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ABSTRACT

The research reported here was initiated and designed to assess the impact of various schedules of incentive delivery (schedules of reinforcement) on performance and attitudes in an Air Force-related setting. Civilian subjects matching the characteristics of Air Force trainees were hired to work for four weeks, one week under each of four schedules of reinforcement: salary, fixed ratio, variable ratio, and variable ratio-variable amount. The results indicated that the salary schedule resulted in the lowest performance and attitudes. Performance was best under the variable ratio-variable amount schedule, while attitudes were best under the fixed ratio schedule. It was concluded that instituting a fixed or variable ratio-variable amount schedule of incentive delivery would be a highly cost-effective procedure in computer managed Air Force training. (A bibliography, examples of task materials, tests, and questionnaires are appended.) (Author)

AFHRL-TR-74-32

AIR FORCE HUMAN RESOURCES LABORATORY

THE EFFECTS OF VARYING SCHEDULES OF INCENTIVE DELIVERY ON TECHNICAL TRAINING

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September 1974

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This technical report has been reviewed and is approved.

MARTY R. ROCKWAY, Technical Director
Technical Training Division

Approved for publication.

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The research reported here was initiated and designed to assess the impact of various schedules of incentive delivery (schedules of reinforcement) on performance and attitudes in an Air Force-related setting. Civilian subjects matching the characteristics of Air Force trainees were hired to work for four weeks, one week under each of four schedules of reinforcement: salary, fixed ratio, variable ratio, and variable ratio-variable amount. The results indicated that the salary schedule resulted in the lowest performance and attitudes. Performance was best under the variable ratio-variable amount schedule, while attitudes were best under the fixed ratio schedule. It was concluded that instituting a fixed or variable ratio-variable amount schedule of incentive delivery would be a highly cost-effective procedure in computer managed Air Force training.

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SUMMARY

Problem

Optimal use of incentive management techniques in training settings requires that attention be paid not only to the value of the incentives but also to the conditions under which they are dispensed. Specifically, questions of timing and contingency in the delivery of incentives must be addressed. At issue are potential differences between fixed and variable schedules. Fixed schedules require a certain period of time to elapse (fixed interval) or a certain number of responses to occur (fixed ratio) before a response is reinforced. Variable schedules introduce some uncertainty into the situation since responses are reinforced at uneven rates. The purpose of this investigation, therefore, was to explore the effect of different schedules of incentive delivery on performance and attitudes in Air Force related technical training.

Approach

Literature was reviewed covering the areas of reinforcement schedules, incentive programs in industry, training, and vigilance behavior in order to derive implications for the conduct of incentive-based Air Force training. The major conclusions were that more sophisticated schedules (i.e., variable schedules) can have positive effects on training performance and that such schedules are completely feasible in computer-managed delivery modes.

For the experimental portion of this study, the basic procedure was to hire subjects for what they felt was a real job of 4-week duration. The job dealt with learning self-paced material on electricity, electronics, and transistors. Incentives were financial in nature. The amount paid was kept constant over the 4-week period, but the way in which the pay was delivered varied as follows. In a repeated measures Latin square design, a group of subjects worked for 4 weeks--one week under each of four schedules: (a) salary, (b) fixed ratio (FR)--every third successfully passed test was rewarded, (c) variable ratio (VR)--<u>on the average</u>, every third passed test was rewarded but reward was random around that average, and (d) variable ratio/variable amount (VR-VA)--in addition to varying the rate, the <u>amount</u> of reward was allowed to vary around an average of $3 per hour.

Measures were made of nine performance variables: number of tests taken, number of tests passed, percent correct on all tests taken, inter-passed test time, inter-test time, total earnings, comprehensive test score, and comprehensive test score weighted to reflect differing amounts of material covered. Attitudinal variables measured consisted of job satisfaction, self ratings of effort, perceived equity of pay, job interest, feelings of control and manipulation. In addition, biographical data were collected. Finally, in exit interviews data concerning schedule preferences and overall reactions to the job were obtained.

Results

Taken as a whole, the data clearly indicate that the various schedules of reinforcement had differential effects on performance. Of the four schedules, the salary schedule resulted in much lower performance than the other three schedules. In fact, the mean performance of the other three schedules was 46% higher than performance under the salary schedule. The FR and VR schedules were approximately equal in their effect upon performance, with the VR-VA schedule producing the highest performance levels. The mean VR-VA performance exceeded the FR and VR levels by approximately 9%. Although this difference was not statistically significant, a reliable difference of this magnitude would certainly be of practical significance in an Air Force training context.

Further, the data on quality of performance show that even though more tests were passed under the FR, VR, and VR-VA schedules, the percentage of correct answers was just as high as in the salary schedule. Moreover, comprehensive test results, when weighted to reflect amount of material covered, showed no differences between schedules.

The attitude data also show some interesting results. There were no overall differences in Total Satisfaction, but satisfaction was never highest under the salary condition and, by the end of the week, satisfaction was lowest under salary. Satisfaction with pay did show significant differences on Monday, with the salary schedule resulting in much lower pay satisfaction than the other schedules. A similar, but non-significant, pattern emerged on Fridays. Also, the salary schedule was lowest in job interestingness, and significantly so by the end of the week.

PREFACE

We wish to thank Major Philip J. DeLeo, Ph.D., and Ronald Burkett, Ph.D., of the Air Force Human Resources Laboratory for their continual help and ideas throughout the conduct of the present research effort. Also, great contributions were made by our own research staff: John Hollenback, Richard Flicker, William Goodwin, Robert Mayo, Fred Hoehler, Sidney Levin, Michael Kriegel, and Janet Glaspie.

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STATEMENT OF THE PROBLEM

The mission of the Technical Training Division of the Air Force Human Resources Laboratory (AFHRL) is to conduct research to improve the effectiveness of Air Force technical training. To this end, they have supported numerous in-house and contract research efforts dealing with various aspects of technical training. One of the research areas is the exploration of various techniques to increase trainee motivation, especially incentive motivation techniques. The research presented here falls into this category. It was initiated with the idea that certain schedules of incentive delivery (schedules of reinforcement) could be especially effective in any incentive motivation program.

Such research is particularly applicable to the Advanced Instructional System (AIS), which is an individualized, multi-media adaptive instructional program currently being developed by AFHRL. Specifically, the AIS calls for the use of incentive motivation in a computer-managed instructional program. Such an instructional system would be ideally suited for providing different schedules of incentive delivery.

Thus, the purpose of the research presented here was to explore the effects of various schedules of incentive delivery on performance and attitudes in Air Force related training.

Overview of the Report

This report will first review the literature on the effects of schedules of reinforcement and discuss the implications of this literature for motivating students in technical training. We shall then discuss the methodology of the study and the results of the data analysis. Finally, the results will be discussed with particular attention to implications for Air Force technical training.

REVIEW OF THE RELEVANT LITERATURE

One of the more notable suggestions of a number of theoretical orientations is that increments in motivation and subsequent desired performance can be obtained when reinforcements are contingent or conditional upon such performance. Similar statements of this general position can be found in Thorndike's (1911) Law of Effect, in Vroom's (1964) Concept of Instrumentality, and most explicitly in

Skinner's (1938, p. 21) Law of Acquisition which is stated as follows: "If the occurrence of an operant is followed by presentation of a reinforcing stimulus, the strength is increased."

In a series of papers beginning in 1930, B. F. Skinner proposed a formulation of behavior which emerged from observations of animal performance in a type of experiment that he invented: the bar-pressing activity of a rat in a specially designed box. The experiments and theories were first brought together in book form in his Behavior of Organisms (1938). It was hoped that in the simple, controlled world of levers and mechanical feeders something quite general would emerge. If one took such an arbitrary behavior as pressing a lever and such an arbitrary organism as the albino rat, and set it to work pressing the lever for food, then by virtue of the very arbitrariness of the environment, one would find features of the rat's behavior general to real-life instrumental learning (Seligman, 1970).

Schedules of Reinforcement

Aside from his basic bar-pressing experiments, Skinner is best known for his investigations of various schedules of reinforcement. Indeed, the studies of schedules of reinforcement by Skinner and his associates have produced such an extensive body of data that a large volume appeared devoted to the results of research on this variable alone (Ferster & Skinner, 1957).

The reinforcement of operant behavior in ordinary life is not regular and uniform. The fisherman does not hook a fish with every cast of the line, and the farmer does not always receive a harvest from his planting, yet they continue to fish and to plant. Hence, the problem of maintaining or strengthening a response through intermittent reinforcement is more than a laboratory curiosity. Skinner has explored extensively two main classes or schedules of intermittent reinforcement, now called interval reinforcement and ratio reinforcement.

A schedule of reinforcement is a more-or-less formal specification of the occurrence of a reinforcer in relation to the behavioral sequence to be conditioned. A continuous reinforcement schedule refers to one in which the reinforcer occurs after every response sequence which has been chosen for conditioning. Performance tends to increase rapidly under this schedule. However, when the reinforcer is withdrawn, performance rapidly diminishes in strength, frequency, or persistence. A continuous schedule is rather interesting in our case because it has almost no real analogue in organizational behavior. A schedule of intermittent reinforcement is actually a way of arranging reinforcement contingencies based on the passage of time, the number of responses, or both. The complexity arises from the varied and intricate ways in which these temporal and numerical contingencies can be combined and interrelated in natural and laboratory environments, and from the extreme sensitivity of the behavior of organisms to such conditions. Furthermore, behavior produced by intermittent reinforcement is far more persistent over time than behavior conditioned by continuous reinforcement schedule.

Fortunately, there exists a large and reliable body of information concerning the performance of animals under various schedules of reinforcement (e.g., Ferster & Skinner, 1957), which should prove advantageous in helping one to choose the schedules most likely to produce results in the human setting. While these schedules and their effects are well known to behavioral scientists, it may be useful to review briefly the contingencies involved in four of the most basic, and the characteristics of performance to be expected under each type. These four basic schedules are designated:

Fixed Interval (FI)
Variable Interval (VI)
Fixed Ratio (FR)
Variable Ratio (VR)

In addition to the above, we propose to examine a fifth type of schedule which we have designated as Variable Ratio-Variable Amount (VR-VA). This last schedule, VR-VA, provides the greatest degree of uncertainty with respect to the reinforcement event, corresponding somewhat to real-life gambling situations.

More complex schedules involving multiple, compound, tandem, or concurrent contingencies were not considered in the present study, although further research on such schedules may be indicated after a thorough analysis of the effects of simple schedules has been completed.

> FI--An interval schedule requires that a certain time period elapse before a response is reinforced. A fixed interval schedule is therefore one in which this time period is fixed, or constant. The time period may be initiated with any event, but typically the end of the last reinforcement is used. In real life, the method of payment by monthly or weekly salary corresponds most closely to FI reinforcement.

Performance under this schedule is characterized by low response rate which increase slightly just prior to reinforcement, resulting in the classical "FI Scallop" as shown in the lower left portion of Figure 1. A number of theoretical explanations of the scalloping effect have been proposed, but researchers generally agree that the effect is based on the fact that inter-response times (IRT's) of long duration have a greater probability of reinforcement.

If incentives (reinforcement) are removed completely, as in extinction, performance deteriorates rapidly, as shown by the leveling off of the cumulative record of Figure 1, taken from Reynolds (1968).

It is somewhat ironic that our national economy is built around the FI schedule, a schedule which supports only low to moderate levels of performance. Still, this, the standard method of incentive distribution, provides a control or base-line by which other schedules may be evaluated.

<u>VI</u>--The variable interval schedule is simply FI with variable time interval between reinforcements. The mean time interval can be equated to FI, and whereas performance under VI is somewhat superior to that under the schedule FI[1], as shown in Figure 1, it ranks below either FR or VR in this respect, and for economy's sake, was not investigated in the present research design.

<u>FR</u>--The fixed ratio schedule delivers reinforcement after a set number of responses have been emitted, and corresponds to the "piecework" or "piece-rate" method of payment in industry. As shown in Figure 1, it produces long bursts of sustained effort, followed by brief rest periods known as the post-reinforcement pause (PRP). This schedule rewards good performance directly and has a number of advantages over the standard FI (salary) type of schedule; its disadvantage is that it may become repetitive with extended use when human subjects are involved.

<u>VR</u>--The variable ratio schedule makes reinforcement available after a variable number of responses have been emitted; the mean number of responses required may be equated to a corresponding FR schedule, so that in the long run either schedule would provide equal total amounts of incentive. However, even with incentive equated, it is clear from Figure 1 that the VR schedule produces the highest level of performance of the four simple schedules examined, and the greatest resistance to extinction.

[1]With the method of response recording illustrated in Figure 1, the cumulative record, the slope of the performance line is the indication of response rate. Better performance is indicated by slopes approaching the vertical whereas a horizontal record (0° slope) represents an absence of responding.

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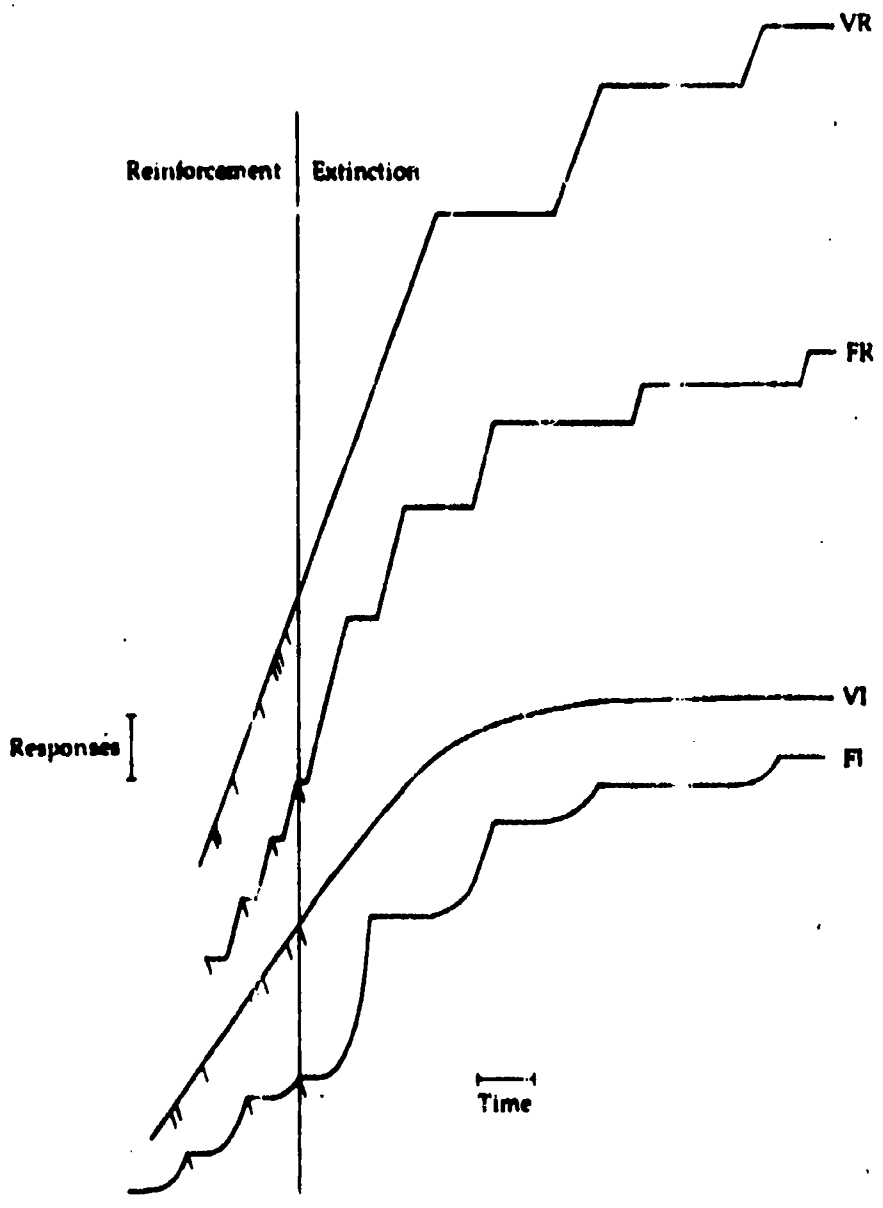
Figure 1



The general course and features of extinction following reinforcement on each of the four simple schedules

VR-VA--Although the VR schedule introduces what is probably a desirable amount of variability and uncertainty into the reinforcement process, variability which should tend to counteract repetitiveness in the programmed instruction task, the amount of reinforcement delivered is always a set, predictable amount. The VR-VA schedule examined does not suffer from this potential defect; reinforcements are delivered after an unpredictable but predetermined mean number of responses, and the amount of reinforcement also varies around a predetermined mean. The real life analogy to the VR-VA schedule is the infamous "one-armed bandit" or slot machine. The motivational force of this type of schedule should be obvious to anyone who contemplates how much he would have to pay someone to spend his working days pulling a lever down. Yet people effectively make payment themselves for this "privilege" (since the expected long-term net-gain is assuredly negative in any casino).

Schedules of Reinforcement Applied to Humans

Most of the research dealing formally with schedules of reinforcement have focused on animal behavior (Ferster and Perrott, 1968; Reese, 1966; Reynolds, 1968; and Skinner, 1969), and the performance effects of the various schedules discussed above are based primarily on this animal research.

There has been extensive research on the effects of increasing contingencies between behavior and reinforcement in humans. However, as we shall see, little careful attempt has been made to formally explore those schedules suggested by the animal literature as being the most powerful.

The few studies that have explored the more complex schedules suggest that humans react to these schedules in a manner similar to animals. For example, Bijou has applied a variety of schedules in the conditioning of preschool children. In one such experiment (Bijou, 1957a) two groups of children were reinforced with trinkets according to a continuous reinforcement (CRF) or VR schedule; the response involved was a simple motor task. Performances were comparable despite less total reinforcement in the VR group, and the VR schedule produced significantly greater resistance to extinction. Further work with FI schedules and a lever pulling response (Bijou, 1957b; Bijou, 1958) were similar to the animal data in most respects, although there were some differences, notably greater variability.

Orlando and Bijou (1960) compared FR and VR schedules in mentally deficient children, ages 9-21. As with rats and pigeons, post-reinforcement pauses (PRP's) were much longer with FR. Other experiments of this type (Fattu, Mach, & Auble, 1955; Long, Hammock, May & Campbell, 1958) have generally found a high degree of consistency between the animal and human data.

A most interesting experiment involving human infants was performed by Brackbill (1958). In the conditioning procedure, sometimes when the infant smiled (response), the experimenter smiled in return, spoke softly, and picked up the infant for approximately 30 seconds (reinforcement). One group was reinforced on a continuous basis, and another on VR-3, which was gradually increased to VR-4 and VR-5. The intermittent schedules were more powerful in maintaining response rate, both during training and extinction.

Verplank (1956) attempted to examine a variety of ratio and interval schedules of reinforcement in normal college students. As with rats, high stable response rates occurred with ratio schedules, and low stable rates occurred with interval schedules. Extinction curves did not differ in any remarkable way from those of infra-human organisms, except that the humans emit statements to the effect that they are losing interest, etc.

Verplank concludes:

> The behavior observed under these schedules corresponds closely with that observed in lower animals. As with lower animals, E will find it impossible to shift directly to a high ratio of reinforcement or to a long fixed interval without extinction. Fixed intervals of 15 seconds and fixed ratios of 6:1 may be established immediately without danger of extinction.

The bulk of literature dealing with schedules and human motivation has dealt with one of the simplest schedules--fixed ratio. Sizeable quantities of literature exist in four major areas: token economies with children and mental patients, industrial rewards, training, and vigilance. The first of these is reviewed in Pritchard, DeLeo, and Von Bergen (1973) and will not be repeated here. The other three will be considered in some detail.

Industrial Settings

Perhaps the most pervasive reinforcer employed across organizations is that of monetary compensation. "Pay is the most important single motivator in our organized society" (Haire, Ghiselli, & Porter, 1963, p. 1). It is surprising, however, that business organizations have done so little research on the effectiveness of pay as an incentive (Porter & Lawler, 1968). In most public and private organizations, the amount of money expended on compensation (e.g., pay and fringe benefits) is the organization's largest single cost (Schuster, Colletti, & Knowles, 1973), yet few organizations have attempted to assess systematically how effectively they are spending this money (Haire, 1956). Dunnette and Bass (1963), in critiquing current personnel management practices, noted that personnel men have relied on faddish and assumptive practices which lack empirical support in administering pay. One reason for such a state of affairs is the limited quality research upon which to base practices. Opsahl and Dunnette (1966, p. 94) observed that "most compensation practices in industry are based on impressionistic evidence characterized by anecdotal accounts and data gathered by means of self-report questionnaires. Studies of the effects of money on behavior need to be conducted in laboratory or in tightly controlled field settings."

As Opsahl and Dunnette (1966) noted, there are various theoretical explanations of money. It would appear that the various learning orientations suggest that money can be best thought of as an object that becomes a secondary reinforcer because of its frequent pairings with a primary reward. A secondary reinforcer has the power to maintain behavior when primary reinforcement no longer occurs. It also may serve as a "reward" for learning acts which are never followed by primary reinforcement. The concept of secondary reinforcement has an important role in the Hullian theory of motivation (Hull, 1943, 1952) and in the theories of Spence (1956) and other stimulus response (S-R) drive theorists.

Skinner has stated that generalized secondary reinforcers can be developed. In contrast to specific secondary reinforcements, generalized ones have been paired with more than one primary reinforcer (Holland & Skinner, 1961; Kelleher & Gollub, 1962; Skinner, 1953a). The argument is that a generalized secondary reinforcer should be extremely effective because some deprivation will usually exist for which the conditioned reinforcer is appropriate. In the case of pay this might mean that deprivation of food, water, or even social relations and esteem could lead to money being a reinforcer if it had been associated with the appropriate primary reinforcers earlier.

In discussing the role of pay in organizations, Lawler (1971) indicated that when pay is contingent on performance, it can motivate performance. Lawler also indicated that satisfaction will be related to performance, and as a result, turnover and absenteeism will be lower among high performers. Further, Lawler notes that tying pay to performance leads to high pay satisfaction and, finally, it can increase the importance of pay.

Additionally, Opsahl and Dunnette (1966) observe that the particular schedule of payment has important potential effects on how the employee responds to any specific amount of money. The best known individual incentive program is that of the piece rate (fixed ratio) in which the salary is contingent upon the number of units produced by the worker. There is considerable evidence that implementation of such plans usually results in greater output per man-hour, lower unit costs, and higher wages in comparison with outcomes associated with straight time payment (fixed interval) systems (e.g., Dale, 1959; Marriott, 1957; Roth, 1960: Viteles, 1953). Such data are analogous to the infra-human data obtained by Ferster and Skinner (1957) employing fixed ratio versus fixed interval schedules of reinforcement.

In the Western Electric studies Roethlisberger and Dickson (1939) report that when workers were placed on a piece rate payment plan, production increased some 12.2 percent. In another investigation, Wyatt (1934) switched employees from a fixed weekly pay system to a competitive bonus system designed to make pay contingent on performance. The effect of the bonus system was a 46 percent production increase. Fifteen weeks later a straight piece rate (fixed ratio) program was instituted which resulted in an additional production increase of 30 percent which remained for the twelve remaining weeks of the investigation. Burnett (1925) hired subjects for eight weeks in which they received an hourly pay (fixed interval) rate. Subjects were then placed on a piece rate based upon their hourly output for the next five weeks. Adoption of the fixed-ratio schedule resulted in an average increase in output of 20.2 percent by the fourth week.

Lawler (1968c), has shown that subjects working on a piece rate system will produce about 20 percent more than subjects working on an hourly basis.

In another study Viteles (1953) cites the Murray Corporation as an example of what can happen when a company switches from a fixed-wage payment system to an individual incentive piece rate situation. Here the change led quickly to average plantwide production gains of 16 percent. Furthermore, accident rates fell, and cooperation with supervision increased.

In a series of behavioristically-oriented experimental studies of monetary incentives, Toppen (1965a; 1965b; 1965c; 1966) found the following relationships between monetary reinforcement, schedule, magnitude of monetary reinforcement, and performance output on a lever-pulling task: (a) larger reward magnitudes and high reinforcement frequencies led to higher output; (b) piece rate (fixed-ratio) payment yielded a higher output than time-rate (fixed interval) payment; (c) decreasing the magnitude of the reward over time resulted in performance decrement; and (d) the above named relationships appeared to hold only in circumstances where the incidence of reinforcement was contingent upon performance. Thus, the investigations by Toppen demonstrate that the principles derived from work with animal subjects on numerous ratios and magnitudes of various types of reinforcement (Jenkins & Stanley, 1950; Lewis, 1960; Pubols, 1960) are applicable to, and consistent with, humans when money is employed as the reinforcement.

An investigation by Yukl, Wexley, and Seymore (1972) examining the effectiveness of pay incentives under variable and continuous reinforcement schedules was conducted under conditions more similar to an organizational environment. In a simulated job situation subjects worked for one hour per day for a period of two weeks. Subjects were paid $1.50 per hour (the standard rate for this type of job) without an incentive for the first week. At the beginning of the second week subjects were randomly assigned to one of three incentive conditions: a 25¢ incentive with a continuous reinforcement schedule (25¢ - CRF), a 25¢ incentive with a 50% variable ratio schedule (25¢ - VRF), and a 50¢ incentive with a 50% variable ratio schedule (50¢ - VRF). It was found that pay incentives were more effective in motivating increased production when employed with a variable ratio schedule than when used with a continuous reinforcement schedule, and that production gains were significantly higher for the group given the larger reinforcement magnitude. The findings are consistent with the operant conditioning literature in demonstrating the effects of size and schedule of reinforcement (Bandura, 1969; Cohen, 1969). Yukl et al., (1972) noted the possibility of employing variable ratio schedules of incentives as a supplement to an organization's present pay program, especially if it is clear to employees that their income will increase. It is doubtful that such schedules would be readily accepted by employees as a substitute for pay currently given on an hourly, salary or piece rate basis.

In summary, it would appear that there is substantial evidence supporting the proposition that tying individual performance to financial rewards under various schedules results in increased motivation, which under most conditions results in increased performance. Even the more conservative investigations suggest that individual incentive plans such as the piece rate eventuate in a 10-20 percent increase in productivity (Lawler, 1971). Similar findings have been noted in several excellent reviews and discussions of various monetary incentive programs, including the piece rate (Marriott, 1957; Lytle, 1942; Balderston, 1930; Dickinson, 1937; Reitinger, 1941).

The effectiveness of incentive plans in general depends upon the employee's knowledge of the relation between performance and earnings (Opsahl & Dunnett, 1966). In Vroom's terminology the valence of effective performance increases as the instrumentality (contingency) of effective performance for the attainment of money increases (Vroom, 1964). Support for such a proposition is extensive (Atkinson, 1958; Atkinson & Reitman, 1956; Kaufman, 1962; Georgopoulos, Mahoney, & Jones, 1957). For example, Georgopoulos et al., (1957) found that workers who perceived higher personal productivity as a means to increased earnings performed more effectively than workers who did not perceive such a relationship. Campbell (1952), working with incentives administered on the basis of the total output of the working group, showed that one of the major reasons for lower productivity in large groups under group incentive plans is that workers often do not perceive the relation between pay and productivity as well as they do in smaller groups. Additionally, Lawler (1964) found that 600 managers perceived their training and experience to be the factors of paramount importance in determining their salary--not their performance on the job. A separate analysis of the most motivated managers, however, confirmed that these managers saw that high pay was contingent on good job performance.

The results of an extensive investigation of managerial personnel conducted by Porter and Lawler (1968) indicate that the more pay is seen to depend on performance factors, the more motivated managers will be to perform their jobs effectively. Porter and Lawler examined attitudes toward pay as they related to the performance of managers in industrial and governmental organizations. They compared the performance of the third of their sample that perceived pay as a probable outcome of performance with the third that saw little relation between performance and pay. Performance (as rated by the subjects and their superiors) was significantly higher for the former group. Galbraith and Cummings (1967) have obtained similar results using production workers from three different companies and Evans (1970), studying worker choices of high and low performance levels, found supporting data. In two very dissimilar types of organizations--a hospital and a public utility--Evans found that if an outcome was highly valued, and if high performance was viewed as eventuating in that outcome, performance tended to be higher. Porter and Lawler (1968, p. 177) add that "... it would seem that organizations should be quite concerned with the psychological impact of the raises they give. Companies that are content to give raises that are not seen as a form of recognition or reward may be missing a potent motivational inducement for better job performance as well as a chance to satisfy some of their manager's more important needs."

Another investigation by Schneider and Olsen (1970) has made comparisons between two (hospital) organizations on the basis of their reward systems. In one hospital reward was contingent upon effort and performance with only minimum annual or biennial increases in salary for tenure. The hypothesis that effort would be greater under a reward system that explicitly rewards effort with valued extrinsic rewards than under a system that does not reward effort with extrinsic rewards was supported. Thus, the differences in actual reward policies between the two organizations resulted in differential effort.

The above studies demonstrate the importance of knowing the relationship between job performance and earnings. The relation between performing certain desired behaviors and attainment of the monetary incentive must be explicitly specified.

One advantage of the operant approach for organizational pay administration procedures is the attention that it focuses on planned and rational administration. Gouldner (1966, p. 397) observed that today much of the behavioral science approach to organizational analysis and methodology is "overpreoccupied with the spontaneous and unplanned responses which organizations made ... and too little concerned with patterns of planned and rational administration." The operant conditioning paradigm may help eliminate the various unsystematic approaches and lead to rational planning in order to control outcomes previously viewed as spontaneous consequences.

Training

Regardless of the level of sophistication and the predictive validity of a selection program, it is almost always necessary to expose the newly-hired employee to some kind of training before he can be maximally effective on his new job. Even if the company is fortunate enough to find employees thoroughly experienced with the machinery or equipment they will be operating, it may still be necessary to inform them of the operating practices and procedures which may be unique to the organization.

Even the most highly experienced worker or manager must learn something of the policies and operating principles of his new employer. However informally such information is presented, it does constitute a kind of training, the purpose of which is to increase the person's productive efficiency.

The training requirements of an employee are greatly complicated when he has had little, if any, actual job experience or is being hired for an entirely different form of work than he has been performing. The selection procedures ideally will ensure that he has sufficient intelligence, aptitude, and attitude to learn the job in question, but once hired it is up to his organization to properly train him in the specific skills required for the job.

Thus, proper training is certainly as important as proper selection in the delicate relationship of placing the right man in the right job. The two activities are complementary in that, as a rule, one cannot succeed fully without the other.

One training technique that appears to be gaining widespread attention is that of programmed instruction. Programmed instruction is a technique of self-instruction. The information to be learned is broken into small, logical steps, progressing from the simple to the complex. Each small step is called a "frame." At each step the learner is tested to ensure that he understands the information: he has to make an active response, like answering a question. He is immediately shown whether or not his answer is correct. He is able to learn quickly or slowly, according to his capabilities. (Christian, 1962b).

Skinner (1958) has been instrumental in the advancement of programmed instruction. For Skinner (1969) teaching and training is the arrangement of contingencies of reinforcement which expedite learning. An individual learns without being taught, but he learns more effectively under favorable conditions. Instructors have always arranged effective contingencies when they have taught successfully, but they are more likely to do so if they understand what they are doing. Skinner (1969) views programmed instruction as a technique taken directly from the operant laboratory designed to maximize the reinforcement associated with successful control of the environment. A program is a set of contingencies which shape topography or response and bring behavior under the control of stimuli in an expeditious manner.

In the late 1950's and early 1960's various research studies on programmed instruction as an industrial training tool were carried out by IBM Corporation, Eastman Kodak Company, General Telephone Company of California, Schering Corporation, DuPont Company, Entelek Corporation, and various U. S. military organizations (Dolmatch, Marting & Finley, 1962; Margulies & Eigen, 1962; Lysaught, 1961; O'Donnell, 1964).

In general, these studies sought to compare the program and lecture methods of instruction in terms of amount of factual information learned (savings in training time), amount retained, and trainee attitude to the new technique. Summarized, the findings indicated that:

A. There was a saving in the time needed to learn information. In terms of time needed to learn subject matter, savings of 25 to 30 percent were reported for the programmed instruction group.

B. There was no significant difference in the retention of factual information. Organizations reported that programmed instruction and lecture groups scored equally well on a test given immediately at the end of the course and again six weeks later.

C. Trainee reaction tended to be favorable. Some trainees, however, disliked the constant page turning and felt that programmed instruction should be interspersed with other training techniques and that discussion periods with an instructor should be provided.

Additionally, Schramm (1964a), having reviewed some 165 papers on programmed learning, was able to summarize some of the generalizations that could be made from the research reports at that time. Schramm noted that of 36 reports comparing programs with conventional classroom instruction (at all levels from primary school to college and adult education), the general summary is that 17 showed superiority for programmed over conventional instruction, 18 showed no significant difference, and 1 showed a final superiority for the conventional classroom method. There is little doubt that programming is an educational method to be taken seriously (Coulson, 1961; Galanter, 1959; Hanson, 1963; Leib, Cusack, Hughes, Pilette, Werther, & Kintz, 1967; Lumsdaine, 1961, 1962, 1964, 1964; Lumsdaine & Glaser, 1960; Smith & Moore, 1962).

A logical extension of programmed instruction is computer-aided instruction with the same step-by-step progressions, branching and immediate feedback of results. Considerable success has been obtained in the development of such programs in subjects ranging from elementary mathematics to Russian. Learning has been found as effective or more so than that obtained from conventional classroom procedures (Suppes & Morningstar, 1969; Cooley & Glaser, 1969). IBM employed computer-assisted instruction to provide course material for such things as a basic introduction to data processing systems. Over a fairly wide range of material, computer-assisted instruction was as effective as programmed instruction and, in several cases, resulted in a savings in training time (Long, O'Neill & Schwartz, 1969).

A related training topic is that of various human relations training programs. Campbell and Dunnette (1968) observed that examination of the research literature leads to the conclusion that while T-Group and other various human relations training seems to produce observable changes in behavior, the utility of these changes for the performance of individuals in their organizational roles remains to be demonstrated and the results are at best equivocal. Fleischman (1967) found that human relations training programs were only effective in producing on-the-job changes if the organizational climate was supportive of the content of the program. More generally, it would appear that industrial behavior is a function of its consequences. Those responses which are rewarded will persist; those responses which are not rewarded or are punished will decrease in frequency. If the organizational environment does not reward responses developed in a training program, the program will be, at best, a total waste of time and money. As Sykes (1962) has shown, at worst, such a program may be highly disruptive.

Another use of behavior contingent rewards in training is the use of incentives to improve trainee performance. For example, Cassileth (1969) used incentives to improve performance typing training in army trainees. In a large scale field experiment Pritchard, De Leo, and VonBergen (1973) used three types of incentive systems to increase performance in Air Force technical training. All three systems were essentially FR schedules, and the results were not overwhelmingly successful. Meaningful performance effects occurred for only one dependent variable (time to criterion) in one course under one type of incentive system.

Vigilance

Current interest in the classical problem of sustained efficiency in monotonous perceptual tasks has centered around situations in which human beings are required to monitor some display in search of critical, but infrequent, signals. Such tasks are numerous and of considerable practical importance for industrial psychology. Increased automation requires human monitoring of equipment which seldom fails. In addition, cases involving assembly-line inspection of products represent another large group of monitoring tasks in which the critical signals may arise relatively infrequently.

Holland (1958) reasoned that success in detecting signals may depend on the emission of responses which will make the detection possible. These could be responses of orienting toward the correct portion of the display and fixating or scanning the display. Such responses can be termed observing responses in that they bring about the observation of signals. Furthermore, Holland noted (1958) these observing responses might follow the same principles as instrumental variables. Holland (1958) hypothesized that the observing responses which make detections possible follow the principles of operant behavior such that the detection itself could exert control over the rate or probability of emission of observing responses in exactly the same manner as food reinforcement controls the rate of operant responses in animals. In investigating this hypothesis Holland had subjects report deflections of a pointer on a dial. The pointer, however, could be seen only when the subject pressed a key which provided a brief flash of light (.07 sec.) that illuminated the dial. If subject wished another look at the dial, the subject had to release and redepress the key. The deflections of the pointer were programmed so as to make possible various schedules of detections (or reinforcements), analogous to the scheduling of more conventional reinforcers, such as food and water, employed in operant conditioning with animals. Employing fixed interval and ratio schedules, variable interval and ratio schedules, and multiple schedules, Holland demonstrated that signal detections can control the rate or probability of emission of observing responses and that this control is of the same nature as that exerted by conventional reinforcers.

Additionally, Nicely and Miller (1957) investigated the effect of unequal spatial distribution of signals on a radar scope. The strobe line rotated at 6-rpm with one quadrant having signals on an average of one every five rotations, while the remaining portions of the display had signals on an average of one every thirty rotations. Nicely and Miller found that the percentage of signals detected increased for the high signal frequency area and declined for the low signal frequency area. After thirty minutes the detection-data curve for the high signal-frequency area had approached a higher asymptote than had that for the low signal-frequency area. The context of the investigation may be viewed as a multiple schedule having a 40-second average variable interval schedule with one stimulus (high frequency area) and a 5-minute average variable interval with another stimulus (low frequency area). Ferster and Skinner (1957) demonstrated that animals on such a multiple schedule show a lower response rate in the presence of the stimulus correlated with the long variable interval than in the presence of the stimulus correlated with the short variable interval.

Additionally, Mackworth (1948) and Adams (1956) have shown that rest periods restore the detection efficiency to nearly what it was at the beginning of the experimental session. Likewise, Ferster and Skinner (1957) have found that response rates on variable interval schedules are increased by interspersing rest periods.

Thus, various investigations have demonstrated that detection of signals can serve as reinforcements for observing responses and, further, that the detection data of vigilance studies reflect the observing response rates generated by the particular schedules employed. Therefore, in a man-machine system, it should be possible for the machine to maintain control over the operator's monitoring behavior by providing a high rate of realistic artificial signals, if need be, on a schedule providing optional observing.

CONCLUSIONS AND IMPLICATIONS OF THE LITERATURE

The mass of literature we have examined indicates that increases in human performance can result if reinforcers are made contingent on that performance. However, the vast majority of this research has dealt with the simplest type of behavior contingent reward system, the FR schedule. This is surprising in that the animal literature suggests that both VR and VR-VA schedules would probably be more powerful.

In the small amount of literature available, the data indicate that humans do respond to schedules such as VR in much the same way animals do. The unmistakable implication is that these more complex schedules, especially VR and VR-VA, should be systematically explored for their effects on human motivation.

The question then becomes whether the implementation of such schedules is feasible for human task performance. It is possible that in some situations they would be difficult to implement. Nurses in mental wards and personnel managers in industry might be hard pressed to use or institute a VR-VA schedule. However, the difficulties should be minimized in a technical training setting such as the Air Force's Advanced Instructional System (AIS). The behaviors to be reinforced are clear, and since reinforcement can be done through the computer, virtually any sort of schedule is simply a matter of writing an appropriate computer program to deliver the reinforcements.

In conclusion, we would argue that more sophisticated schedules of reinforcement can have positive effects on performance, and that such schedules are completely feasible in an AIS computer-managed training setting.

It is with this in mind that the research described here was initiated.

METHOD

Overview

The basic procedure of this study was to hire subjects for what they felt was a real job of four weeks duration. The job dealt with learning self-paced material on electricity, electronics, and transistors. The first group of subjects worked on a straight hourly pay system, and their data were used to refine the task material. The second group of subjects also worked for four weeks--one week under: (a) salary, (b) fixed ratio, (c) variable ratio, and (d) variable ratio-variable amount payment systems. Performance and attitude data were collected throughout the duration of the experiment.

Task

It was felt that the task to be used in the research should be self-paced to simulate the Advanced Instructional System (AIS) and deal with a content area relevant to Air Force technical training. In addition, practical constraints demanded that it should not require a highly-trained instructor, not utilize specialized equipment, and not prerequire specialized knowledge.

A number of possible Air Training Command courses were explored, and the most likely candidate seemed to be the Aircraft Electrical Repairman course. However, after careful analysis, it was decided that the course, taught by ATC, would require too much editing and revising to eliminate the use of specialized electrical equipment.

To avoid this problem, a series of three published programmed texts were selected for the task material. These were Basic Electricity, Basic Electronics, and Basic Transistors (New York Institute of Technology, 1963, 1964, and 1964, respectively.) These books had been developed for technical training and assumed no electrical or electronics knowledge. The three books formed a series, and were geared to a population with at least some high school.

Due to the nature of the design, it was necessary to divide the three volumes of task material into work units. Each work unit was to represent one half hour of work for the average subject. Since the pay of subjects on the three pay schedules other than salary was to be determined by how many work units they completed, these units had to be constructed so that they would take nearly equal time to complete.

The first step in making these divisions was to divide the task material into roughly half-hour units by simple visual inspection. The second step was to actually have a group of subjects go through the task material under conditions similar to those to be used in the actual experiment, and use the data produced by these subjects to obtain final task division.

To this end, eight subjects were hired and worked on the task material for four weeks (five hours per day, five days per week). They worked in the same room and used the same apparatus as did the subjects in the actual experiment. Also, they were of the same ability level as the subjects in the experiment. Data were collected on the time taken to complete each unit of the task. The mean time per unit was calculated, and these data were used to revise the divisions for the actual experiment so that the average subject would complete each task unit in 30 minutes. An example of one unit of task material is presented in Appendix A.

In addition to the actual study material, a short (3 to 8 item) multiple choice test was prepared for each unit. The items for these tests were taken from the published texts and, where needed, additional items were written by graduate students in electrical engineering. An example of a test actually used appears in Appendix B. Thus, a subject studied the given unit of task material and, when finished, took the test associated with that material. Once he passed the test, he would proceed with the next unit of task material.

Subjects

It was deemed very important that subjects be selected who were similar to Air Force technical trainees in terms of age, intelligence, and sex. To this end, a total of 24 male subjects were ultimately hired. They ranged in age between 17 and 19 and their intelligence matched the Air Force population as closely as possible.

The first step in the selection procedure was to place advertisements in the local newspaper and to post flyers in various markets, shopping centers, and around high schools. These ads announced a four-week, part-time summer job which would pay "around $2 per hour, depending on what you do." The ad gave a telephone number to call for more information. Applicants who called were not given detailed information about the job, but they were told it "involved going over reading and study materials and required no special skills." It was felt that actually explaining that the job dealt with electricity and electronics materials might discourage some subjects who felt they had little background for such a job.

Callers who were interested were told to go to the company's office (in downtown Lafayette, Indiana) to complete an application. Candidates were scheduled so that several applied at one time, usually between 2 and 10 participated in each session.

Applicants in these sessions were told that the company did contract work and they now had a contract to evaluate the effectiveness of certain types of programmed instruction. They were told that they would be going through task material in electricity, electronics, and transistors. They were also told that no special background was required to do the job. Finally, they were told that the pay "depended on what they did," but should average $2 per hour. Since some of the applicants would be working entirely under the $2 per hour condition, it was felt that a description of the other payment system should not be made at this time.

After answering any questions, they completed an application blank, the Otis-Lennon Mental Ability Test, Advanced Level Form J (Otis & Lennon, 1967), an arithmetic test, and an electricity-electronics test. The arithmetic test was developed for this project, and consisted of arithmetic operations necessary for completing the task material. It covered such areas as multiplication and division of whole numbers, fractions, and decimals; scientific notation (e.g., 3.12×10^3) and solving simple equations. A copy of this test appears in Appendix C. It was felt that subjects who had no arithmetic ability should be rejected, since they would be unable to get through the task material. In fact only 2 or 3 applicants had to be rejected for this reason.

The electricity-electronics test (Appendix D) was also developed for this research and consisted of items that most people would not know unless they had considerable knowledge of electricity and electronics. Sample items were "Describe Coulomb's law of electric charges;" "Define diode ... transducer ... rectify." It was felt that a clear test of the effects of the schedules on training performance could only be made if all subjects had essentially no knowledge of electricity and electronics. Consequently, only subjects who scored very low on this test were selected.

After completing these instruments, subjects were thanked and told they would be contacted. In all, 57 people completed the application procedures.

After scoring the various tests, the final selection of subjects was made. The characteristics of the 24 subjects who were ultimately selected (8 for the initial four-week pilot and 16 for the actual experiment) are described in Table 1.

Selection of Schedules

The rationale behind the selection of specific schedules to be used in this experiment was based in part on a desire to include as many aspects as possible of the basic schedules: FR, VR, FI, VI, as well as to include schedules which would most closely approximate real-life conditions of Air Force training. The ratio schedules presented few problems. The fixed-ratio (FR) schedule is the direct counterpart of the piece-work schedule frequently encountered in industrial settings. On the basis of the pilot experiment, we were able to divide the task material such that a "response" of passing a single test consumed roughly one-half hour of the subject's time. Since our goal was to equate all conditions at a base pay rate of $2 per hour, providing the subjects worked at a rate equivalent to that in the pilot experiments, each test passed under a ratio schedule would be worth approximately $1. An FR-3 schedule was selected for evaluation in the experiment and subjects, therefore, received a single payment of $3 after passing three tests.

The variable ratio (VR) was selected because it is equivalent to an FR schedule except for one factor: variability is introduced since payment occurs randomly after an average of three tests have been passed. Variability was built into the schedule such that a subject in the VR condition could sometimes receive as many as three consecutive $3 payments ranging to the opposite extreme in which the subject had to pass eight tests before receiving the $3 payment. Thus, subjects on the VR schedule, working at the same rate determined from the pilot experiment, would average $2 per hour but would have no basis at any given point in time on which to predict how many tests would have to be passed to gain the next reinforcement.

The interval schedules presented more of a problem. The fixed-interval schedule (FI) is quite similar to the traditional salary schedule already used by the Air Force, but differs in that the FI schedule requires that at least one response be made (test passed) after the specified time interval has elapsed in order for the subject to receive his reinforcement. This schedule is so close to the hourly pay system used in this study as a control condition that it was not felt worthwhile to include a separate FI schedule. The salary group thus, constituted the basic control group by which performance on the various other schedules was evaluated.

Table 1. Descriptive Statistics on Pilot and Experimental Subjects

Variable	8 Pilot Subjects			16 Experimental Subjects		
	$\bar{X}$	S.D.	Range	$\bar{X}$	S.D.	Range
I. Q.	111.30	11.00	96-128	117.60	13.30	98-146
Age in Months	208.00	8.35	196-225	213.10	9.53	200-236
Years of Education	11.40	0.92	10-13	11.40	0.56	11-13
Arithmetic [a]	7.50	1.85	5-11	4.63	3.31	0-10
Electricity-Electronics [b]	1.00	2.45	0-7	1.25	3.05	0-12

[a] Score is number of errors

[b] Score is number correct

Finally, a second type of variable ratio schedule was employed--one in which the amount of each reinforcement varied around a mean of $3, the same as that used in the VR schedule. These reinforcements, or payments, ranged from as little as $0.50 to a maximum of $10.00. We have called this schedule the variable ratio-variable amount (VRVA), and performance on this schedule can be compared directly to performance on a VR schedule to determine the added effect of variance in amount of reinforcements upon VR performance. It might be noted that this VRVA schedule is a direct equivalent of the type of payment schedule used on slot machines--a slot machine is programmed to pay off at a certain rate, but the gambler never knows precisely which response will receive payment nor what the amount of that payment will be. Thus, these four schedules--salary, FR, VR, and VRVA--were the independent variables in this experiment.

Operation of Schedules

Data input, test scoring, delivery of reinforcement, and data output were all controlled on line by a small computer (Automated Data Systems, Inc.) interfaced to each of eight response-input consoles. An illustration of a sample response console, constructed expressly for this project, is shown in Figure 2. The leftmost pushbutton of this console was black in color and served as an "enter" key. The remaining five pushbuttons were labelled A, B, C, D, and E and were used to input test data from the multiple choice test items. The sloping face of the console contained three different colored lights, with the left (blue) light called the "feedback" light, the center (white) light called the "ready" light, and the rightmost (yellow) light called the "answer" light. A small three-digit counter was also mounted centrally on the console.

A description of the sequence of programming operations is facilitated by referring to the flow chart presented in Figure 3. A precision internal clock within the computer ran 24 hours a day and initiated the first shift at precisely 7:30 a.m. each morning. At the beginning of the day all response consoles were activated and so indicated by lighting the ready light on each console. After a subject had decided on the answer to all the test items and was ready to input his answers, he began by pressing the left "enter" button, which immediately shut off the ready light on the other seven consoles and essentially locked them out from the information flow into the computer. Entering a test consumed approximately 30 seconds; and since a subject who had just entered a set of test data was locked out from the system for 5 minutes, it was not possible for one person to monopolize the computer, and people seldom had to wait to go "on line." Since only one response console was permitted control of the computer at a time, difficult and potentially unreliable time-share programming was not required.

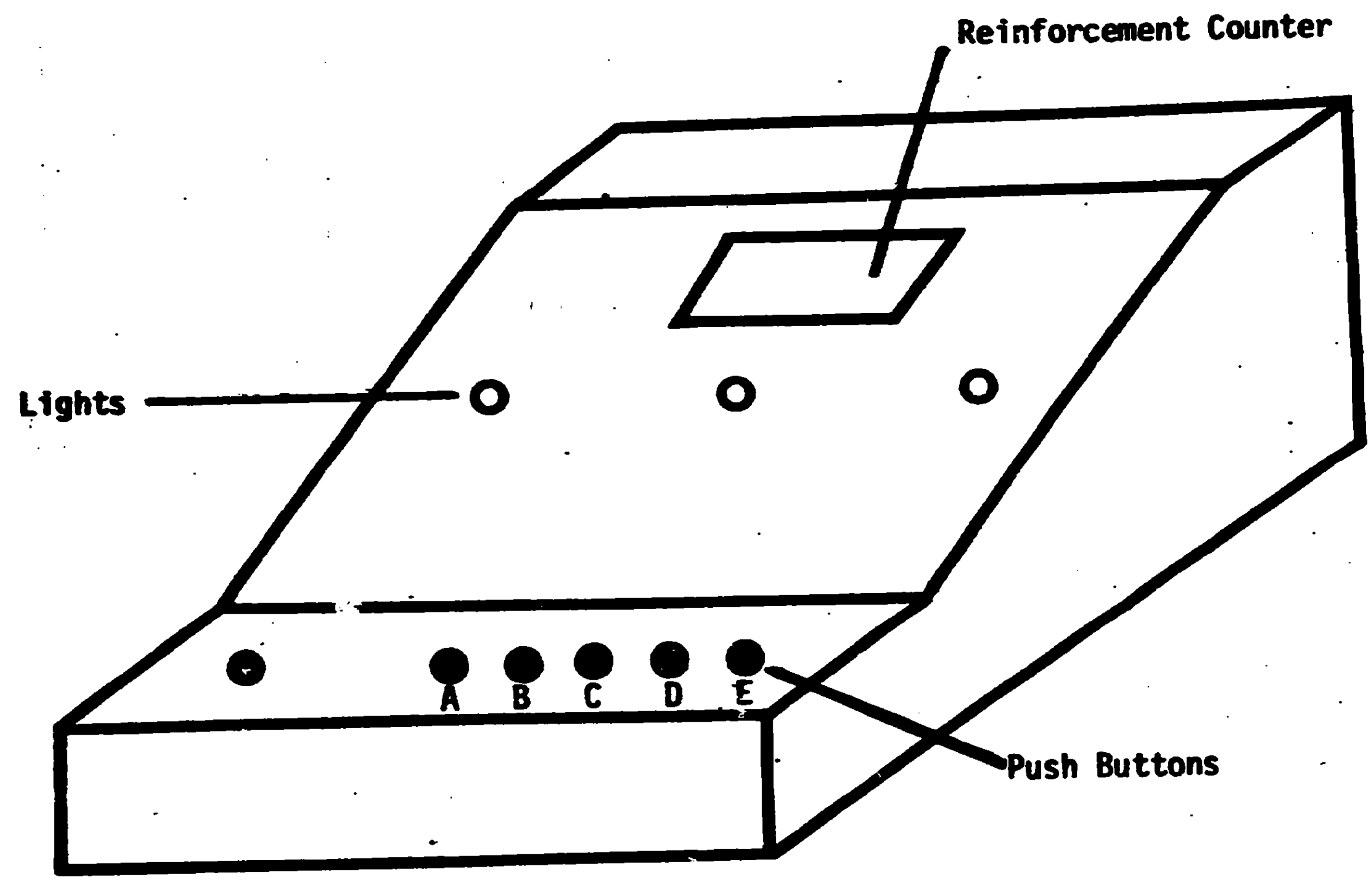


Figure 2. Illustration of Response Console

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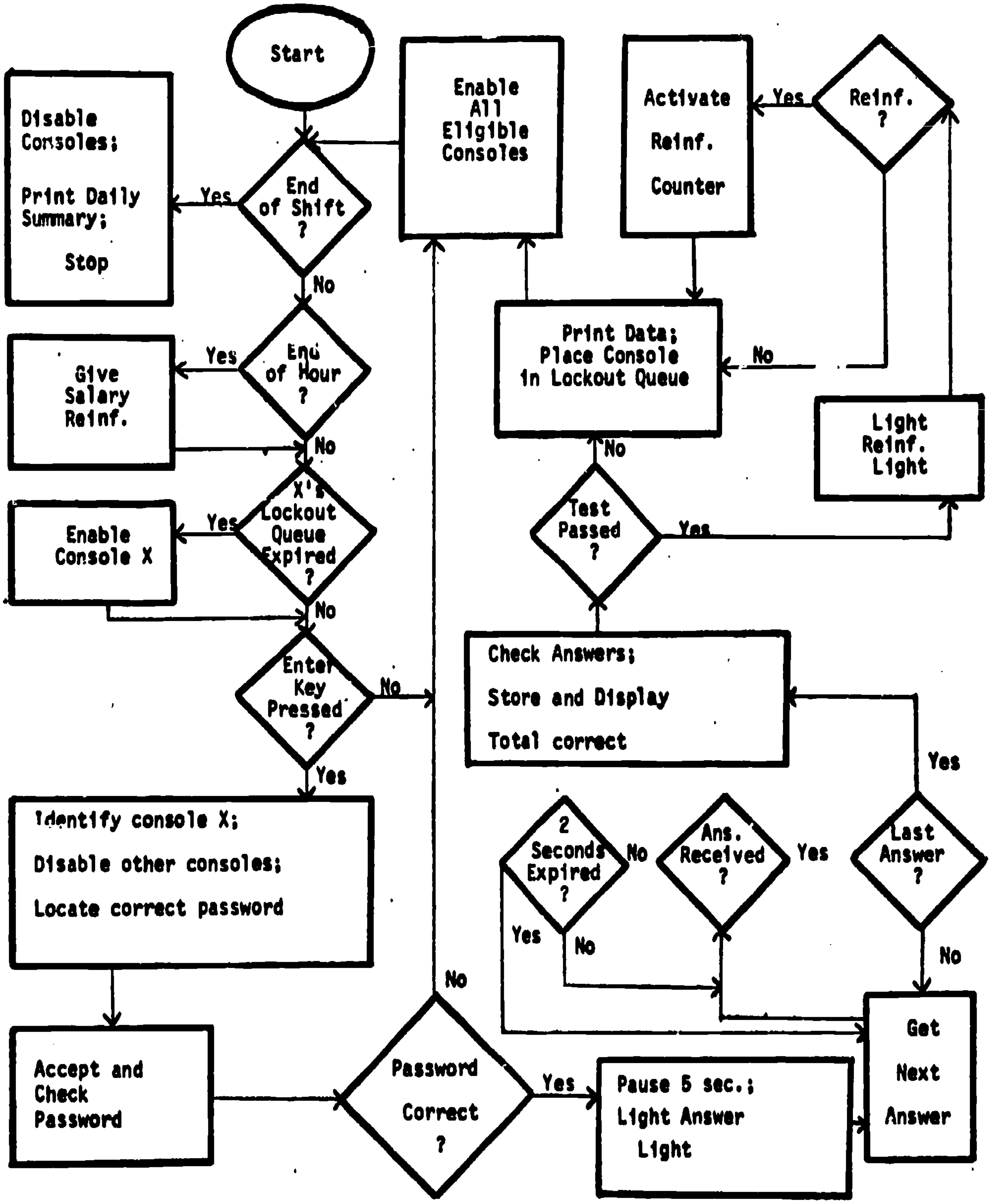
Figure 3. Program Flow Chart for Reinforcement Schedules



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To prevent other persons from entering incorrect data on an unattended response console, each console was assigned a pass-word code, which consisted of a three-letter word known only to the subject who operated a particular console. After a subject has pressed in the "enter" button, the answer light was used to time the entry of information, with a maximum of two seconds allowed for all inputs, including the pass-word and the test answers. If the pass-word was incorrect, the computer immediately enabled all eligible consoles; that is, consoles which had not already been placed in the five-minute lock-out phase. If the entered pass-word was correct, a five-second pause was initiated after which the answer light came on to signal that the computer was ready for the first test answer to be inputed.

The computer accepted only the required number of answers, with the subject having two seconds to press the response button corresponding to the correct answer. If a button was not pressed within the time limit, the answer was scored as incorrect and the computer moved on to accept the next answer. After the last answer had been received, the answer light went off and the computer began to flash the feedback light several times, corresponding to the total number of correct answers inputed. If the number of correct answers failed to meet the criterion score stored in the computer memory, all lights on the box were extinguished and the five-minute lock-out period was initiated. The computer then printed the relevant data on a teletype, including the time the subject had logged on, the subject's number, the test number, the number of correct answers, the fact that the subject had failed to meet criterion on the test, and the amount of reinforcement, which in this case would be zero. The computer then enabled all other eligible consoles, including those whose five-minute lock-out period had elapsed as the current subject was entering data.

If the subject passed the pre-established criterion, the reinforcement light, after flashing the number of correct answers, came on and remained lit throughout the period that reinforcement was being presented. Stored in computer memory was a table of the reinforcement conditions to be applied to each response console; and since the particular enable key identified the response console, the computer searched out the appropriate amount of reinforcement and activated the reinforcement counter the appropriate number of times. Each count on the reinforcement counter was equivalent to one dime (10¢) of reinforcement. After reinforcement had been presented, the computer printed out the relevant data and again enabled all eligible consoles after putting the appropriate console into the five-minute lock-out phase. Thus, a complete record was kept of every time the subject had attempted to enter test data into the computer and the consequences of that action. Each hour on the hour, all boxes except the salary consoles were disenabled briefly and the $2 salary reinforcement was inputed into the reinforcement counters on those two consoles. At the end of a daily five-hour shift, the computer disabled all boxes and printed a daily summary of the data.

The actual reinforcement for each schedule was predetermined in the computer program. For the salary schedule, the internal clock of the computer merely kept track as to whether or not an hour had elapsed and then disabled all response consoles except the two salary consoles and delivered a sequence of 20 pulses, corresponding to the 20 dimes needed for a $2 per hour pay rate. In the Fixed Ratio schedule the computer simply kept track and reinforced each third set of test data which met the pass-fail criterion. The computer then pulsed the reinforcement counter of that particular response console 30 times corresponding to a $3 reinforcement. Programming of the Variable Ratio schedule was somewhat similar to the FR schedule except that the $3 payment was made after a variable number of passed tests, averaging three in number. Whenever a test which passed criterion was inputed on one of the VR boxes, the computer referred to an internal memory table, 99 locations in length. Thirty-three of these locations had been selected randomly to contain a reinforcement code. The computer merely stepped along this table once per each passed test and delivered the $3 reinforcement whenever one of the 33 pay locations was encountered. Table 2 describes the frequency distribution of reinforced tests. With the schedule employed, as indicated in the table, the longest series of non-reinforcements encountered by a given subject was seven in length, with occasional reinforcements occurring consecutively. When the computer reached the end of the 99 location table, it recycled again to the first table entry and cycled through the table again. With a total of 99 locations and no marker to identify the beginning of the series, it was virtually impossible for any subject to anticipate the number of correct responses required for a reinforcement. A second randomly generated table, similar to that used for the VR schedule, was employed for the Variable Ratio-Variable Amount schedule. Again, the reinforcement locations were randomly selected, with each location containing the amount of reinforcement to be delivered, if any. The computer stepped along a 99 location table and delivered reinforcement if it encountered a non-zero amount in a particular location following a passed test. Table 2 also presents the reinforcement sequences used for this table. The amounts of reinforcement ranged from $.50 to $10.00 with an average of $3.00. There were 4 reinforcements of $.50, 4 of $1.00, 4 of $1.50, 4 of $2.00, 4 of $2.50, 4 of $3.00, 4 of $3.50, 2 of $5.00, 2 of $7.00, and 2 of $10.00, for a total of $100.00 delivered per 100 tests passed.

Thus, although the schedules varied considerably, if the performance of all subjects was equal to the performance in the pilot, all subjects would earn $2.00 per hour. As performance increased in the FR, VR and VR-VA schedules, pay would correspondingly increase.

Procedures and Experimental Design

As described previously, two experimental sessions were run--the first to refine the task materials, and the second to actually conduct the experiment. The orientation for the subjects in the pilot session

Table 2. Reinforcement Sequences Employed in the VR and VRVA Schedules

Sequence	#	Frequency VR	Frequency VRVA
Intervening Non-Reinforcements	0*	6	8
	1	10	9
	2	7	4
	3	4	5
	4	1	3
	5	3	3
	6	1	1
	7	1	0

*Zero intervening non-reinforcements indicates that two reinforcements occurred in succession. These include one instance in each schedule in which a sequence of three consecutive reinforcements occurred.

was identical to that for the actual experiment described below, except that they were told that the pay would be $2.00 per hour for the entire time they would work.

The sixteen individuals selected for the actual experiment reported for an orientation the Saturday before their first work week. Eight subjects reported for the morning shift and eight for the afternoon shift. In these orientation sessions the apparatus was explained and the test-taking procedures were demonstrated and clarified. To familiarize subjects with the apparatus a number of reading comprehension tests were used. These tests, similar in many respects to the actual tests subjects would later take, required the subjects to read a relatively small amount of material and then answer several questions over the material.

The experimental room contained four large (3 x 8 foot) tables with two consoles on each table and a chair in front of each console. It was explained that the consoles were the mechanism by which they took tests, found out how well they did on the tests, and which determined their pay. These consoles were hooked up to a computer in another room and the wires and actual computer were shown to all the subjects. This "computer room" also included a teletype, numerous rolls of paper tape, tools, and miscellaneous gear that added realism to the setting. In fact, all the equipment was indeed being used, none of it was "planted."

The testing procedure required each subject to read and study a specified segment of task material which, based on the pilot data, should take, on the average, one half hour to complete. When the subject felt he knew the material, he took his copy of the task material to the supervisor who was seated in another room. The supervisor would then take his task material and give him a copy of the test appropriate for the material. The subject would then return to his console and answer the test by hand. After he had answered it, he would use his console to input his answers into the computer. The test would be scored, and the subject would be informed, through his console, of the number of items correct, whether he passed the test, and how much reinforcement (pay) he was to receive, if any.

The entire procedure of entering the answers and receiving feedback on the test took less than 30 seconds. If no reinforcement was given, the test taking procedure ended. If reinforcement was to be given, the counter immediately started to click, accumulating to the actual amount earned.

It was pointed out to the subjects that each of the four tables (with two consoles on each) worked on a different payoff system. They were told that the first table (salary) paid a straight $2.00 per hour. The second table (FR) paid off $3.00 for every three tests passed. The third table (VR) also paid $3.00 when it did pay off, but the computer determined when it actually did pay off; and it could vary from paying off three times in a row ($9.00 for three tests) or it might go 6 or 7 tests without paying off. The fourth table (VR-VA) also paid off intermittently, but that amount of payoff could vary from $.50 to $10.00. It was explained that if they worked at an "average pace," all the schedules would result in earnings of about $2.00 per hour.

It was stressed that they would work the first week on one of the tables (under one of the schedules) but that they would shift to a new table on the Monday of each week. Thus, each person knew from the start that he would work for one week on each schedule.

The subjects were told that the researchers were also interested in the reactions of the employees during the four weeks. To this end subjects were told that they would be given a short questionnaire on Monday and Friday of each week.

Before leaving the Saturday orientation, subjects were administered a short battery of personality measures. Lastly, subjects were given a brief review of several mathematical computations that had been incorrectly answered by many of the subjects on the arithmetic test given them at their interview sessions. An explanation of division by fractions, raising a number to a negative power, and solving simple equations was presented. The subjects worked through several examples and any problem areas were identified and corrected. Subjects were asked to report for work on Monday for their respective shifts (morning or afternoon) and then released.

On the following Monday subjects reported for their respective shifts (7:30 a.m. to 12:30 p.m. or 1:30 p.m. to 6:30 p.m.) and the apparatus, pay system, and procedures were briefly reviewed. They were given the first unit of task material and started working. When finished with this first set of material, they took their first test.

Test length varied from 3 to 8 items and in order to pass the test the subject had to reach a criterion of 75% correct. Once a test was taken, subjects were required to return to the supervisor and obtain the task material appropriate to the next test. In the event of test failure, the subject was given the same task material and was required to restudy the material to better prepare himself for the test; if the test was passed, the subject was given new task material.

The behavior of the supervisor encompassed two major activities: distribution of the test and task material and maintenance of order. Thus, rather than performing instructional activities the supervisor's behavior could more appropriately be characterized as that of a monitor or proctor. The supervisor advised the subjects that there were no scheduled breaks but that breaks were self-determined and could be taken by simply leaving the office so as not to disturb their fellow employees who were still taking tests. An unlimited supply of coffee and soft drinks were provided for the subjects on a self-service basis.

Each Friday subjects were administered a comprehensive test over the material studied during that week. Because different subjects progressed at different rates, the length of the comprehensive test varied from subject to subject. Typically, the comprehensive test asked two to four questions over each chapter the subject had completed that week with no questions asked on those chapters partially completed.

The experimental design was essentially a Latin Square repeated measures with four treatments. The four treatments were the four schedules: salary, FR, VR, and VR-VA. Each subject worked one week under each pay schedule, and the order was determined by a randomly selected balanced Latin Square.

Dependent Variables

Performance dependent variables were those related to test-taking behavior. They included number of tests taken, number of tests passed, percent correct on all tests taken, percent correct on tests passed, time between each test taken, time between each passed test, and earnings. Scores on the comprehensive tests taken at the end of each week comprised the final performance dependent variable.

In addition to those performance-related dependent variables, attitude and personality data were also collected. One group of measures was given at the orientation, the same day that the subjects learned to use the apparatus. The measures were included in a single questionnaire termed the Personal Reactions Questionnaire (Appendix E).

The first section of this instrument consisted of eight items from the Internal-External Locus of Control Scale (Rotter, 1966). It is a measure of the degree to which a person feels that his rewards are controlled by his own efforts as opposed to being controlled by luck or chance. The second scale (Items 1 and 2, Part II) measured need for money. The third measure (Item 3, Part II) dealt with perceptions of the amount of effort a person feels he should expend on the job. The last scale (Part III) was derived from the Protestant Ethic Scale (Mirels & Garrett, 1971), which measures the degree to which a person feels that hard work is worthwhile.

The second group of measures was given at the end of the work day on Monday and Friday of each of the four weeks. These measures were included in one questionnaire termed the Bi-Weekly Reactions Questionnaire (Appendix F). The measures and their location on the instrument are described below:

Measure	Location
Job Satisfaction*	Part I
Degree to which pay method makes job interesting	Part II; item 1
Effect of pay on effort	Part II; item 2
Self-Ratings of effort	Part II; items 3, 4
Equity	Part II; items 5, 6
Perceived Control	Part II; items 7, 8
Job interestingness	Part II; item 9
Expected and actual earnings	Part II; items 10, 11
Attractiveness of expected and actual earnings	Part II; items 10a, 11a
Perceptions of manipulation	Part II, item 12
Effort-performance expectancy	Part III; items 1, 5
Performance-reward expectancy	Part III; items 2, 6
Effort-reward expectancies	Part IV; items 3, 4

*Adapted from Minnesota Satisfaction Questionnaire (Weiss, Dawis, England, & Lofquist, 1967)

In addition to these questionnaires, subjects were asked to sign up for a half hour time period on the Saturday after the last working day. They were to be paid for this time and it was explained that they would get their last paycheck and go through an exit interview at this time. Subjects appeared in groups of two and were given a semi-structured interview dealing with various aspects of the job.

Relevance to the Air Force

Throughout the design and implementation of the research a consistent attempt was made to simulate the Air Force situation as closely as possible. This was done most carefully in three distinct aspects of the project: the subjects, the task, and the procedures. The subjects were male, of the same age range as resident technical training students, and their ability was as close as possible to Air Force trainees. Our best estimate of actual Air Force trainee I. Q. is based on a small sample (N=200) provided by J. R. Burkett of AFHRL. These data indicate that the mean I. Q. of Air Force students is approximately 106, with a standard deviation of 10. Our experimental subjects showed a mean of 117.6 with a standard deviation of 13.3. Thus, our subjects were approximately one standard deviation from actual Air Force students and had comparable variability. Unfortunately, a lower ability sample was not available.

The task was similar to that used in many aspects of technical training. Many Air Training Command courses deal parially or completely with electricity and electronics. Furthermore, the actual topics covered in our task material are very similar to those covered in Air Force training. For example, the majority of the electricity topics covered in the electrical material used for this research are covered in the Aircraft Electrical Repairman course at Chanute Air Force Base, Illinois.

The procedures used in this research are also analogous to those planned for the Advanced Instructional System. Students reviewed small segments of material, took frequent tests, used the computer to take tests, tests were computer scored, and feedback was given mechanically. In addition, the material was programmed, self-paced, and subjects spent approximately the same amount of time on the task each day and each week as in actual resident training.

RESULTS

The data analyses to be presented fall into four major categories: checks on the manipulations, performance results, attitude-personality results, and a description of the results of the exit interviews.

Checks on the Manipulations

Since the purpose of the various schedules of reinforcement was to make pay more or less contingent upon performance, it is important to ascertain whether the subjects actually perceived that the various schedules did indeed result in differential behavior-reward contingencies. In line with classical expectancy-valence models of motivation (e.g., Porter and Lawler, 1968; Campbell and Pritchard, 1974) three sets of perceptions were measured. Specifically, measures were made of perceptions of effort-performance expectancy [e.g., "On this job the more effort I put in (the harder I work) the more material I can get thru in a day"], performance-reward instrumentality (e.g., "The more material I can get thru in a day the more money I make), and effort-reward expectancy [e.g., "The more effort I put in (the harder I work) the more money I make"]. These were taken on Monday and Friday of each week. No differences were predicted for effort-performance expectancy since the degree of relationship between effort and performance should not be effected by the actual reward system. However, performance-reward instrumentalities and effort-reward expectancies should be highest for the FR, VR, and VR-VA schedules since the greater the effort and/or performance, the greater the reward. The salary schedule should be lowest since effort and/or performance was not related to pay. Within the FR, VR, and VR-VA schedules, FR should show the highest instrumentality and expectancy since pay was clearly and consistently tied to behavior. The VR schedule should be lower since frequency of pay did not directly follow from performance, and VR-VA should be the lowest of the three since both amount and frequency of pay did not directly follow from performance.

Data from the three sets of perceptions are presented in Table 3. This table presents means, p-values, and the error term (MS error) of

Table 3. Expectancies and Instrumentalities by Schedule and Time

Item No.	Content	Day	Sal	FR	VR	VR-VA	p	MS error
			Schedule					
1 & 5	Effort-Performance	M	14.2	13.8	13.3	13.6	.31	1.69
		F	14.0	13.9	12.9	12.6	.02	2.26
		F-M	-.19	.13	-.44	-1.06	.59	4.14
2 & 6	Performance-Reward	M	7.1	15.1	12.8	12.9	.0000	6.80
		F	6.4	14.6	12.7	11.3	.0000	7.34
		F-M	-.69	-.50	-.13	-1.56	.54	6.80
3 & 4	Effort-Reward	M	7.3	14.2	12.8	12.5	.0000	6.02
		F	6.8	13.6	12.3	11.2	.0000	7.29
		F-M	-.50	-.56	-.56	-1.31	.76	6.01

the analysis of variance for the data collected on Mondays and Fridays, and the change score (Friday-Monday).

The table indicates that the effort-performance expectancies, as expected, were not different from schedule to schedule on Mondays. However, by Frid , expectancies for VR and VR-VA were lower. The performance-rewa . instrumentalities and effort-reward expectancies show exactly the pattern anticipated. Figures 4 and 5 present these means graphically. In each case the salary schedule shows a much lower mean than the three other schedules. Within the FR, VR, and VR-VA schedules, FR is highest, VR next, and VR-VA lowest.

These data clearly indicate that subjects did perceive that pay was contingent upon performance in the FR, VR, and VR-VA schedules, and that these contingencies were highest for FR, followed by VR, followed by VR-VA.

Performance Results

From the performance data collected, seven dependent variables were calculated. The seven performance-dependent variables were: (1) the total number of tests passed on each schedule, (2) the total number of tests taken on each schedule, (3) the mean percent correct on passed tests, (4) the mean percent correct on all tests taken (whether passed or failed) on each schedule, (5) the mean inter-passed test time (IPTT), i.e., the mean time between passing two successive tests, (6) the mean time between taking two tests regardless of whether the subject passed the tests or not, and (7) the total earnings on each reinforcement schedule.

In addition to the seven performance variables above, two scores on the weekly criterion tests were analyzed. The two scores were the percent correct and the percent correct multiplied by the number of task units covered by the criterion test. Since the amount of material covered on a criterion test varied considerably, the latter adjusted test score was used to weight the criterion test performance by the amount of material covered by the test.

In one case, missing data was present and performance data values were estimated. This situation arose when one subject quit after the first week since he was unable to do the task. On the last four days of that first week, he was able to pass only about 6 tests as compared to the average of well over 40 tests for the same time period. He apparently was unable to grasp the material and was earning almost no money. He was replaced for the second week, and this replacement subject worked for the remainder of the experiment.

This caused the problem of no data being available for this replacement subject for the first week. Consequently, his performance data were estimated, and these missing data estimates were used in

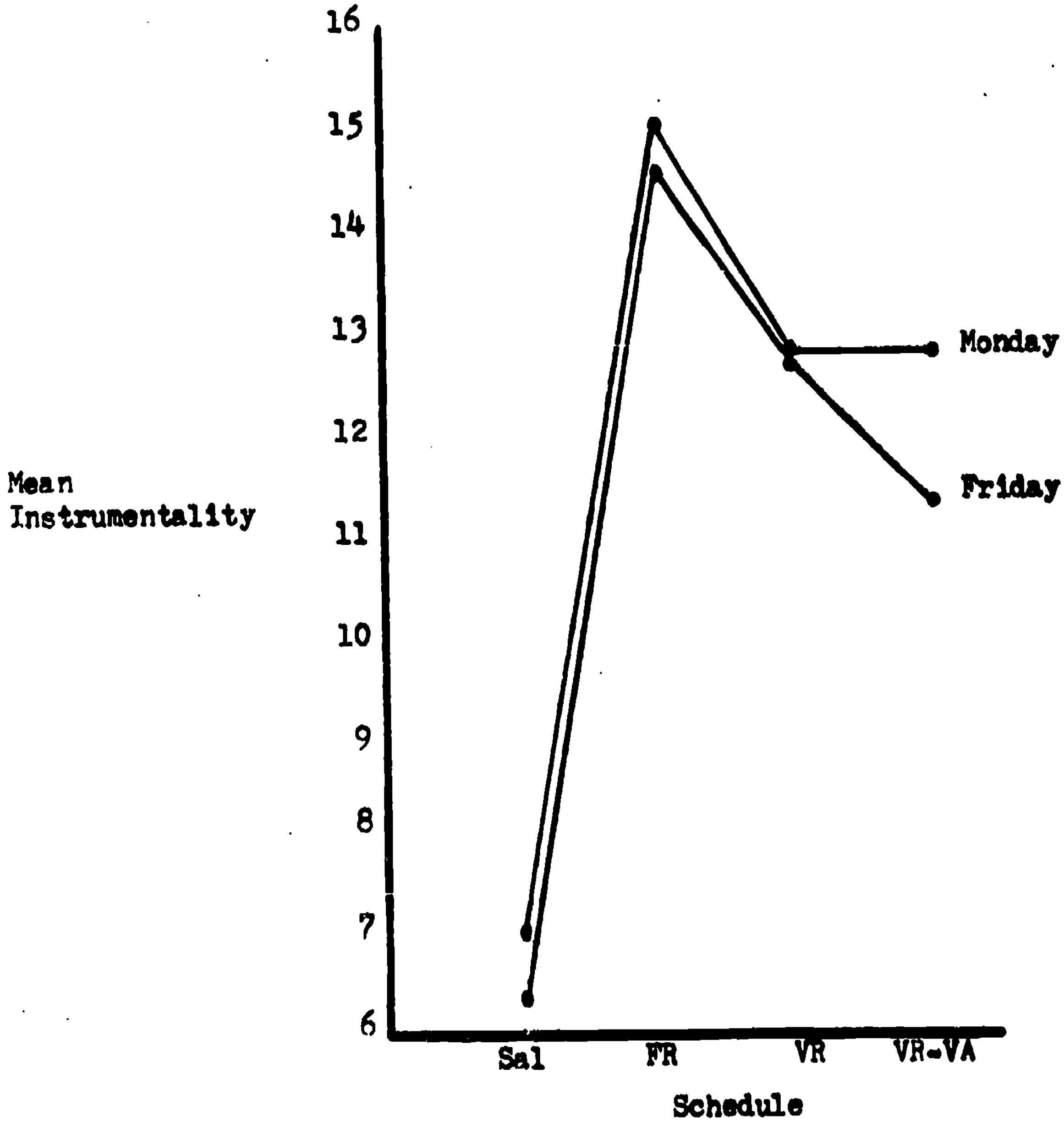

Figure 4. Performance-Reward Instrumentalities by Schedule and Time

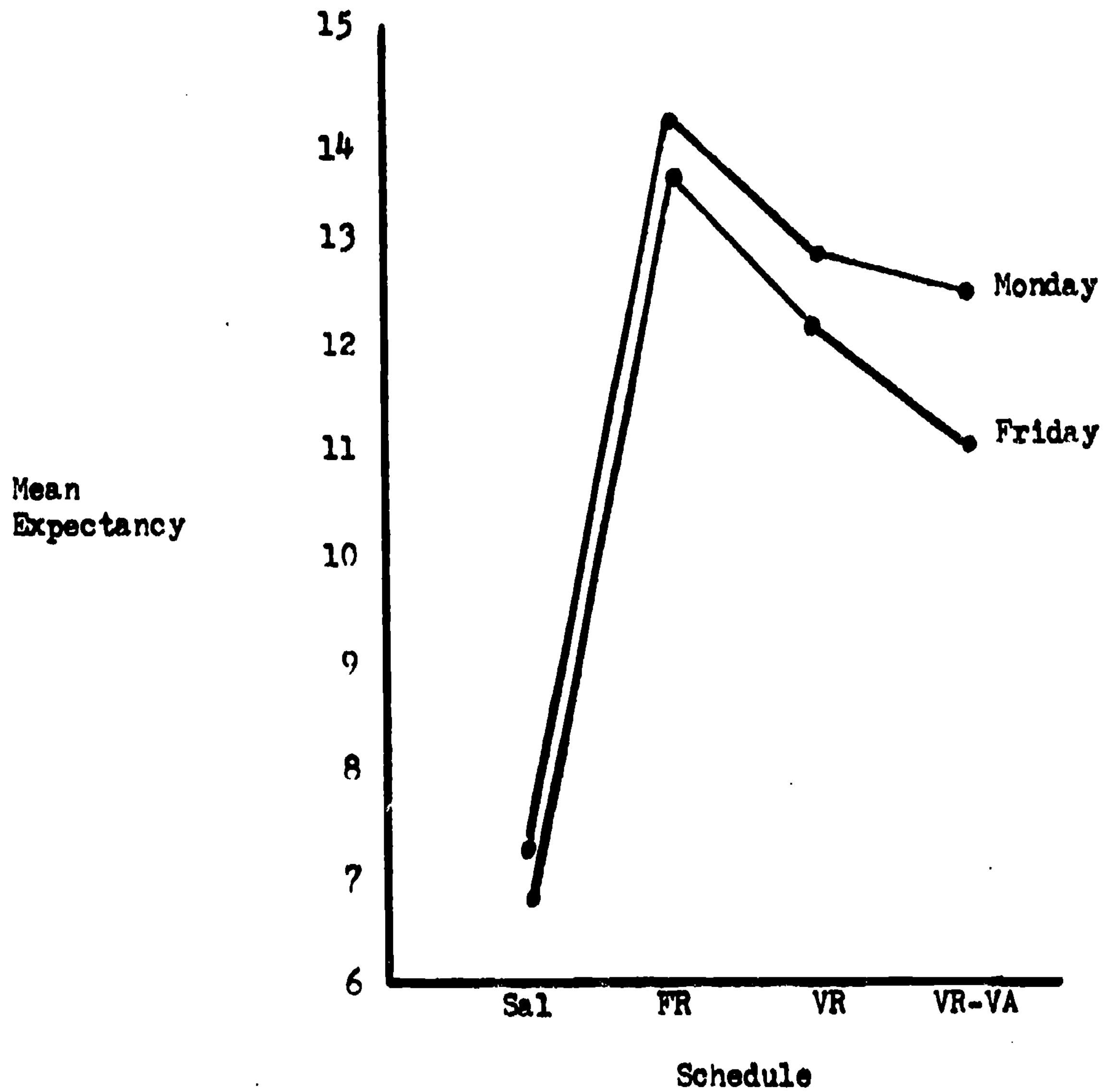

Figure 5. Effort-Reward Expentancies by Schedule and Time

the analyses. This estimation procedure was done as follows. It was assumed that the VR-VA schedule would show the same effect relative to the other schedules for the missing subject as it did for the other 15 subjects. Thus, the mean performance for the 15 subjects over Salary, FR, and VR schedules was calculated and compared to the VR-VA performance for the 15. A percentage difference was then calculated. This correction percentage was then applied to the replacement subject's data by calculating his mean performance over Salary, FR, and VR and adjusting this mean by the correction percentage obtained from the rest of the sample. This procedure was felt to be on the conservative side since the replacement subject showed larger schedule effects than the average subject. Thus, we would expect that his actual VR-VA performance would have been higher than that produced by our estimating procedure.

All performance-dependent variables were analyzed by a within-subjects analysis of variance with schedules of reinforcement as the within variable. Since each subject served in all conditions and the Latin Square design counterbalanced the order of reinforcement schedules over subjects, the effects of order of working on the schedules were disregarded in the analyses.

The performance data are summarized in Table 4. The single variable of greatest importance is number of tests passed. The means for each schedule are presented in Figure 6. This figure clearly shows that the salary schedule resulted in the fewest tests passed, FR and VR next and about equal to each other, and VR-VA showed the most tests passed. The overall F is highly significant ($p < .001$). Planned comparisons indicated that salary was significantly lower than the other schedules ($p < .01$), VR-VA was not significantly higher than FR or VR. However, VR-VA did show a 9% increase over the FR schedule.

Number of tests taken (Table 4) shows essentially the same pattern of results as number of tests passed. As expected, inter-test time and inter-passed test time show the same pattern. That is, the salary schedule produced significantly longer times than the other schedules ($p < .01$) but FR, VR, and VR-VA were not significantly different from one another. Actual earnings also shows the same pattern.

Data on the percent correct for the task material tests appears in Table 4 and Figure 7. These data indicate that the increased performance under the FR, VR and VR-VA schedules did not reduce subjects' scores on the tests. There were no significant differences ($F < 1.0$) in percent correct for either the tests taken or tests passed.

Data on the weekly comprehensive tests are presented in Table 4 and Figure 8. The results indicate that there were differences ($p < .01$) in retention when simple percent correct was used as the

Table 4. Summary of Performance Data

Variable	Salary	FR	VR	VRVA	p	MS error
Number of tests passed	41.810	59.310	59.190	64.810	.0005	209.740
Number of tests taken	81.630	106.630	112.430	116.130	.0002	436.510
Percent correct on tests passed	86.110	85.600	85.370	86.290	.5500	4.140
Percent correct on all tests taken	66.430	66.650	67.020	67.940	.9000	37.540
Time between passed tests	.727	.454	.442	.421	.0002	.037
Time between all tests taken	.359	.244	.236	.227	.0013	.010
Earnings	46.250	58.500	58.190	62.810	.0320	254.730
Percent correct on comprehensive	.734	.666	.602	.609	.0030	.011
Weighted comprehensive score	31.62	40.51	37.23	40.29	.05	102.95

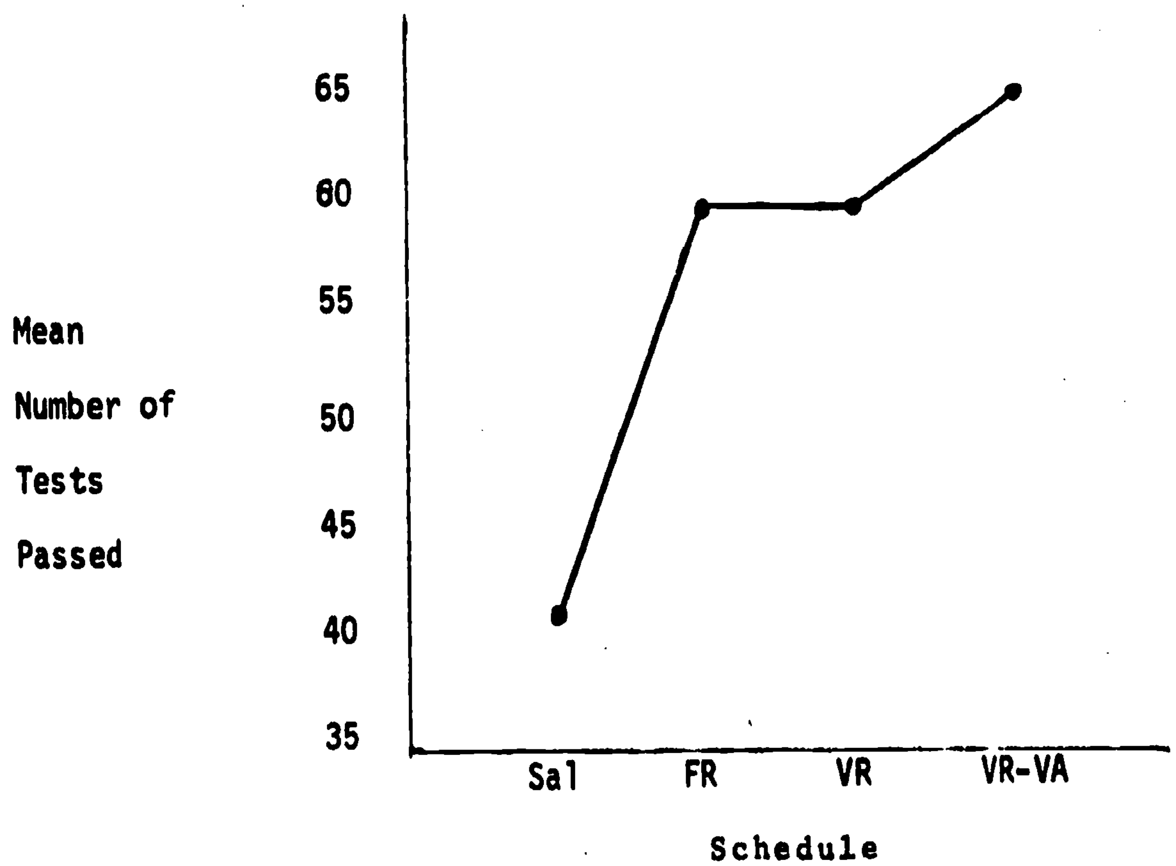

Figure 6. Number of Tests Passed, by Schedule

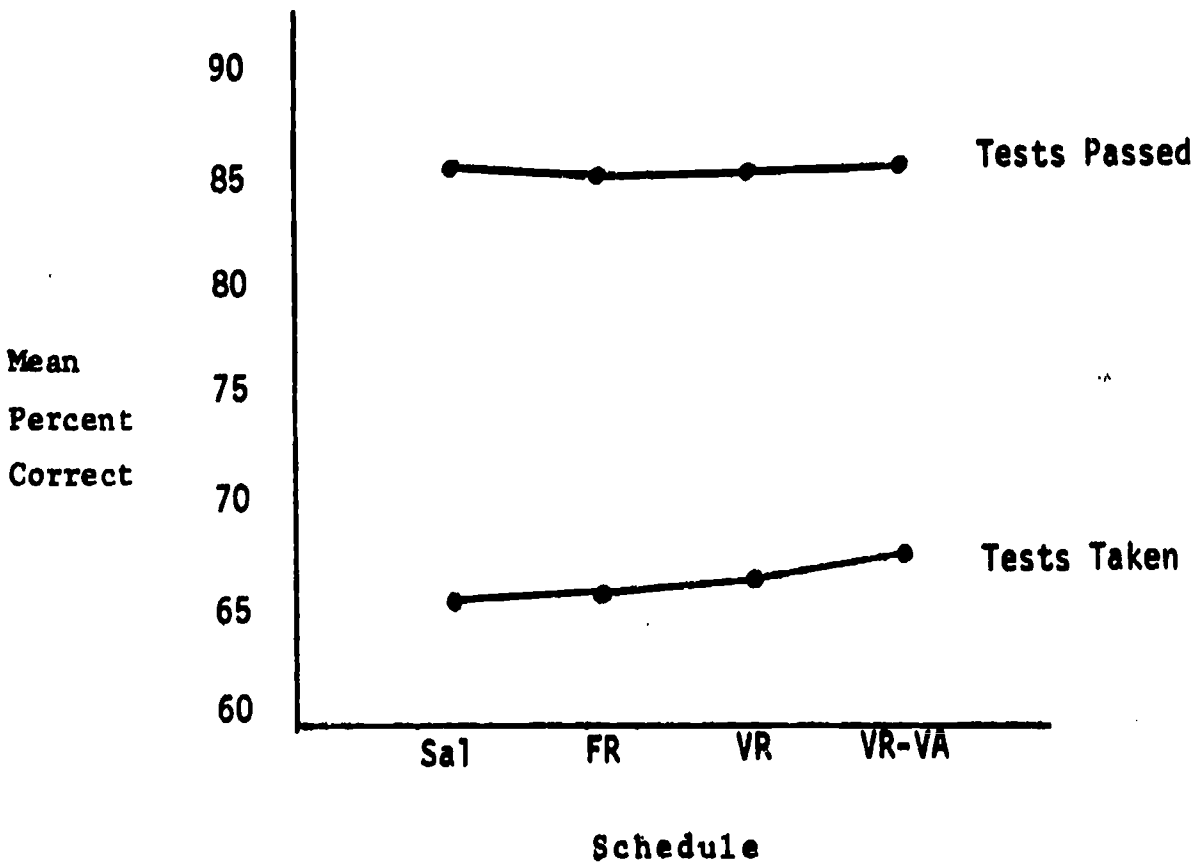

Figure 7. Percent Correct on Tests Taken and Tests Passed, by Schedule

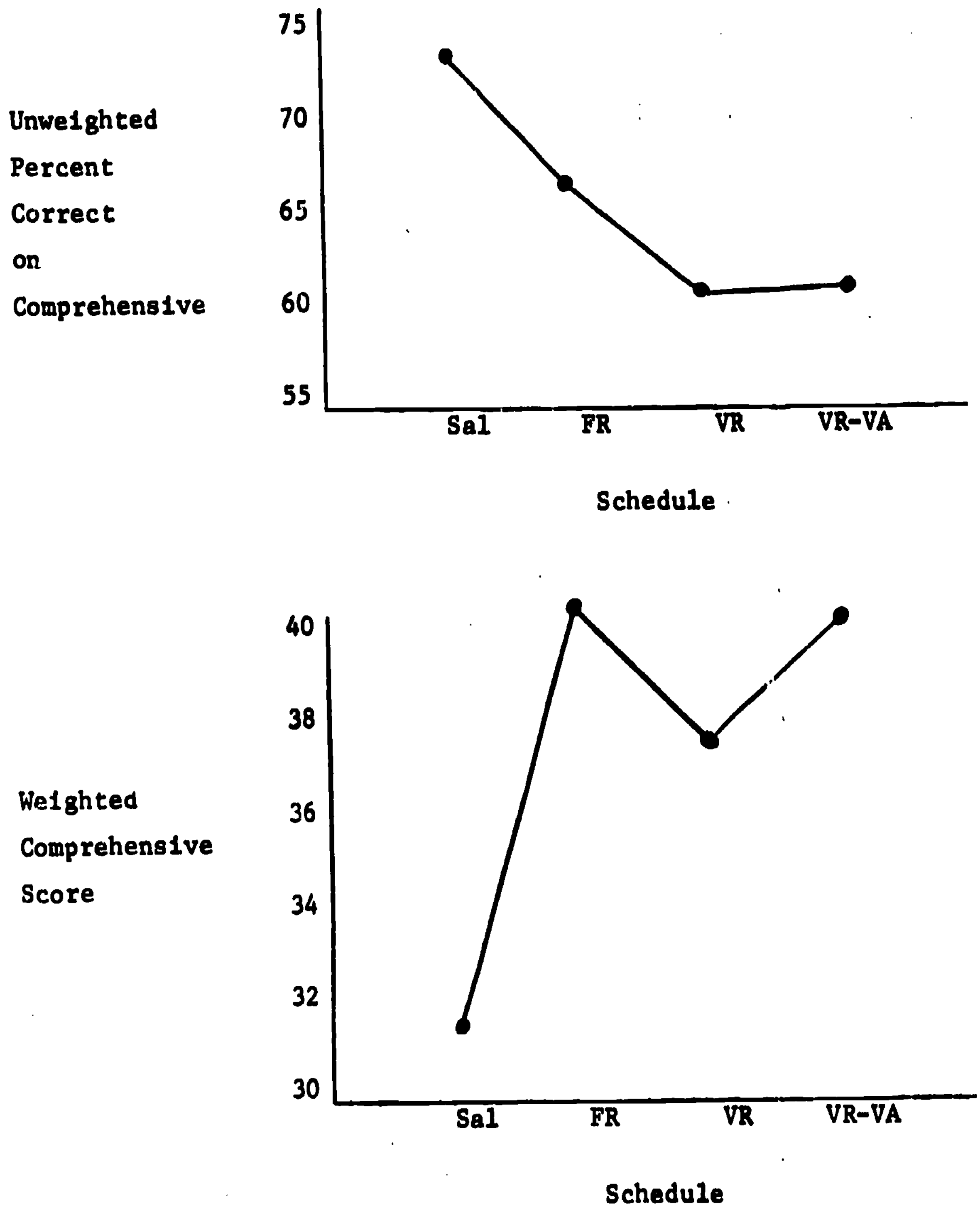

Figure 8. Weighted and Unweighted Comprehensive Scores, by Schedule

dependent variable, with the salary schedule showing the highest comprehension. However, it should be recalled that subjects on the schedules other than salary had covered more material during the week and thus had more to remember. When the scores on the comprehensive tests were weighted by the amount of material covered, the hourly condition actually showed the lowest retention, and the other three schedules were about equal.

Attitude Results

As was discussed above, a job attitude questionnaire was given at the end of the work day on Monday and Friday of each week (Appendix F, part I). The first measure in this questionnaire consisted of a job satisfaction questionnaire. Table 5 presents the data from this instrument by schedule and day of administration. Item-by-item data are presented as well as total satisfaction (the sum of the 16 items).

The table indicates that total satisfaction was not significantly different under the various schedules on Mondays or on Fridays. However, as Figure 9 indicates, on Monday satisfaction was highest under VR-VA, but by Friday FR was highest.

Satisfaction with pay (item 10) is of particular interest. Table 5 and Figure 10 indicate that significant differences in pay satisfaction occurred on Monday, with FR resulting in the highest satisfaction. The pattern is the same on Friday, but the overall F is not significant. The salary schedule resulted in the lowest pay satisfaction on both Monday and Friday.

Significant effects were also found for "The freedom to use my own judgement" (item 11). While there were no differences on Monday, by the end of the week the FR schedule resulted in the highest satisfaction. Item 16, "The feeling of accomplishment I get from the job," resulted in significant differences on both Monday and Friday. On Monday, satisfaction was highest on VR-VA; but by Friday, VR-VA was lowest and FR was highest.

The overall finding seems to be that by the end of the week, the FR schedule resulted in the highest satisfaction.

The next attitude measure to be discussed deals with subjects' self-ratings of effort. Two items assessed effort and these items were summed. Means of this composite are presented in Table 6 and Figure 11. The data indicate that perceived effort was far less under the salary schedule than under any of the other schedules. On Monday, subjects felt they exerted the greatest amount of effort under the FR schedule; while, by Friday, VR-VA was seen as resulting in the highest level of effort.

Table 5: Job Satisfaction Items by Schedule and Time

Item No.	Day	Sal	FR	VR	VR-VA	p	MS error
				Schedule			
1	M	4.0	4.1	4.0	4.1	.92	.130
	F	3.9	4.1	4.1	4.0	.56	.136
	F-M	-.13	0.00	.06	-.06	.68	.204
2	M	3.6	3 9	3.8	3.9	.27	.260
	F	3.8	3.9	3.8	3.9	.78	.228
	F-M	.19	0	0	0	.71	.296
3	M	3.8	3.9	3.5	3.8	.04	.186
	F	3.8	3.9	3.8	3.8	.98	.293
	F-M	.06	-.06	.31	0	.20	.266
4	M	3.9	3.8	3.9	3.8	.50	.174
	F	3.8	3.9	3.8	3.9	.75	.206
	F-M	-.19	.13	-.19	-.06	.57	.371
5	M	3.9	3.8	3.7	3.9	.40	.182
	F	3.9	3.8	3.6	3.8	.06	.146
	F-M	0	0	-.13	-.13	.85	.306
6	M	3.3	3.2	3.1	3.3	.40	.104
	F	3.1	3.3	3.2	3.3	.19	.085
	F-M	-.13	.13	.06	0	.34	.160
7	M	3.3	2.9	3.0	3.3	.30	.343
	F	3.3	3.1	3.1	3.3	.24	.096
	F-M	0	.13	0	0	.80	.185
8	M	4.2	3.9	3.9	4.1	.23	.207
	F	4.1	4.0	3.9	3.9	.72	.226
	F-M	-.13	.13	-.06	-.13	.52	.291
9	M	3.9	3.8	3.8	3.7	.60	.155
	F	3.8	3.7	3.8	3.6	.59	.160
	F-M	-.06	-.06	0	-.06	.98	.238
10	M	3.6	4.4	4.0	3.9	.05	.636
	F	3.4	4.1	3.8	3.6	.25	.807
	F-M	-.19	-.38	-.19	-.31	.91	.774
11	M	4.1	4.1	3.9	4.0	.56	.260
	F	3.7	4.3	4.0	3.7	.004	.232
	F-M	-.44	.19	.13	-.31	.01	.402
12	M	4.1	3.9	3.6	3.9	.053	.197
	F	3.8	3.9	3.9	3.8	.84	.294
	F-M	0.25	.06	.31	-.13	.07	.381
13	M	4.4	4.3	4.2	4.4	.61	.203
	F	4.3	4.3	4.4	4.4	.62	.171
	F-M	-.13	0	.19	.06	.30	.215
14	M	4.3	4.2	4.3	4.3	.40	.125
	F	4.2	4.1	4.3	4.3	.86	.224
	F-M	-.13	0	-.06	0	.88	.257
15	M	3.4	3.3	3.3	3.6	.18	.205
	F	3.3	3.6	3.6	3.3	.29	.332
	F-M	-.19	.25	.25	-.31	.04	.464
16	M	3.8	3.8	3.8	4.3	.003	.143
	F	3.8	4.2	3.9	3.6	.04	.297
	F-M	0	.38	.06	-.63	.0002	.296
TOTAL	M	61.5	61.1	59.8	62.3	.20	10.46
	F	59.8	62.0	60.7	60.2	.25	10.22
	F-M	-1.69	.88	.88	-2.06	.04	13.58

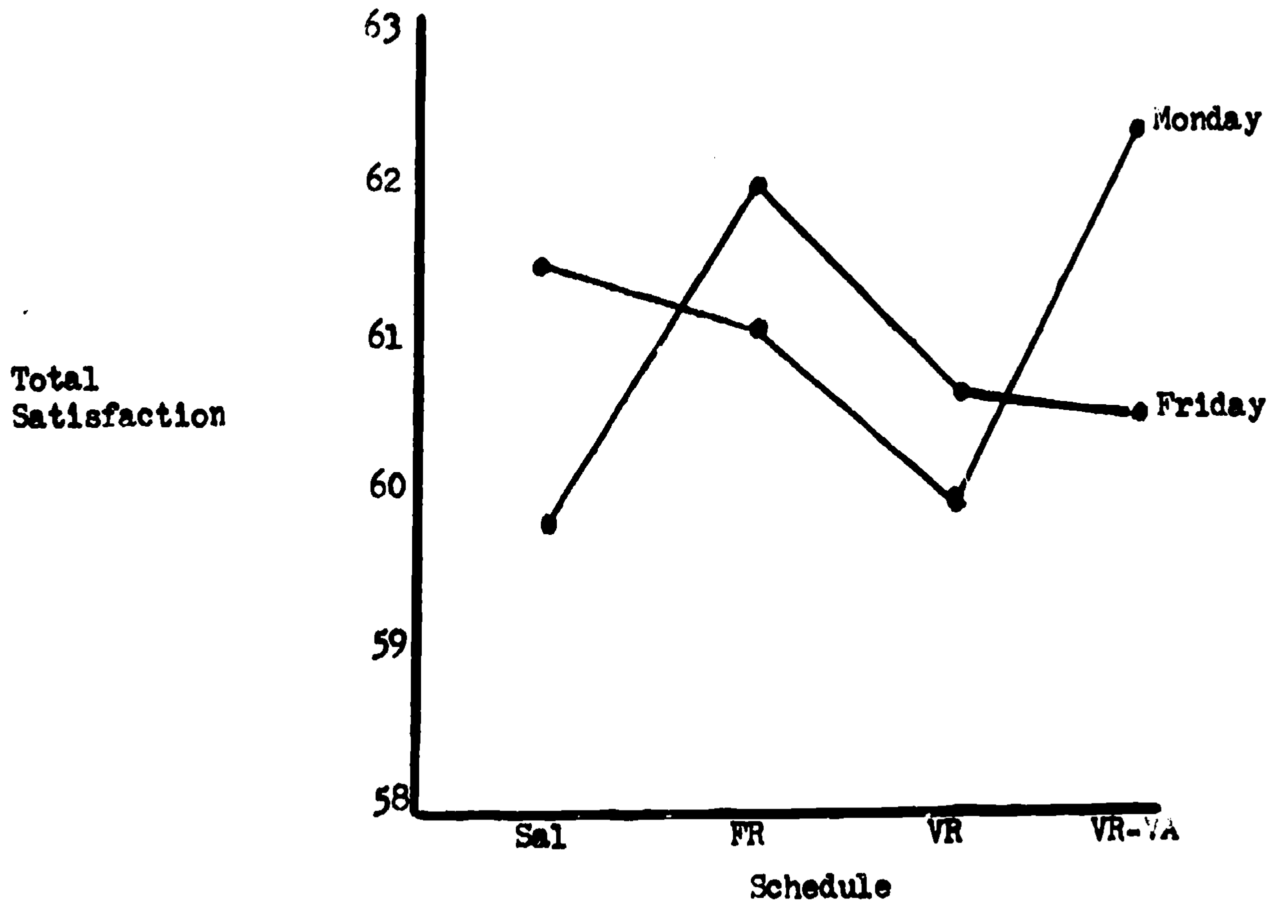

Figure 9. Total Satisfaction by Schedule and Time

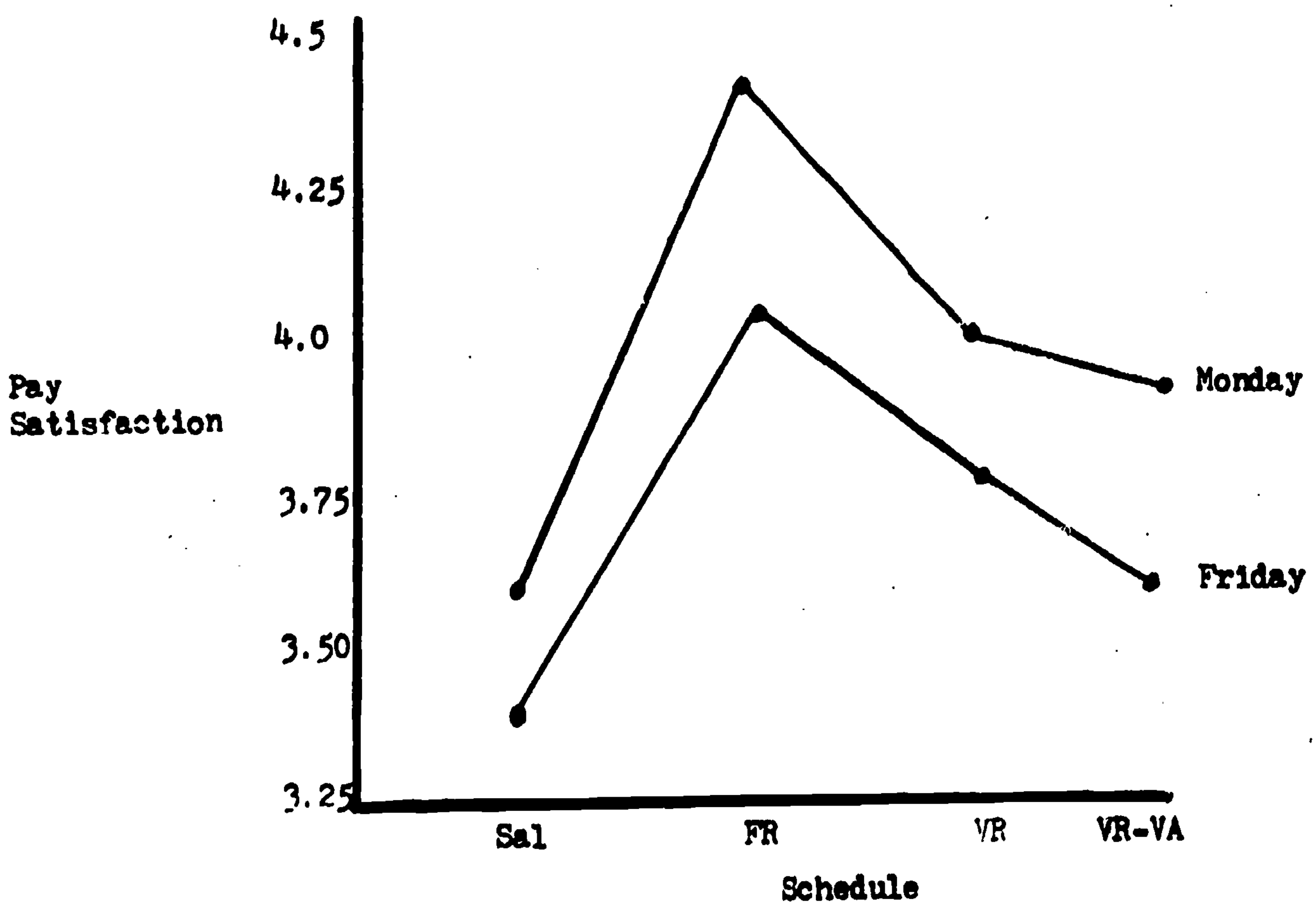

Figure 10. Satisfaction with Pay by Schedule and Time

Table 6 : Job Attitude Items by Schedule and Time

Item No.	Response Range	Content	Day	Schedule Sal	FR	VR	VR-VA	p	MSW
1	1-9	Effect of payment method on job interest	M	5.1	6.9	7.1	7.3	.002	2.80
			F	4.3	7.0	6.5	6.7	.0002	2.80
			F-M	-.81	.13	-.63	-.63	.18	1.63
2	1-9	Effect of payment method on effort	M	4.7	6.8	6.9	7.0	.002	3.14
			F	3.5	7.2	6.9	6.3	.0000	3.77
			F-M	-1.19	.38	.06	-.75	.09	3.58
3&4	2-18	Self-perceived effort	M	12.3	15.2	14.3	14.7	.0006	3.62
			F	11.3	14.2	14.1	14.8	.0006	5.27
			F-M	-1.0	-1.0	-.19	.06	.27	3.59
5&6	2-18	Perception of equity	M	9.6	10.2	11.0	9.6	.10	3.23
			F	9.7	10.3	9.8	9.1	.51	4.78
			F-M	.13	.06	-1.3	-.56	.14	3.47
7&8	2-18	Personal control	M	12.1	13.4	13.6	12.9	.14	3.77
			F	13.4	13.8	13.5	13.3	.61	1.28
			F-M	1.3	.44	-.06	.38	.36	4.84
9	1-9	Job interestingness	M	6.8	6.8	7.0	7.2	.36	.471
			F	6.1	6.9	6.8	6.9	.02	.67
			F-M	-.69	.06	-.19	-.25	.07	.624
10,11		Pay expectation and actual	M	50.75	67.88	62.60	62.63	.03	248.6
			F	49.50	64.69	58.19	64.69	.06	320.0
			F-M	-1.25	-3.19	-4.43	2.06	.63	220.2
10a,11a	1-9	Valence of pay	M	5.3	5.6	6.2	5.7	.07	2.12
			F	5.4	6.1	5.9	5.9	.72	2.58
			F-M	.19	-.50	-.25	.19	.52	2.39
12	1-9	Feelings of manipulation	M	5.7	5.8	5.1	5.4	.60	2.41
			F	5.6	6.0	5.9	5.4	.19	.67
			F-M	-.13	-.13	.44	-.50	.26	1.76

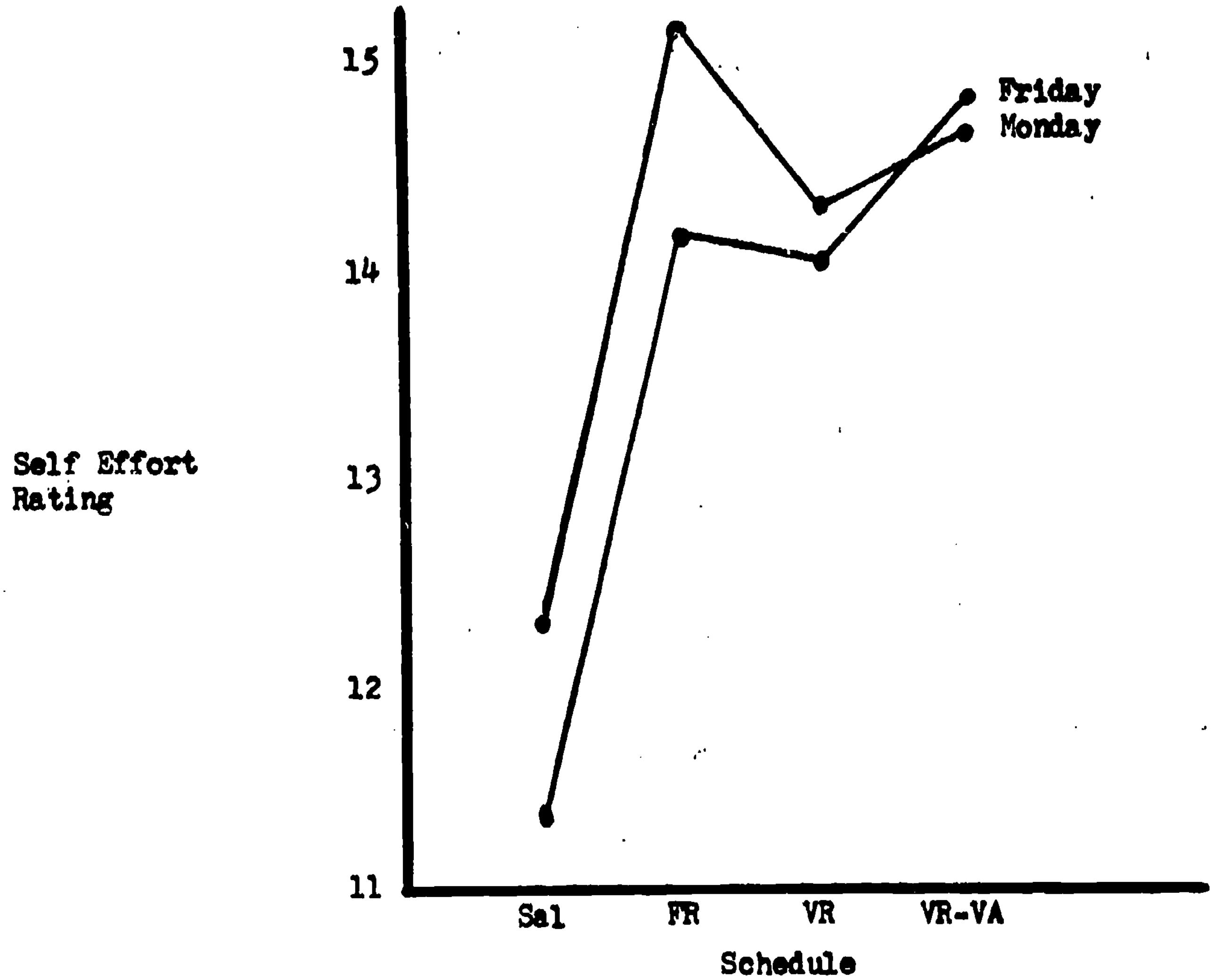

Figure 11. Self-Ratings of Effort
by Schedule and Time

Subjects' perception of the equity of their pay was also assessed. Means for the sum of the two questionnaire items are also presented in Table 6. The results indicate that subjects perceived the various schedules as being equally equitable.

Subjects felt the different schedules resulted in differential job interest (Table 6, item 1). They felt the salary schedule resulted in the least job interest by far. On Monday VR-VA was felt to yield the greatest job interest, but by Friday FR was highest.

The perceived effect of schedule on effort (Table 6, item 2) followed a similar pattern. Salary was lowest, on Monday VR-VA was highest, but by Friday FR was highest.

The two items dealing with feelings of control over the work setting showed no [illegible] effects.

The measure [illegible] interestingness of the job (Table 6, item 9) showed no differences on Monday, but by Friday differences emerged, with salary resulting in low interestingness and the other schedules about equal.

Pay expectations (Monday) and actual pay (Friday) are reported in Table 6, items 10, 11. The pay expectations data show salary the lowest by far, and FR the highest. The actual pay data are fairly uninterpretable since they reflect the fact that some subjects were occasionally absent, and this absence is reflected in their actual pay. The valence of pay data follow essentially the same pattern as the pay expectation data.

Finally, subjects did not feel that any of the pay schedules manipulated them (Table 6, item 12) any more than any other schedule.

Analyses dealing with the biographical data are presented in Table 7. This table presents correlations between the various biographical variables and performance as measured by the number of tests passed under each schedule. Although none of the correlations are significant ($r_{.05} = .50$) one is struck by the magnitude of the correlations across schedules. For example, years of education correlates .44 with performance under the salary schedule, but -.34 under the VR-VA schedule. This difference is highly significant. However, when one attempts to explain such findings, one draws a blank. Unfortunately, with such a small sample size, subgroup analyses which might shed light on these relationships are impossible.

Table 7 also presents analogous correlations between the scales of the Personal Reactions Questionnaire and performance. Locus of control and perceptions of expected effort did not show significant

Table 7. Correlations of Biographical Data and Personal Reactions Questionnaire with Number of Tests Passed, by Schedule

	Item No.	Sal	FR	VR	VR-VA
Biographical Data					
Years of education		.44	.21	-.30	-.34
Arithmetic score [a]		-.05	-.31	-.29	-.45
Electricity score [b]		-.13	.36	.20	.04
Intelligence		.25	.40	.19	.37
Age		.14	.05	-.26	-.38
Personal Reactions Questionnaire					
Internal Locus of Control	I, 1-8	.00	-.08	.29	-.21
Need for money	II, 1-2	-.21	-.15	-.57*	-.32
Perceptions of expected effort	II, 3	.13	-.00	-.28	.23
Protestant Ethic	III, 1-7	-.61**	-.20	.24	.18

a. Arithmetic score = number of errors
b. Electricity score = number correct
c. High score = high internal locus of control

* r.05 = .50
** r.01 = .61

correlations with performance. The need for money scale unexpectedly showed <u>negative</u> correlation with performance, and for the VR schedule, significantly negative. Correlations with the Protestant Ethic Scale showed a significantly negative correlation in the salary schedule, but small positive correlations under VR and VR-VA.

The major conclusion from both the biographical and personality data seems to be that due to the large variability in the size of the correlations, strong interactions seem to exist between individual differences and the effects of the schedules on performance.

Exit Interviews

Subjects were asked to come to an interview at the end of the project, and 9 subjects showed up for these exit interviews. The interviews were scheduled for one half hour time blocks and two persons were interviewed at a time.

The most informative questioning centered around the preference of the various subjects for the various pay schedules. Each subject was asked to rank order the four schedules from highest to lowest in terms of preference. The results are summarized in Table 8. As seen in the Table, the subjects preferred the FR schedule by far, giving it an average ranking of 1.4. The single subject who gave it a ranking of only 3 (subject #4) did so because he expressed a great deal of enthusiasm for gambling and, thus, rated the two "gambling" schedules (VR-VA and VR) first and second. In his opinion, however, the FR schedule ranked much closer to his first two choices than did the salary schedule, which ranked a distant last. The two other instances in which FR ranked other than first (subjects #3 and #8) seemed to be related to the fact that these subjects happened to make inordinately large amounts of money on the schedule preferred first.

When asked what they liked about the FR schedule, a typical comment was that they felt they were in control. For example, subject #1 expressed his feelings this way: "I felt that with this schedule (FR) I was in control of what I did. If I came in in the morning with a headache or feeling tired, I knew I could go ahead and make my $10 (his daily minimum goal) and then see what happened after that. On the gambling schedule (VRVA) you might work all morning and make nothing."

The two "gambling" schedules, VRVA and VR, ranked equal in preference and below FR, even though many subjects earned the most money under these schedules. Except for those one or two subjects who liked to gamble, many subjects expressed a fear of having a long "dry spell" if forced to work on one of these schedules for an extended time period, such as several months.

Table 8. Post-Experimental Preference Ranking of Schedules*

	Schedule			
Subject	Salary	FR	VR	VRVA
1	3	1	4	2
2	4	1	2	3
3	4	2	3	1
4	4	3	2	1
5	4	1	2	3
6	4	1	2	3
7	4	1	3	2
8	4	2	1	3
9	4	1	2	3
mean rank	3.9	1.4	2.3	2.3

* A rank of 1 indicates the most preferred schedule, 4 being least preferred

The salary schedule was by far the least preferred of the four schedules. However, some subjects felt that this schedule seemed worse since they could compare it so readily with the other schedules. In fact, performance under the salary schedule was lower during the last two weeks of the study than under the first two weeks. It appeared that over time, subjects clearly realized that they did not have to work as hard under salary. This "contrast effect" would suggest that it might prove disadvantageous to have both a salary type schedule and an incentive schedule operating in the same work situation.

Evaluations of the salary schedule usually focused upon the low motivation it inspired; e.g., "it made you so you didn't want to work," or, "I knew I was going to get paid whether or not I did anything, so I just felt like goofing off." Subjects admittedly took their longest breaks and covered the least material on this schedule. A few subjects felt that they may have "learned more" when working under the salary schedule, but further questioning indicated that this impression was related to the fact that the subjects covered far less material during the salary schedule and were, therefore, able to achieve higher scores on the weekly comprehensive tests. (When corrections for amount of material covered were made, comprehension did not differ across schedules).

Other information gained from the exit interviews can be summarized in the following categories.

Cheating. Passing answers, etc., was apparently done very rarely, despite ample opportunity. The fact that all subjects worked at their own pace and were therefore working on different material at any point in time made cheating more difficult. Also, for subjects working on the three response contingent schedules, taking time out to give answers to a friend meant less time to earn money for oneself. According to the subjects, occasional help might be given to someone who was having a particularly difficult time on a specific test, and was therefore unable to proceed. Since the interview subjects unanimously admitted that some cheating had occurred, but were virtually uniform in their assessment of the extent of such activity, we conclude that cheating was not a serious problem with our procedure.

Apparatus. The exit interviews also produced unanimous agreement on advantages of the response console and the computer-controlled testing. Subjects remarked that entering answers on the consoles introduced a good deal of variety into the situation and enhanced their interest. Also, they felt that the impersonal nature of the computer scoring was advantageous in that they perceived it to be less threatening and less punitive than a teacher-testing procedure. They particularly liked the immediate feedback provided by the reinforcement counter and claimed that it helped them to set daily work goals. The major criticism of the apparatus was that it did not provide specific information as to which test answers were correct or incorrect, but instead it gave them only the total correct answers for each test.

Work Atmosphere. The subjects enjoyed the relaxed work atmosphere, the fact that they were permitted to take breaks whenever they wished, and the fact that they could work at their own pace. All reported that they would definitely take the job again if offered and felt that it had been an instructive and worthwhile experience.

General Criticism. When asked for criticism, the remarks centered primarily on two things: disruptive behavior by a few individuals, and the lack of an expert instructor who could answer questions and assist them when needed. A few subjects remarked that at times it was difficult to concentrate when a few individuals persisted in loud talk or "fooling around"--although the experimenter on duty attempted to keep such disruptive behavior to a minimum, instructing noisy individuals to leave the room and take a break outside. It appears that persons working on the non-motivating salary schedule were particularly inclined to such disruptive behavior.

The second criticism was related to the need for a qualified instructor who would be available for questions and explanations. Subjects working hard on the incentive schedules were particularly upset when their inability to comprehend a particular passage or problem prevented them from moving ahead. This problem, of course, should not arise in the Air Force setting, since such instructors would presumably be on hand at all times.

DISCUSSION

Taken as a whole the data clearly indicate that the various schedules of reinforcement had differential effects on performance. Of the four schedules, the salary schedule resulted in much lower performance than the other three schedules. In fact, the mean performance of the other three schedules was 46% higher than performance under the salary schedule. The FR and VR schedules were approximately equal in their effect upon performance, with the VR-VA schedule producing the highest performance levels. The mean VR-VA performance exceeded the FR and VR levels by approximately 9%. Although this difference was not statistically significant, a difference of this magnitude, if replicated, would certainly be of practical significance in an Air Force training context.

Equally important are the findings regarding quality of performance; i.e., percentage correct on tests. The data indicate that even though the FR, VR, and VR-VA schedules resulted in more tests being passed than in the salary schedule, the percentage of correct answers on the tests was just as high. In addition, the data from the weekly comprehensive tests also show that more learning was taking place under the FR, VR, and VR-VA schedules. That is, although the raw scores show that the salary condition had the highest raw percent correct on the comprehensives, when the amount of material covered is taken into consideration, the three partial schedules were superior to the hourly condition.

The attitude data also show some interesting results. Satisfaction was highest for VR-VA on Monday, but highest for FR by Friday. Also, highest under the salary condition and, by the end of the week, satisfaction was lowest under salary. Satisfaction with pay did show significant differences on Monday, with the salary schedule resulting in much lower pay satisfaction than the other schedules. A similar, but non-significant, pattern emerged on Fridays. Also, the salary schedule was lowest in job interestingness, and significantly so by the end of the week.

One finding of considerable significance is the change in attitude from Monday to Friday. A fairly consistent pattern was for the VR-VA schedule to be preferred at the beginning of the week but for FR to be preferred by the end of the week. This pattern appeared for Total Satisfaction, effect of schedule on job interest, effect of schedule on perceived effort, and job interestingness. These findings suggest that subjects reacted to the schedules differently after experience. Clearly, the evaluation of such schedules must occur only after subjects have experience working under the schedule.

One problem anticipated with the use of partial schedules of reinforcement, especially VR and VR-VA, was that feelings of inequity or manipulation might occur on the part of subjects under these schedules. The data indicate that no difference in feelings of equity or manipulation occurred under these schedules. Furthermore, responses to these items were near the neutral point for all schedules.

When one compares the overall findings regarding performance and satisfaction, a curious result emerges. In general, subjects' attitudes were most favorable towards the FR schedule, yet their performance and earnings were highest under the VR-VA schedule. When asked about this in the exit interviews, they generally indicated that the uncertainty in the VR-VA schedule caused their lower evaluation of that schedule. Our findings would suggest that the highest performance would occur under VR-VA, but attitudes would be best under an FR schedule.

Results from the biographical and personality analyses showed rather large and variable correlations with performance. Unfortunately, no systematic patterns emerged from these analyses and due to the small sample size, examination of these correlations through subgroup analyses is impossible. However, one unmistakable implication emerges. Strong interactions exist between individual differences and the effects of the schedules on performance. Any attempt to utilize various schedules in task performance should carefully explore these effects. Specifically, our results suggest that people with certain characteristics might perform highly under one schedule, but not so well under another. For example, our findings (although limited in their generalizability) would suggest that a trainee who is relatively young, of higher education, and who had low Protestant Ethic values might perform better under an FR schedule than a VR-VA schedule. Future research should carefully explore these type of individual differences interactions.

Our results have certain implications related to theoretical considerations involving expectancy-valence theory. Expectancy-valence models suggest that performance will be highest when effort-reward expectancies are highest. In this study, the FR schedule should result in higher effort-reward expectancies than the VR-VA schedule since a given amount of effort is more closely followed by a given amount of reward (pay) in the FR schedule as compared to the VR-VA. In fact, the checks on the manipulations and the exit interviews both support the fact that subjects perceived this to be the case. However, contrary to the prediction of expectancy-valence theory, performance was actually higher in the VR-VA condition than in the FR condition. One might argue that the amount of pay expected or the valence of pay could be higher in the VR-VA schedule than the FR schedule and, thus, account for the results. However, both expected earnings and valence of pay were actually lower in the VR-VA schedule as compared to FR. Clearly, then, the expectancy-valence model cannot account for VR-VA showing greater performance effects than FR.

In addition to these theoretical implications, our findings have substantial practical implications as well. Most importantly, use of an FR or VR-VA schedule can result in substantial increases in performance and attitudes toward the task as compared to a salary schedule. From a cost-effectiveness point of view, these effects are eminently feasible in an Advanced Instructional System. Such a system can easily include computer controlled reinforcement with any of the schedules used here.

The exit interviews provided some valuable insights about how such a system might be designed. Subjects reported that one of the things they liked about the system was the impersonal nature of the performance feedback. They felt that having the computer score their tests and report to them the number correct removed the stigma of an instructor informing them that they failed. To the extent such a procedure removed some of the anxiety from failing; e.g., in low ability trainees, this could have positive effects.

The nature of the feedback was also significant on other grounds. Subjects reported that the immediate nature of the feedback was a positive feature. More importantly, however, was the manner in which both the performance and reinforcement feedback was given. The system was intentionally designed so that this feedback information accumulated. That is, the light indicating the number of test items correct would start to flash, one flash per correct answer. Thus, the subject did not know how many he had answered correctly until the light stopped flashing. An analogous situation existed for the reinforcement counters. The counter would start to count, with an audible click, in units of 10¢. In the VR-VA schedule, subjects did not know how high the counter was going to go until it stopped. Observation of the subjects as well as the exit interviews indicated that subjects attended to both the flashes for number correct and the reinforcement counters very carefully. When the counters of the subjects at the VR-VA table started counting, every subject in the room was carefully attending to how much money was being made. Thus, the cumulative nature of the performance and reward feedback generated a certain amount of suspense which seemed, according to the subjects, to break the monotony. Incorporating such a feature into the AIS seems to be worthy of careful consideration.

It is interesting to note that while the incentive motivation techniques employed in this study resulted in substantial gains in performance, a similar field experiment conducted by some of the present researchers (Pritchard, DeLeo, and Von Bergen, 1973) was not so effective. This field experiment was conducted at an Air Force technical training base and essentially employed a FR reinforcement schedule. Three incentive systems were employed with each of two technical training courses. The results indicated that the incentive system was only effective for one dependent variable, in one course, under one of the three incentive systems.

The results of this field experiment are in marked contrast to those found in the present research. This is extremely important from an applications point of view since it brings into question the generalizability of our findings to a field setting. To explain the conflicting findings one might argue that the incentives used in the present research were more powerful than those used in the field experiment. This argument may have some validity for two of the incentive conditions used in the field experiment, but the third system employed substantial financial incentives (up to $40 per week) as well as a variety of non-financial rewards. Yet, in the high incentive condition no performance effects were observed for one of the courses, and only one of the two major dependent variables showed increased performance in the other course. Thus, an explanation based on the strength of the incentives should probably be ruled out.

However, there are two arguments which could explain the difference in the findings of the two studies. The first deals with the amount of reward offered by the incentive system relative to the total rewards available in the situation. In the present research, the majority of the extrinsic rewards available to the subjects were controlled by the incentive system (i.e., the schedules). In the field experiment this was not nearly so true. Within the technical school environment, the instructors had substantial reward power in the way they treated the students and the students tended to perceive, correctly or incorrectly, that the technical instructors had some control over their future careers. Outside of the technical school environment, the military instructors also had substantial reward power.

To the extent that these sources of reinforcement generated contingencies between rewards and behavior incompatible with high performance, the effects of the incentive system would be weakened. The implication of this line of reasoning is that in a field setting, the majority of the trainees rewards, both within and outside the technical school environment, should come from the incentive system. To the extent that meaningful rewards are controlled by sources outside the system, the power of the system will probably be weakened.

The second explanation for the disparity in the findings of the field experiment and the present research deals with effort-performance expectancies. In the field experiment it was noted (Pritchard et al., 1973) that the students in the course showing no performance effects were near the upper limit of their performance and thus perceived little relationship between increased effort and increased performance. In the present study this was not the case since increased effort would result in increased performance. The issue revolves around the nature of the tests used in the training situation. Tests of low difficulty could be passed by nearly everyone with low effort, and increased effort would not substantially change performance. Tests of very high difficulty could result in a similar situation where a student comes to realize that increased effort will not result in passing the tests any better or faster, but that he must simply "plough through" the material. If he increases his pace, he finds he will fail the test. This line of reasoning suggests that effort-performance expectancy would be highest, and thus incentive effects strongest, in a situation where tasks or tests are of moderate difficulty.

Thus, it seems likely that if a field situation were generated where most rewards were controlled by the system and tests were of moderate difficulty for the trainees involved, results similar to those obtained by the present research would be more likely to be found in a field setting. Clearly, the AIS has the potential to meet these conditions.

In summary, the present research has indicated that substantial positive effects on performance can be realized utilizing FR and VR-VA schedules of reinforcement, that such schedules are completely feasible in a computer controlled situation such as the AIS, and that these gains in performance could probably be realized in a field situation as well.

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Appendix A

Example of One Unit of Task Material

Audio Amplifiers II

Power amplifiers Part 1

8 • 1 Refer to Fig. 7 • 2, the block diagram of a complete audio amplifier system. We have discussed several typical preamplifiers and drivers. The remaining amplifier stage to which we shall give our attention now is the ________ amplifier.

8 • 2 (power) Amplifiers may be single-ended or push-pull. If an amplifier is single-ended, it normally uses a single transistor in that stage. A push-pull amplifier makes use of ____ transistors.

8 • 3 (two) In Fig. 8 • 3, two transistors are employed in a single power amplifier stage. Both of these transistors contribute to the gain of the same stage. This is evidently a ________ ________ circuit since two transistors are involved in the same stage.

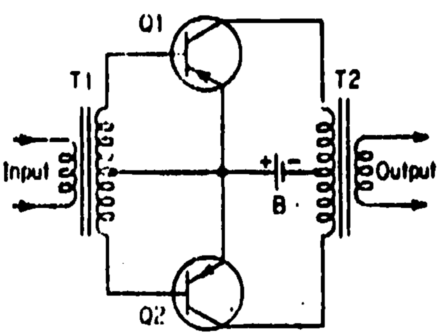

Fig 8·3

8 • 4 (push-pull) Battery *B* supplies only the collector-emitter voltage. Since there is no other battery, nor is there any network that would enable *B* to supply base-emitter bias, the system will operate under conditions of zero ________ difference between emitter and base when there is no input signal.

8 • 5 (voltage) This condition is called "zero bias." There is no forward bias on either transistor. Assuming that I_{CEO} (leakage current) is negligible, the collector current with zero signal may then be considered to be ________.

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8•6 (zero) Thus, very high efficiency is obtained because neither transistor conducts during the period when the signal is zero. With a signal applied to the primary of the input transformer, a signal of the same frequency will appear across the __________ of the input transformer.

8•7 (secondary) During signal input, the base of one transistor will be positive-going, while the base of the other transistor will be __________-going.

8•8 (negative) At the instant that the base of $Q1$ is driven negative, the base of $Q2$ will be driven __________.

8•9 (positive) For a PNP transistor, a negative base voltage is a "forward" voltage. That is, as the base is driven negative with respect to the emitter, the collector current of the transistor __________.

8•10 (increases) A positive base voltage (PNP) is a "reverse" voltage. If the collector current of a transistor is zero for no-signal conditions, applying a positive voltage to the base will not change the __________ current.

8•11 (collector) Thus, assume that the base of $Q1$ in Fig. 8•3 is driven negative while the base of $Q2$ is driven positive. For this condition, only transistor ______ will conduct in its collector circuit.

8•12 ($Q1$) When the signal reverses, then the base of $Q2$ will be made negative-going while the base of $Q1$ is positive-going. For this condition, only transistor ______ will conduct.

8•13 ($Q2$) This shows that each transistor conducts on alternate half-cycles of the input signal. The output signal is a composite of the signals from both transistors; the combination of the two signals occurs in the primary of the output transformer, identified as ______ (Fig. 8•3).

8•14 ($T2$) To obtain a picture of the total output waveform we consider the dynamic transfer characteristic for the amplifier. Figure 8•14 shows the characteristic for one of the transistors. The dynamic transfer characteristic is a graph showing the relationship between collector current and __________ __________.

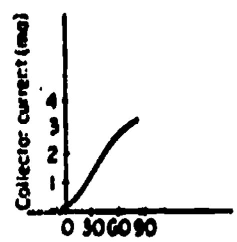

Fig. 8•14

8•15 (base current) Assuming that both transistors have identical characteristics, the total output characteristic can be obtained by placing two characteristic curves back-to-back as in Fig. 8•15. Note that the zero line of each curve is lined up vertically to reflect the fact that the bias current is ________ for no-signal conditions.

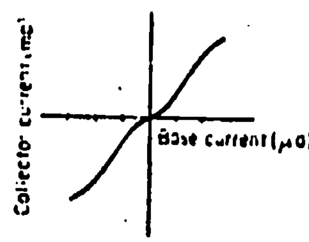

Fig. 8 15

8•16 (zero) The curves are said to be "combined" when their zero lines are thus lined up. In Fig. 8•16, the effect of an input ____________ current upon the output collector current is shown.

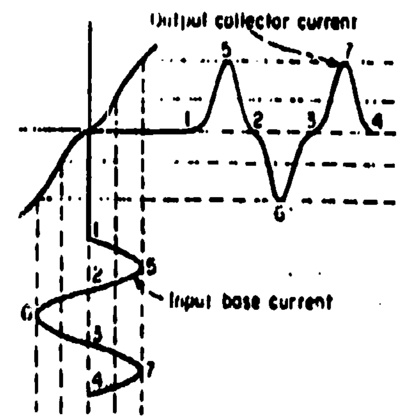

Fig. 8•16

8•17 (base) As may be seen from the curve on the vertical axis, the input base current is sinusoidal. It is projected upward on the combined characteristic, then to the right to produce the waveform of the ____________ collector current.

8•18 (output) Severe distortion occurs at the "crossover points." The crossover points are 1, 2, 3, and ______.

8•19 (4) For faithful reproduction of the input signal it is necessary to eliminate or minimize the distortion at the ____________ points.

8•19 (crossover)

8·20 To appreciate how crossover distortion is minimized, refer first to Fig. 8·20. This circuit differs from the push-pull amplifier discussed in the last section in that it contains two additional components: *R*1 and ______.

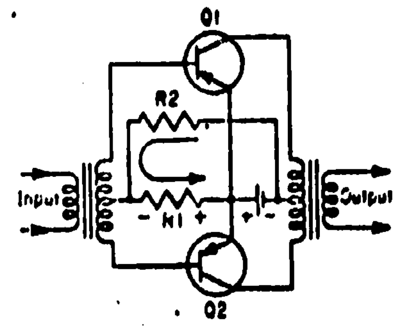

Fig. 8·20

8·21 (*R*2) *R*2 and *R*1 form a voltage divider through which current from the battery flows. The voltage drop across *R*1 has the polarity shown. This polarity is such as to make the emitters of both transistors more ____________ than the bases.

8·22 (positive) When the emitter of a PNP transistor is more positive than the base, the transistor is then operating under conditions of forward ____________.

8·23 (bias) Thus the *R*2-*R*1 voltage divider provides a small amount of forward bias for both transistors. The dynamic transfer characteristics in *uncombined* form are shown in Fig. 8·23. In this form, the two curves have been aligned so that zero base current for one is immediately above ____________ base current for the other.

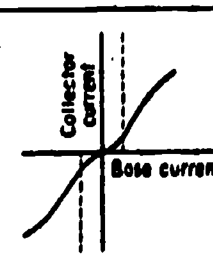

Fig. 8·23

8·24 (zero) This alignment is incorrect since, with forward bias applied, the base current of neither transistor is equal to ____________.

8·25 (zero) The base current in one transistor for zero-signal conditions is shown by the dashed line above the horizontal axis. The base current in the other transistor for zero-signal conditions is shown by the dashed line ____________ the horizontal axis (Fig. 8·23).

8·26 (below) To combine the characteristics properly, the top dashed line must be aligned with the ____________ dashed line, as shown in Fig. 8·26.

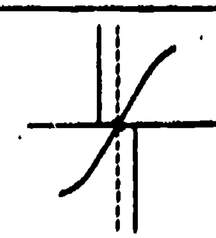

Fig. 8·26

8 · 27 (bottom *or* lower) When this is properly done, as in Fig. 8 · 26, the combined push-pull dynamic characteristic follows a reasonably ________ line as it crosses the horizontal and vertical axes at the origin.

---

8 · 28 (straight) Then, as indicated in Fig. 8 · 28, a projected input base current sinusoid gives rise to a projected output ________ current sinusoid of the same waveshape as the input.

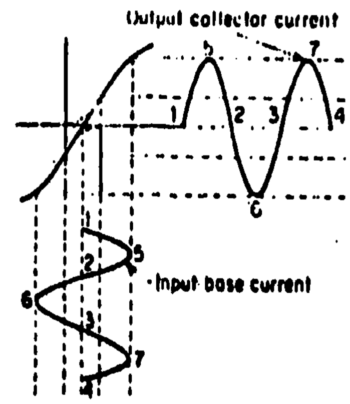

Fig. 8·28

---

8 · 29 (collector) Thus, by applying a small forward bias to the push-pull amplifier, ________ distortion is virtually eliminated.

---

8 · 30 (crossover) Figure 8 · 30 shows the effect of adding a bypass capacitor across *R*1. This capacitor is identified in the schematic as ________.

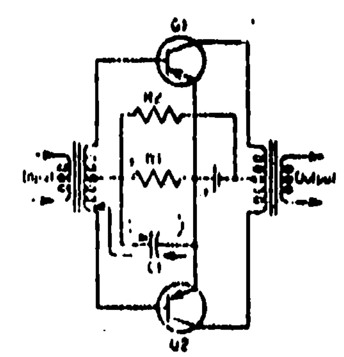

Fig. 8·30

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8 · 31 (*C*1) With a signal applied to the base of the lower transistor *Q*2, capacitor *C*1 would tend to charge through the ________-emitter junction of *Q*2, as shown by the solid arrows.

---

8 · 32 (base) This action would occur during the time that *Q*2 was conducting because of a negative-going half-cycle on its base (forward voltage). During the positive half-cycle, *C*1 would tend to discharge through ________, as shown by the dashed arrow

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8·33 . (*R1*) This discharge current would develop a voltage drop across *R1* having the polarity indicated in Fig. 8·30. This voltage drop would tend to make the base ________ with respect to emitter (for each transistor).

8·34 (positive) This is *reverse* bias which would tend to drive both transistors beyond cutoff into the class C region. Class C operation would be very undesirable because an audio amplifier operating in class C would produce severe ________.

8·35 (distortion) Thus, the use of a bypass capacitor in the circuit of Fig. 8·30 is forbidden. When the capacitor is not used, the transistors operate in class ____ since they are virtually at cutoff when there is no signal.

8·36 (B) Class B operation at audio frequencies is permissible provided that ______ transistors are used in a push-pull circuit.

8·37 (two) During class B operation, one transistor conducts for one-________ the input cycle while the other is nonconducting except for the small amount of collector current due to the forward bias used to minimize crossover distortion.

8·38 (half) In ordinary *RC* coupling to a class B push-pull stage, a certain undesirable effect occurs. Refer to Fig. 8·38. Assume that the input signal is, at a particular moment, driving the base of *Q1* in a negative direction. Since a ________-going signal has a forward effect, *Q1* will conduct.

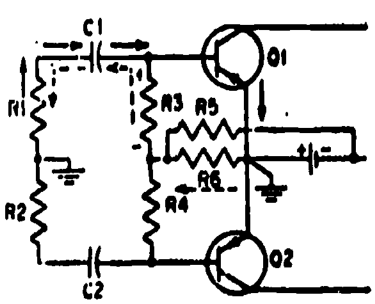

Fig. 8·38

8·39 (negative) Electrons leave the right-hand plate of *C1*, enter the base-emitter junction of *Q1*, flow down to the emitter ground connection, up from ground to the connection between *R1* and *R2*, up through ______, and back to the left-hand plate of *C1*.

8·40 (*R1*) This path is shown by the ____________-line arrows in Fig. 8·38

78

8·41 (solid) Resistor *R*1 is the output resistance of the previous stage and has a relatively low value. Since the base-emitter junction also has a low resistance, the entire charging path for *C*1 is low-resistance. This means that the time for charging *C*1 is ____________. Even if the output resistance of the previous stage were large, there is the problem of the nonlinear *RC* time constant due to the transistor's rectification-like characteristic.

8·42 (short *or* small, etc.) In a PNP transistor, the path from emitter to base for electron flow is virtually an open circuit. For *C*1 to be able to discharge through the emitter-base junction, electrons would have to flow from emitter to base. Hence, *C*1 cannot ____________ through this junction.

8·43 (discharge) The only discharge path it has is shown by the dashed arrows in Fig. 8·38. Electrons move out of the left-hand plate of *C*1, down through *R*1 to ground, up from ground at the emitter ground point, to the left through *R*6, and up through ______ to the right-hand plate of *C*1.

8·44 (*R*3) This discharge is slow because *C*1 must discharge through resistor *R*3. Normally, *R*3 is made quite __________ to avoid shunting signal currents around the base-emitter junction of *Q*1.

8·45 (large) The discharge current through *R*3 develops a voltage across *R*3 having the polarity shown in Fig. 8·38. This polarity causes the base to become ____________ with respect to the emitter.

8·46 (positive) This is *reverse* bias, causing the operating point of the transistor to move from class B toward class ______ as previously described.

8·47 (*C*) Since class C operation causes severe __________, this condition of emitter-base rectification of the signal to produce a reverse bias must be corrected.

8·48 (distortion) Rectified reverse bias can be avoided by making the circuit and component changes shown in Fig. 8·48. In this circuit, resistors *R*3 and *R*4 have been replaced by diodes *CR*1 and ______.

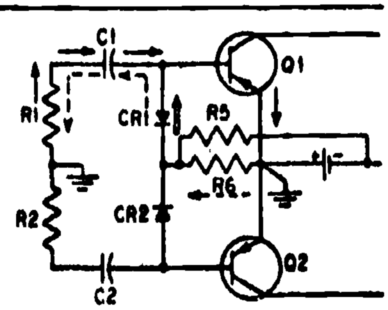

Fig. 8·48

8•49 (*CR2*) The electron conduction direction of *CR*1 is upward in Fig. 8•48. This __________ conduction direction is shown by the double arrow in the drawing.

8•50 (upward) The signal is applied to the base of *Q*1 through *C*1. Electrons flowing out of the right-hand plate of *C*1 must follow the same charge path as before (solid arrows), because the conduction direction of *CR*1 is such that it will not permit __________ to flow downward through it.

8•51 (electrons *or* current) Hence, during the conduction cycle of *Q*1, *CR*1 does not shunt out the signal and the circuit operation is normal. The discharge path is also the same as before, except that electrons now flow through *CR*1 to the right-hand plate of *C*1 instead of having to flow through a large-valued __________ as they did before.

8•52 (resistor) *CR*1 is fully conductive for the discharge electrons. As such, it represents an extremely ______ resistance.

8•53 (low) *C*1 is now discharging, therefore, through a very low-valued resistance. Hence, its discharge time is correspondingly __________.

8•54 (short *or* small, etc.) Thus, *C*1 charges *and* discharges rapidly in the circuit of Fig. 8•48. This makes it impossible for a reverse-bias charge to build up on *C*1. Also, since *CR*1 has negligible resistance in the discharge direction, the voltage developed across it is very __________.

8•55 (small) Hence, the base always has a small forward bias because of the *R*5-*R*6 voltage divider, and the circuit can operate in class ______ without developing a reverse bias that could drive it into class C.

8•55 (B) TEST 233

Appendix B

Example of One Single Unit Test

(corresponds to task material in Appendix A)

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Transistor Test 233

Name________________________________

Date__________________________

1. In the push-pull circuit of Fig. 8-3, one reason for high-power efficiency is that:
   a. The CE configuration is used.
   b. A small forward bias is used.
   c. Each transistor conducts on different cycles of the input signal.
   d. There is no collector current with no input signal.
2. Crossover distortion occurs because:
   a. The combined dynamic transfer curve has its greatest nonlinearity at zero base current.
   b. The input signal is most distorted when it is at zero.
   c. Switching from one transistor to another introduces distortion.
   d. The transistors are overdriven at the crossover points.
3. In the push-pull amplifier of Fig. 8-20, there would be a reduced power efficiency because:
   a. There will be collector current flow in both transistors even with no input signal.
   b. There will be collector current flow in one transistor even with no input signal.
   c. There is voltage divider action by R1-R2.
   d. The emitter resistor is unbypassed.
4. In Fig. 8-38, C2 discharges through a. R1, R6, and R3 b. R4 and R6 c. R2 and R4 d. R2, R6, and R4.
5. In Fig. 8-48, capacitor discharge current flowing through R6 does not reverse the bias because:
   a. The capacitor discharges slowly.
   b. It is flowing in the wrong direction for bias reversal.
   c. The diode shunts R6.
   d. The battery current through the resistor is larger.

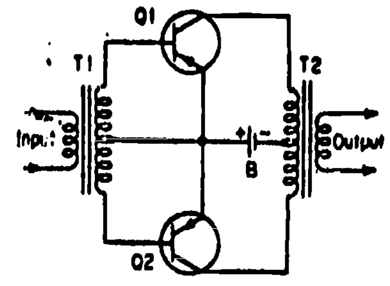


Fig. 8-3

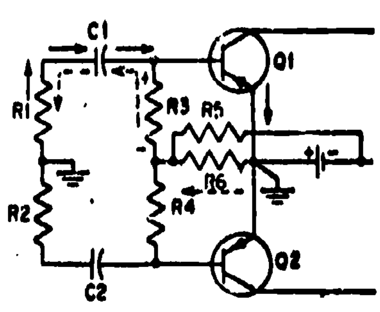


Fig. 8-38

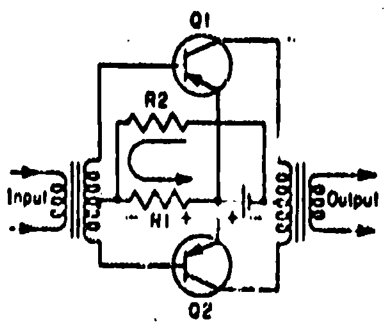


Fig. 8-20

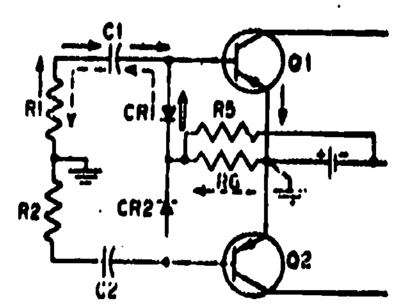


Fig. 8-48

Appendix C

Arithmetic Test

ARITHMETIC

Name ____________________

Date ____________________

Answer the following questions in the blanks provided.

1. 100 + 120 = ________
2. 50 - 20 = ________
3.
```
  - 100
  + 150
  -----
```
4.
```
  +  75
  - 175
  -----
```
5. 10 ÷ 2 = ________
6. 10 ÷ 3 = ________
7. 18 ÷ 6 = ________
8. 190 ÷ 21 = ________
9. 14/7 = ________
10. 30 X 1/2 = ________
11. 18 X 1/3 = ________
12. 8 ÷ 1/2 = ________
13. 10 ÷ 1/3 = ________
14. 8 X 4.5 = ________
15. 16 X 3.1 = ________
16. 4.12 X .02 = ________
17. 3.28 X 1.021 = ________
18. 12 X .0005 = ________
19. 40 X .03 = ________

20. $4^2 =$ __________

21. $10^5 =$ __________

22. $10^{-3} =$ __________

23. $2.56 \times 10^3 =$ __________

24. $.31 \times 10^{-6} =$ __________

Consider the following equation.

$$H = \frac{S_1 \times S_2}{r^2}$$

a. If $S_1 = 10$, $S_2 = 5$, $r = 25$, what is H? __________

b. If $S_1 = 5.5$, $S_2 = 6.1$, $r = 10$, what is H? __________

c. If H is 5, $S_1 = 10$, $r = .3$, what is S_2? __________

Appendix D

Electricity-Electronics Test

ELECTRICITY & ELECTRONICS

Name______________________

Date______________________

1. Describe Coulomb's law of electric charges.

2. What 3 factors influence the resistance in a conductor?

3. Describe Ohm's law.

4. Identify each of the following symbols.

a.  ______________________

b.  ______________________

c.  ______________________

d.  ______________________

e.  ______________________

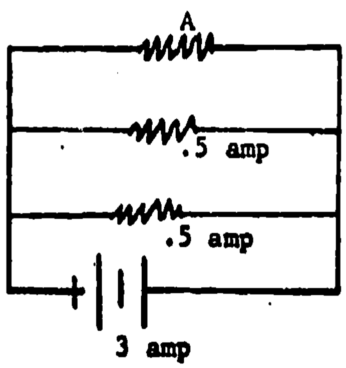
f.  ______________________

g. 

____

5. Define parallel circuits.

6. In the diagram below, what is the current at point A? Why?



7. Which was does the current flow in the diagram in question 6? Why?

8. Define the following electronics terms:

a. diode

b. triode

c. transducer

d. class B amplifier

e. rectify

Appendix E

Personal Reactions Questionnaire

PART I

Directions: Each of the 8 items below has two statements. Circle the one statement of the two which you feel is most true.

1. a. Without the right breaks one cannot be an effective leader.

   b. Capable people who fail to become leaders have not taken advantage of their opportunities.

2. a. Becoming a success is a matter of hard work, luck has little or nothing to do with it.

   b. Getting a good job depends mainly on being in the right place at the right time.

3. a. The average citizen can have an influence in government decisions.

   b. This world is run by the few people in power, and there is not much the little guy can do about it.

4. a. In my case getting what I want has little or nothing to do with luck.

   b. Many times we might just as well decide what to do by flipping a coin.

5. a. Who gets to be the boss often depends on who was lucky enough to be in the right place first.

   b. Getting people to do the right thing depends upon ability, luck has little or nothing to do with it.

6. a. As far as world affairs are concerned, most of us are the victims of forces we can neither understand, nor control.

   b. By taking an active part in political and social affairs the people can control world events.

7. a. Many times I feel that I have little influence over the things that happen to me.

   b. It is impossible for me to believe that chance or luck plays an important role in my life.

8. a. What happens to me is my own doing.

   b. Most of the time I can't understand why politicians behave the way they do.

PART II

1. Circle the number that best describes how much you need the money that you will earn on this job. You can circle any one of the numbers. For example, if you feel you are in between the statement in number 5 and the statement in number 7, circle number 6.

   9. I <u>desperately</u> need the money I will make from this job.
   8.
   7. I <u>very much</u> need the money I will make from this job.
   6.
   5. I <u>could use</u> the money, but I don't really need it very badly.
   4.
   3. I <u>really don't need</u> the money I will make from this job.
   2.
   1. I <u>really don't care at all</u> about the money I will make.

2. If you were paid $2.00 per hour on a job that lasted all summer, what would be the maximum number of hours that you would be willing to work per week. (Answer as if you had nothing else to do such as summer school, another job, etc.)

   1. 1-10 hours per week
   2. 11-20 hours per week
   3. 21-30 hours per week
   4. 31-40 hours per week
   5. 41-50 hours per week
   6. 51-60 hours per week
   7. 61-70 hours per week

3. On a job like this I think I: (Circle any number as in first question above)

   1. should not work very hard
   2.
   3. should put in some effort, but not too much
   4.
   5. should put in an average level of effort
   6.
   7. should work fairly hard
   8.
   9. should work very hard

PART III

Directions: In the 7 questions below indicate whether you agree or disagree with the statement by checking one of the spaces.

SA means Strongly agree
A means Agree
N means Neutral - don't agree or disagree
D means Disagree
SD means Strongly Disagree

	SA	A	N	D	SD
1. There are few satisfactions equal to the realization that one has done his best at a job.	___	___	___	___	___
2. Most people who don't succeed in life are just plain lazy.	___	___	___	___	___
3. Any man who is able and willing to work hard has a good chance of succeeding.	___	___	___	___	___
4. People who fail at a job have usually not tried hard enough.	___	___	___	___	___
5. Hard work offers little guarantee of success.	___	___	___	___	___
6. The man who can approach an unpleasant task with enthusiasm is the man who gets ahead.	___	___	___	___	___
7. If one works hard enough he is likely to make a good life for himself.	___	___	___	___	___

Appendix F

Bi-Weekly Reactions Questionnaire

PART I

Ask yourself: How satisfied am I with this aspect of my job this week?
VS means I am very satisfied with this aspect of my job.
S means I am satisfied with this aspect of my job.
N means I can't decide whether I am satisfied or not with this aspect of my job.
DS means I am dissatisfied with this aspect of my job.
VDS means I am very dissatisfied with this aspect of my job.

On my present job, this is how I feel about:	VDS	DS	N	S	VS
1. Being able to keep busy all the time.	___	___	___	___	___
2. The chance to work alone on the job.	___	___	___	___	___
3. The chance to do different things from time to time.	___	___	___	___	___
4. The way my boss handles his men.	___	___	___	___	___
5. The competence of my supervisor in making decisions.	___	___	___	___	___
6. The chance to do things for other people.	___	___	___	___	___
7. The chance to tell people what to do.	___	___	___	___	___
8. The chance to do something that makes use of my abilities.	___	___	___	___	___
9. The way company policies are put into practice.	___	___	___	___	___
10. My pay and the amount of work I do.	___	___	___	___	___
11. The freedom to use my own judgment.	___	___	___	___	___
12. The chance to try my own methods of doing the job.	___	___	___	___	___
13. The working conditions.	___	___	___	___	___
14. The way my co-workers get along with each other.	___	___	___	___	___
15. The praise I get for doing a good job.	___	___	___	___	___
16. The feeling of accomplishment I get from the job.	___	___	___	___	___

PART II

Circle the number that best describes your feelings <u>this week</u>. Circle any number. If you feel you are, for example, between the statement in number 7 and the statement in number 5, circle number 6.

1. The way I'm paid on this job makes the job:

    9. Much more interesting

    8.

    7. More interesting

    6.

    5. Neither more nor less interesting

    4.

    3. Less interesting

    2.

    1. Much less interesting

2. The way I'm paid on this job makes me want to work harder:

    1. Strongly disagree

    2.

    3. Disagree

    4.

    5. Neutral

    6.

    7. Agree

    8.

    9. Strongly agree

3. On this job I am working:

    9. As hard as I possibly can

    8.

    7. Fairly hard, but not killing myself

    6.

    5. About average

    4.

    3. Not very hard

    2.

    1. I am taking it easy

4. If you are just putting an average amount of effort on this job and then you really start putting in your maximum effort,

1. You will earn less money
2.
3. You will not earn any more money
4.
5. You will earn a little more money
6.
7. You will earn considerably more money
8.
9. You will earn a great deal more money

5. If you are putting in an average amount of effort on this job and then you really start putting in your maximum effort,

1. You will finish less material
2.
3. You will not finish any more material
4.
5. You will finish a little more material
6.
7. You will finish considerably more material
8.
9. You will finish a great deal more material

6. If you are finishing an average number of tests per day and then you start finishing a large number of tests per day,

1. You will earn less money
2.
3. You will not earn any more money
4.
5. You will earn a little more money
6.
7. You will earn considerably more money
8.
9. You will earn a great deal more money

PART III

When answering the 6 questions below, think only about how you feel about the job during this week.

1. On this job, the more effort I put in (the harder I work) the more material I can get thru in a day.

   9. Strongly agree
   8.
   7. Agree
   6.
   5. Don't agree or disagree
   4.
   3. Disagree
   2.
   1. Strongly disagree

2. The more material I can get thru in a day the more money I make.

   9. Strongly
   8.
   7. Agree
   6.
   5. Don't agree or disagree
   4.
   3. Disagree
   2.
   1. Strongly disagree

3. The more effort I put in (the harder I work) the more money I make.

   9. Strongly agree
   8.
   7. Agree
   6.
   5. Don't agree or disagree
   4.
   3. Disagree
   2.
   1. Strongly disagree

Answer the next question on <u>Monday's</u> <u>only</u>:

10. During the coming week I expect to earn about _______ dollars.

10a. I feel that this amount of money is:

1. Not very attractive to me
2.
3. Somewhat attractive to me
4.
5. Fairly attractive to me
6.
7. Quite attractive to me
8.
9. Extremely attractive to me

Answer the next question on <u>Fridays</u> <u>only</u>:

11. During the last week I earned about _______ dollars.

11a. I feel that this amount of money is:

1. Not very attractive to me
2.
3. Somewhat attractive to me
4.
5. Fairly attractive to me
6.
7. Quite attractive to me
8.
9. Extremely attractive to me

12. This job manipulates me and the other workers:

1. Strongly agree
2.
3. Agree
4.
5. Neutral
6.
7. Disagree
8.
9. Strongly disagree

4. In terms of the total amount of effort I could put in on this job, I am putting in about:

1. 10% effort
2. 20% effort
3. 30% effort
4. 40% effort
5. 50% effort
6. 60% effort
7. 70% effort
8. 80% effort
9. 90% effort

5. Compared to what the other guys are getting paid for what they do:

1. I'm getting <u>far</u> <u>less</u> money than I should
2.
3. I'm getting <u>less</u> than I should
4.
5. I'm getting paid about right
6.
7. I'm getting <u>more</u> than I should
8.
9. I'm getting <u>far</u> <u>more</u> than I should

6. When I compare how much I do on this job with how much I get out of it, I feel:

9. Highly overpaid
8.
7. Overpaid
6.
5. Paid about right
4.
3. Underpaid
2.
1. Highly underpaid

7. On this job, I feel that I have control over what I do and when I do it:

9. Strongly agree
8.
7. Agree
6.
5. Neutral
4.
3. Disagree
2.
1. Strongly disagree

8. This job dictates everything I do and how I do it:

1. Strongly agree
2.
3. Agree
4.
5. Neutral
6.
7. Disagree
8.
9. Strongly disagree

9. I find this job interesting.

9. Strongly agree
8.
7. Agree
6.
5. Neutral
4.
3. Disagree
2.
1. Strongly disagree