incentives can improve performance on monitoring tasks, are not as convincing as those from studies that have examined the effects of incentives on other types of tasks. For example, in laboratory studies, Vecchio (1982), Frisch and Dickinson (1990), and Farr (1976) all found that incentives dramatically improved the performance of repetitive production/assembly tasks in comparison to hourly pay. In
applied settings, gains of 200-300% have been reported for the number of items proved per hour by bank proof operators (Dierks & McNally, 1987), 174%-200% for the daily dollar amount billed to customers by machinists (Gaetani et al., 1985), 20% for the number of optical lenses produced by press operators (Bushhouse et al., 1982), and 18%-26% for the number of customers served by waitpersons (George & Hopkins, 1989). Performance of monitoring tasks, which require constant vigil without frequent changes in the environment, thus, may be more difficult to alter with contingent pay. Nonetheless, the signal detection or, possibly more accurately, the observing responses of the two well-motivated subjects were controlled by the presence or absence of the contingent pay conditions in the present study. These data support Holland's (1958) assertion that behaviors that lead to vigilance are affected by alterations of their environmental consequences as are other operant behaviors.

The contingent pay conditions in the current study were less confounded by other simultaneously-occurring interventions than in previous studies, and thus the data more accurately reflect the isolated effects of contingent pay systems. Although Grunzke et al. (1974) reported that subjects who received monetary rewards detected more signals than those receiving only performance feedback, subjects in the incentive condition received partial knowledge of results. This confound led the authors to question whether the incentives, the feedback, or the combination of the feedback and incentives was actually responsible for the improved performance. In the present study, feedback was systematically provided to all subjects after every experimental session in the same manner, thus making it more likely that any observed differences in vigilance performance were due to the differences in the pay systems.

In addition, in the current study, monetary incentives were made contingent upon hits (Pay B) and on a combination of hits and misses (Pay C) in different
experimental phases and their relative effects on hits and misses assessed. Although hits and misses were not differentially affected by the two pay systems, the experimental design permitted that assessment, which was not the case in the most directly related study, the Grunzke et al. study (1974). Although Grunzke et al. consequated both hits and misses, they did not examine how the intervention affected hits and misses independently. Several authors (Karp & Layng, 1988; Mackworth, 1948; Nevin, 1991) have noted that the four possible signal detection responses (hits, misses, false alarms, and correct rejections) may covary together in sometimes unpredictable ways, thus making it important to measure each one.

Levy (1989) also examined the effects of incentives on two stimulus-response combinations, hits and false alarms, and did so in a way that allowed assessment of differential effects on these two stimulus-response combinations. In Levy's study, subjects who received incentives were more vigilant than those who didn't, however, similar to the results from the current study, subjects did not respond differently under different types of performance contingent pay. These results suggest that the specific parameters of a monetary incentive system may not be as important as the fact that at least some pay is contingent upon performance. Researchers who have examined the effects of monetary incentives on the performance of other types of tasks have advanced the same argument (Frisch & Dickinson, 1990; LaMere et al., 1993; Oah & Dickinson, 1992).

Despite the contributions of Levy's (1989) study, it did not escape criticism. Levy himself noted that the use of a special population as subjects (children diagnosed with ADD) severely limited the applicability of his results to actual work settings. In addition, Levy's intervention consisted of a point system, in which earned points were later redeemed for monetary rewards, instead of paying his subjects directly after their
work was completed. This point system differs from compensation systems used in the work place and further limits the applicability of Levy's results.

The current study attempted to avoid these limitations by using a different population of subjects and a pay system that was more similar to those found in the working world. Subjects were college undergraduates who may engage in tasks that require vigilance in their part- or full-time employment while in school or after graduation. In fact, one subject reported that one of his responsibilities at the convenience store where he worked was to monitor closed circuit television screens, screens that displayed corners of the store that were not visible from the employees' work station.

The pay system used in the current study was also more similar to those found in work settings than has commonly been the case in vigilance research. Subjects were paid in cash at the end of each experimental session, so there were no points or tokens which subjects were required to exchange for their pay. This pay system could perhaps be made even more realistic by paying subjects weekly or bi-weekly, possibly by check. However, in the current study, because of the relatively small amounts of money available to pay subjects, it was felt that the immediacy of the pay might serve to compensate for the larger, more delayed pay that workers receive in actual work settings.

Several other attempts were undertaken in the present study to achieve a realistic work simulation. The task itself was based on observations of working security guards, so the display was quite similar to that found in the guards' work stations. Further, the work schedule used in the study required subjects to work for two hours four days per week. This schedule was similar to that required of students who work part-time on campus. In addition, as recommended by Mackie (1984), subjects
attended their "job" for an extended period of time rather than attending just one or a very few sessions. Finally, and perhaps most importantly, the signal rate employed in the current study, which averaged five signals per two-hour session, was more realistic than has been common in vigilance research. Although this rate did not approach that used by Warrick et al. (1965) of one or two every six months, it was much more realistic than that employed in the majority of vigilance studies which Mackie (1984) reported as being between 21 and 60 per hour.

In summary, the data from the current study suggests that performance of monitoring tasks can be influenced by contingent pay systems, and that such performance may be studied under relatively realistic conditions in a laboratory setting. Future research can further clarify the extent to which performance monitoring can be improved through the use of contingent pay by eliminating the potential confounds that existed in the present study, most notably by ensuring that subjects are well-motivated by assessing their financial need and that the interpersonal relations between subjects do not introduce extra-experimental contingencies.
Appendix A

Human Subjects Institutional Review Board Approval
Date: December 9, 1992
To: Gordon Henry
From: M. Michele Burnette, Chair
Re: HSIRB Project Number 92-12-10

This letter will serve as confirmation that your research protocol, “Effects of incentives and response cost on the performance of a simulated monitoring task” has been approved after full review by the HSIRB. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the approval application.

You must seek reapproval for any change in this design. You must also seek reapproval if the project extends beyond the termination date.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: December 9, 1993

xc: Dickinson, PSY
Appendix B

Subject Recruitment Script
My name is Gordon Henry, and I'm a doctoral student in the Psychology Department at Western. I'm inviting you to participate in a study in which you will perform a task like a security guard's. It involves viewing a television monitor and detecting signals which appear on the screen. The purpose of the study is to examine the effects of different pay systems on the performance of this task.

The study will be conducted for approximately thirteen weeks during the Winter semester. Four 2-hour sessions will be conducted each week so your time commitment would be 8 hours per week.

You will be paid for your participation. You'll receive at least $4.00 per session and will have the opportunity to earn $8.00 per session depending upon how you perform the task. You can earn an additional $50.00 bonus for completing the study.

You will be asked to sign an informed consent prior to the beginning of the study. This form will emphasize that any data collected from the study will be used in ways which protect the privacy of the participants such as identifying subjects by number only. It also indicates that your decision to participate or not is strictly voluntary and will not affect your status in any class in any way. Also, you may leave the study at any time prior to its completion with no adverse consequences except losing the completion bonus.

So, if you are interested in participating, please put your name and phone number on the paper being passed around. I will contact you to schedule an interview during which you will learn more about the study and experimental sessions will be scheduled if needed. Thank you.
Appendix C

Informed Consent Form
INFORMED CONSENT

My name is Gordon Henry and I am a doctoral student in the Psychology Department at Western Michigan University. I am conducting a study to examine the effects of different pay systems on the performance of a simulated security guard's task.

If you decide to participate in this study you will be requested to attend four 2-hour experimental sessions each week for a time commitment of eight hours per week. The study will last approximately ten to twelve weeks but I can't tell you exactly how long it will take to complete because it depends upon the data I collect during the study. All experimental sessions will be held in the Performance Management laboratory, Room 272A, Wood Hall, and will be scheduled at your convenience.

You will earn at least $4.00 for each session you attend and may earn up to $8.00 depending upon your performance. If you complete the study, you will receive a bonus of $50.00.

Your participation in this study will not expose you to much risk, although, due to the nature of the task, you may experience some boredom or fatigue. You will be allowed to take breaks to use the restroom or to get a drink as often as you wish, although I ask that you not bring other materials such as homework or magazines to your sessions. There is a clock/radio in the experimental room which you may use.

Your standing in any class or in the university will in no way be affected by your decision to participate or not, your performance in the study, or by your decision to terminate your participation prior to the end of the study. Your participation in this study is completely voluntary and you may withdraw at any time by informing an experimenter in person or by calling the Performance Management laboratory at 387-4439. Please note however that it may not be possible to use the data of subjects who have not completed the study, and that you will forfeit your opportunity to earn the $50.00 bonus.

In order to protect your confidentiality, when the results of this study are presented publicly, your data will be identified only by a number which will be assigned to you. A master list of participant names and corresponding numbers will be kept in a locked file cabinet and will be destroyed after the completion of the study.

If you have any questions regarding this research, please feel free to contact me at 387-4439 or Dr. Alyce Dickinson at 387-4473.

YOUR SIGNATURE BELOW INDICATES THAT YOU UNDERSTAND THE ABOVE INFORMATION AND HAVE DECIDED TO VOLUNTARILY PARTICIPATE.

(Please PRINT your name)

__________________ (Signature) __________ (Date)
Appendix D

Subject Questionnaire
In the space provided, please answer the following questions regarding your performance only during the last pay system in effect.

1. On this scale of 1 to 5, indicate how much you enjoyed the task.

   1 2 3 4 5
   (Didn't enjoy it at all) (Enjoyed it very much)

2. Describe things you were doing during the experimental sessions which may have caused you to miss signals.

3. Describe strategies you used or things you did, if any, in an attempt to detect all the signals.

4. If you would like a copy of the results sent to you, provide your permanent address.
Appendix E

Instructions to Subjects
Instructions given prior to the first session of each experimental phase

Pay A: "You will be paid $8 today regardless of how many signals you detect. You'll receive your pay at the end of the session. Do you have any questions?"

Pay B: "Before you begin today, please take a minute to complete this questionnaire and let us know what you thought of the pay system you've been on."
After questionnaire completed: You will be paid $6 today for your participation. In addition, you may earn an additional $2 by detecting all the signals. You'll receive your pay at the end of the session. Do you have any questions?"

Pay C: "Before you begin today, please take a minute to complete this questionnaire and let us know what you thought of the pay system you've been on."
After questionnaire completed: "Your pay today will start at $6. In addition, you may earn an additional $2 by detecting all the signals. However, $2 will be subtracted from your base pay if you miss any signals at all. Do you have any questions?"

Instructions given prior to all other experimental sessions

Pay A: "Remember, at the end of today's session you'll receive $8. Any questions?"

Pay B: "Remember, at the end of today's session you'll receive either $6 or $8, depending on your performance. Any questions?"

Pay C: "Remember, at the end of today's session you'll receive either $4 or $8, depending on your performance. Any questions?"
BIBLIOGRAPHY


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