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THE CONTINUOUS PERFORMANCE TEST:

EXPLORATORY STUDIES

COMPARING SCHEDULES OF REINFORCEMENT

A thesis presented in partial fulfillment of
the requirements for the degree of
Master of Science in Psychology
with an endorsement in Clinical Psychology
at Massey University

GERALD ALEXANDER

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ABSTRACT

The first study was designed to demonstrate that Continuous Performance Test responding was subject to reinforcement effects. A version of the CPT which requires detection of a target stimulus which had been preceded by another, and which required subjects to respond on one key to target stimuli and on another to all other stimuli was used. Responding during baseline was compared with conditions where correct responses to target stimuli were reinforced and all correct responses were reinforced for four intellectually handicapped subjects using an ABCBA design. The results demonstrated a rise in impulsivity with reinforcement delivery. The overall results although weak showed that reinforcement did alter behaviour on the CPT and reinforcing correct responding on both keys was better than just reinforcing correct responding on one key, in terms of accuracy, time on-task and efficiency. Experiment II used a version of the CPT which requires detection of a target stimulus, and which required subjects to respond on one key to target stimulus and on another to all other stimuli. To reduce anticipatory responding impulsivity was redefined by dramatically shortening the period of time available for impulsive responses to occur. Two intermittent schedules were compared to explore the capabilities of the CPT as a research tool to compare between schedules of reinforcement. An alternating treatments design, with baseline being one of the treatment conditions, was used with four intellectually handicapped subjects. The results, though weak, were able to show a difference in performance under the schedules. As predicted, impulsivity was low. There were indications for the potential of developing the CPT as a research tool. Suggestions for further research were offered.

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CHAPTER 1

OVERVIEW

One of the general problems faced by the intellectually handicapped and their supervisors is finding the appropriate reinforcement schedule to implement in field settings, like sheltered workshops. Suitable reinforcement schedules will enhance appropriate responding and set the stage for learning to occur. Such schedules of reinforcement also help the setting to meet job contracts. For example, packing Weetbix for a local health food company. The adequate completion of a contract by the due date often carries with it financial rewards, and the promise of further contracts so necessary for the running of such sheltered workshops.

Typically schedules of reinforcement have been studied in experimental laboratories using animals as subjects. The experimental chamber does not necessarily replicate the conditions existent in the real world setting. Jobs like packing marbles and selecting out flawed ones require among other things sustained attention, discrimination and selection, capabilities which while they may be required are not necessarily measured in the animal laboratory. There seems to be a need for an experimental task which has the accuracy of measurement of laboratory methodology but more directly parallels the type of jobs carried out by dysfunctional populations in sheltered workshop settings. Such an experimental task could be used in these settings and could measure the different aspects of performance above. This would allow the assessment of the effects of different schedules of reinforcement on different parameters of performance. However, there are few techniques available for conducting such research in the field.

The Continuous Performance Test (CPT) has the potential to be such a research tool in natural settings. The CPT is a short duration vigilance task. The subject is required to monitor continuously and to report signals whenever they occur. The development of the CPT as a tool for comparing different schedules of reinforcement needs to address three questions. The first, the sensitivity of CPT performance to reinforcement effects overall. Second, the accuracy of performance and third, the effects on the total number of responses emitted (total duration on-task). The CPT should also include the addition of a requirement to report non-signals (second response key) to aid in the objective recording of on-task behaviour, as not only correctness of responding but amount of responding are important measures for dysfunctional populations. If reinforcement made available for correct responding either on one or on both keys does improve performance, the CPT can then be used to compare different schedules of reinforcement.

Therefore, the aim of this research was to conduct exploratory studies on the CPT in order to generate a new methodology using the CPT as a research tool for comparing between schedules of reinforcement in the field.

CHAPTER 2

INTRODUCTION I:

The Continuous Performance Test As a Research Tool

Reinforcement Schedules in Industrial, Organizational and Experimental Psychology.

Thorndike's Law of Effect (1911) emerged from experiments with animals in problem boxes, from which the food deprived animals could escape by operating an appropriate device that released the door. Thorndike noted that, with repetition, the animal operated the device sooner after being placed in the box. This law went through many revisions but its essence is that responses can be made more probable by some consequences and less probable by others. Out of this has developed a principle of reinforcement which states that increases in performance can be obtained if valued rewards are made contingent on the performance.

The reinforcement principle is clearly articulated in the industrial and organizational area by the current emphasis on expectancy-valence models of motivation (e.g., Georgopoulus, Mahoney and Jones, 1957; Vroom, 1964; Porter and Lawler, 1968; Mitchell and Biglan, 1971; Dachler and Mobley, 1973; Campbell and Pritchard, 1975). There are three basic components in these models:- (1) the action has a high probability of leading to an outcome (expectancy); (2) that outcomes will yield other outcomes (instrumentality); and (3) those other outcomes are valued (valence). These models thus emphasize the establishment of performance-reward contingencies as well as indirectly suggesting that performance will be maximized when every response is reinforced. That is, continuous reinforcement of performance (Pritchard, Leonard, Von Bergen Jr.,and Kirk, 1976).

In contrast, the experimental psychology literature suggests that performance will be maximized under conditions where the performance-reward relationship is not perfectly contiguous. That is, partial or intermittent reinforcement of performance. Within the operant conditioning literature performance under a variety of such intermittent schedules of reinforcement has been extensively analysed (e.g., Skinner, 1938; Ferster and Skinner, 1957; Reese, 1966; Reynolds, 1968).

The chief criticism of the research on intermittent schedules of reinforcement is that most of the studies have been done with animal subjects and the question often arises as to whether results can be generalized to human behaviour. There is, however, increasing supportive research emerging which suggests that humans may, in certain circumstances, react in a similar manner to animals when responding to different schedules of reinforcement. For example, similar patterns of behaviour have been noticed between animal and human responding on complex schedules (Fattu, Mach and Auble, 1955; Verplank, 1956; Bijou, 1957a and b; Bijou, 1958; Brackbill 1958; Long, Hanmack, May and Campbell, 1958 ; Orlando and Bijou, 1960), and when responding to Fixed Ratio(FR) schedules (Mariott, 1957; Lawler, 1971). Similar responding between animals and humans has also been noted by Catania and Cutts (1963). They looked at concurrent schedule performance of both pigeons and humans. Using pigeons, pecking was maintained on two keys by a concurrent Variable Interval (VI)1-min VI 2-min schedule. Then the reinforcement for the VI 2-min key was discontinued (extinction). The pigeon continued pecking at a steady though somewhat reduced rate on the extinction key throughout the 12 1-hour sessions. Similar results were obtained from 13 human subjects pressing two buttons on a concurrent VI 30-sec Extinction (Ext) schedule. Most of the subjects responded at a substantial rate on the button associated with extinction. Although never explicitly reinforced, responses on that button often occurred in close temporal proximity to reinforcement for the other button thus showing control of one response by the schedule for another.

Catania and Cutts (1963) also looked at the effect a changeover delay (COD) had on concurrent schedule responding. The COD insures a separation in time between response A and the reinforcement of response B , thus preventing adventitious reinforcement of AB sequences (Hernstein, 1961). With the introduction of a 1 second COD for the pigeons on the concurrent schedule, when the schedule for one key changed to extinction, responding on the extinction key rapidly declined to zero. Without the COD, responding on the extinction key continued at a steady rate. In the human experiment the introduction of a COD between 2 and 15 seconds in duration substantially reduced, and in many cases eliminated, responding on the extinction key.

According to the matching law (Hernstein, 1970) the relative frequency of a response will match the relative frequency of the reinforcers produced by that response. Although this law developed from animal studies, Schroeder and Holland (1969) confirmed response-matching in human subjects. They monitored eye-movements for pointer deflections which were delivered to two left-hand dials on a variable-time (VT) schedule and to two right-hand dials on a second, independent VT schedule, with a 2.5 second COD for one subject and 1 second CODs for the others. All six subjects in the experiment matched relative scanning eye movement rates (number of fixations per minute) on each side to the relative signal frequencies on each schedule.

Thus, the experimental literature clearly shows that partial or intermittent schedules of reinforcement have a greater effect on performance than continuous reinforcement. Moreover, applied research using human subjects has tended to support the notion that partial reinforcement is superior to continuous reinforcement in a variety of settings (e.g., see Yukl, Wexley, and Seymore, 1972).

Choice of the research tool

In the therapeutic setting the emphasis might be on the training, rehabilitation, and education of client groups such as chronic psychiatric patients, the mentally retarded and delinquents. Such application of techniques from the experimental literature to the industrial/organizational field, commonly found in some therapeutic settings, offers much scope for the maximizing of gains for the clients and the optimizing of profits for the setting.

Such settings as sheltered workshops make use of reinforcement schedules not only on an individual basis but also on a group basis to enhance appropriate behaviours of their trainees. Implementing such reinforcement programmes on a group basis has been made possible by the use of token economy systems (Kazdin, 1982).

There are several key parameters that may govern the choice of appropriate reinforcement schedules for such purposes. For example, keeping the client engaged for an extended period on an appropriate task might be of paramount importance. More time spent on-task would not only enhance learning of the target skills by the client but also aid in the smoother running of the setting. Sensitivity to the rate of reinforcement might be another parameter to consider. If a particular schedule of reinforcement evokes an immediate response this may or may not be preferred, depending on the situation, to one which evokes a delayed response. Thus each situation calls for its appropriate schedule of reinforcement. For example, if the setting has a job contract to fulfil within a short period of time, a particular reinforcement schedule which evokes immediate responding of the clients would be desirable. Yet another parameter to consider would be accuracy of responding. A schedule which evokes accurate responding would be preferred to one which evokes less accurate responding.

Accuracy in performance not only aids the setting in getting the job done well, but also aids the clients by increasing their self esteem.

In summary, useful parameters to look at in the choice of appropriate reinforcement schedules would include the time spent on-task, sensitivity to the rate of reinforcement and the accuracy of performance.

Fortunately, there is a research tool available that has the potential to measure these parameters. This is the Continuous Performance Test (CPT), developed by Rosvold, Mirsky, Saranson, Bransome and Beck(1956).

Characteristics of the CPT

Sustained attention is a behavioural construct and thus cannot be directly measured, but must be inferred from other data. The vigilance task has been regarded as providing "the fundamental paradigm for defining sustained attention as a behavioural category" (Jerison, 1977, p.29). A characteristic of vigilance performance is the vigilance decrement, which is a reliable drop in the average number of correct responses as the vigil progresses (e.g., see Mackworth, 1950).

In the study of sustained attention, the test most frequently used in research on a wide spectrum of populations, including hyperactive, learning-disabled and brain-damaged children has been the CPT, a short duration cognitive vigilance task (Davies and Parasuraman, 1982).

Analyses of performance over time have seldom been reported on the CPT. Thus it is not clear if a vigilance decrement reliably occurs on this test.

The CPT involves a task which is experimenter-paced. That is, it is the experimenter rather than the subject who controls the arrival and duration of task stimuli (typically letters or digits) . The subject is required to monitor, either visually or aurally, previously specified stimuli or signals, and to respond to these whenever they occur, usually by pressing a key. This task thus requires the subject to sustain his or her attention for the duration of the session in order to maximize detection. Presentation of the signals is unpredictable and momentary lapses of attention show up as a performance decrement.

A wide variety of response indices have been employed as measures of sustained attention including: signals detected (hits), response to non-signals (false alarms or errors of commission), missed signals (misses or errors of omission) and a variety of signal detection measures.

The CPT typically involves the presentation of a quasi-random series of visual/auditory stimuli at a fixed and rapid pace (typically one every 1 to 2 seconds) and with exposure times being brief (100 to 200ms. range) (O'Dougherty, Nuechterlein and Dew, 1984). There are two versions of the CPT both described by Rosvold et al. (1956). In the simpler version the detection of one specified stimulus (e.g., "A") is indicated by pressing a key. All other stimuli are meant to be ignored. In the difficult version of the CPT, the subject is required to detect one specified stimulus (e.g., "X") which has been preceded by another stimulus (e.g., "A"), and press a key. All other combinations are meant to be ignored.

History of the CPT :- Beginnings

The CPT had its beginnings in electro-encephalographic research on alertness or sustained attention (Rosvold et al., 1956). It was noted that the electro-encephalograms (EEG's) of working brain damaged patients were quite similar to those from the brain of a sleeping subject (Lindsley, 1944, cited in Rosvold et al., 1956), especially in terms of hypersynchronous (high amplitude) activity. Rosvold and his colleagues also noted that the traditional measures of attention or alertness, such as the digit span and the digit substitution subtests of the Wechsler - Bellevue, had not shown a reliable decline in performance following brain damage (e.g., Mettler, 1952; Partridge, 1950; Petrie, 1952; all cited in Rosvold et al., 1956). It was argued that for those patients who showed intermittent bursts of high amplitude EEG activity, and hence only momentary lapses in attention, had inconsistent results on these traditional measures because the subjects could, to a great extent, choose their own time to respond, and so reorganize their attention between momentary lapses. It was felt that these lapses would not have affected the score to any measurable degree.

These considerations suggested to Rosvold and his colleagues that any test which would require a high level of continuous attention over an appreciable interval of time, and which would not allow subjects to choose their own time to respond, might reflect a deficit in performance that other procedures would have missed. The pioneering work by Rosvold et al. (1956) indicated that brain damaged individuals performed poorly relative to non-brain damaged controls on the simpler version of the CPT, and, even more poorly on the difficult version of the CPT.

Signal Detection Analysis of the CPT

Based on the theory of signal detection (Green and Swets, 1966), Rutschmann, Cornblatt and Erlenmeyer-Kimling introduced signal detection analysis of the performance on the CPT in 1977. This method of analysis helped differentiate between two components of sustained attention, one based on the concept of attentiveness or sensitivity (d′), and the other based on a subject′s willingness to report an event as a signal, that is , response bias (β). Sensitivity refers to the distance between the means of a hypothetical noise distribution and a signal plus noise distribution. Response bias refers to the subject′s willingness to respond that a signal has occurred and therefore represents the degree of cautiousness expressed by the subject. Signal detection analysis provides a method for assessing sensitivity (or attentiveness) that is relatively independent of the potential confounding effects of response bias (Green and Swets, 1966). Such an analysis not only takes into account the subject's hit rate but also the subject's false alarm rate (errors). When signal events are to be discriminated from noise events with less than complete certainty, hit rate is some function of false alarm rate. Thus, in general, a high hit rate will be accompanied by a high false alarm rate (risky decision criterion, low β), and conversely a low hit rate will be accompanied by a low false alarm rate (conservative decision criterion, high β). These signal detection variables (d' and β) apply not only to the analysis of performance on the CPT but also to other vigilance tasks as well. On long vigils, d' decrements over time have been related to the requirements of continuous visual fixation (Loeb and Binford, 1968), high event rates and successive discriminations (Parasuraman, 1979). On the other hand, decision bias changes (β) can be influenced by many factors. For example, the administration of barbiturates (Hink, Fenton, Tinklenberg, Pfefferbaurn and Kopell, 1978), and expectancy effects (Baddley and Colquhorun, 1969).

CPT studies

Since the introduction of the CPT in 1956 it has been widely used. It has been found that learning disabled children display lower accuracy on the CPT (Anderson, Halcomb and Doyle, 1973; Keogh and Margolis, 1976, Aman, 1979) and that they make more errors of omission and commission than normal children (Dainer, Klorman, Salzman, Hess and Davidson, 1981). Swanson (1981) examined children with learning disabilities and found that there was impairment in overall perceptual sensitivity level but found no difference in decision criterion or in perceptual sensitivity decrement over time in comparison to normal (control) children.

Hyperkinetic children showed that they were less accurate than controls on the CPT (Sykes, Douglas and Morgenstern, 1972; Sroufe, 1975; Busby and Broughton, 1983). The CPT has been used to differentiate hyperactive children from normal children (Douglas, 1972). Impulsive errors (responding prematurely) have been found to occur at substantially higher rates among hyperactive children than controls on the CPT (Sykes, 1969; Sykes, Douglas, Weiss and Minde, 1971; Sykes, Douglas and Morganstern, 1972, 1973). But the performance of the hyperactive children was not as impaired as that of the brain-damaged and centrencephalic epileptic children studied by Rosvold et al. (1956) and Fedio and Mirsky (1969). Sostek, Buchabaun, and Rapoport, (1980) studied hyperactive children and found that they had a significantly lower perceptual sensitivity (d′) level than did normal children on a form of the CPT that increased the stimulus presentation rate after each hit and decreased it after each false alarm. Unfortunately they did not report whether this decrement in signal discrimination level was accompanied by significantly greater sensitivity decrement over time (i.e., sustained attention deficit).

The CPT was administered to a group of children considered at risk for the eventual manifestation of schizophrenia and to a group of "normal" children. The high risk group performed the worst (Rutschmann, Cornblatt and Erlenmeyer-Kimling, 1977). Nuechterlein (1983) compared children of schizophrenic mothers, with hyperactive children and with children of non-psychotic, psychiatrically disordered mothers. It was found that whereas a disproportionally large sub-group of children at risk for schizophrenia displayed a deficit in perceptual sensitivity level, the hyperactive children's vigilance performance was characterized by low impulsivity (low β). With respect to the performance of the schizophrenic patients themselves on the CPT, it was found that the response errors were significantly greater for at least some types of schizophrenic patients than in other psychiatric patients (Kornetsky and Mirsky, 1966; Orzock and Kornetsky, 1966; Kornetsky, 1972).

In summary it can be seen that the CPT has been extensively used to help in the assessment of children suffering from learning disabilities, hyperactivity, and those at risk for schizophrenia.

The CPT has also been used to assess the effects of sleep deprivation and of various drugs (Mirsky and Cardon, 1962). In one typical study it was found that 68 hours of sleep deprivation and a 200mg dose of the drug chlorpromazine both produced considerable impairment in performance, which approached the level found in patients with epileptic foci in the mesodiencephalic reticular formation (Davies and Parasuraman, 1982). CPT performance has proved sensitive to other drug effects, especially those of amphetamine (Rapoport, Buchsbaun, Zahn, Weingartner, Ludlow and Mikkelsen, 1978). In one study, employing 12 hyperactive boys, performance on the CPT showed significant improvements during amphetamine treatment. Fewer commission and omission errors were made on the CPT during administration of medication (Porrino, Rapoport, Behar, Ismond, and Bunny, 1983).

Dextroamphetamine was found to be effective in reducing the number of total errors on the CPT for a 9 year old male who was classed as being a delinquent, distractible and hyperactive boy. (Horn, Chatoor and Conners, 1983).Rapoport, Buchsbaum, Weingartner, Zahn, Ludlow and Mikkelsen (1980) also reported that dextroamphetamine enhanced performance on the CPT to a significant level in both hyperactive and normal subjects. Although highly sedative, amitriptyline, a tricyclic antidepressant drug, has been found to facilitate performance on the CPT measure of attention for behaviourally disordered children (Yepes, Balka, Winsberg, and Bialer, 1977).

Using the CPT, Alexander (1973) compared the performance of hospital patients with organic senile dementia with patients in whom brain damage had not been diagnosed, and a group of non-hospitalized subjects. He found that the senile dementia group detected significantly fewer signals than did the control groups and that subjects in this group were also the only ones to make more errors of commission than omission. The CPT has also been used to measure sustained attention in adults who had not sustained brain damage and it was found that CPT errors were highly correlated with age. Older subjects performed worse on the CPT than younger subjects (Kupietz and Richardson, 1978; Canestrari, 1962; Davies and Davies, 1975).

Another area where the CPT has been used is with children with Attention Deficit Disorder(ADD) (e.g., see Cantwell, 1972). The performance on the CPT of normal children was compared to that of ADD children and it was found that the ADD children performed less accurately. It was concluded that the clinical group's poor performance was a symptom of generalized behavioural problems that appeared as inattentiveness and distractibility in other settings (Sykes, Douglas and Morgenstern, 1973).

Clear developmental trends had been shown in studies of selectivity and inhibition using the CPT with normal children, but no age normative data had been described. (Campbell, Douglas and Morgenstern, 1971; Conners and Rothschild, 1968; Sykes et al., 1971; Rutschmann, Cornblath and Erlenmeyer-Kimling, 1977). However, a study by Levy (1980) demonstrated a clear development in capacity for sustained attention in normal children between 4 and 6 years.

A study carried out by Swanson (1983) compared the CPT performance of children having specific reading disability with that of normal readers of the same chronological ages. It was found that the reading-disabled subjects made fewer correct detections and made more false alarms than the control group at each age level and they also showed lower sensitivity (d′) and a more conservative criterion (higher β). For both disabled and normal readers, the decision criterion changed with time on task but sensitivity was relatively unaffected.

In a study carried out by Klee and Garfinkel (1983), the CPT was considered a brief, engaging task that could be applied to a clinical population in the preadolescent age range. It appeared to measure inattention and impulsivity in a global way comparable to, but not exactly the same as, the Kagan Matching Familiar Figures Test - children's version (MFFT); and the Wechsler Intelligence Scale for Children- Revised (WISC-R) coding and arithmetic subtest. Further it appeared related to the child care worker's rating of the child's behaviour.

Retarded children exhibit attentional deficits very similar in nature to those shown by hyperactive children. For example, several studies using the CPT (e.g., Crosby, 1972) and other tests (e.g., Flick, 1970; Semmel, 1965; Terdal, 1967) have reported that retarded children are less able to sustain attention than normal IQ children. Furthermore, one review paper (Heal and Johnson, 1970) has concluded that retarded children show heightened impulsivity as well. It should be noted that Zeaman and House (1963) hypothesized on the basis of extensive, carefully gathered evidence, that retardates are much slower than normals to start learning discrimination tasks, because they fail to selectively attend to the relevant features or dimensions of the discrimination. Thus, on the CPT, since they are required to discriminate between target and non-target stimuli, they would be expected to perform poorly.

In summary, this short review of the literature shows that the CPT has been used in a variety of settings and with a variety of subject populations. It has been shown to be useful in assessing a wide range of behavioural, pharmacological, developmental and psychiatric problems. Populations manifesting these problems often show deficits in performance on the CPT compared to normals. It appears that the CPT might be of use in therapeutic settings where such dysfunctional populations are present.

Motivation Studies done with CPT

To develop the CPT as a research tool, which can be used to compare between schedules of reinforcement, it is necessary to show that performance on the CPT can be modified with motivational changes, such as the availability of reinforcement for correct responding. The typical vigilance situation, where attention has to be sustained in order to detect the signals, provides little intrinsic motivation because it is so monotonous, although Smith (1966) suggests that the manipulation of task characteristics such as signal frequency can reduce monotony and increase intrinsic motivation. However, the effects of increasing extrinsic motivation are more pronounced. The principal factors which comprise extrinsic motivation in the vigilance situation are knowledge of results (KR), rewards and punishments and a group of factors comprising the degree and kind of supervision, "motivating" instructions and attitudes towards the experimenter.

Warm, Epss and Fergusson (1974) found that both true and false KR produced faster and less variable detection latencies than a control condition in which no KR was given, irrespective of whether the signal presentation schedule was regular or irregular. Furthermore, an increase in detection latency with time was found only in the control condition. However, other studies have not always shown the reinforcing effects of KR (e.g., see Montague and Webber, 1965)

In some experiments the provision of incentives has been shown to exert a beneficial effect on the overall level of detection efficiency (Bevan and Turner, 1965; Smith, Lucaccini and Epstein, 1967) while in others it has not (Levine, 1966; Wiener, 1969). In any case, the effects of incentives seem to be short lived (Bergum and Lehr, 1964).

Other ways of increasing extrinsic motivation have also failed to produce consistent effects, particularly with respect to the vigilance decrement. Detection efficiency has been found to be enhanced and the decrement to be reduced by making the opportunity to listen to a local radio station contingent upon the detection of signals, a result shown not to be attributable to the variety of stimulation provided (Ware, Kowal and Baker, 1964). Similar results were obtained by Halcomb and Blackwell (1969) using cross credit as an incentive with student subjects. The presence of the experimenter or some "authority figure" in the testing room has been demonstrated to result in a significant increase in the number of correct detections (Bergum and Lehr, 1963c; Putz, 1975). Putz (1975) also found that detection efficiency could be reliably enhanced by other forms of supervision, such as closed circuit television and a one-way vision screen. However, both Bergum and Lehr, and Putz, found a decrement in vigilance occurred in all their supervisory conditions. Subjects identifying with or admiring the experimenter are no more efficient than subjects to whom the experimenter is unknown (Halcomb, McFarland, and Waag, 1970) and "motivating" instructions, while sometimes improving the overall level of performance (Nachreiner, 1977; Neal, 1967), have produced conflicting results as far as the vigilance decrement is concerned (Nachreiner, 1977; Neal, 1967).

In one study which used the Bakan Test, a cognitive vigilance task similar to the CPT involving the detection of odd-even-odd combinations of successive non-repetitive digits, it was found that decision bias changes could be influenced by monetary payoffs. One third of the subjects received no-payoff insructions. The rest were divided into the risky or cautious group, both being paid nine cents for each hit. The risky group lost nine cents for each miss and one cent for each false alarm. The cautious group lost one cent for each miss and nine cents for each false alarm. It was found that the decision bias was lower for the risky group than for either the cautious or no-payoff groups (Sostek, 1978).

To date no studies with the CPT have directly looked at the use of reinforcements for correct performance on the task. Nevertheless, one interesting study was done on hyperactive, hypoxic, and normal children (with no sensory, neurological, behavioural or learning disabilities), comparing three CPT conditions which included one that provided auditory feedback on correct performances (O'Dougherty et al., 1984). The simple version of the CPT, that is, detecting one stimulus, was utilized for all three conditions. They found that feedback increased the overall hit rate as well as overall perceptual sensitivity level, indicating a motivational component inherent in the CPT. The presence of an inherent motivational component suggests that reinforcement, a form of motivation, may also affect performance on the CPT.

In summary the effects of increasing extrinsic motivation on the vigilance task, in the form of knowledge of results, reinforcements, punishments, motivating instructions and attitudes toward the experimenter, have been mixed. It is therefore not possible to draw any strong conclusions. Even though there is a lack of literature on the use of reinforcement on the CPT there is a hint that reinforcement could increase performance on the CPT based on the findings from the Bakan Test and from the CPT study by O'Dougherty et al. (1984). If this is so, the CPT has the potential to be developed as a tool to compare between different schedules of reinforcement.

Purpose of Experiment I

It was earlier suggested that the experimental literature on reinforcement schedules has much to offer in therapeutic settings, such as sheltered workshops. Further, it was argued that in the natural setting, the CPT would potentially be an ideal tool to measure the effects of reinforcement on different parameters of human responding. Such a study , using the CPT and a variety of reinforcement schedules may aid in selecting the appropriate reinforcement schedule to enhance the target behaviour of clients either individually or in a token economy system in settings like sheltered workshops.

The purpose of Experiment I was to test the potential of the CPT as a research tool, to measure the effects of reinforcement on accuracy of performance and the time spent on-task.

The same schedule of reinforcement was applied to two differently defined responses. One reinforced every hit while the other reinforced every correct detection (hits and/or correct rejections). The aim was to see which was better at improving performance on the CPT along the parameters stated above.

Based on the findings of O'Dougherty et al. (1984), the difficult version of the CPT was used in this study to explore the generalizability of motivational effects, like reinforcement, on CPT performance.

It was decided to use a single-subject design with the CPT so that the sensitivity of responding to the rate of reinforcement could be investigated. The traditional CPT utilizes only one key for responding to target stimuli. So if the subject is not on-task for a particular period of time, and during that period no target stimuli are presented, there is no objective way of confirming that the subject was not on-task. It was felt that adding an extra key provided an opportunity to measure the time spent on-task objectively. With the additional key, both target and non-target stimuli were to be detected. If the subject was not on-task some of the stimuli would not be detected during that period of time. The total number of target and non-target stimuli responded to could then serve as an objective measure of time on-task. Using two keys also provided the opportunity to measure not only decision bias, as in previous signal detection analysis of the CPT , but also a response bias, that is, to which of the two keys the client was more often responding (McCarthy and Davison, 1980).

CHAPTER 3

Method I

Subjects

The study was carried out on four subjects (K, M, D, and I) selected from trainees at the Intellectually Handicapped Society Sheltered Workshop at Cook Street in Palmerston North, New Zealand. They were selected on the basis of reports from their instructor that they were relatively poor at being on-task on any particular job. All four subjects were approached and their consent obtained before progressing further.

Subject K. (Sex F, Age 31 years).

The cause of this subject's mental retardation was thought to be birth injury. On the Peabody Picture Vocabulary Test her age equivalent was four years and six months. On the Standford Binet Test of Intelligence she presented herself as being very cooperative and eager to please. She achieved a basal age of five years and managed to pass four subtests from the six year category. Overall, her mental age was set at five years four months. She was thus classified as being severely retarded but "trainable" (IQ 20-34).

Subject M. (Sex F, Age 23 years).

The cause of retardation was Down's Syndrome. On the Peabody Picture Vocabulary Test her age equivalent was 4 years and 3 months. On the Standford Binet Test of Intelligence she had difficulty with explanations and descriptions. Her behaviour during some parts of the test was aimed at getting attention. For example, half way through the test she started crying for no apparent reason. The test had to be terminated and after a short period of talking about a variety of topics with her, the crying ceased and she was well enough to carry on with the testing with no further interruptions. She achieved a basal age of 3 years and passed twenty-one subtests between the age categories of three years and six months and seven years. Overall, her mental age was 4 years 9 months. She was thus classified as being severely retarded but "trainable" (IQ 20-34).

Subject D. (Sex M, Age 31 years).

The cause of retardation was Down's Syndrome. On the Peabody Picture Vocabulary Test he obtained an age equivalent of 2 years 3 months. On the Stanford Binet Test of Intelligence he had great difficulty expressing himself verbally. He achieved a basal age of 3 years and passed ten sub-tests between the age categories of three years and six months and five years. Overall, his mental age was 3 years 10 months. He was thus classified as being severely retarded but "trainable" (IQ

20-34).

Subject I. (Sex M, Age 34 years).

The subject had epilepsy with cerebral palsy. On the Peabody Picture Vocabulary Test his age equivalent was 9 years 1 month. On the Weschler Adult Intelligence Scale - Revised Version he was very happy and cooperative. During the test itself, it appeared difficult for him to follow instructions. Nevertheless, his Verbal I.Q. was two I.Q. points above his Performance IQ. Comparatively he did well on the Information, Vocabulary and Comprehension subtests, but poorly on the Similarities subtest on the Verbal Scale, where he obtained a Verbal I.Q. of 55. On the Performance Scale he did comparatively well on the Picture Completion subtest and his Performance I.Q. was 53. His Full Scale IQ was 49 (IQ 44-54). He was thus classifed as bordering between Moderately retarded but "trainable" (IQ 35-49) and Mildly retarded but "educable" (IQ 50-69).

All four subjects had normal eyesight and no impairment of colour vision.

Task Description

The subject sat facing the colour monitor in front of the typewriter keyboard of the Apple 2+ computer with keyboard overlay. The keyboard overlay had two response keys, the Yes key and the No key. During each session the CPT computer programme presented sequences of letters on the colour monitor. Typically the subject had to sustain attention on the colour monitor and respond on the Yes(Y) key when the letter "X" was presented on the screen after the letter "A". The No(N) key was to be used when the letter "X" was presented on the screen after any letter other than "A".

Apparatus

The following equipment was utilized:-

Two Apple 2+ computer systems with colour monitors and typewriter keyboards, with keyboard overlays with a key marked 'Yes' corresponding to the number "3" key on the Apple computer keyboard, and a key marked 'No' corresponding to the hyphen "-" key on the Apple computer keyboard.

A supply of chocolate sweets("Pebbles") were used as reinforcers (see subsection on Reinforcement).

Playcards made of cardboard sheets 13cm. wide and 20cm. long, which had single letters (A,G,W,V,C,U,Z,K,S,R,D, and X) printed on each in the upright position. These served in the shaping of appropriate behaviour on the CPT (see subsection on Procedure).

Specification of the CPT programme

There were three separate CPT programmes. The experimenter had control over the CPT programme to run in each session. Each programme ran for about twenty minutes. One programme was baseline condition (A) with no reinforcements for correct responding. Another programme (B) reinforced the subject for every hit (correct responding on the Yes key) on a CRF schedule of reinforcement (see Reinforcement subsection). The third programme (C) reinforced the subject for every correct detection (correct responding on either key) on a CRF schedule of reinforcement (see Reinforcement subsection). Each programme had the following in common. Each programme allowed a total of 272 stimuli sequences to be presented. There were 68 A-X sequences and 204 non-A-X sequences. The non-A letters were as specified by the playcards and display of each was randomly assigned by the programme. Each programme had a white background with the letters typed in bold black text. Each programme ran for about 20 minutes and constituted an experimental session for the subject. (There were three experimental session per day for each subject.) The rate of presentation of each sequence of letters was one every 1.5sec. The "non-X" letters were flashed on for 0.2 seconds and the interval after this and the"X" was 0.7 seconds. All these were within the specifications of the CPT (O'Dougherty et al., 1984). The letter"X" followed and stayed on for 2 seconds. This was to give the subjects enough time to respond and press either key as required.

Table 1 shows the performance parameters recorded.

Table 1:Performance Parameters Recorded In All Three CPT Programmes

Letter X on Screen	X preceded by A	Key Pressed	Parameter recorded
Yes	Yes	Yes	Hits
Yes	No	Yes	False alarms
Yes	Yes	No	Misses
Yes	No	No	Correct Rejections

Pressing either of the keys after the disappearance of a non-X letter and before the presentation of the letter "X", a duration of 0.7 seconds, was also recorded. This is referred to as impulsive or pseudo-responding. To prevent double recording of responses each impulsive response started a new sequence. For example, if the first sequence was "A"-"X" and the second sequence was "B"-"X" and if the subject responded to the letter "A" of the first sequence then rather than complete the first sequence, the second sequence "B"-"X" was presented.

Table 2 shows the impulsive parameters recorded.

Table 2: Impulsive Parameters Recorded In All Three CPT Programmes

Letter that was on Screen	Key Pressed	Parameter Recorded
A	Yes	Pseudo-Hits
A	No	Pseudo-Misses
Non-A	Yes	Pseudo-False Alarms
Non-A	No	Pseudo-Correct Rejections

Reinforcement

Every reinforcement (pebble) was represented by an asterisk (*) that appeared on the top of the screen of the colour monitor. When twenty asterisks accumulated they were cleared off the screen and symbolized with a graphic "superlolly". These graphic superlollies remained on the screen untill the end of the session. At the end of each session the experimenter counted up with the subject the number of asterisks and graphic super lollies showing on the screen and gave them small token sheets of paper which could be cashed in at lunch time for the appropriate number of pebbles.

Setting

The back half of the computer room at the Cook Street Workshop was utilized for the experiment. Cardboard screens and curtains were used as much as possible to give privacy and exclude distractions. However, since the front half of the room had to be used for the daily computer training programmes by other trainees of the centre, it was not possible to exclude all noise and distractions. As two computers were available for the study, two subjects were run at any one time. The subjects sat back-to-back, slightly away from each other, facing their own screens. There was minimal interference due to this setup. The experimenter left the room after starting a session.

Design

An ABCBA design (Kazdin, 1982) was used. Each session during phase A1 made use of the baseline CPT programme. During phase B1 each session made use of the CPT programme which reinforced the subject for every hit, while during phase C subjects were reinforced for every correct detection. The reversal phases B2 and A2 used the programmes which reinforced the subject for every hit, and the baseline programme respectively.

Procedure

Responding was shaped using the following sequence. Subjects were seated at the computer and given the following instruction: "When you see an X on the screen after seeing the letter A you press the Yes key". Appropriate playcards were placed in front of the screen and, if necessary, a subject's hand was guided to the Yes key. A subject passed this stage of the shaping procedure if he or she got four consecutive correct responses without guidance.

Next, the subject was told: "When you see an X on the screen after seeing another letter that was not the letter A you press the No key". Even if the subject could not name the letter A, the appropriate shape was shown for each, to identify the target letter. Once again appropriate playcards were used and the hand guided to the No key if necessary. This stage was successfully learned if the subject got four consecutive correct rejections without guidance.

A series of set trials were then run. The set trials used were A-X, Q-X, A-X, and S-X. The criterion for success was 100% correct rersponding. The final leg of the shaping procedure involved introducing the subjects to the actual computer programme, using the baseline condition. Each subject passed the final test and was deemed competent for the experiment after four consecutive correct responses (two hits and two correct rejections).

The main experiment started with phase A1 for all subjects. Advancing through each phase of the design depended on the stability of the data for both, hits and correct detections (hits and correct rejections combined). The usual recommendation has been to define stability of the data in a given phase in terms of a number of consecutive sessions or days that fall within a prespecified range of the mean (Gelford and Hartman, 1957; Sidman, 1960) This method ensures that data do not show a systematic increase or decrease over time and fall within a particular range . However, rather than using the actual raw data, a running average was calculated based on the previous three sessions. This procedure minimized fluctuations in the plotted data, thus aiding in the comparison between phases. The running average data for the start of each phase began with the average of the raw data for the last three sessions of that particular phase. If the running average was equal to or below the prespecified range for three consecutive sessions and there were no obvious trends, then the data were considered stable and the experiment progressed to the next phase.

The specifications for the prespecified range were not the same for all subjects since each showed different levels of variability. Thus, those with wide fluctuations in performance from one session to another had a broader range.

Range around the running average of the number of Hits for each subject were:-

K ± 12 Hits

M ± 20 Hits

D ± 12 Hits

I ± 20 Hits

Ranges around the running averages of the number of Correct Detections for each subject were:-

K ± 80 Correct Detections

M ± 95 Correct Detections

D ± 80 Correct Detections

J ± 80 Correct Detections

Where possible the phase was changed for all subjects at the same time. The criteria for stability of data applied for all phases.

Analysis of Results

The following data were examined:

i) Hits;

ii) Correct rejections;

iii) Correct detections;

iv) Pseudo-hits;

v) Pseudo-correct rejections;

vi) Total Duration On-Task.

The first two variables are defined in Table 1. Correct detections involved combining the hits scored per session with the correct rejections scored per session to give a single score per session. The next two dependent variables are defined in Table 2. Total Duration On-Task was calculated by subtracting the total number of stimulus sequences which were not responded to by the subject from the total number of possible responses available per session (272), and multiplying this by the duration of a sequence presentation (2.9 seconds).

Visual inspection was utilized as a major method of analysis. A judgement was reached about the reliability or consistency of the intervention effects by visually examining the graphed data. It should be borne in mind that the insensitivity of visual inspection for determining weak effects has often been viewed as an advantage rather than a disadvantage because it encourages investigators to look for potent interventions or to develop weak interventions to the point that large effects are produced (Parsonson and Baer, 1978).

Criteria for the Visual Inspection

Visual inspection depended on many characteristics of the data but especially those that pertained to the magnitude of the changes across phases and the rate of those changes. The two characteristics related to the magnitude of change were, changes in the mean rate of responding and in the level of responding (that is, discontinuity between the end session in one phase and the beginning session in the next phase). The characteristics related to the rate of change were changes in the trend in the data and the latency of the change.

Also considered were the variability of performance within a particular phase (the standard deviation), the duration of the phase, and the consistency of the effect across phases or baselines (Kazdin, 1982). It should be noted that the standard deviations provide a somewhat confounded measure, since variability is not only due to the normal fluctuations in stable data but also to changes due to the effects of reinforcements. Therefore, standard deviation figures are not presented.

Signal Detection Analysis

Analysis derived from the generalized matching law.

According to the generalized matching law, response distribution between two concurrently-available response alternatives is a function of the distribution of reinforcers obtained from these alternatives (Baum, 1974). Stated mathematically:

$$\log P_1/P_2 = a \log [R_1/R_2] + \log c \qquad (1)$$

where P_1=number of responses emitted on key 1

P_2=number of responses emitted on key 2

R_1=number of reinforcements obtained on key 1

R_2=number of reinforcements obtained on key 2

c =bias or tendency for the animal to emit

proportionally more responses on one key

than on the other when equal reinforcements

are obtained.

a =sensitivity of the ratio allocation of responses

to changes in the ratio of obtained reinforcements.

Davison and Tustin(1978) applied this formula to a typical stimulus-response matrix in the yes-no detection task (Green and Swets, 1966). The matrix is shown in Figure 1.

		RESPONSE	
		P (left)	P (right)
STIMULUS	S_1	W (Rft)	X (Ext)
	S_2	Y (Ext)	Z (Rft)

Figure 1. The matrix of stimulus and response events in the yes-no detection task. P_{left} is the same as P_1 while P_{right} is the same as P_2 in equation (1). S_1 and S_2 are the discriminative stimuli. W,X,Y, and Z denote the number of events in each cell, and Rft and Ext denote reinforcement and extinction respectively.

In the logarithmic form, the matching law becomes

$$\log(P_w/P_x) = A_r \log(R_w/R_z) + \log d + \log c \qquad (2)$$

following S_1, and

$$\log(P_w/P_x) = A_r \log(R_w/R_z) - \log d + \log c \qquad (3)$$

following S_2;

where P and R denote the number of responses and number of reinforcers obtained, respectively, and the subscripts refer to the cells of the matrix shown in Figure 1.

The parameter, log d, is the bias caused by the discriminability of the two stimuli, S_1 and S_2. The better the animal can discriminate the stimuli, the larger will be log d and so the larger the ratio of hits to misses, (P_w/P_x) and the smaller the ratio of false alarms to correct rejections (P_y/P_z). The reason why log d has opposite signs in equations 2 and 3 is due to the fact that the numerators in the two equations are both left key measures. The parameter A_r in equations 2 and 3 is the same as parameter a in equation 1. As for equation 1, log c is assumed to remain constant across experimental conditions.

Equations 2 and 3 may be used to generate independent measures of stimulus discriminability and response bias (McCarthy and Davison, 1980). Subtracting equation 3 from equation 2 gives a bias-free measure of stimulus discriminability:

$$\log d = .5 \log (P_w/P_x \cdot P_z/P_y)$$

This log d measure is analogous to the detection-theory measure, d′ (McCarthy, 1983).

Adding equation 2 to equation 3 gives an expression for response bias independent of the discriminability of the stimuli:

$$\text{log response bias} = .5 \log (P_w/P_x \cdot P_y/P_z)$$

Positive logarithmic values indicate a left key bias while negative logarithmic values indicate a right key bias (McCarthy, 1983).

Signal Detection Theory Analysis.

Sensitivity Measure

The usual measure of sensitivity in SDT analysis is d′. The formula employed in calculating d′ from a pair of P(S|s) (the probability of reporting a signal when a signal has occurred), and P(S|n) (the probability of reporting a signal when a noise has occurred) values is:

$$d' = z(S|n) - z(S|s)$$

where z(S|s) is the z-score corresponding to P(S|s), the hit rate, and z(S|n) is the z-score corresponding to P(S|n), the false alarm rate.

d′ is the value of the signal distribution mean, measured in standard deviation units of the noise distribution mean when the noise distribution mean is equal to zero. It is an indication of the extent to which signal and noise distributions overlap (McNicol, 1972). This measure is a parametric measure of sensitivity, assuming the signal and noise distributions are normal with equal variance (see Green and Swets, 1966).

Due to the uncertainty concerning the assumptions underlying d′, a non-parametric measure of sensitivity, $P(\bar{A})$, was also employed in this experiment. $P(\bar{A})$ is analogous to d′ and was used by O′Dougherty et al. (1984).

The formula for calculating $P(\bar{A})$ is:

$$P(\bar{A})=1/2 + \frac{(y-x)(1+y-x)}{4y(1-x)} ,$$

where x is the proportion of non-target trials to which the subject responds to $p(S|n)$, and y is the proportion of target trials to which the subject correctly responds $p(S|s)$. (For example, see McNicol, 1972).

For the occasional instances of perfect hit or false alarm rates during a session, the hit rates were estimated as 2-1/t and false alarm rates as 1/2-1/t, where t= the number of trials on which the relevant stimulus type (signal or noise) occurred, as suggested by Davies and Parasuraman (1982).

$P(\bar{A})$ values per session were visually analysed. The means of x and y were calculated for each phase and the corresponding $P(\bar{A})$ values calculated for the phases. Comparison was made with log d values (derived from the matching law) calculated for each phase by using the means of hits, false alarms, misses and correct rejections.

Decision Criterion Measure

In SDT analysis the degree of caution expressed by a subject in reporting the evidence required to the occurrence of a signal is often referred to as response bias. Since response bias is also used in the generalized matching law analysis, for clarity, SDT response bias will be referred to as decision criterion bias.

There appears to be no uniform measure in the literature in reporting decision criterion bias. For example Rutschmann et al. (1977) reported likelihood ratio values; Buchbaum and Sostek (1980) reported β values; Swanson (1981) reported B values; and O'Dougherty et al. (1984) reported $z(S|n)$ values (decision criterion cutoff).

Since a non-parametric sensitivity measure was chosen for this study, it was decided to use a non-parametric decision criterion measure as well (O'Dougherty et al., 1984). The decision criterion cutoff $z(S|n)$ was used, which is simply the z-score of obtained false-alarm rate $(P(S|n))$. For the occasional instances of perfect hit or false alarm rates the same estimates as used for sensitivity (see Sensitivity subsection) were used.

CHAPTER 4

RESULTS I

Table 3 shows the number of sessions for each subject during each phase of the experiment.

Table 3:- The number of sessions for each subject for each experimental phase on the CPT.

PHASE / SUBJECT	A1	B1	C	B2	A2
K	20	18	20	19	7
M	20	20	18	16	7
D	20	20	20	15	8
I	20	20	20	14	8

For each session during phase A1 subjects responded on the CPT without reinforcements (baseline condition). Phase B1 reinforced subjects every session on a CRF schedule for every hit, while phase C provided reinforcement on a CRF schedule for every correct detection (hits and/or correct rejections). The reversal phase B2 reinforced subjects on a CRF schedule for every hit while the final reversal to phase A2 reintroduced baseline.

HITS

TABLE 4:- MEANS OF RUNNING AVERAGES OF
HITS FOR EACH EXPERIMENTAL PHASE.

	BASELINE		INTERVENTION		BASELINE
	A1	B1	C	B2	A2
SUBJECT					
K	31.65	35.94	4.69	32.80	27.58
M	25.19	26.84	32.29	24.55	19.43
D	11.06	10.08	15.03	16.61	15.40
I	53.31	52.08	53.49	58.37	40.60

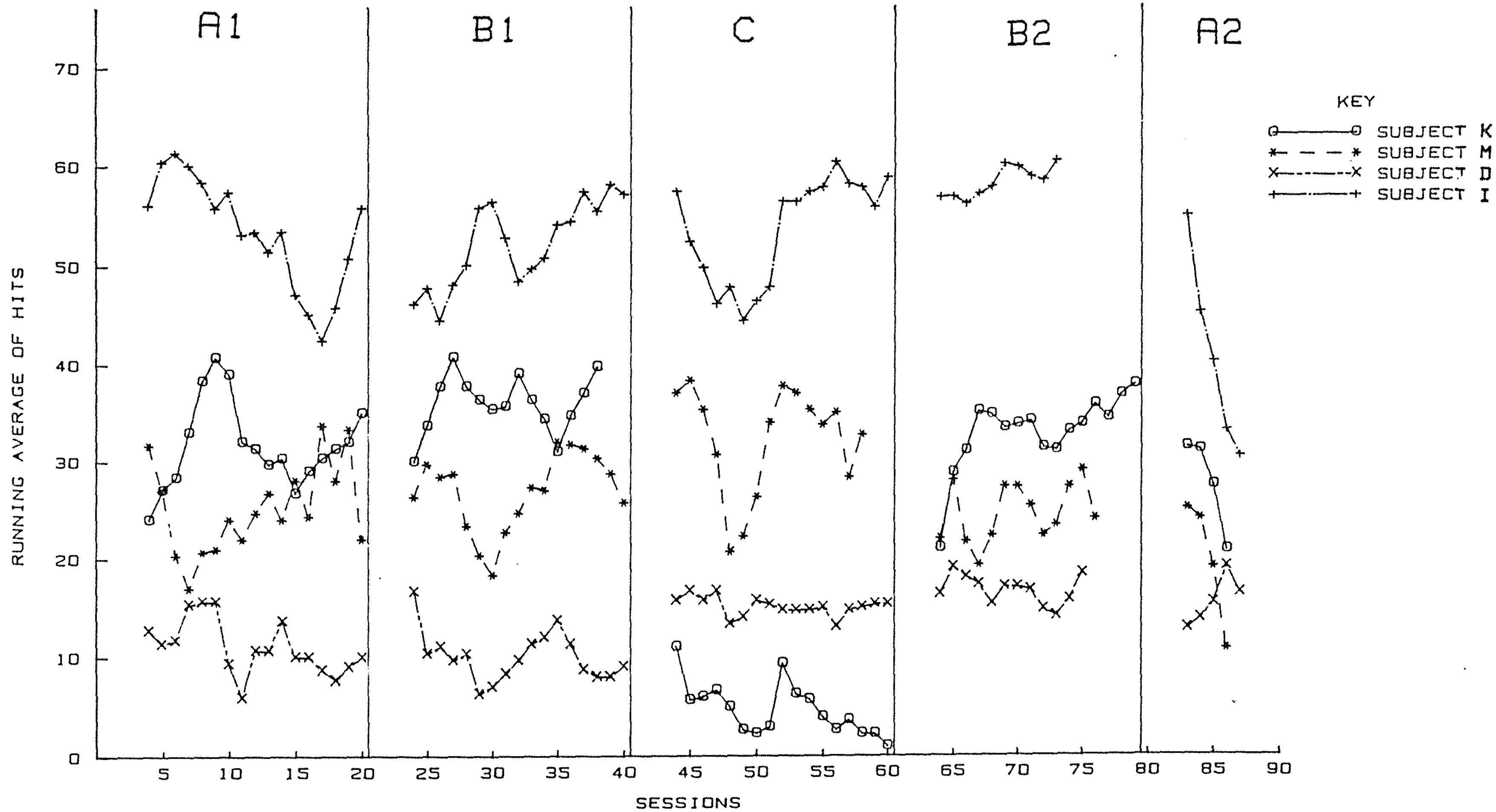

FIGURE 2. RUNNING AVERAGES OF HITS PER SESSION SCORED ON THE CPT.

Table 4 shows the means of the running averages of hits for each phase for each subject and Figure 2 shows the running averages of hits per session across phases for each of the four subjects.

Subject K:- Reinforcing correct detections (phase C) saw a drop in the level and a dramatic fall in the mean hits by 31.25 (see Table 4). The reversal phase of reinforcing hits (phase B2) saw a return of the mean number of hits upwards by 28.11. A clear increasing trend was present across this phase. The final return to baseline condition (phase A2) saw a small drop in the level with a decreasing trend in the data (see Figure 2).

Subject M:- The onset of reinforcing correct detections (phase C) saw an increase in the level and in the mean number of hits by 5.45. Return to reinforcing hits only (phase B2) saw a drop in the mean by 7.74 hits, and a drop in the level (see Table 4 and Figure 2). There was no obvious trend. The final return to baseline (phase A2) saw a decrease in the mean number of hits by 5.12 hits and a downward trend in the data.

Subject D:- Reinforcing correct detections (phase C) brought an obvious increase in the mean by 4.95 hits as well as an increase in the level. The reversal to reinforcing hits (phase B2) brought an increase by 1.58 mean hits. Return to baseline (phase A2), saw a drop in the level with an initially increasing trend in the data.

Subject I:- During Phase B1 (reinforcing hits), there was an increasing trend in the data. Return to reinforcing hits (phase B2) showed a decrease in variability in data compared to the preceding phases (see Figure 2). A return to baseline condition (phase A2) saw a drop in level as well as a reduction in the mean by 17.77 hits. There was an obvious downward trend in the data and the latency of change was immediate.

In summary, reinforcing correct detections (phase C) saw a drop in hits for one subject, an increase for two subjects and no real change for the other. The reversal phase of reinforcing hits (phase B2) produced an increase in hits for two subjects, a small decrease for one subject and no change for the other. The final baseline (phase A2) showed decreasing trends for all four subjects, the only systematic change noted.

Correct Rejections

TABLE 5:- MEANS OF RUNNING AVERAGES OF

CORRECT REJECTIONS FOR EACH EXPERIMENTAL PHASE.

	BASELINE		INTERVENTION		BASELINE
	A1	B1	C	B2	A2
SUBJECT					
K	13.47	6.04	88.21	11.75	6.42
M	66.73	88.51	101.36	74.03	73.00
D	23.53	25.39	50.00	45.83	44.53
I	0.00	0.00	0.06	0.03	0.00

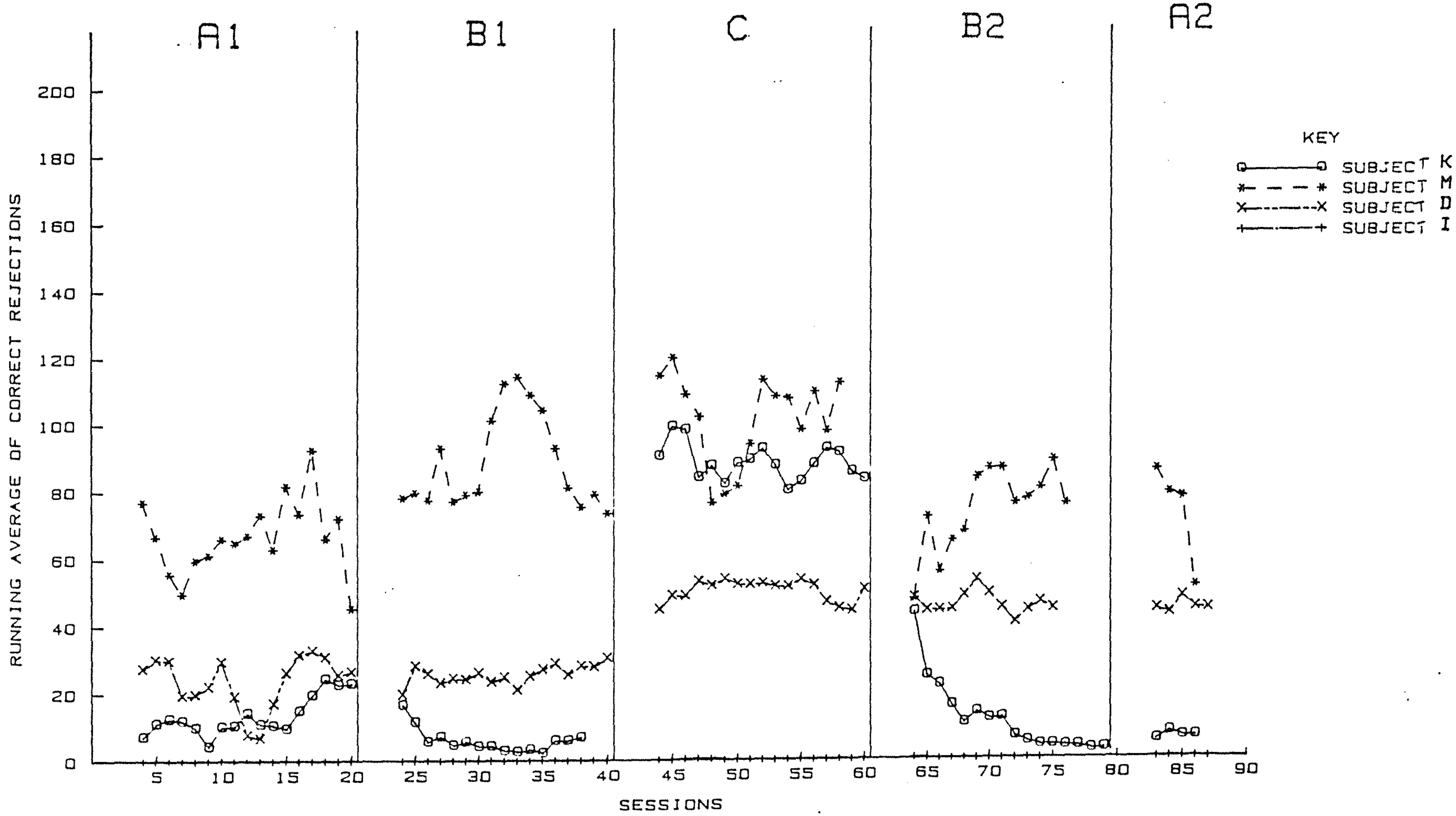

FIGURE 3. RUNNING AVERAGES OF CORRECT REJECTIONS PER SESSION SCORED ON THE CPT.

Table 5 shows the means of the running averages for correct rejections for each subject across all experimental phases. Figure 3 shows the running averages of correct rejections per session across phases for each of the four subjects.

Subject K:- Reinforcing hits (phase B1) saw the overall mean dropping by 7.43 correct rejections compared to the preceeding phase (see Table 5). When reinforcing correct detections (phase C) there was a dramatic increase in the level and the overall mean during this phase was more than 14 times greater than the mean of the previous phase (see Table 5 and Figure 3). The reversal to reinforcing hits (phase B2) saw a drop in the level and a decrease in the mean by 76.46 correct rejections. There was an initial downward trend as well but the data stabilized at a low level over the last four sessions of the phase.

Subject M:- When hits were reinforced during phase B1 there was an increase in the level and an increase in the mean by 21.78 correct rejections. Reinforcing correct detections (phase C) produced an increase in the level with an increase in overall mean of this phase as compared to the previous phase by 12.85 correct rejections. The reversal to reinforcing hits (phase B2) saw a dramatic drop in the level, and the mean dropped by 27.33 correct rejections. There was an increasing trend in the data across this phase. The final reversal to baseline condition (phase A2) produced a downward trend.

Subject D:- Reinforcing correct detections (phase C) produced an obvious increase in the level and a near doubling of the mean correct rejections. No overall trend in the data was apparent. Performance seemed unaltered during either the reversal to reinforcing hits (phase B2) or return to baseline (phase A2).

Subject I:- This subject did not respond on the No key. Therefore, no reliable measure of correct rejections was recorded.

In summary, during phase B1 (reinforcing hits), correct rejections decreased for one subject and increased for another. Reinforcing correct detections (phase C), increased correct rejections for three subjects. Reversal to phase B2 (reinforcing hits), produced a decrease in correct rejections for two subjects. During the final reversal to baseline (phase A2) there was a decreasing trend in the data for one subject. Thus the most obvious systematic change across the majority of subjects was seen during phase C.

Correct Detections

TABLE 6:- MEANS OF RUNNING AVERAGES OF
CORRECT DETECTIONS FOR EACH EXPERIMENTAL PHASE.

	BASELINE		INTERVENTION		BASELINE
	A1	B1	C	B2	A2
SUBJECT					
K	45.08	41.98	92.71	44.54	34.03
M	91.92	115.27	133.65	98.60	92.68
D	34.59	35.47	65.05	62.45	59.92
I	53.31	52.08	53.54	58.40	40.60

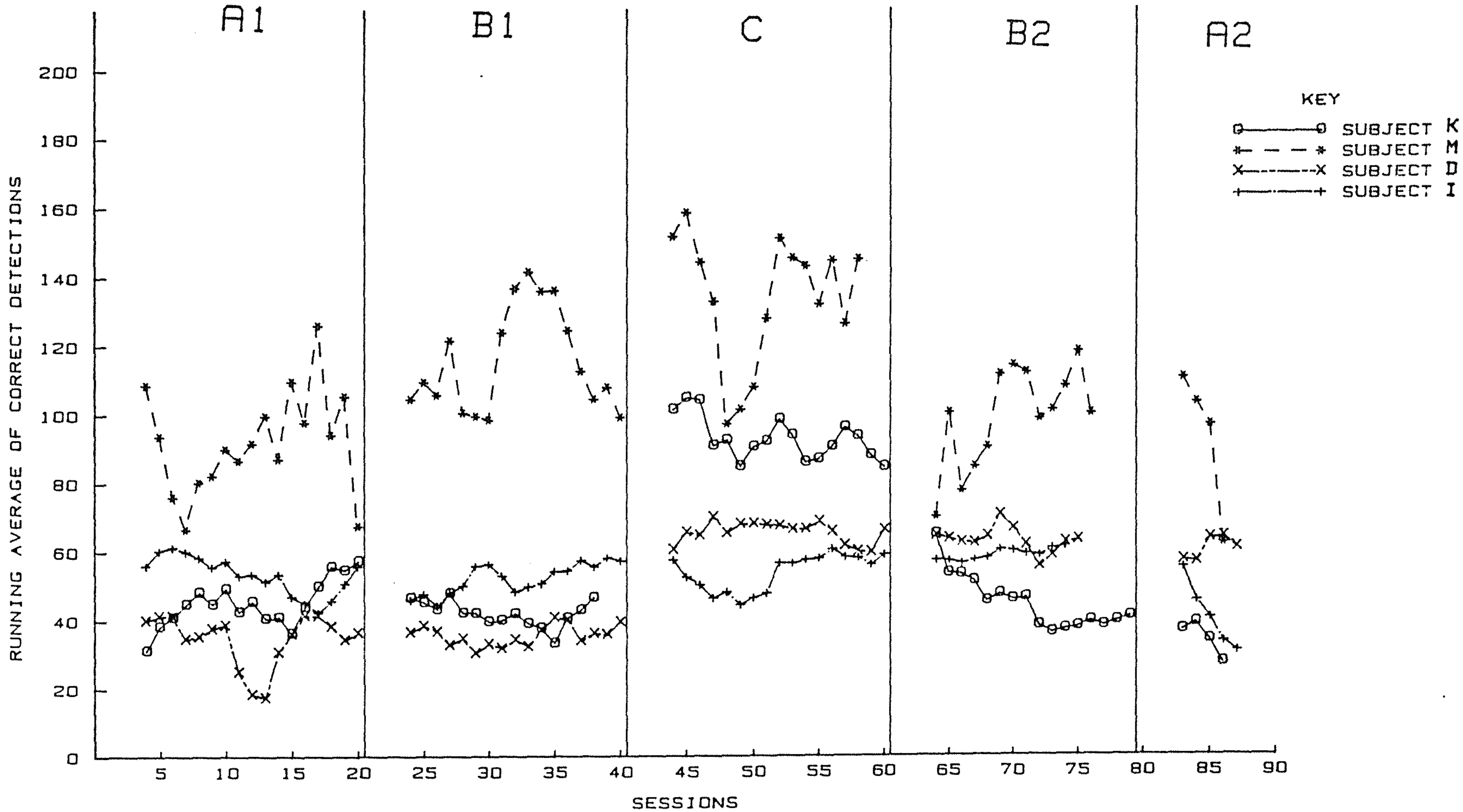

FIGURE 4. RUNNING AVERAGES OF CORRECT DETECTIONS PER SESSION SCORED ON THE CPT.

Table 6 shows the means of the running averages of correct detections for each experimental phase for each subject. Figure 4 shows the running averages of correct detections per session across phases for each of the four subjects.

Subject K:- Reinforcing correct detections (phase C) saw the level increase greatly with a similar jump in the mean Figure by 50.73 correct detections (see Table 6). There was a general downward trend (see Figure 4). With the onset of reinforcing hits (phase B2), again, the level dropped and the mean fell by 48.17 correct detections (see Table 6 and Figure 4). The final reversal to baseline condition (phase A2) saw only a small drop in the level but a larger drop in the mean of this dependent variable, by 10.51 correct detections. There was an obvious downward trend in the data.

Subject M:- Reinforcing hits (phase B1) saw an increase in the mean by 23.35 correct detection. There was great variability in the data. When reinforcing correct detections (phase C) there was a jump in the level and a rise in the mean by 18.38 correct detections. Variability in the data was still evident. The reversal to reinforcing hits (phase B2) saw a dramatic drop in the level and a fall in the mean by 35.05 correct detections. The final reversal to baseline condition (phase A2) showed an obvious downward trend.

Subject D:- With the reinforcement of correct detections (phase C), the level increased sizeably and the mean went up by 29.58 correct detections. Nothing much can be noted for the other sessions.

Subject I:- Since subject 'I' was predominantly pressing only the Yes key these data are the same as those presented for the 'hits' scored (see Figure 2).

In summary, reinforcing correct detections (phase C) saw an increase in correct detections for three subjects. This was the most systematic change across the phases. Reversal to reinforcing hits (phase B2) saw a drop in correct detections for two subjects. The final return to baseline (phase A2) saw a decreasing trend also for two subjects.

PSEUDO-HITS

Pseudo-hits occur when subjects respond on the Yes key within the 700ms. from the disappearance of the letter "A" and before the onset of the letter "X". This variable has often been taken as an indicator of impulsive responding.

TABLE 7:- MEANS OF RUNNING AVERAGES OF PSEUDO-HITS FOR EACH EXPERIMENTAL PHASE.

	BASELINE		INTERVENTION		BASELINE
	A1	B1	C	B2	A2
SUBJECT					
K	7.53	20.38	3.86	15.42	11.43
M	0.64	7.84	4.91	4.88	1.68
D	16.06	21.98	15.98	13.90	11.74
I	12.98	15.08	11.72	4.36	21.48

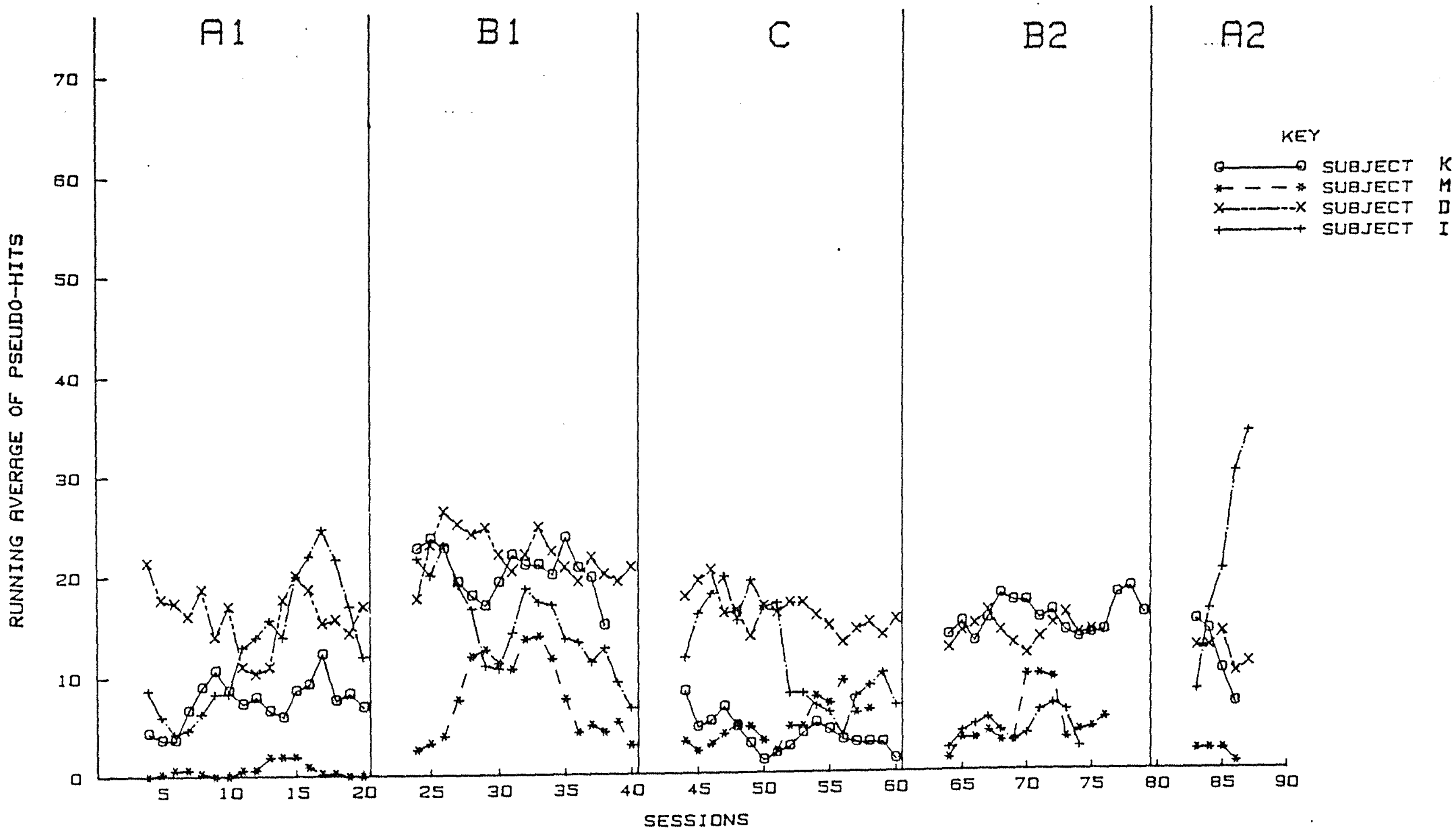

FIGURE 5. RUNNING AVERAGES OF PSEUDO-HITS PER SESSION SCORED ON THE CPT.

Table 7 shows the means and standard deviation of the running averages of pseudo-hits for each phase for each subject, while Figure 5 shows the running averages of pseudo-hits per session across phases for each of the four subjects.

Subject K:- When reinforcing hits (phase B1), there was an increase in the level, and the mean pseudo-hits was more than doubled (see Table 7 and Figure 5). During the last four sessions there was a downward trend. Reinforcing correct detections (phase C) produced a drop in the level as well as a drop in the mean by 16.52 pseudo-hits. There was a rise in the level and an increase in the mean, by 11.56 pseudo-hits during reversal to reinforcing hits (phase B2) . There was a downward trend in the data during the return to baseline (phase A2).

Subject M:- With the introduction of reinforcing hits (phase B1) the level increased and there was an increase in the mean. The data also showed high variability. Return to baseline (phase A2) saw a decrease in mean pseudo-hits by 3.2.

Subject D:- Reinforcing hits (phase B1) was accompanied by an increase in the mean of 5.92 pseudo-hits. With the introduction of reinforcing correct detections (phase C) there was a small drop in the level as well as a drop in the mean. The return to reinforcing hits (phase B2) have a decrease in the level and a small decrease in the mean by 2.08 pseudo-hits. There was a downward trend in pseudo-hits through the last four phases for this subject.

Subject I:- With the introduction of reinforcing hits (phase B1) there was a jump in the level with an increase in the mean by 2.1 pseudo-hits. The data showed an obvious downward trend. Reinforcing correct detections (phase C) noted an increase in the level, but a decrease in the mean by 3.36 pseudo-hits (see Table 7 and Figure 5). The reversal to reinforcing hits (phase B2) produced a drop in the level with a relatively large drop in the mean by 7.36 pseudo-hits. The last phase of the baseline condition (phase A2) had an increase in the level as well as a noticeable rise in the mean by 17.12 pseudo-hits. There was an increasing trend throughout the phase.

In summary, the reinforcement of hits (phase B1) produced a rise in pseudo-hits for all four subjects. Reinforcement of correct detections (phase C) saw a decrease in pseudo-hits for three subjects. Return to reinforcing hits (phase B2) showed a drop in pseudo-hits for two subjects but an increase for one subject. Three subjects showed downward trends in pseudo-hits during the final return to baseline (phase A2) while one showed an upward trend.

Pseudo-Correct Rejections

Pseudo-correct rejections represents responding on the No key within the 700ms. from the disappearance of a "non-A" letter and before the onset of the letter "X". As for pseudo-hits this is often taken as another indication of impulsive responding.

TABLE 8:- MEANS OF RUNNING AVERAGES OF
PSEUDO-CORRECT REJECTIONS FOR EACH EXPERIMENTAL PHASE.

	BASELINE		INTERVENTION	BASELINE	
	A1	B1	C	B2	A2
SUBJECT					
K	2.50	3.57	43.01	5.23	3.60
M	1.28	10.26	6.77	4.84	5.6
D	46.66	60.13	43.66	38.53	37.90
I	0.02	0.05	0.32	0.11	0.74

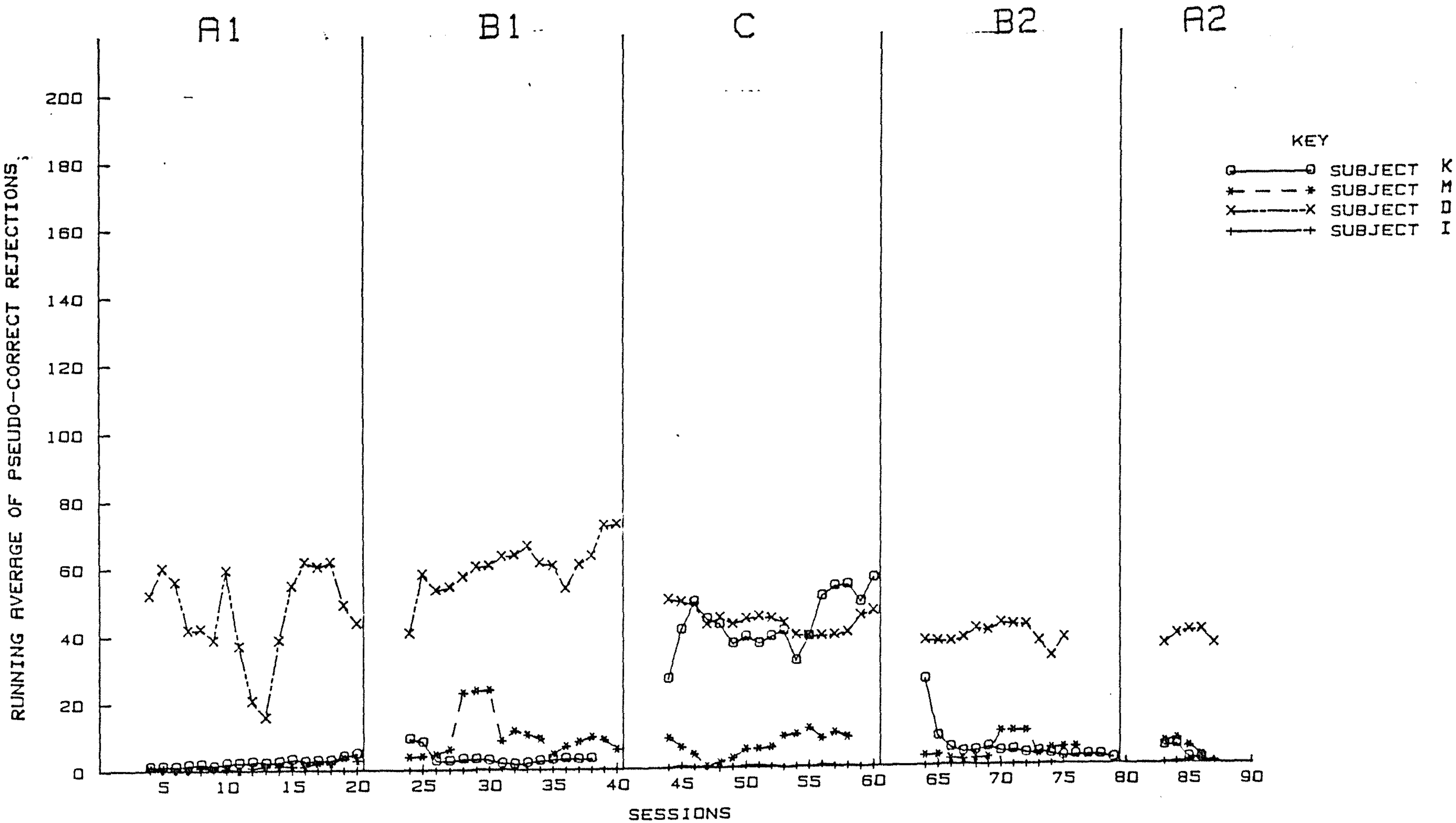

FIGURE 6. RUNNING AVERAGES OF PSEUDO-CORRECT REJECTIONS PER SESSION SCORED ON THE CPT.

Table 8 shows the means of running averages of pseudo-correct rejections for each phase for each subject separately, while Figure 6 shows the running averages of pseudo-correct rejections per session across phases for each of the four subjects.

Subject K:- With the introduction of reinforcing correct detections (phase C) there was an increase in the level as well as an increase in the mean by 39.44 pseudo-correct rejections (see Table 8 and Figure 6). There was an increasing trend as well. On return to reinforcing hits only (phase B2), the level dropped and the mean decreased by 37.78 pseudo-correct rejections. There was less variability during the later stages of the phase and a very small downward trend.

Subject M:- Reinforcing hits (phase B1) was accompanied by a near 10 fold increase in the mean pseudo-correct rejections for this 20 session phase. There were also great fluctuations in the dependent variable. The introduction of phase C (reinforcing correct detections) produced a decrease in the mean by 3.49 pseudo-correct rejections. Return to reinforcing hits (phase B2) indicates a small drop in the mean by 1.93 pseudo-correct rejections. Return to baseline (phase A2) saw a downward trend in the data.

Subject D:- When reinforcing hits (phase B1), a rising trend was noted in the data. With the introduction of phase C (reinforcing correct detections) a drop in level and a drop in the mean figure by 16.47 pseudo-correct rejections was obtained. Return to reinforcing hits (phase B2) saw a small drop in the level and a small drop in the mean by 5.13 pseudo-correct rejections. With the reversal to baseline (phase A2) there was a declining trend in the data.

Subject I:- Since, Subject I was not following the rules of the present CPT task, no reliable data were available for the 'No' key responses.

In summary, reinforcing correct detections (phase C) saw an increase for one subject and a decrease for two subjects in pseudo-correct rejections. Returning to reinforcement of hits (phase B2) saw a drop in pseudo-correct rejections for three subjects. The final return to baseline saw a decreasing trend in pseudo-correct rejections for two subjects. Thus the most systematic responding occurred during phase B2.

Total Duration On-Task

Total Duration On-Task was calculated by subtracting the total number of stimulus sequences not responded to from the total number of stimulus sequences presented during the session (272). This was multiplied by the duration of a stimulus sequence presentation (2.9 seconds) to give a measure of the time spent on-task.

TABLE 9:- MEANS OF RUNNING AVERAGES OF TOTAL DURATION ON-TASK FOR EACH EXPERIMENTAL PHASE.

	BASELINE		INTERVENTION		BASELINE
	A1	B1	C	B2	A2
SUBJECT					
K	532.42	683.91	601.45	620.64	481.61
M	277.1	401.68	429.79	321.07	301.30
D	585.64	711.38	720.28	676.95	617.84
I	759.80	764.29	531.49	232.56	482.64

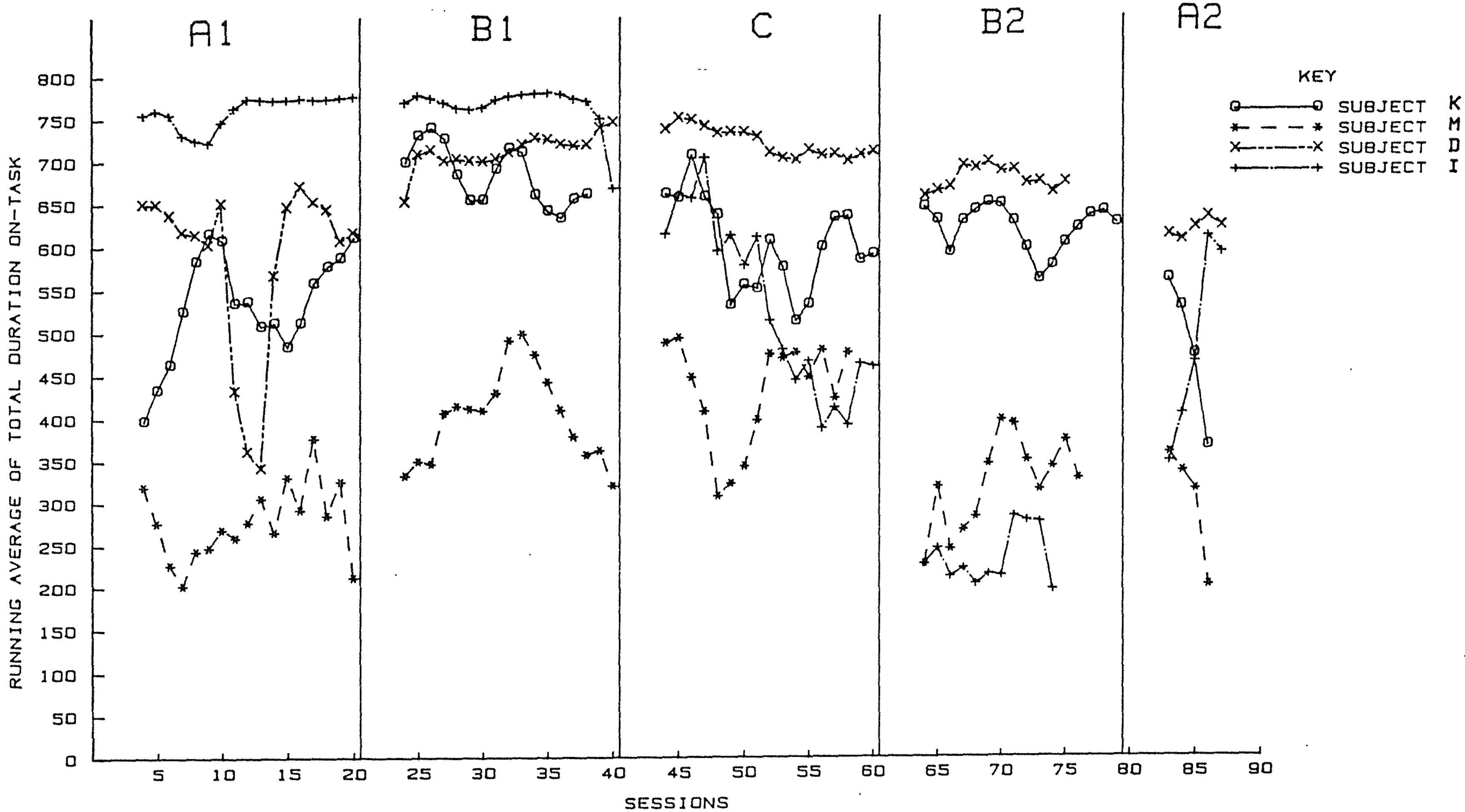

FIGURE 7. RUNNING AVERAGES OF TOTAL DURATION ON-TASK PER SESSION ON THE CPT.

Table 9 shows the means of running averages of total duration on-task for each phase for each subject and Figure 7 shows the running averages of total duration on-task per session across phases for each of the four subjects.

Subject K:- Upon introduction of reinforcing hits (phase B1), the level increased and so did the mean total duration on-task by 151.49 secs. (see Table 9 and Figure 7). Reinforcing correct detections (phase C) produced a fall in the mean total duration on-task by 82.46 secs. and an increase in the fluctuation. On return to reinforcing hits (phase B2), the mean total duration on-task increased by 19.19 secs.. Finally, baseline (phase A2) showed a drop in the level and a decrease in the mean total duration on-task by 139.03 secs.. A clear downward trend was also seen, indicating decreasing time spent on-task.

Subject M:- With reinforcing hits (phase B1) the mean total duration on-task increased by 124.58 secs.. Reinforcing correct detections (phase C) saw a rise in the level and a rise in the mean total duration on-task by 28.11 secs.. The return to reinforcing hits (phase B2) produced a drop in the level and a decrease in the mean total duration on-task by 108.72 secs.. Return to baseline (phase A2) showed a decrease in the mean by 19.77 secs.. The data also showed a clear downward trend, as for Subject K.

Subject D:- The introduction of reinforcing hits (phase B1) produced a slight increase in the level and a large increase in the mean total duration on-task across the phase by 125.74 secs.. Reinforcing correct detections (phase C) showed an increase in the mean total duration on-task by 8.9 secs.. With return to reinforcing hits only (phase B2) there was a drop in the level as well as a decrease in the mean total duration on-task by 43.33 secs.. Return to baseline (phase A2) saw both a drop in the level and in the mean total duration on-task by 59.11 secs..

Subject I:- Reinforcing hits (phase B1) produced a small drop in the level and a slight increase in the mean total duration on-task by 4.49 secs.. The data were quite stable over the majority of sessions but a downward trend developed near the end of this phase. The introduction of reinforcing correct detections (phase C) was accompanied by a small drop in the level and a decrease in the mean total duration on-task by 232.8 secs.. The data showed great variability throughout the phase and a clear downward trend was evident except for the last few sessions. With return to reinforcing hits (phase B2) there was a another drop in the level as well as in the mean. Return to baseline (phase A2) produced an increase in the level as well as an increase in the mean total duration on-task by 250.08 secs.. The data was highly variable but there was an obvious increasing trend.

In summary, the reinforcement of hits (phase B1) produced an increase in time spent on-task for all four subjects. Reinforcing correct detections (phase C) noted a decrease in time spent on-task for two subjects and an increase in time spent on-task for two subjects.

Reversal to reinforcing hits only (phase B2), saw a decrease in time spent on-task for three subjects and an increase for one. The final return to baseline (phase A2) produced a further decrease in total time on-task for three subjects with two of these showing downward trends. The fourth subject had increased time spent on-task with an upward trend in the data. Thus a fairly systematic pattern of responding across most subjects occurred during phases B1, B2 and A2.

Signal Detection Analysis

Sensitivity Measurement[1]

TABLE 10:- SIGNAL DETECTION ANALYSIS OF SUBJECT K's PERFORMANCE FOR EACH PHASE ON THE CPT.

PHASE	A1	B1	C	B2	A2
NUMBER OF SESSIONS	20	18	20	19	7
MEAN OF $P(S\|s)$	.45	.53	.07	.48	.40
MEAN OF $P(S\|n)$	.47	.54	.07	.48	.37
$z(S\|n)$	.08	.10	1.48	.05	.33
$P(\bar{A})$	.48	.49	.50	.50	.53
log response bias	0.89	1.23	-0.76	0.89	1.14

---

[1] d′ values obtained from tables found in Swets (1964) were highly correlated with the calculated $P(\bar{A})$ values for each phase. Log d values, a measure of sensitivity derived from the matching law also showed high reliability with d′ and $P(\bar{A})$ values for each phase. Therefore for the sake of simplicity, only $P(\bar{A})$ values were presented.

TABLE 11:- SIGNAL DETECTION ANALYSIS OF SUBJECT M's PERFORMANCE FOR EACH PHASE ON THE CPT.

PHASE	A1	B1	C	B2	A2	
NUMBER OF SESSIONS	20	20	18	16	7	
MEAN OF P(S|s)	.38	.41	.47	.35	.28	
MEAN OF P(S|n)	.49	10.00	2.45	2.14	1.40	(all x 10^{-3})
z(S|n)	3.30	2.33	2.88	2.88	3.09	
P($\bar{A}$)	.84	.84	.87	.84	.82	
log response bias	-0.54	-0.24	-0.50	-0.47	-0.75	

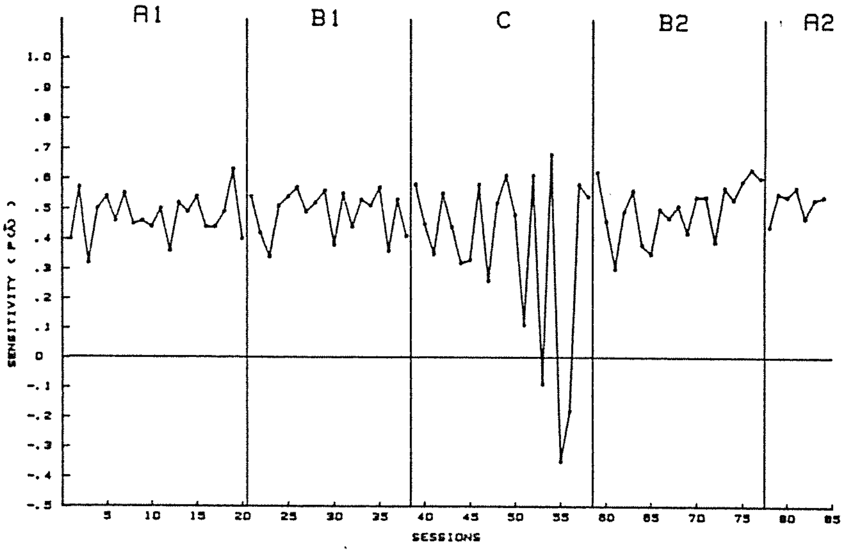

FIGURE 8. SENSITIVITY ON THE CPT FOR SUBJECT K.

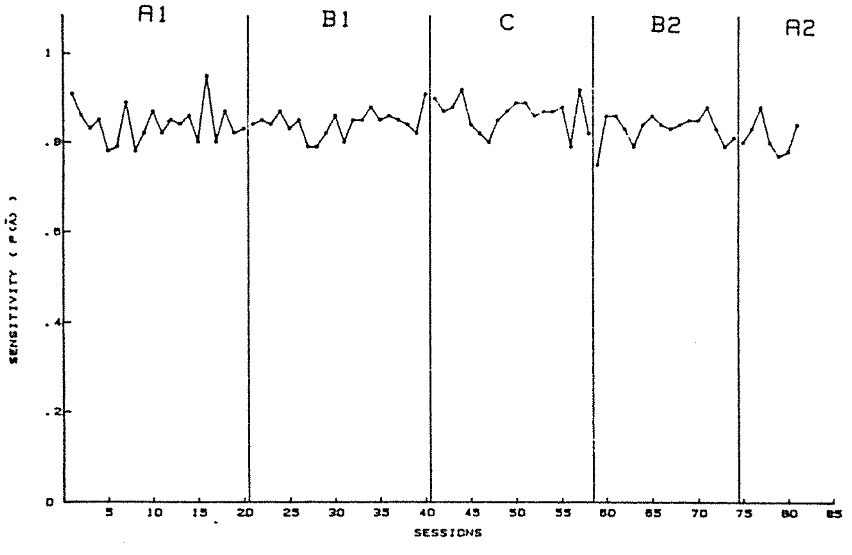

FIGURE 9. SENSITIVITY ON THE CPT FOR SUBJECT M.

Tables 10 and 11 show the $P(\bar{A})$ values for each experimental phase for Subjects K and M while Figures 8 and 9 show the sensitivity ($P(\bar{A})$) values, per session for Subjects K and M.

Subject K

Phase C produced large fluctuations in the data. A downward trend was noted in this phase. With return to phase B2 there was a small but consistent upward trend during this phase (see Figure 8).

The $P(\bar{A})$ values given in Table 10 show no change in average sensitivity across phases.

Subject M

Taking into consideration expected random fluctuations in performance, no obvious changes in sensitivity occurred across sessions (see Figure 9).

The calculated sensitivity values across phases also showed no change (see Table 11).

TABLE 12:- SIGNAL DETECTION ANALYSIS OF SUBJECT D's PERFORMANCE FOR EACH PHASE ON THE CPT.

PHASE	A1	B1	C	B2	A2
NUMBER OF SESSIONS	20	20	20	15	8
MEAN OF P(S|s)	.16	.16	.23	.25	.22
MEAN OF P(S|n)	.16	.17	.24	.25	.21
z(S|n)	1.00	.95	.71	.68	.81
P(Ā)	.50	.48	.49	.50	.51
log response bias	0.12	0.11	-0.01	0.06	-0.02

TABLE 13:- SIGNAL DETECTION ANALYSIS OF SUBJECT I's PERFORMANCE FOR EACH PHASE ON THE CPT.

PHASE	A1	B1	C	B2	A2
NUMBER OF SESSIONS	20	20	19	14	8
MEAN OF P(S|s)	.80	.78	.82	.86	.58
MEAN OF P(S|n)	.79	.74	.49	.06	.36
z(S|n)	.81	.64	.03	1.56	.36
P(Ā)	.52	.55	.76	.95	.68
log response bias	-	-	4.67	4.10	-

(Note that Subject I had zero number of misses and correct rejections during Phases A1, B1, and A2. Therefore, response bias for this subject could not be calculated for these phases.)

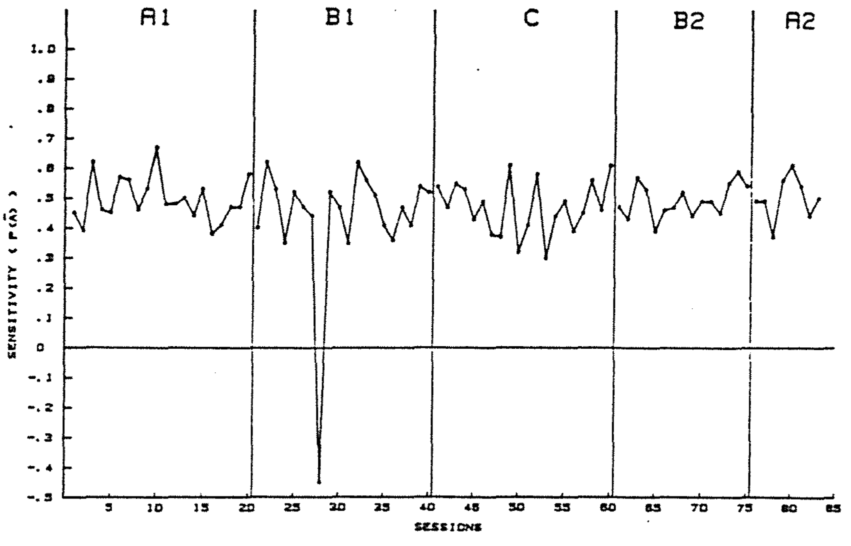

FIGURE 10. SENSITIVITY ON THE CPT FOR SUBJECT D.

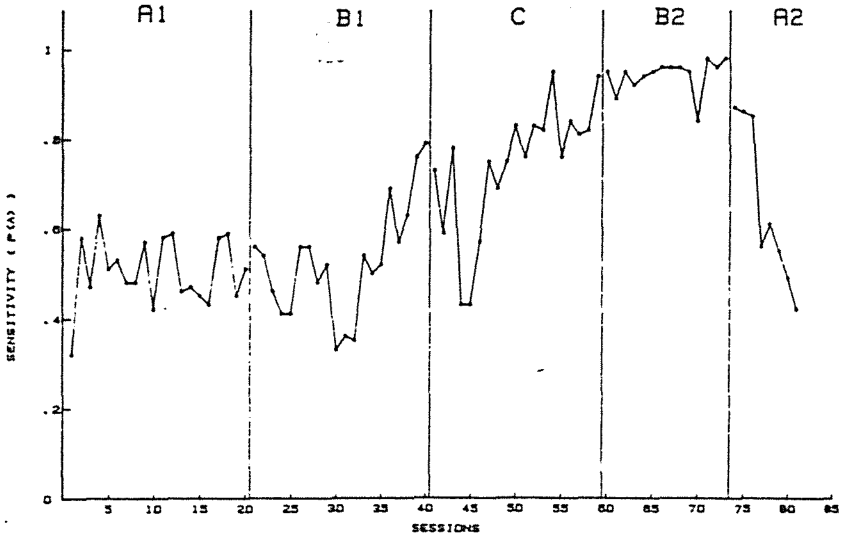

FIGURE 11. SENSITIVITY ON THE CPT FOR SUBJECT I.

Sensitivity values for each session of the experiment for Subjects D and I are shown in Figures 10 and 11.

P($\bar{A}$) values for each experimental phase for Subjects D and I are shown in Tables 12 and 13.

Subject D

Except for phase B1, where the sensitivity fell to a negative value (during session 28), all other phases generally showed relative stability (see Figure 10).

As for the previous subjects, no noticeable change in sensitivity was seen across phases (see Table 12).

Subject I

Phase A1 showed that the sensitivity of the subject was variable. Movement into phase B1 saw a rise in the level but variability remaining. The shift to phase C saw a fall in the level and fluctuations still present throughout the phase. Returning to phase B2 there was a small rise in the level of sensitivity with the data showing less fluctuations. There was a noticeable upward trend. The shift to phase A2 saw a drop in the level with an obvious downward trend present in the data.(See Figure 11).

Sensitivity increased by 21 % from phase B1 to phase C, and went up by 19 % on reversal to phase B2. The final reversal to phase A2 saw a drop of 17 % in P($\bar{A}$). (See Table 13).

Summarizing then, three subjects showed no noticeable change in sensitivity across phases. One subject showed increasing sensitivity during the reinforcement phases (phases B1, C and B2), and decreasing sensitivity during the reversal to baseline (phase A2).

Decision Criterion Measurement

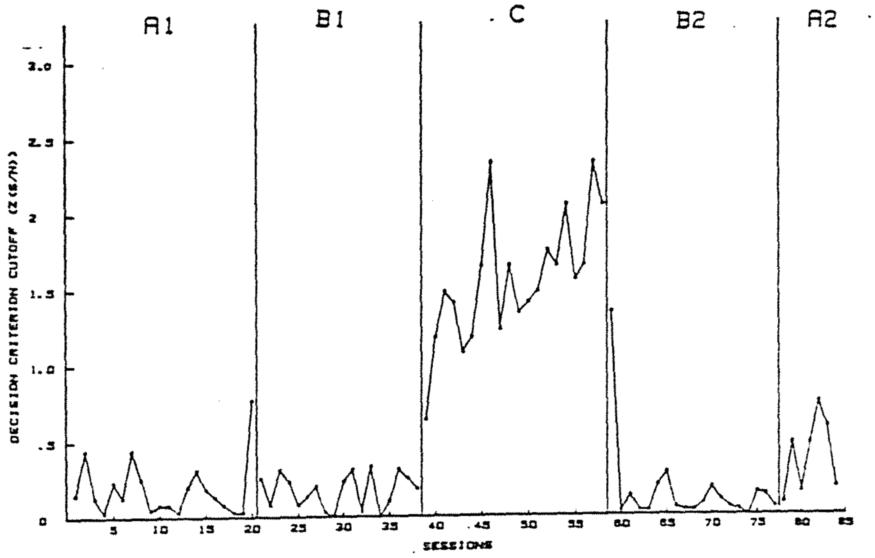

FIGURE 12. DECISION CRITERION CUTOFF (z(S|n)) PER SESSION FOR SUBJECT K.

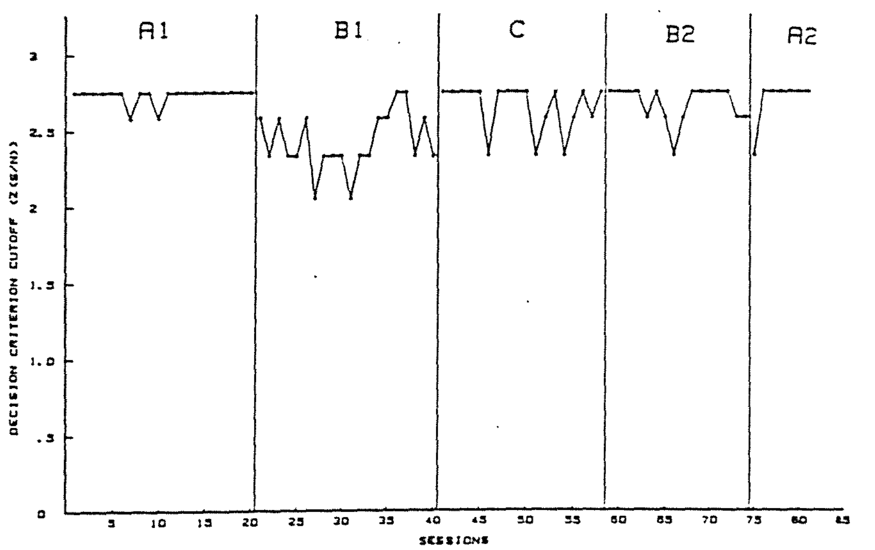

FIGURE 13. DECISION CRITERION CUTOFF (z(S|n)) PER SESSION FOR SUBJECT M.

Figures 12 and 13 show the decision criterion cutoff (z(S|n) values) for Subjects K and M.

Subject K

The z(S|n) values during phases A1 and B1 showed relatively little fluctuation. However during phase C there was an increasing trend in the data. That is, a shift towards caution. The shift into phase B2 noted a reversal towards risk with no trend and minimal fluctuation. (See Figure 12).

Subject M

Apart from phase B1 all phases produced relatively stable data. Phase B1 shows a decrease in the level with fluctuations in the data. (See Figure 13). The z(S|n) values were relatively higher for this subject as compared Subject K. That is, this subject employed greater caution in reporting 'signals'.

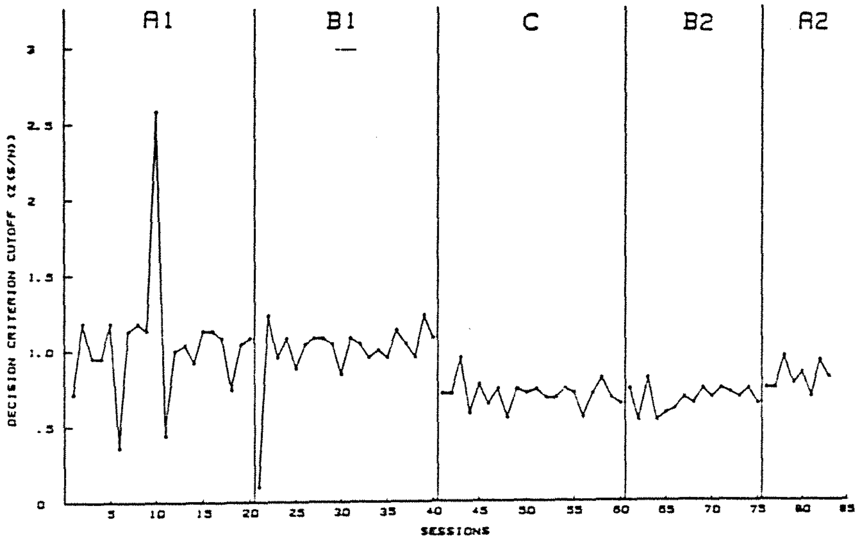

FIGURE 14. DECISION CRITERION CUTOFF (z(S|n)) PER SESSION FOR SUBJECT D.

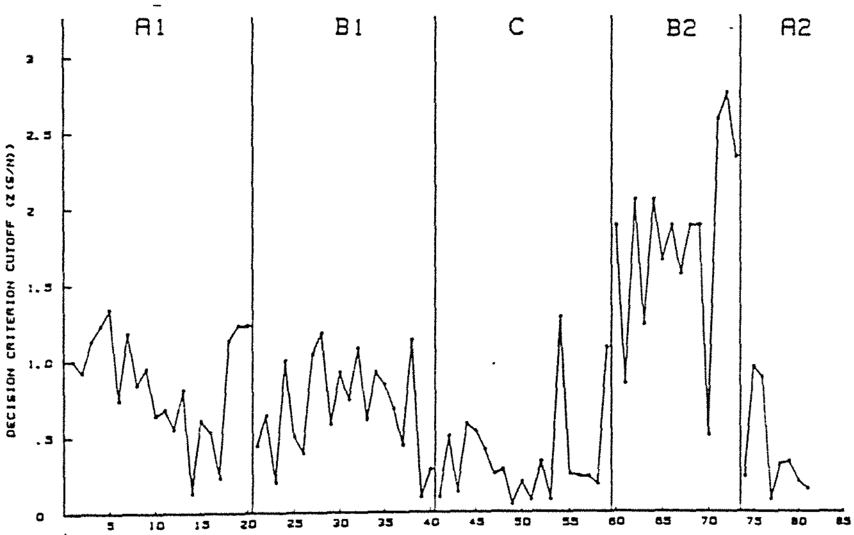

FIGURE 15. DECISION CRITERION CUTOFF (z(S|n)) PER SESSION FOR SUBJECT I.

Figures 14 and 15 show the decision criterion cutoff (z(S|n) values) per session for Subjects D and I.

Subject D

There were fluctuations in the data during phases A1 and B1. Phase C saw a drop in the level and a small shift towards risk which was maintained across phases B2 and A2. (See Figure 14). However, overall, the decision criterion cutoff for Subject D showed no major shifts.

Subject I

(Subject I was only using the Yes key to respond.)

The data in each phase showed large fluctuations. Phase B2 produced a rise in level and a shift towards caution while phase A2 saw a drop in level and a shift towards risk.

In summary, there was no consistent shifts in criterion bias across the subjects. It therefore seems that the intervention employed had no systematic effect on the subjects' decision criteria.

Response Bias

It will be recalled that response bias is a variable derived from the matching law. It is a measure of bias towards one of two concurrently available response alternatives. In the present study the left key (Yes key) was to be used when the letter 'X' was preceded by the letter 'A' (hits). The right key (No key) was to be used when the letter 'X' was preceded by a 'non-A' letter (correct rejections).

For Subject K (see Table 10) Phases A1 and B1 showed a response bias to the left key with left key bias being stronger during Phase B1. With Phase C the response bias switched to the right key but return to Phase B2 saw a reversal of the bias back to the left key. The final reversal to Phase A2 saw this bias strengthen on the left key.

For Subject M (see Table 11) the response bias through all phases was on the right key. This right key bias was strongest during Phase A2 followed by Phase A1 and then Phase C. It was weaker during Phase B2 and weakest during Phase B1.

For Subject D (see Table 12) Phases A1 and B1 showed response bias to the left key with left key bias being stronger during Phase A1. With Phase C the response bias switched to the right key but reversed to the left key during Phase B2. The final reversal to Phase A2 saw the response bias switch back to the right key.

For Subject I,(see Table 13), the response bias was always on the left key throughout the phases of the experiment. The bias was strongest on the left key during Phases A1 and B1 and weakest during Phases B2 and C.

In summary, responses were systematically biased for two subjects and unbiased for the other two.

Summary of Results I

Overall, the results may be summarized as follows:

(1)Reinforcing hits (phase B1) increased pseudo-hits and total duration on-task.

(2)Reinforcing correct detections (phase C) produced increases in correct rejections and correct detections, while pseudo-hits decreased.

(3)Reversal to reinforcing hits (phase B2) had pseudo-correct rejections and total duration on-task decrease.

(4)The final reversal to baseline (phase A2) had hits, pseudo-hits and total duration on-task decreasing.

(5)Generally, sensitivity remained constant throughout the phases.

(6)There were no systematic shifts in criterion bias across subjects.

(7)Responses were consistently biased for two subjects and unbiased for the other two.

(8)The data show a high degree of variability across subjects.

CHAPTER 5

DISCUSSION I

To explore the usefulness of the CPT as a research tool this study set out to examine if reinforcement affected performance on the CPT. Three parameters, sensitivity to the rate of reinforcement, accuracy of performance, and the time spent on-task, were used to evaluate two reinforcement conditions, reinforcing hits and reinforcing correct detections.

When hits were reinforced during phase B1 the most systematic changes across subjects were increases in both pseudo-hits and total duration on-task. Reinforcement made available on the left key increased impulsive responding on this key. This implies that reinforcement on this particular task increases impulsive behaviour. If this impulsive behaviour had not occurred the subjects' hits may have increased. This is supported by the fact that the subjects showed increased detection of the infrequent stimulus (letter 'A'), suggesting that reinforcement may have caused increased vigilance. But since impulsive behaviour increased concurrently, gains in performance as a result of an increment in vigilance may have been masked.

Both subjects M and D showed a rise in pseudo-correct rejections during the reinforcement of hits only (phase B1). These subjects also showed a rise in pseudo-hits as would be expected if reinforcement elicited impulsive responding. Increased impulsive responding on the response key for which there was no reinforcement could be explained in terms of induction (Ferster and Culberston, 1982), the spread of the effect of reinforcement to other responses.

Reinforcement also increased the number of responses emitted, as shown by the increment in total duration on-task.

Reinforcing correct detections during phase C increased correct rejections and correct detections, and decreased pseudo-hits. The contingency of reinforcement operating during this phase must have been working since correct detections increased. However, a closer scrutiny of the results reveals that hits did not increase but, rather, correct rejections did. Since more non-signals than signals were presented, the subjects would have received more reinforcements if they concentrated chiefly on detecting the non-signals. Since correct rejections (detecting non-signals) did improve, it could be assumed that the subjects were maximizing gains by giving most of their attention to non-signals. This attention focus on the No key may also have resulted in the decrease in pseudo-hits.

Reinforcing hits only during the reversal phase, B2, decreased pseudo-correct rejections and total duration on-task. Correct responding on the No key was put on extinction during this phase. Since there seems a high likelihood that reinforcement evoked impulsivity, impulsive behaviour on the No key (pseudo-correct rejections) would be expected to decrease, as was the case in this phase.

The decline in total duration on-task indicates that the subjects are responding less often. No statement can be made about changes in efficiency in detecting signals or non-signals because the changes in hits or correct rejections are not systematic across subjects. Therefore, all that can be said is that this schedule evoked less responding.

The return to baseline (phase A2) decreased hits and total duration on-task. Both patterns of behaviour can be adequately explained in terms of extinction behaviour. Since reinforcement was withdrawn for correct responding on both keys, decreased responding on both keys would be expected as a consequence. This is supported by the drop in hits and the drop in total responses.

In summary, for all four subjects reinforcement per se was seen to have an effect on performance at least in increasing the subjects time spent on-task and in increasing impulsivity. Increased impulsivity is obviously undesirable in settings such as sheltered workshops where one of the aims of reinforcement is to aid in teaching appropriate skills to the trainees rather than to facilitate impulsive behaviour. As to which contingency was better there was a suggestion, albeit a weak one, that reinforcing correct detections was more effective, in terms of increasing correct detections, time on-task and efficiency.

Idiosyncratic effects of reinforcement across all four subjects can be partially explained in terms of the level and manner of responding of the subject during baseline (phase A1). Subject K's baseline responding fluctuated around a low level and showed the expected shifts in responding with reinforcement changes. Subject M followed the rules of the CPT stringently from baseline. Therefore very little fluctuation in performance could be expected with reinforcement changes. Subject D appeared not to follow the rules of the CPT from baseline. But as the phases progressed he improved in accuracy. This implies that he was learning the task as the experiment progressed, thus confounding the effects of any reinforcement changes. Subject I responded only on the left key. His hits were relatively high during baseline. His slightly increased hit level with a decrement of time on-task during phase C implies that he was getting more efficient on-task, reducing the number of Yes responses to non target stimuli.

It is noteworthy that in increasing correct detections, a measure of total accuracy, reinforcing correct responding on both keys was more effective than reinforcing correct responding on just one key. But, if the purpose of the reinforcement schedule was aimed to improve absolute accuracy (maximising hits only), then it would be appropriate if correct responding on one key only was reinforced. Phase B2 (reinforcing hits) showed an increase in hits for Subject K.

Signal Detection Analysis

For subject K sensitivity during phase C (reinforcing correct detections) fluctuated, but comparing the mean values of sensitivity across phases revealed no obvious change in sensitivity. Thus the majority of subjects (subjects K,M and D) showed no real change in sensitivity between baseline and the reinforcement phases (reinforcing hits and reinforcing correct detections). This is in line with previous research with reinforcement on a related task, the vigilance task (see Davenport, 1968, 1969). Subject I did show fluctuations in sensitivity but caution is required in interpreting such changes since, unlike the other subjects, subject I was most often responding on the Yes key and not following the rules of the task.

Previous research had shown inconsistent results with respect to changes in decision criterion bias when reinforcement was used in a task related to the CPT, the vigilance task (Davies and Parasuraman, 1982). The present study showed similar findings. Subject K showed a shift towards caution while subject D showed a slight shift towards risk when correct detections were reinforced (phase C). Subjects M and I showed shifts towards risk when hits were reinforced (phases B1 and B2 respectively). Therefore, reinforcement did not appear to have any consistent effects on decision criterion bias.

Evaluating sensitivity using the matching law variable of log d showed that it was consistent with both the calculated $P(\bar{A})$ values and d′

values. Log d added no additional information in terms of sensitivity. Nevertheless, log response bias, a measure of the subject's key bias, did complement the data since it helped substantiate the evidence that reinforcement did have an effect on responding. The majority of subjects had a left (Yes) key bias during baseline (phase A1). This bias was still present during the reinforcement of hits (phase B1). But when the reinforcement of correct detections was in effect the bias for the majority of subjects switched to the right (No) key. This could be predicted if it is assumed that the subjects wanted to maximize gains; this key afforded the greater opportunity for reinforcement.

According to Zeaman and House's (1963) theory of discrimination learning, the chief problem for the mentally retarded is attending to the relevant dimensions, in the present case, the form of the letters in sequence. Fisher and Zeaman (1973) expanded this theory to include other possible deficits to account for poor learning by the mentally retarded. They included difficulty in remembering the specific responses and rewards, as well as the limited breadth of attention that these subjects have (able to observe only a limited number of dimensions on any one trial). A study by Mackie and Mackay(1982) in which attention was compared with retention in discrimination learning of low mental age retarded adults and (mental age)-matched non-retarded children showed that retention failure accounted for poorer performances by the low mental age retarded subjects rather than attention deficits. But these results do not invalidate the hypothesis that breadth of attention is a developmental variable. The multistore models of memory proposed by Atkinson and Shiffrin (1968), which Fisher and Zeaman utilized in developing their theory, underwent revision by Mosley(1980). In this revised model the chief control process of selective attention hinged upon the sensory store, which is an orienting-response component, and the long-term store, which is an internal-cue selection component. This model explained poor performances by low mental age subjects showing that these subjects, when confronted with unfamiliar stimuli, failed to retain the most noticeable features of the stimulus event that could serve as cues for the recognition task, thus failing to encode. Secondly, these subjects were not able to access aspects of previously stored information that could serve as accurate cues for the task at hand. Both theories predict that reinforcement for correct responding would overcome these deficits by helping the subject associate the right responses with appropriate rewards and thus aid in discrimination learning.

In the present study this was seen to be the case for three of the four subjects. Performances were increased above baseline levels under the appropriate contingencies of reinforcement applied in the phases. Thus the present results are consistent with both Zeaman and House's and Fisher and Zeaman's theories.

Previous studies have shown that methods of increasing extrinsic motivation had failed to produce consistent effects particularly with respect to overcoming vigilance decrements in the course of a vigilance session. For example, in some experiments the provision of incentives has been shown to exert a beneficial effect on the overall level of detection efficiency (Sipowicz et al., 1962; Bevan and Turner, 1965;

Smith et al., 1967); while in others it had not (Levine, 1966; Weiner, 1969). This discrepancy could not be attributed to the type of subject population tested nor to the size of, for example, monetary incentives used (Davies and Parasuraman, 1982). Could this discrepancy be explained by an increase in impulsivity which could have masked an effective increase in performance? The design of the present study along with the performance measures used allowed a detailed examination of the effects of reinforcement, and it is clear that impulsivity increased during reinforcement conditions and may have had a masking effect on performance. The point to be made is that when extrinsic motivation is raised, there is certainly an effect, may it be 'overtly' overcoming the vigilance decrement by an increase in target performance, or 'covertly' by an increase in impulsivity.

It is worth noting that strict rules were laid down for the CPT task in the present experiment. These rules were explicit and subjects were told what to look for in terms of discriminating stimuli, what responses were required, and their consequences. This information should have led to rule-governed behaviour. Therefore, the subjects in this experiment did not start off naively since rules for the CPT were laid down from the start of the experiment and to a large extent these rules were followed. It may be that reinforcement effects, other than being hampered by increased impulsivity, may have been affected by this rule governed behaviour. If rules were not in operation reinforcement effects might have been much stronger. That is, for most subjects target response rate was already quite high because the rules were being followed. The effect of reinforcement could therefore only be a limited one in terms of bringing about any further improvement in response rate.

The application of extrinsic reinforcement over and above the explicit rules did produce increased accuracy and increased time spent on-task on the CPT. Although the effects of reinforcement were not marked, the present results clearly indicate that it may be worth considering the use of reinforcement in vigilance-like tasks where simple rule-governed behaviour should occur. The majority of subjects in this study did show that they were able to follow the rules of the task. Performance was slightly raised with the introduction of reinforcement.

This has wide implications for settings such as sheltered workshops. Rules need to be laid down and followed to ensure safe and smooth running in such places, but something like a token economy system could be introduced over and above this, to aid in training as well as to increase productivity of the workshop.

The modified CPT employed in this experiment produced results which look promising for developing the CPT further. A major problem in the present experiment was the rise in impulsive responding which may have masked the effects of reinforcement. The aim of the second experiment was to attempt to lessen the impact of impulsive responding so that the effects of different reinforcement schedules could be better assessed.

CHAPTER 6

Introduction II:

Further exploratory tests of reinforcement on the CPT

Types of Schedules of Reinforcement

In the field of operant conditioning, schedules of reinforcement refer to patterns of "timing" for delivery of reinforcers. The continuous reinforcement schedule ensures that reinforcers are delivered after each occurrence of the target behaviour, that is, on a continuous basis. Intermittent or partial reinforcement schedules refer to those in which reinforcement follows some, but not all correct or appropriate responses (Skinner, 1953). Since each occurrence of the behaviour is no longer reinforced, intermittent schedules reduce satiation effects. Behaviours maintained on intermittent schedules are also more resistant to extinction (Catania, 1979). The two categories of simple intermittent schedules most often used are ratio schedules and interval schedules (Ferster and Skinner, 1957; Skinner, 1953). These schedules are used when it is the frequency of response which is of concern. When increasing the duration of a response is the experimenter's primary goal, response duration schedules (Stevenson and Clayton, 1970) may be used. These three types of intermittent reinforcement schedules aim to increase the target behaviour. Typical types of intermittent reinforcement schedules used to decrease behaviour are the Differential Reinforcement of Low Rates (DRL); Differential Reinforcement of other Behaviours (DRO); and Differential Reinforcement of Incompatible Behaviour (Martin and Pear, 1983). All these schedules of reinforcement require that the reinforcement be contingent on target behaviour. One particular schedule which does not require this contingency but rather provides response - independent reinforcement is the Time schedule which provides reinforcers only if a particular time has elapsed, irrespective of whether a response was emitted. Typically, such schedules tend to decrease behaviour (e.g., Sizemore and Lattal, 1977).

Thinning Schedules of Reinforcement

The reinforcement system can be looked upon as a temporary structure used to produce rapid behaviour change. Sometimes the eventual plan is to bring the subject's behaviour under the control of more natural reinforcers, for example verbal praise. This is achieved in the practical setting by gradually decreasing the subject's dependence on artificially supplied reinforcers, for example lollies, by a process called schedule thinning. Thinning is the process in which reinforcement gradually becomes available less often, or becomes contingent upon greater amounts of appropriate behaviour. Thus it is a movement from a dense schedule (continuous) to a sparse or intermittent schedule of reinforcement.

Table 14 presents an elemental scheme for schedule thinning. As schedule shifts are made from a continuous schedule to a fixed schedule to a variable schedule, there finally comes a point where predetermined "timing" of reinforcer delivery is no longer required. It is at this point that the behaviour is under the control of naturally occurring reinforcers.

Table 14: Schedules for delivery of reinforcers

```
                  Continuous Reinforcement Schedule (CRF)
                                    |
DENSE              Intermittent/Partial Reinforcement Schedule
  |                |            |                    |
  |   Ratio Schedules    Interval Schedules     Response Duration
  |                |            |               Schedules
  |                |            |                    |
  |   Fixed-Ratio        Fixed Interval         Fixed Response
  |   Schedules (FR)     Schedules(FI)          Duration
  |                |            |               Schedules (FRD)
  |                |            |                    |
  |   Variable-Ratio     Variable Interval      Variable Response
  |   Schedules (VR)     Schedules (VI)         Duration
  |                 \           |               Schedules (VRD)
  |                  \          |                   /
  |                   \         |                  /
SPARSE              Non-Scheduled delivery of reinforcement
                            (naturally occurring)
```

Thinning schedules of reinforcement have been shown to result in higher and steadier levels of respondings (e.g., Logan, 1960; Reynolds, 1968). The target behaviours that have been established under intermittent reinforcement schedules, that is, moving away from a dense schedule to a sparse schedule of reinforcement, have shown greater resistance to extinction (e.g., Warm,Hagner and Meyer, 1971; Lambreth, Gouaux and Davis, 1972; Williams, 1973). There appears to be a transfer of control from the reinforcer to more natural methods such as praise and attention (O'Leary and Becker, 1967), especially if schedule thinning is done in conjunction with pairing social reinforcers with tokens or primary reinforcers.

It should be borne in mind that there is a possibility of ratio strain occurring during thinning when the schedule has been thinned so quickly that the ratio for correct responding and reinforcement is too large. In such instances the subject does not earn the reinforcements often enough to maintain responding, and there is a marked decrease in response rate even to the point of cessation. (Catania, 1979).

There are a number of factors that influence the effectiveness of thinned schedules of reinforcement, two of which are the valence of the reward and the probability of obtaining the reward (Vroom, 1964; Galbraith and Cummings, 1967). The valence of the reward refers to the strength of the person's desire for that reward (Lewin, 1938). For a given quantity of reward to be distributed throughout a session, the valence of each of the reinforcements is inversely related to the probability of obtaining it (the expectancy). This probability depends on the frequency of the reinforcement. If the frequency was high, the probability would have been high which in turn would have lowered the valence of each reward since the given quantity is now divided into smaller portions, thus lowering the motivation for the reward. Conversely, if the frequency of reinforcement was low, the probability of obtaining it would have been low, which in turn would have increased the valence of each reward since the given quantity would have been divided into bigger portions. Thus the motivation for each reinforcement would have been high. Therefore, some expectancy theories consider that intermediate frequencies are superior to either high or low frequencies (Edwards, 1962; Atkinson, 1966).

It has been suggested that the attractiveness of the reward and the frequency of reinforcement can be influenced by not only the total size of the reward to be distributed but also the amount of effort required. For example, when the total size of the reward is relatively large and the required effort is relatively substantial, a high degree of reinforcement accompanied by a low degree of variation in the amount of reward is preferred over a low frequency of reinforcement (Chung and Vickery, 1976).

Another interesting finding has been the resistance to extinction following training with partial reinforcement schedules. An inverted - U relationship was said to exist between resistance to extinction and percentage of reinforcement. That is, 100% and 0% reinforcement were more prone to extinction with the peak of resistance being at the peak of the inverted - U, around 50% reinforcement (Lewis, 1960). It is argued that between 100% and 50% reinforcement in intermittent reinforcement schedules, there are greater opportunities for learning and subsequent conditioning to be established, as compared to that between 50% and 0% reinforcement (Chung and Vickery, 1976).

The attractiveness of thinned schedules of reinforcement has immense appeal in some token economy systems found in the field, when for example, the level of target behaviours may need to be raised. The objectives of establishing high, steady and persistent responding with the flexibility of transfering control of behaviour onto naturally occurring reinforcers,such as praise, are satisfied through the use of intermittent reinforcement schedules.

Comparison between Variable Ratio

and

Variable Interval Schedules of Reinforcement.

In the present study, two intermittent reinforcement schedules which generate constant response rates were used. Both VR and VI schedules have the potential for maintaining target behaviour at specified levels. This is useful in applied settings where some target behaviours need to be improved and maintained at certain levels.

Under the Ratio Schedule, the number of times a target behaviour occurs determines the timing of reinforcer delivery. If a subject is reinforced on completion of a specified number of correct responses this is termed a fixed ratio reinforcement schedule. The typical characteristics of behaviour under this schedule include higher rates of responding compared to that under Continuous Reinforcement; an increase in the rate of behaviour will result in increases in the frequency of reinforcement; there is a possibility of inappropriate fluencies for a given behaviour resulting (related behaviour to target may be affected); and as the schedule ratio increases the subject will often stop responding for a period of time following delivery of the reinforcer, taking what is termed a post reinforcement pause (Zeiler, 1977).

Under the Variable Ratio schedule, the target behaviour is reinforced on the average of a specified number of correct responses. Under this schedule problems of fluency and post reinforcement pause are eliminated, and given the unpredictability of reinforcer delivery on a VR schedule, the subject's rate of responding evens out since "the probability of reinforcement at any moment remains essentially constant and the subject adjusts by holding to a high constant rate" (Skinner, 1953, p. 104). Nevertheless it should be borne in mind that if the average specified number of correct responses is very high, there is a high possibility of getting ratio strain (Catania, 1979).

Under the Interval Schedule a passage of time followed by a target behaviour determines the timing of reinforcer delivery. If a subject is reinforced on completion of a constant specified time followed by the target behaviour it is termed a fixed interval reinforcement schedule. The typical characteristics of behaviour under this schedule include the concave upward pattern of cumulative patterns of responding (sometimes called F1 scalloping).

Under the Variable Interval schedule the delivery of a reinforcer depends on the passage of a variable time and then the emission of a single response. The rate at which reinforcers are delivered is not affected by the rate of responding. The schedule provides a specified and relatively constant rate of reinforcement over a wider range of possible response rates. There is, a lower limit to the response rate that will produce all of the scheduled reinforcers since reinforcers are not delivered unless responses occur. Thus this schedule generates constant reponse rates due to the varying intervals from one reinforcer to the next. A low rate of VI reinforcement produces less responding than a high rate of VI reinforcement but in both cases responding is uniformly distributed in time (Nevin, 1973).

The VR and VI schedules differ considerably in the effects on behaviour. Catania, Matthews, Silverman and Yohalem (1977) confirmed that VR response rates were higher than VI response rates, for two pairs of pigeons yoked under the schedules. Another interesting difference was the way the pattern of responding was affected when reinforcement was reduced or discontinued. It was shown that during extinction after VI reinforcement, the decrease in response rate was gradual; whereas extinction after VR reinforcement usually produced abrupt transitions from high response rates to periods of no responding (Ferster and Culbertson, 1982).

One plausible theory put forward to explain the rate difference between VR and VI schedules is that a larger proportion of long inter-response times (IRT) than short IRTs is reinforced in VI than in VR schedules. An increase in these longer times between responses necessarily implies lower response rates (Kuch and Platt, 1976).

Purpose of Experiment II

Field settings, such as sheltered workshops, may make use of reinforcement schedules to enhance and sustain target behaviours. Intermittent schedules achieve these goals far better than continuous schedules of reinforcement. However different intermittent schedules are useful for different specifications of target tasks. The CPT was suggested as a potential tool to be used in the field for comparing between different schedules of reinforcement. Through this, it was hoped that appropriate schedules to improve similar target behaviours as those required for the CPT, could be found.

The difficult version of the CPT, that of detecting the 'X' stimulus which had been preceded by the 'A' stimulus, had reinforcement effects at least partially masked by impulsive responding in the preceding study. However, this experiment did establish that reinforcement had an effect on responding on the CPT (with the additional response key). It was seemed that this difficult version of the CPT would not be appropriate for comparison of schedules of reinforcement unless the focus was on the effects on impulsivity. Auditory feedback has been shown to improve performance on the simpler version of the CPT (O'Dougherty et al., 1984), where only a single specified stimulus had to be detected. During that study by O'Dougherty et al. (1984), impulsivity was defined as any response during the first 200ms. after the presentation of a stimulus. It is possible that this simpler version showed this improvement since impulsive responding was defined differently to the definition used in experiment I, where impulsivity was defined as any response until 700ms. after the disappearance of a particular stimulus. It is also possible that reinforcement does not increase impulsivity on the simpler version of the CPT. The literature does not offer any clue as to which is the more likely reason. However, there was the possibility that reinforcement for correct responding would improve performance on this simpler version without the masking effect of impulsivity, if impulsivity was redefined, by reducing the period of time for anticipatory responses to occur. Thus it was decided that the simpler version of the CPT was to be used for this stage of the study.

The chief purpose of Experiment II was to show that reinforcement affected performance on the simpler version of the CPT (with the additional response key) and was useful for comparing between schedules of reinforcement. Two intermittent schedules of reinforcement were to be compared to assess the value of the CPT as a measure of schedule effects. The two schedules examined were Variable Ratio and Variable Interval schedules of reinforcement. One required correct responding to achieve reinforcement and the other reinforced any response correct or not (on-task behaviour). The VR and VI schedules were compared on the CPT along the three parameters of sensitivity to the rate of reinforcement, accuracy in performance and time spent on-task, to see which reinforcement schedule was better at improving performance along these measures. The same measures were used in the present study as were used in Experiment I.

An alternating treatments design was used with baseline condition being one of the treatment conditions. The number of reinforcements delivered under the VR and the VI schedules in each phase were adjusted to be the same, to help in the comparison. If no difference in treatment conditions was found, a more lenient contingency was to be applied to the VR schedule (reducing the required ratio to a lower ratio) to see if this would show a difference between the two schedules.

CHAPTER 7

METHOD II

Subjects

Four further subjects were chosen from the Intellectually Handicapped Society Sheltered Workshop at Cook Street in Palmerston North, New Zealand.

The selection was based on reports from their instructor that they could understand the simple instructions that were to be used.

Subject A. (Sex F, Age 21 years).

The cause of A's mental retardation was Down's Syndrome. On the Peabody Picture Vocabulary Test her age equivalent was 3 years 3 months. On the Stanford Binet Test of Intelligence she had difficulty with the verbal items but was better on the performance items. She achieved a basal age of 4 years and passed six subtests between the age categories of four years six months and six years. Overall, her mental age was 4 years 6 months. She was thus classified as being severely retarded but "trainable" (IQ 20-34).

Subject B. (Sex M, Age 20 years).

The subject suffered from epilepsy. On the Peabody Picture Vocabulary Test his age equivalent was 5 years 10 months. On the Weschler Adult Intelligence Scale-Revised Version he did relatively better in the Vocabulary and Similarities subtests of the verbal tests. He achieved a Verbal IQ of 59. On the Performance Tests he did relatively better in the Picture Completion and Block Design subtests. His Performance IQ was four IQ points below his Verbal IQ (PIQ55). His Full Scale IQ was 55 (IQ 50-60). He was thus classified as being in the category of mildly retarded but "educable" (IQ 50-69).

Subject C. (Sex F, Age 33 years).

The subject was reported to have suffered brain damage at birth. On the Peabody Picture Vocabulary Test her age equivalent was 10 years 10 months. On the Weschler Adult Intelligence Scale - Revised Version she did relatively better on the Digit Span, Comprehension and Vocabulary subtests of the verbal tests. She achieved a Verbal IQ of 70. On the performance tests she did relatively better on the Object Assembly, Picture Completion and Block Design subtests. Her Performance IQ was four IQ points below her Verbal IQ (PIQ66). Her Full Scale IQ was 66 (IQ 61-71). She was thus classified in the category of mildly retarded but "educable" (IQ 50-69).

Subject G.(Sex M, Age 28 years).

On the Peabody Picture Vocabulary Test his age equivalent was 5 years 3 months. On the Weschler Adult Intelligence Scale - Revised Version he did relatively better in the Comprehension, Vocabulary and Similarities subtests of the verbal tests and achieved a Verbal IQ of 57. On the performance tests he did relatively better on the Block Design subtest. His Performance IQ was three IQ points below his Verbal IQ (PIQ54). His Full Scale IQ was 52 (IQ 47-57). He was thus classified as bordering between moderately retarded but "trainable" (IQ 35-49) and mildly retarded but "educable" (IQ 50-69).

As for the first experiment all four subjects were approached and their consent obtained before progressing further.

Apart from the fact that Subject C wore glasses, all four subjects had normal vision. Subject G had trouble naming the colours although it was certain he knew what the colours were. For example, when it was a green screen he said it was the colour of grass and when it was a red screen he pointed at his own red sweat shirt and said it was the same colour.

Task Description

The equipment was the same as in experiment I (see Method I). The CPT programme presented letters on the screen and the subject had to press the Yes key when it was the letter "A" and the No key when it was any other letter.

Apparatus

The same equipment was used as in the first study ,except that the playcard with the letter "X" was not used in the present experiment (see the apparatus subsection in Method I).

Specifications of Computer Programme

There were three components to the CPT programme. One component was the baseline component (without reinforcement). Another component reinforced correct detections on a variable ratio schedule (see reinforcement subsection). The third component reinforced any response on a variable interval schedule (see reinforcement subsection).

Each of the components had the following common features:- Each letter was flashed on the screen for 0.2 seconds and the interletter interval was 1.4sec.. These aspects of timing fall within the usual limits for such a task (e.g., see Crosby, 1972).

Responding after 50ms of target letter disappearance and before onset of the next letter constituted a valid response and was categorized as shown in Table 15.

Table 15:Performance Parameters Recorded In All Three CPT Components

Letter on screen	Key pressed	Parameter recorded
A	Y	Hits
non-A	Y	False Alarms
non-A	N	Correct Rejections
A	N	Misses

Any responses up to 50ms. after the disappearance of a letter, was recorded as an impulsive response. Therefore, the definition for an impulsive response was changed from being, response up to 700ms. after the disappearance of a stimulus in experiment I, to response up to 50ms. after the disappearance of a stimulus in experiment II. These impulsive responses were recorded as shown in Table 16.

Table 16:Impulsive Parameters Recorded In All Three CPT Programmes

Letter that was on screen	Key pressed	Parameter recorded
A	Y	Impulsive Hits
non-A	Y	Impulsive False Alarms
non-A	N	Impulsive Correct Rejections
A	N	Impulsive Misses

To prevent double recording of responses, each impulsive response brought on the next letter, without having the intervening duration specified for a response like hits, false alarms, etc. That is, if the subject responded within 50 ms. of the disappearance of a letter on the screen, the next letter was presented.

There were a total of 140 possible appearances of 'A's (140 possible hits) and 420 possible appearances of non-A's (G,W,V,C,U,Z,K,S,R,D - 420 possible correct rejections).

Presentation of each letter was randomly assigned by the computer. Each component ran for about 15 minutes and the letters were typed in black, bold, upper case text.

Reinforcements

The baseline component did not reinforce the subject while on the CPT programme. During baseline the screen had a white background and at the end of the time period the subject was shown a white stimulus card and asked to identify the colour of the background on the monitor and the colour of the stimulus card. This was to aid in stimulus discrimination.

The variable ratio component reinforced correct detections (hits and/or correct rejections) on a variable ratio schedule, whose specifications were predetermined by the experimenter (VR16 for Intervention I and VR8 for Intervention II). The reinforcement features on the colour monitor were as for Experiment I (see reinforcement subsection in Method I). During the VR component the screen had a green background. At the end of the time period on this component a green stimulus card with two labelled red buttons (simulating the response keys) was presented to the subject. It was hoped that this procedure would enhance stimulus discrimination. The subject was made to identify the colour of the background on the monitor and the colour of the stimulus card. The number of reinforcement cues on the screen were then totalled up and the equivalent sweets (pebbles) given in a cup which carried the subject's name. These cups could only be claimed at lunch time after the experimental session.

The variable interval component reinforced any responses (any of the responses listed in Tables 16 and 17), on a variable interval schedule. During the VI component the screen had a red background. At the end of the component a red stimulus card with two labelled dark red buttons (simulating the response keys) was presented to the subject to enhance stimulus discrimination. The subject had to identify the background colour on the monitor and the colour of the stimulus card. The appropriate number of reinforcements obtained during this time period were dispensed as for the variable ratio component.

Setting

The setting and subjects' seating arrangements were identical to the first study (see setting in Method I).

Design

An alternating treatments design was utilized (Barlow and Hayes, 1979) with one of the treatment conditions being baseline condition (Ollendick, Shapiro and Barrett, 1981). It was felt that this design would be the best to compare the two schedules of reinforcement. Each session had three time periods of 15 minutes each and there were three phases, the Baseline Condition, Intervention I and Intervention II. Intervention I had for one of its treatment conditions a Variable Ratio of 16 while Intervention II used a Variable Ratio of 8. Each day the subject had three time periods on the computer, thus being exposed to each of the treatment conditions. The only modification to the basic design was the exclusion of the final phase where the most effective treatment condition was to be presented for all three time periods.

Procedure

During the establishment and implementation of a standardized training programme, the subjects individually worked with the experimenter in a testing room at the workshop. The procedure was broken up into five stages.

Stage I:- Using the same keyboard overlay as for the actual experiment, the Experimenter, sitting in front of the subject, held up the letter card 'A' and said: "When you see this card "A" (pointing out the shape of the letter to the subject) press the Yes key (pointing out the key on the keyboard)."

The subject practised until he or she get 10 consecutive correct Yes responses.

Stage II:- The experimenter showing the other ten cards to the subject and said: "If it is not A, (pointing out the other cards), press the No key (pointing out this key on the keyboard)."

The subject practised until he or she got 10 consecutive correct No responses.

Stage III:- The experimenter said: "Now lets try them altogether" and shuffled in the A card with the 10 other cards.

The subject practised until he or she got 20 correct responses to the haphazardly presented letters.

Stage IV:- The subject then moved on to the experimental setting and had the playcards put before the Computer monitor and, as in Stage III, practised till he or she got 20 correct responses.

Stage V:- Working on the baseline component of the CPT programme the subject practised until he or she got at least five consecutive correct responses on the Yes key (five hits) and at least five consecutive correct responses on the No Key, (five correct rejections). After passing this stage the subject was deemed competent for the experiment.

During baseline condition, each time period had the subject working on the baseline component. Stability criteria as outlined in the previous study were not strictly enforced during the baseline condition since the baseline component would be carried on as one treatment condition during interventions I and II.

During interventions I and II, each time period of a session had one randomly assigned treatment component in effect (baseline, variable ratio or variable interval component).

During Intervention I, reinforcements on the variable ratio condition were programmed to be delivered on a variable ratio of 16. By estimation, or following from the previous time period with the variable ratio condition, it was ensured that an equal number of reinforcements were delivered during the variable interval condition time period of that session. This enabled a systematic comparison of performance between the two schedules of reinforcement. An example will serve to illustrate the method of reinforcement. During session one, say 20 reinforcements were delivered during the variable ratio condition, then 20 reinforcements would be delivered during the variable interval condition. In session two if the variable interval was to be presented first then 20 reinforcements would be delivered (based on session one). Assume that the variable ratio condition only delivered 10 reinforcements during session two. In session three if 20 reinforcements were delivered during the variable ratio condition, then 10 reinforcements would be delivered during the variable interval condition. Therefore, over the three sessions 50 reinforcements were delivered during each reinforcement condition.

The VR schedule in the computer programme arranged a string of ascending numbers from one to N, where N was equal to (the VR number x 2) - 1. So for a VR 16, this would be (16x2 - 1), with the consequent string of numbers ranging from one to 31. A number was randomly selected from this string and if the subject scored this number of correct detections, reinforcement was delivered. This random selection, from the generated string of numbers, specifying the number of correct detections to be reinforced, continued till the end of the session. This method ensured that the required variable ratio was operating during the particular session. For the VI schedule, the number of reinforcements to be delivered were randomly allocated into time slots within the duration of the session. Any response after the completion of a time slot signalled a reinforcement delivery.

During Intervention II a similar procedure was followed except that the reinforcements on the variable ratio condition were delivered on a variable ratio of 8. This was carried out to see if doubling the availability of reinforcements would enhance the differences in performance under the two reinforcement conditions.

Analysis of Results

The following dependent variables were examined:

1. Hits

2. Correct Rejections

3. Correct Detections

4. Impulsive Hits

5. Impulsive Correct Rejections

6. Total Duration On-Task

The first two variables are defined in Table 15. The dependent variable Correct Detections involved combining the Hits scored per session with the Correct Rejections scored per session to give a single score per session. The next two dependent variables are defined in Table 16. Total Duration On-Task was calculated by subtracting the total number of stimulus sequences which were not responded to by the subject from the total number of possible responses available per session (560) and multiplying this by the duration of a sequence presentation (1.6 seconds).

The data were presented in their raw form and not as running averages to simplify presentation in this alternating treatments design. Visual inspection was again a major method of analysis. Means for the dependent variables was also obtained and used in the analysis.

Signal Detection Analysis

The measures used were exactly as for the first experiment (see signal detection analysis in Method I).

CHAPTER 8

RESULTS II

Experiment II was planned and executed with the intent that the VI component would reinforce the subject under a variable interval schedule. It was not until after the experiment was completed that it was realized that the schedule used did not operate as a VI schedule. What actually occurred was that a fixed number of reinforcements, based on either the same number of reinforcements the subject achieved while on the VR component of the same session, or an estimated number of reinforcements the subject achieved on the the VR component of the previous session, were being randomly assigned by the computer to variable time slots within the duration of the whole session. However, unlike a VI schedule the next interval was not started by reinforcement delivery, but automically following reinforcement availability. Hence reinforcements could be queued and following any response on one of the two keys, the reinforcement would be delivered. Thus there existed the possibility for the subject to ignore the majority of the session, and then keep pressing any key, no matter what appeared on the screen, and reinforcement would be delivered after every key press. This schedule of reinforcement is not a VI schedule. In fact the schedule is more like a tandem Variable Time- Fixed Ratio(1) schedule with accumulating reinforcements possible even after the particular variable time had passed. However, provided subjects had a reasonably high rate of responding the schedule operated similarly to a VI and a comparison between the two schedules was possible since both operated in a yoke-like manner (equal number of reinforcements delivered under both schedules).

During the intervention phases, the three conditions were randomly assigned to one of the three time periods of a session. Order effects were negligible.

As a means of simplifying Table and Figure presentations Tables 17 to 24 will refer to each of the treatment conditions as follows: B(Baseline component), VR(Variable ratio component), and VI(Variable interval component). Correct Rejections and Correct Detections will be referred to as CR and CD, respectively. Impulsive Hits and Impulsive Correct Rejections will be represented by IH and ICR. Total duration on-task will be referred to as TTDR. The letter "n" refers to the number of time periods per treatment condition. The same nomencalture for treatment conditions applies to Figures 16 to 39. However, for the sake of clarity, these abbreviations were not used in the text.

Hits

A hit was recorded if the subject responded on the Yes key, after 50ms of the disappearance of the letter "A" and before the onset of the next letter.

Table 17 :- MEANS OF THE MAJOR DEPENDENT VARIABLES FOR EACH TREATMENT CONDITION OF EACH PHASE FOR SUBJECT A.

	BASELINE	INTERVENTION I			INTERVENTION II		
DEPENDENT VARIABLE	B	B	VR	VI	B	VR	VI
n	9	21	21	21	17	17	17
HITS	33.78	76.19	77.76	64.14	61.71	64.76	57.41
CR	334.33	268.24	286.90	270.38	184.59	255.29	219.06
CD	368.11	344.43	364.67	332.52	246.29	320.06	277.06
IH	0.56	0.71	0.48	0.76	0.94	0.82	1.12
ICR	24.44	15.76	18.95	20.71	17.59	21.12	19.94
TTDR	768.18	627.50	666.21	625.75	469.55	606.87	528.47

Table 18 :- MEANS OF THE MAJOR DEPENDENT VARIABLES FOR EACH TREATMENT CONDITION OF EACH PHASE FOR SUBJECT B.

	BASELINE	INTERVENTION I			INTERVENTION II		
DEPENDENT VARIABLE	B	B	VR	VI	B	VR	VI
n	12	21	21	21	11	11	11
HITS	79.92	76.10	87.14	89.90	54.55	70.64	70.64
CR	164.33	178.81	250.62	241.14	173.09	266.27	257.73
CD	244.25	255.14	336.95	332.67	227.64	336.91	328.36
IH	2.58	3.14	3.14	3.33	1.45	3.64	3.27
ICR	14.83	23.33	37.14	41.71	28.09	49.64	40.18
TTDR	455.33	517.49	676.95	666.59	470.02	710.69	677.96

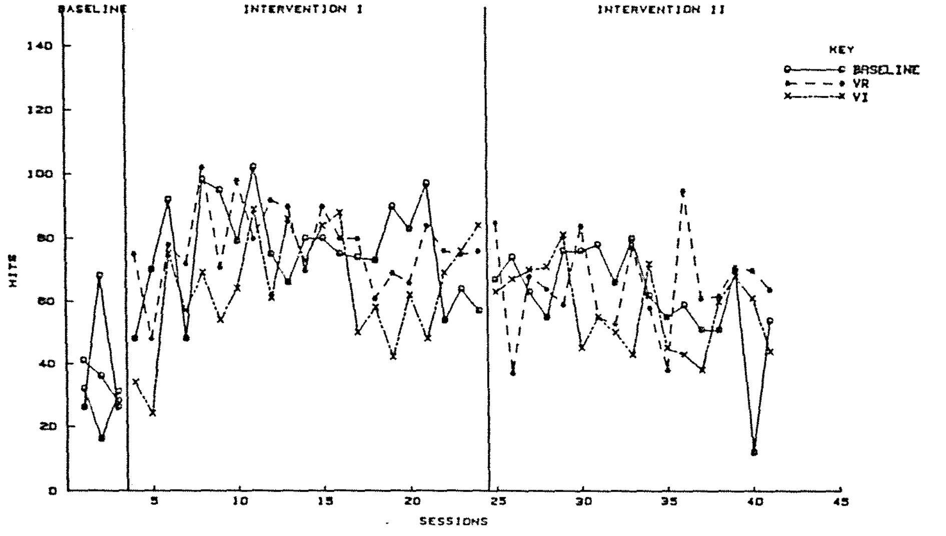

FIGURE 16. HITS PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT A.

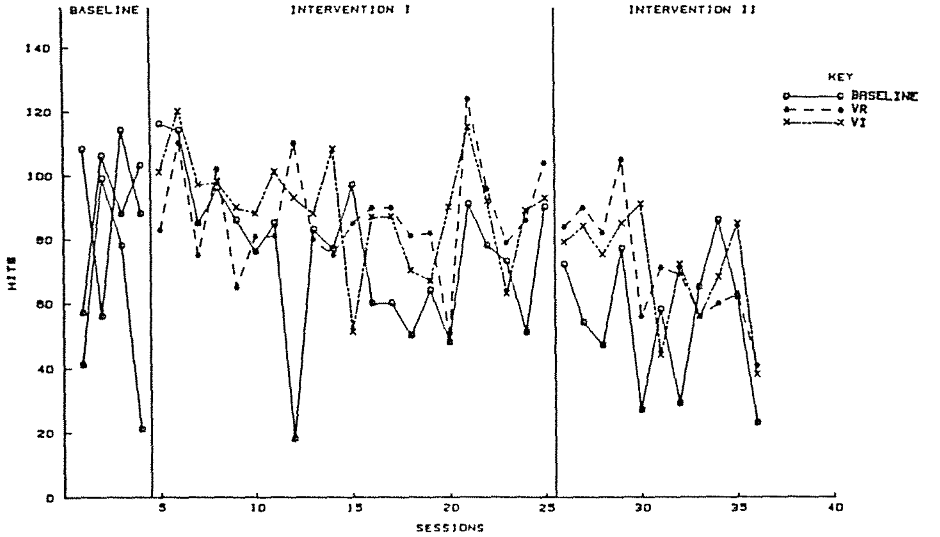

FIGURE 17. HITS PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT B.

Tables 17 and 18 show the means of the hits scored for each treatment condition of each phase for subjects A and B, while Figures 16 and 17 show graphically the number of hits per session scored for each treatment condition of each phase for subjects A and B.

Subject A

It is clear from Figure 16 that there were no differences between schedules but overall changes in performance were evident. During Intervention II the mean values of all treatment conditions were lower than Intervention I. The VI component had the lowest mean values of the three treatment conditions during Interventions I and II (see Table 17).

Subject B

The mean hits were higher during the Baseline phase than during any of the treatment conditions of Intervention II. During Intervention I the data show great variability but hits during the VI component, and the VR component (especially from session 12 onwards), was more often higher than that during the baseline component. Hits during Intervention II showed more clear cut patterns from session 26 to session 30 with hits during reinforcement conditions being higher than during baseline condition (see Figure 17 and Table 18). There were wide fluctuations in the data. A discrimination effect was seen between the reinforcement conditions and the baseline condition especially between sessions 26 to 28 (see Figure 17). (In this study a discrimination effect is distinguished from behavioural contrast in that for the former, the response rate under one of the multiple schedules changes direction. For the latter, response rate under both of the multiple schedules change in opposite directions (Nevin and Shettleworth, 1966)).

Table 19 :- MEANS OF THE MAJOR DEPENDENT VARIABLES FOR EACH TREATMENT CONDITION OF EACH PHASE FOR SUBJECT C.

	BASELINE	INTERVENTION I			INTERVENTION II		
DEPENDENT VARIABLE	B	B	VR	VI	B	VR	VI
n	12	11	11	11	14	14	14
HITS	112.92	111.00	113.91	109.91	68.07	97.57	79.64
CR	328.33	292.27	322.45	296.55	195.86	273.93	240.00
CD	441.25	394.36	445.27	406.45	263.93	372.21	319.64
IH	1.75	4.45	2.55	3.27	2.79	1.36	2.14
ICR	14.25	21.64	15	14.55	28.00	23.64	30.86
TTDR	775.47	746.33	782.69	692.00	557.71	697.94	651.89

Table 20:- MEANS OF THE MAJOR DEPENDENT VARIABLES FOR EACH TREATMENT CONDITION OF EACH PHASE FOR SUBJECT G.

	BASELINE	INTERVENTION I			INTERVENTION II		
DEPENDENT VARIABLE	B	B	VR	VI	B	VR	VI
n	12	14	14	14	17	17	17
HITS	44.42	7.29	11.93	5.14	5.82	11.24	10.18
CR	117.17	77.86	84.86	69.36	109.65	99.71	91.65
CD	161.58	85.50	96.79	74.50	115.47	110.94	101.82
IH	4.00	2.86	3.36	3.43	2.82	16.94	14.71
ICR	32.75	22.43	24.43	21.71	22.59	75.00	65.76
TTDR	396.27	289.83	313.6	257.71	366.4	568.47	506.54

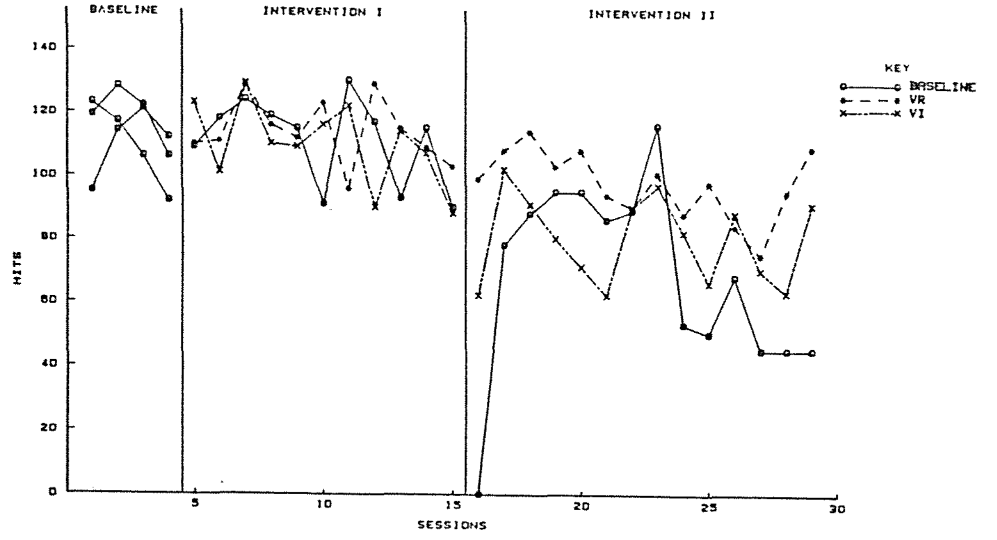

FIGURE 18. HITS PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT C.

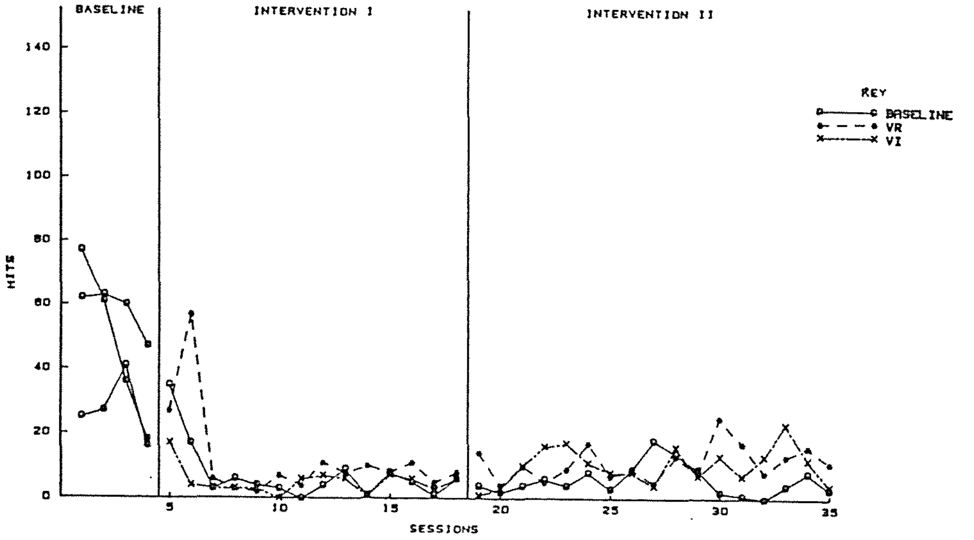

FIGURE 19. HITS PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT G.

Tables 19 and 20 show the means of hits scored for each treatment condition for subjects C and G. Figure 18 and 19 show the number of hits per session graphically for subjects C and G.

Subject C

The Baseline phase produced more hits compared to any treatment condition of Intervention II. Intervention I showed no obvious effect. During Intervention II hits were greater during the reinforcement schedules than that during the baseline component, with the highest mean value and lowest of fluctuations being for the VR component followed by the VI component (see Figure 18). Discrimination effects between the treatment conditions and baseline is evident from session 24 onwards (see Figure 18).

Subject G

The Baseline phase was higher than any treatment condition of Interventions I and II. Intervention I shows no obvious effects. During Intervention II the data increased in variability for hits during the reinforcement conditions, being generally higher than during the baseline component. The VR component had the highest mean value but the highest amount of variability followed by the VI component (see Table 20) . An obvious but small discrimination effect can be seen between the VR component and the baseline component from session 20 to session 31 (see Figure 19).

Overall, for three subjects, the Baseline phase had more hits than any treatment condition of Intervention I. Intervention I showed no common treatment effects for all four subjects. Intervention II showed discrimination effects between the VR component and the baseline component for three subjects. The mean hits during the VR component was higher than baseline. Discrimination effects were also seen between the VI component and the baseline component for two subjects with mean hits being higher for the VI component.

Correct Rejections

A correct rejection was recorded if the subject responded on the No key after 50ms of the disappearance of a "non-A" letter and before the onset of the next letter.

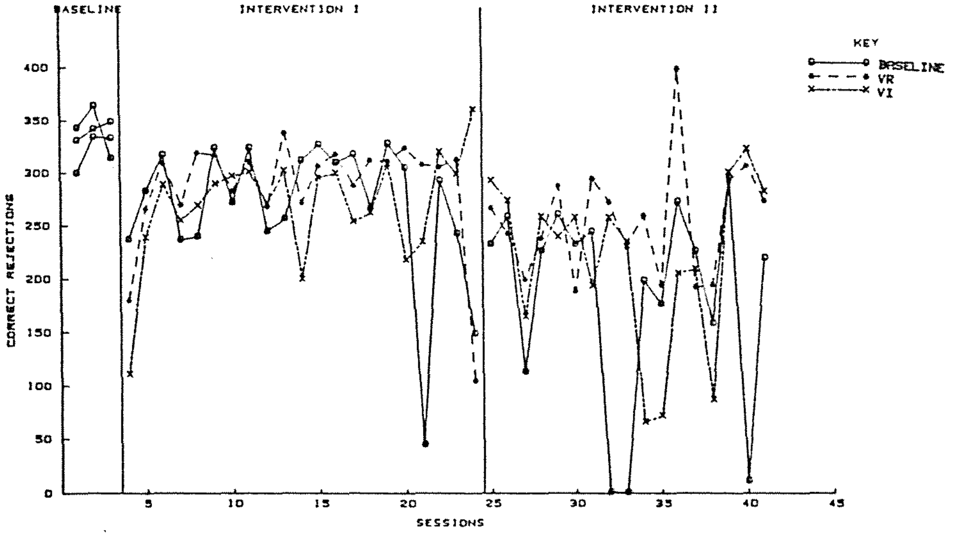

FIGURE 20. CORRECT REJECTIONS PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT A.

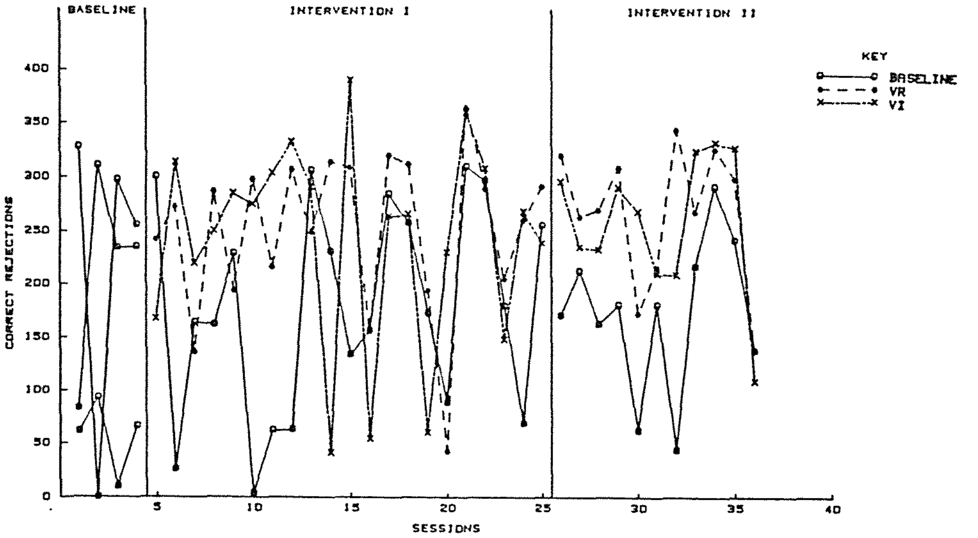

FIGURE 21. CORRECT REJECTIONS PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT B.

Tables 17 and 18 show the means of correct rejections for each treatment condition of each phase for subjects A and B, while Figures 20 and 21 show graphically the number of correct rejections per session for subjects A and B.

Subject A

Correct rejections were highest during the Baseline phase compared to the other phases (see Table 17 and Figure 20). Intervention I showed no obvious effect. During Intervention II, it was evident that correct rejections during the VR component were more often higher than during the baseline component or during the VI component. The mean values for correct rejections for this subject (Table 17) confirm this to be the case.

Subject B

A discrimination effect can be seen between the VI component and the baseline component with the baseline component dropping in level during sessions 6 to 12 (see Figure 21). During Intervention II a clear pattern existed for correct rejections. Both of the reinforcement conditions are superior to the baseline component. The VR component has the highest mean value and lowest amount of variability, followed by the VI component (see Table 18). However, no clear pattern emerged between the VR and VI components. It was obvious that a discrimination effect was present between the reinforcement conditions and the baseline component, especially during the first five sessions of this phase (see Figure 21).

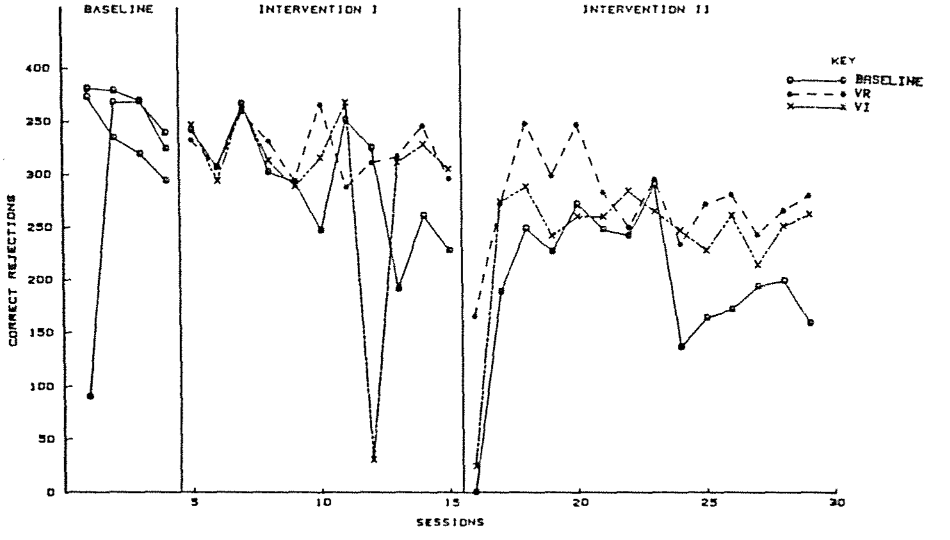

FIGURE 22. CORRECT REJECTIONS PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT C.

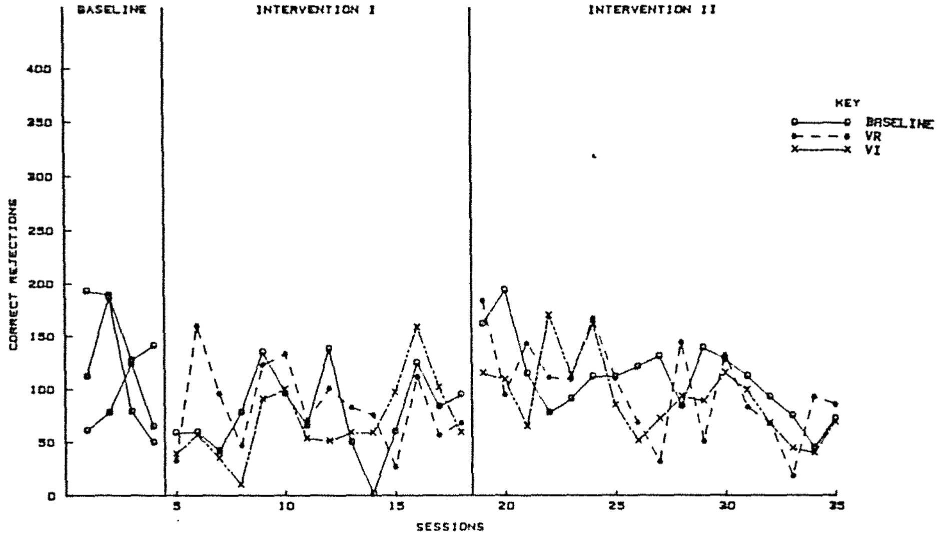

FIGURE 23. CORRECT REJECTIONS PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT G.

Table 19 and 20 show the means of correct rejections scored for each treatment condition of each phase for subjects C and G. Figures 22 and 23 show the number of correct rejections per session for each treatment condition of each phase for subjects C and G.

Subject C

During the Baseline phase a downward trend in the data was apparent. Correct rejections during the Baseline phase were more frequent than during any other treatment condition of Interventions I and II. During Intervention I there was some evidence of discrimination during sessions 13, 14 and 15. It is clear that correct rejections during the reinforcement conditions were much higher than during the baseline component (see Figure 22). Between the two reinforcement conditions, the VR component had the higher overall correct rejections, as shown by the mean values in Table 19. The shift to Intervention II saw a drop in the level for all three conditions. During this phase correct rejections during the reinforcement conditions were generally higher than that during the baseline component. Once again, the VR component generally produced higher correct rejections than the VI component (see Table 19). During the last half of Intervention II Figure 22 shows some discrimination effects, particularly between baseline and the reinforcement components.

Subject G

Correct rejections during the Baseline phase were higher than during any other treatment condition of Interventions I and II. During Intervention I and II no clear pattern was seen between the three conditions. Correct rejections were at a low rate during both Interventions I and II, and no clear differences emerged (see Figure 23). During Intervention II the mean correct rejection was lowest during the baseline component (see Table 20).

Overall, three subjects showed higher correct rejections during the Baseline phase than during any other phase. Intervention I showed no common pattern across subjects. Two subjects showed discrimination effects between reinforcement components and baseline during Intervention II with baseline having the lowest mean value. During Intervention II, three subjects had the highest mean value of correct rejections during the VR component.

Correct Detections

Correct detections refers to the sum of hits and correct rejections.

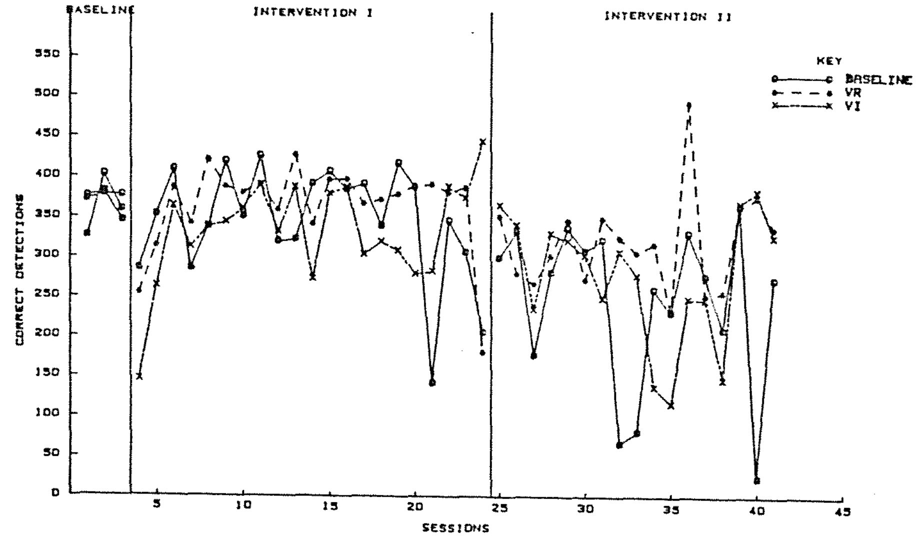

FIGURE 24. CORRECT DETECTIONS PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT A.

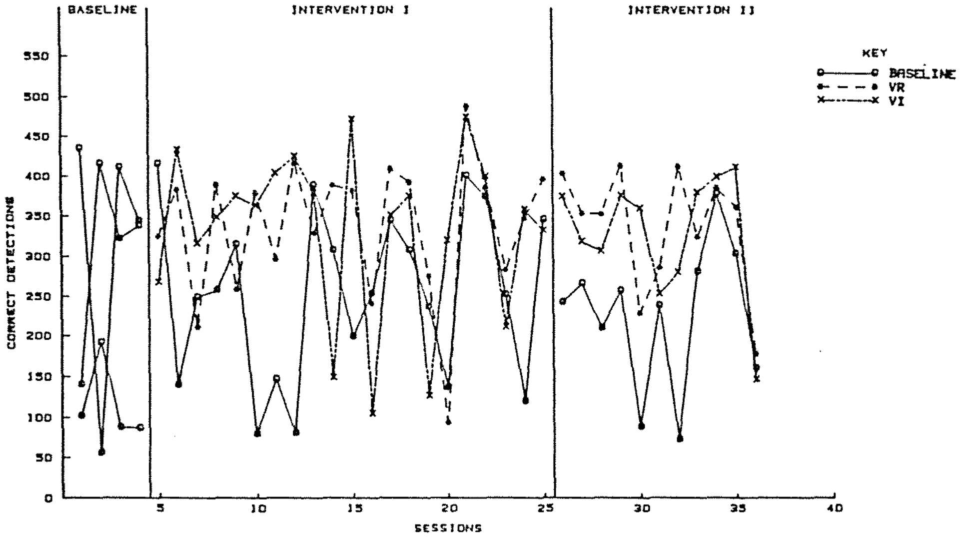

FIGURE 25. CORRECT DETECTIONS PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT B.

Tables 17 and 18 show the means of correct detections scored for each treatment condition of each phase for subjects A and B. Figures 24 and 25 graphically show the number of correct detections per session for subjects A and B.

Subject A

Correct detections were highest during the Baseline phase as compared to the other phases (see Table 17 and Figure 18). Intervention I showed a drop in level for all three components. During Intervention I the VR component had the highest mean value and lowest amount of fluctuation. During Intervention II it was noticeable that correct detections during the VR component were more often emitted than in the baseline component or in the variable interval component. This can also be seen in Table 17 where the VR component provided the highest mean correct detection value.

Subject B

During Intervention I the VR component had the highest mean figure followed by the VI component. With the onset of Intervention II, a clear pattern was seen between the baseline condition (the baseline component) and the reinforcement conditions (the VR component and the VI component) with correct detections during the reinforcement conditions being higher than during the baseline condition. The VR component had the highest mean value followed by the VI component (see Table 18). A discrimination effect occurred especially during the first five sessions of this phase (see Figure 25).

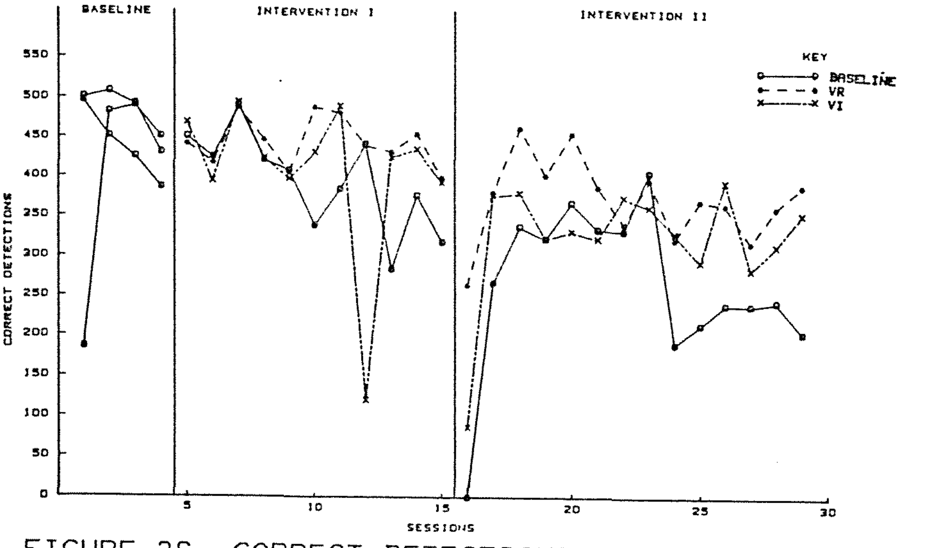

FIGURE 26. CORRECT DETECTIONS PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT C.

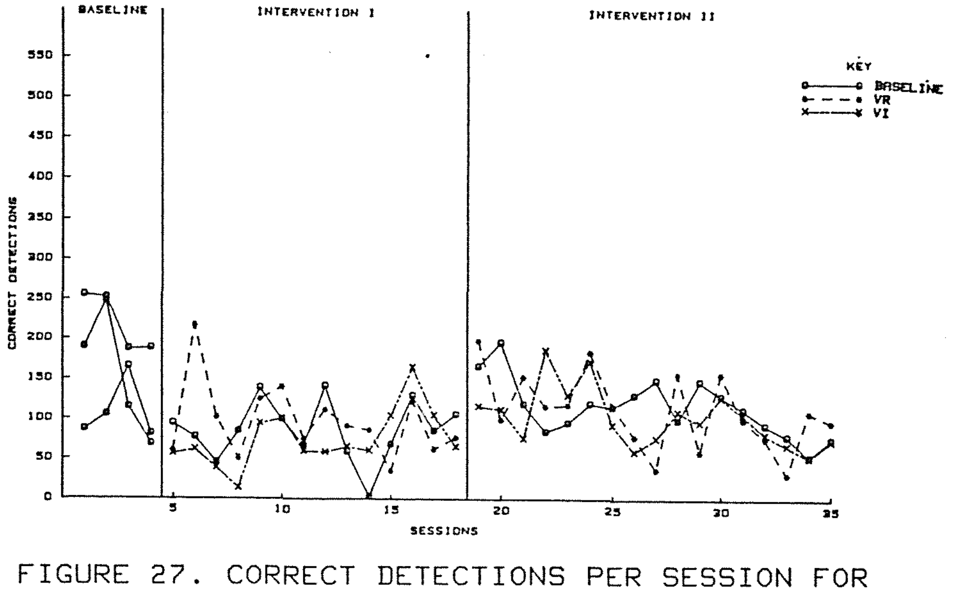

FIGURE 27. CORRECT DETECTIONS PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT G.

Tables 19 and 20 show the means of correct detections for each treatment condition of each phase for subjects C and G, while Figures 26 and 27 show the number of correct detections per session for subjects C and G.

Subject C

Correct detections were higher during the Baseline phase compared to the treatment conditions of Intervention II (Table 19). From session 10 onwards correct detections during the VR component were greater than that during the baseline component. Discrimination effects seemed to be emerging between sessions 10 and 15. Correct detections during the VR component were higher than that during the VI component most of the time during this phase (see Figure 26). During Intervention II the correct detections during the reinforcement conditions were generally higher than during the baseline component, especially after session 23. The VR component had the highest mean figure followed by the VI component. Overall, during Intervention II a clear discrimination effect between baseline and reinforcement components occurred (see Figure 26).

Subject G

Correct detections during the Baseline phase were higher than during Interventions I and II (see Table 20). However, no clear pattern was evident during Interventions I and II (see Figure 27). The overall level of correct detections was low.

In summary, correct detections during the Baseline phase were higher than those for Intervention I for two subjects, and highest compared to Interventions I and II for three subjects. Looking across the subjects, the most common feature during Intervention I was that the mean correct detections during the VR component was highest compared to the other two treatment conditions for three subjects. Discrimination effects between the reinforcement conditions and baseline were also seen for two subjects during Intervention II.

Impulsive Hits

An impulsive hit refers to responding on the Yes key in the first 50ms. after the disappearance of the letter "A". Such a response could only be an anticipatory (impulsive) response. Note that this time interval is drastically shorter than the 700ms. time period used to define impulsive responding in experiment I.

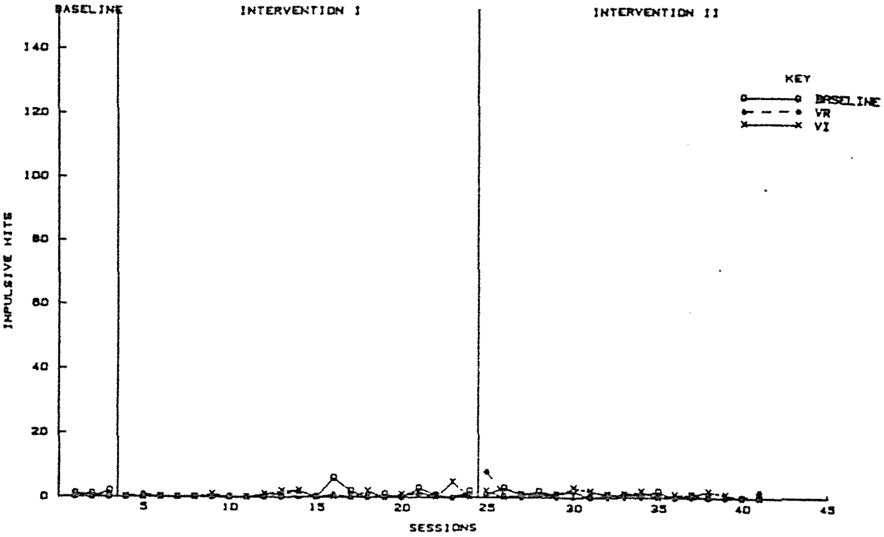

FIGURE 28. IMPULSIVE HITS PER SESSION FOR FOR EACH TREATMENT CONDITION FOR SUBJECT A.

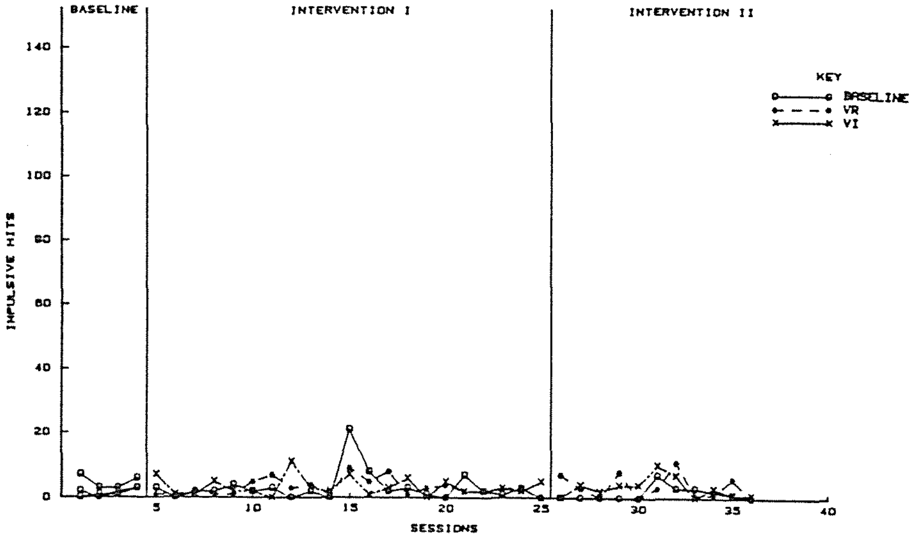

FIGURE 29. IMPULSIVE HITS PER SESSION FOR FOR EACH TREATMENT CONDITION FOR SUBJECT B.

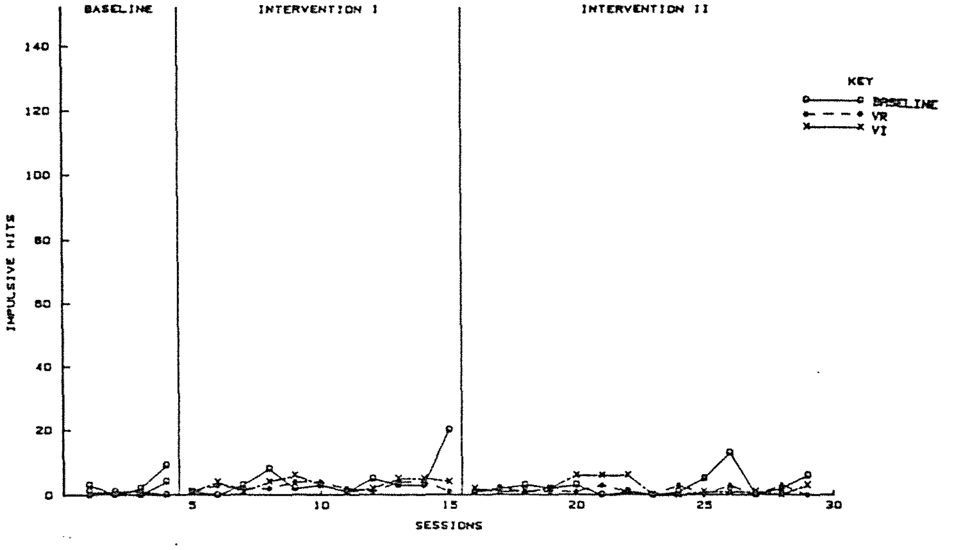

FIGURE 30. IMPULSIVE HITS PER SESSION FOR
FOR EACH TREATMENT CONDITION FOR SUBJECT C.

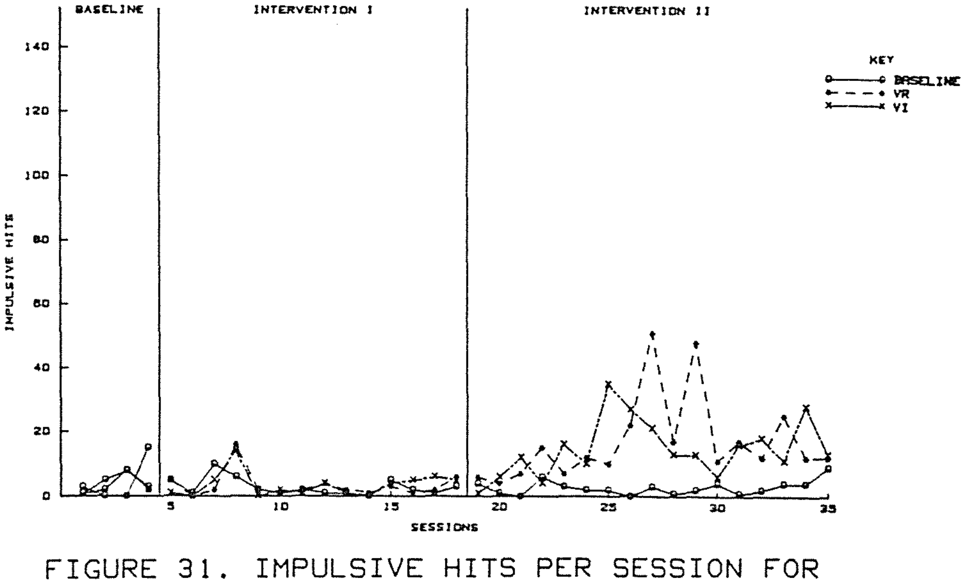

FIGURE 31. IMPULSIVE HITS PER SESSION FOR
FOR EACH TREATMENT CONDITION FOR SUBJECT G.

Tables 17 to 20 show the means of impulsive hits for each treatment condition for Subjects A, B, C and G, while Figures 28 to 31 show the impulsive hits per session for Subjects A, B, C and G.

All subjects, except subject G, showed low impulsive hits with no obvious patterns between treatment conditions across phases. Subject G showed discrimination effects between treatment conditions and baseline during Intervention II with mean impulsive hits being greatest during the VR component.

Impulsive Correct Rejections

An impulsive correct rejection refers to responding on the No key up to 50ms. after the disappearance of a "non-A" letter. This response is also considered as an anticipatory response.

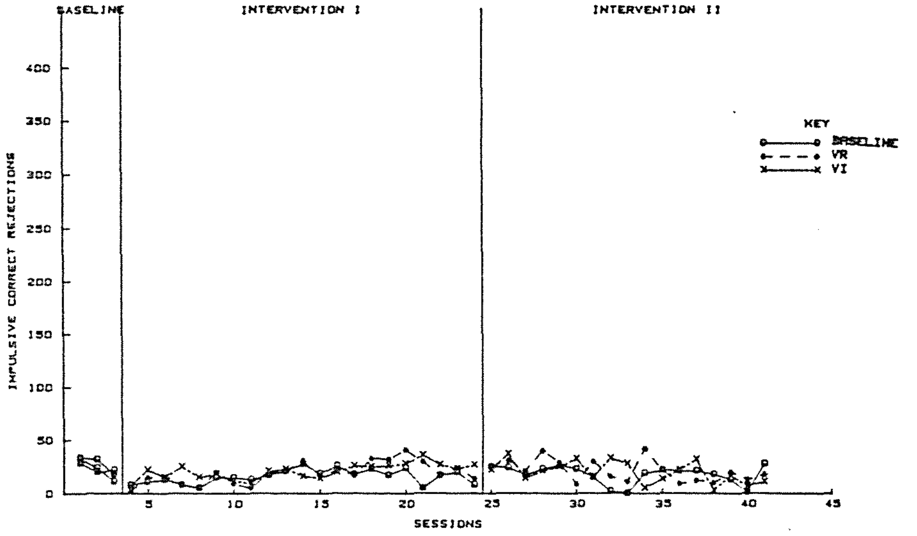

FIGURE 32. IMPULSIVE CORRECT REJECTIONS PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT A.

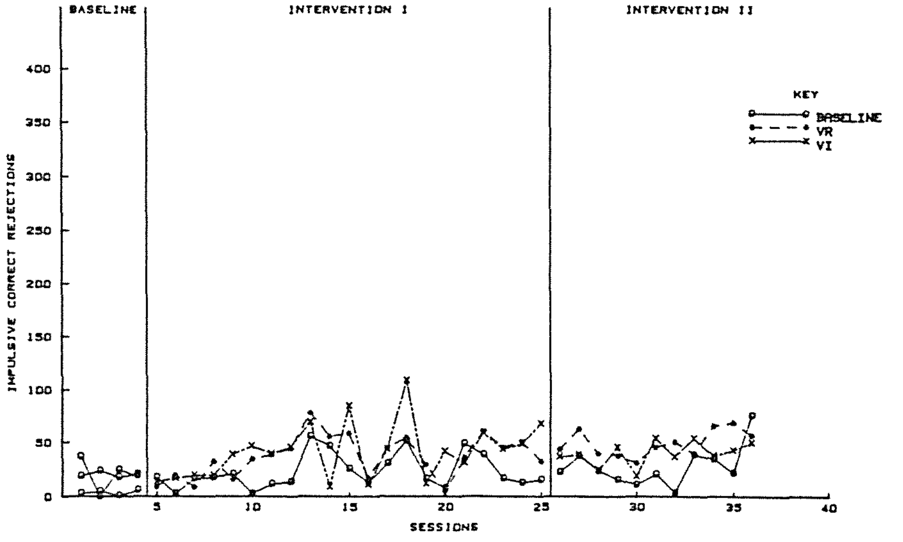

FIGURE 33. IMPULSIVE CORRECT REJECTIONS PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT B.

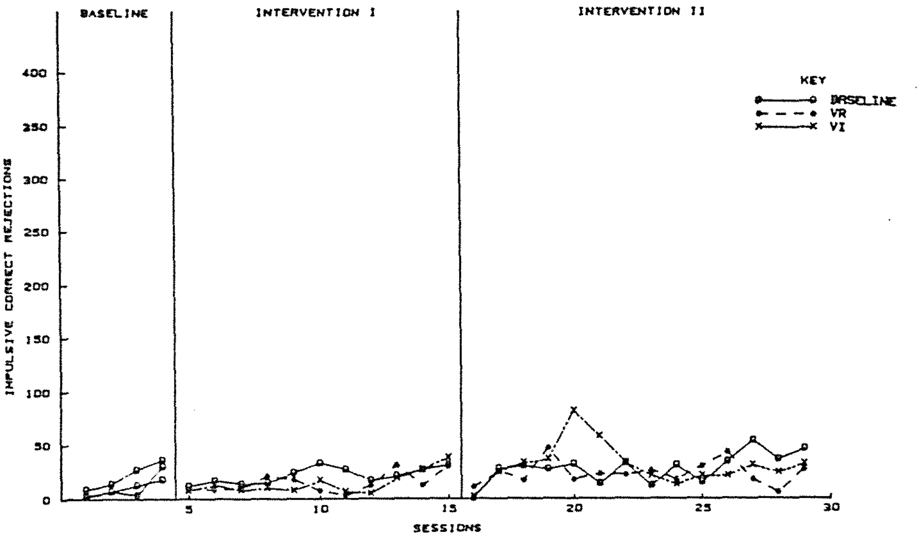

FIGURE 34. IMPULSIVE CORRECT REJECTIONS PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT C.

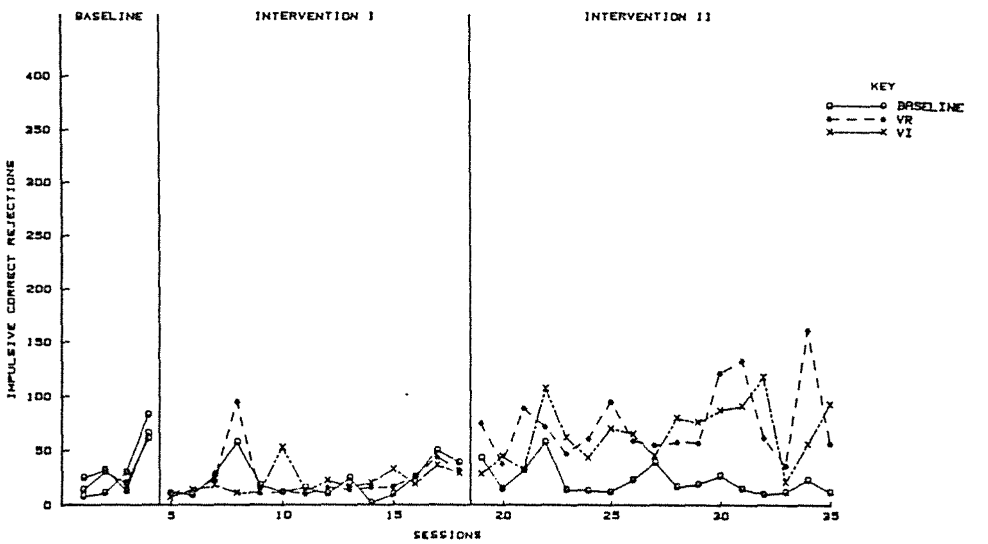

FIGURE 35. IMPULSIVE CORRECT REJECTIONS PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT G.

Tables 17 to 20 show the means of impulsive correct rejections for each treatment condition for subjects A, B, C and G. Figures 32 to 35 show the plotted data of impulsive correct rejections per session for subjects A, B, C and G.

For the majority of subjects impulsive correct rejections were low across all phases. Subject G showed behavioural contrast between the reinforcement conditions and baseline during Intervention II. The mean impulsive correct rejection was greatest during the VR component during Intervention II.

Total Duration On-Task

Total Duration On-Task was calculated by subtracting the total number of stimulus sequences which were not responded to by the subject from the total number of possible responses available per session (560) and multiplying this by the duration of a sequence presentation (1.6 seconds). This measure is important in that it shows the length of time a subject spends on the task, emitting either correct or incorrect responses, and provides a measure of total responses emitted.

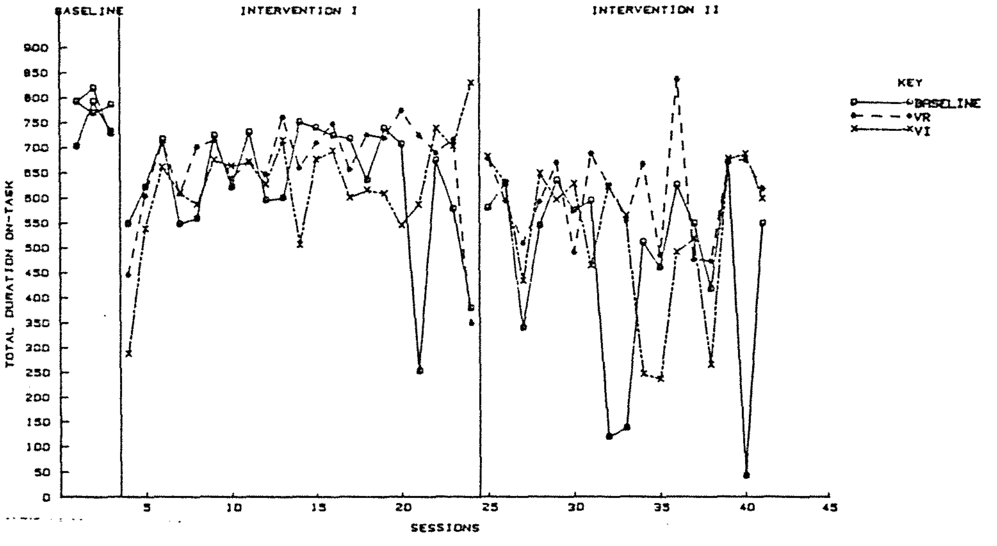

FIGURE 36. TOTAL DURATION ON-TASK PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT A.

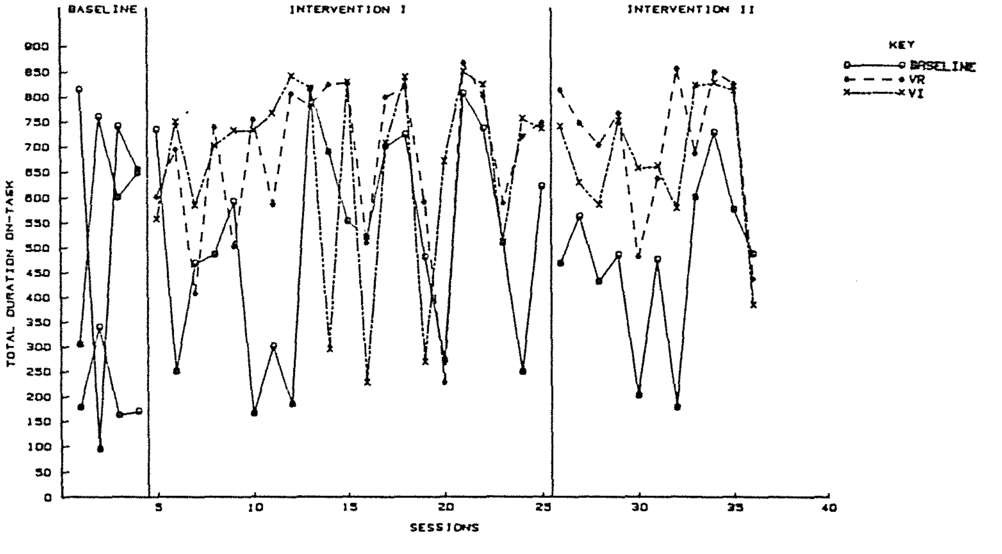

FIGURE 37. TOTAL DURATION ON-TASK PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT B.

Tables 17 and 18 show the means of the total duration on-task for each treatment condition of each phase for subjects A and B. Figures 36 and 37 show the total duration on-task per session for each treatment condition of each phase for subjects A and B.

Subject A

Total duration on-task is highest during the Baseline phase compared to the other phases. This is in line with earlier findings which showed correct rejections and correct detections more frequent during this phase (see Table 17). The data are very variable in Interventions I and II with no noticeable patterns between treatment conditions (see Figure 36). Nevertheless, in terms of overall duration on-task, the VR component had the highest mean values during Interventions I and II (see Table 17).

Subject B

During Intervention I it is clear that duration on-task was longer during the reinforcement conditions than during the baseline component, but it is not possible to distinguish between the VR and VI components. Intervention II saw a drop in the level of total duration on-task for the baseline component but an increase in the level for the VR component. It is clear that on-task behaviour was greater during the reinforcement conditions than during the baseline component, with the VR component having the highest mean value (see Table 18). This is consistent with the finding that correct detections also had the highest mean during the VR component for Intervention II (see Table 18). A discrimination effect was very noticeable from the last two sessions of Intervention I through to almost the end of Intervention II (see Figure 37).

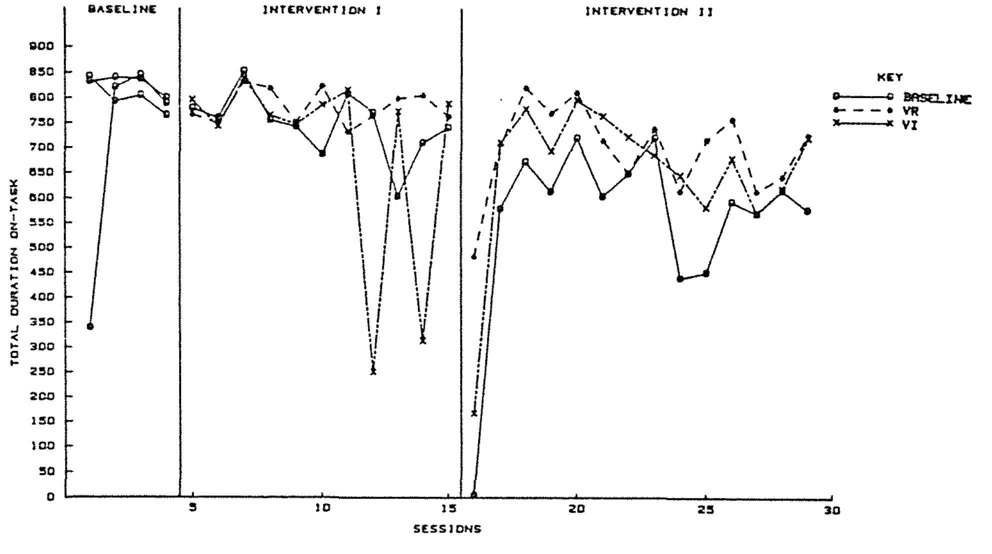

FIGURE 38. TOTAL DURATION ON-TASK PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT C.

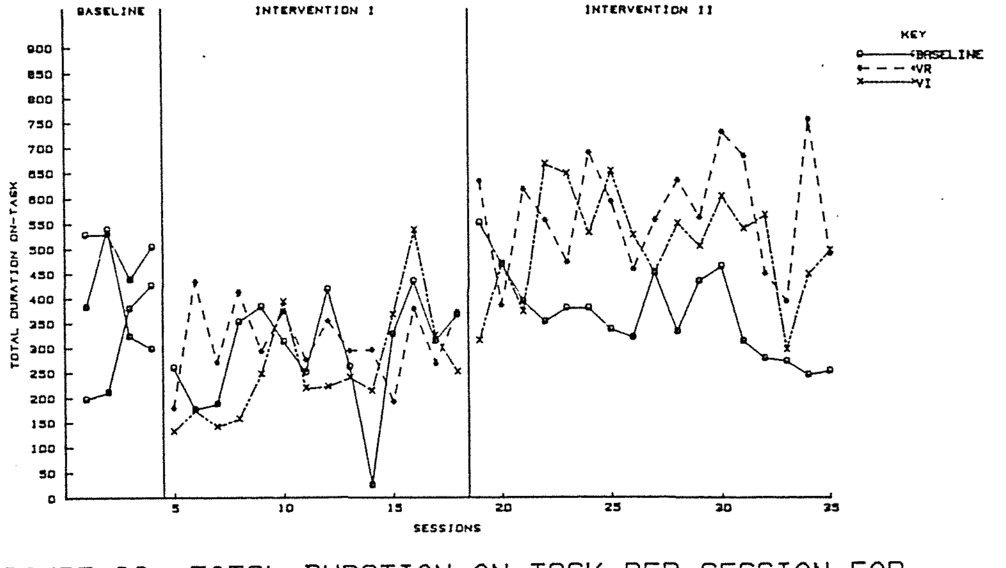

FIGURE 39. TOTAL DURATION ON-TASK PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT G.

Tables 19 and 20 show the means of the total duration on-task for each treatment condition for subjects C and G, and Figures 38 and 39 show the total duration on-task per session for subjects C and G.

Subject C

Total duration on-task was longer during the Baseline phase compared to Intervention II. During Intervention I the data showed wide fluctuations for the VI component with no clear pattern emerging between the three conditions. The VR component showed the highest mean value and lowest amount of variability followed by the baseline component (see Table 19). Intervention II saw a drop in the level of total duration on-task for all three conditions. During this phase the duration on-task was longer during the reinforcement conditions as compared to during the baseline component but it is not possible to distinguish between VR and VI performance (see Figure 38). However, the VR component had the highest mean value. The VR component in both Interventions I and II show the highest mean values of total duration on-task (see Table 19), which complements the findings that the mean correct detections were also highest during this treatment component in both these phases as well (see Table 19). There was some indication of discrimination effects between the reinforcement schedules and the baseline component during Intervention II (see Figure 38). Once again, though, the data showed great variability overall and no clear effects emerged.

Subject G

Total duration on-task was higher during the Baseline phase compared to Intervention I. More responding occurred during this phase. For example hits, correct rejections and correct detections were higher in this phase compared to Intervention I (see Table 20). Intervention I showed no obvious contrasts but the shift into Intervention II saw an increase in the level of total duration on-task, especially for the baseline component and the VR component. During Intervention II there was a decreasing trend for the baseline component and it was obvious that on-task behaviour was enhanced during the reinforcement conditions compared to the baseline component (see Figure 39). The VR component showed the highest mean value followed by the VI component (see Table 20). This is in line with the finding that correct rejections, correct detections impulsive hits and impulsive correct rejections were highest during the VR component of this phase (see Table 20). Behavioural contrast between treatment conditions and baseline is clearly apparent.

In summary, two subjects showed total duration on-task greater during the Baseline phase as compared to Intervention I. Two subjects had total duration on-task greater during the Baseline phase as compared to Intervention II. During Intervention I, three subjects had total duration on-task greatest during the VR component. During Intervention II, three subjects had total duration on-task greater during both reinforcement components. All subjects had total duration on-task greatest during the VR component.

SIGNAL DETECTION ANALYSIS

Sensitivity Measure [2]

P(Ā) is a measure of sensitivity free of the possible confounding effects of decision criterion bias. As stated previously, the manipulation of the payoff matrix (including reinforcement) in a related task (the vigilance task) did not appear to affect sensitivity (Davenport, 1968, 1969). It was hypothesized that neither reinforcement conditions would alter sensitivity on the CPT compared to baseline. The definitions of P(S|s) and P(S|n) are found in the SDT analysis subsection of Method I.

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[2] As for Experiment I, d′ values obtained from tables found in Swets (1964) were highly correlated with the calculated P(Ā) values for each treatment condition. Log d values, a measure of sensitivity derived from the matching law, also showed high consistency with d′ and P(Ā) values for each phase. Therefore for simplicity only P(Ā) values are presented.

Table 21:- SIGNAL DETECTION ANALYSIS OF SUBJECT A's PERFORMANCE FOR EACH TREATMENT CONDITION OF EACH PHASE ON THE CPT.

	BASELINE	INTERVENTION I			INTERVENTION II		
	B	B	VR	VI	B	VR	VI
NUMBER OF TIME PERIODS	9	21	21	21	17	17	17
MEAN OF P(S|s)	.24	.54	.56	.46	.44	.46	.41
MEAN OF P(S|n) (Note each mean value is x 10^{-3})	0.53	1.93	0.57	1.25	2.38	2.53	2.10
z(S|n)	3.09	2.88	3.09	3.09	2.88	2.75	2.88
P(Ā)	0.81	0.88	0.89	0.86	0.86	0.86	0.85
log response bias	-1.77	-1.01	-1.30	-1.18	-0.89	-1.00	-1.02

Table 22:- SIGNAL DETECTION ANALYSIS OF SUBJECT B's PERFORMANCE FOR EACH TREATMENT CONDITION OF EACH PHASE ON THE CPT.

	BASELINE	INTERVENTION I			INTERVENTION II		
	B	B	VR	VI	B	VR	VI
NUMBER OF TIME PERIODS	12	21	21	21	11	11	11
MEAN OF P(S|s)	.57	.54	.62	.64	.39	.50	.50
MEAN OF P(S|n)	.01	.03	.03	.03	.02	.01	.02
z(S|n)	2.33	1.88	1.88	1.88	2.05	2.33	2.05
$P(\bar{A})$	.89	.87	.89	.90	.83	.87	.86
log response bias	-0.19	-0.25	-0.30	-0.27	-0.47	-0.72	-0.59

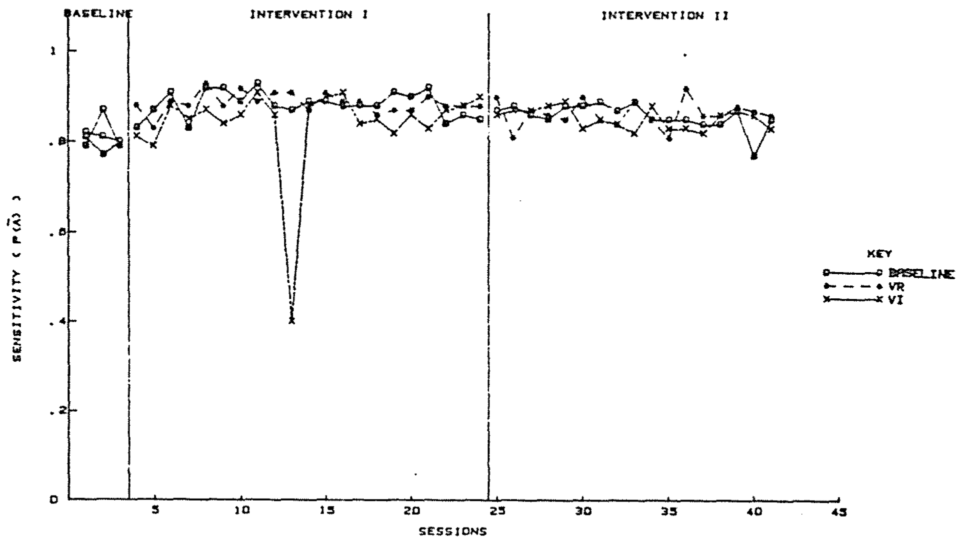

FIGURE 40. SENSITIVITY PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT A.

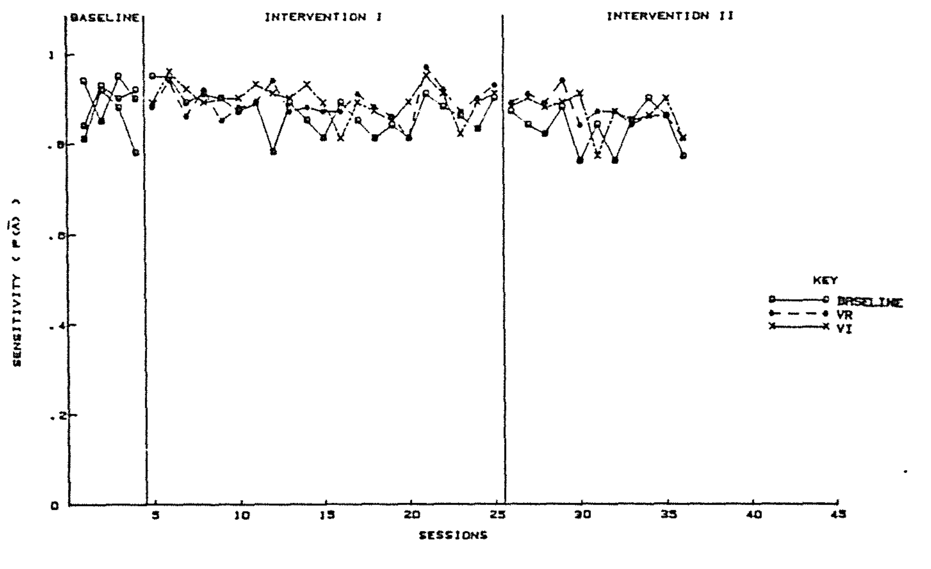

FIGURE 41. SENSITIVITY PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT B.

Tables 21 and 22 show the sensitivity levels calculated for each treatment condition of each phase for subjects A and B, and Figures 40 and 41 show the data for sensitivity ($P(\bar{A})$) per session for subjects A and B.

Subject A

Both Figure 40 and Table 21 show little variation in $P(\bar{A})$ apart from that due to expected fluctuation in performance. Sensitivity was maintained at a relatively high rate throughout all phases of the experiment.

Subject B

As for subject A, $P(\bar{A})$ showed little or no variation as a result of the interventions. $P(\bar{A})$ values remained remarkably constant over all sessions.

TABLE 23:- SIGNAL DETECTION ANALYSIS OF SUBJECT C's PERFORMANCE FOR EACH TREATMENT CONDITION OF EACH PHASE ON THE CPT.

	BASELINE	INTERVENTION I			INTERVENTION II		
	B	B	VR	VI	B	VR	VI
NUMBER OF TIME PERIODS	12	11	11	11	14	14	14
MEAN OF $P(S\|s)$	.81	.77	.84	.78	.49	.70	.57
MEAN OF $P(S\|n)$	.02	.04	.03	.03	.05	.04	.04
$z(S\|n)$	2.05	1.75	1.88	1.88	1.65	1.75	1.75
$P(\bar{A})$	.95	.93	.95	.93	.84	.91	.87
log response bias	-0.26	-0.05	-0.13	-0.12	-0.22	-0.25	-0.29

TABLE 24:- SIGNAL DETECTION ANALYSIS OF SUBJECT G's PERFORMANCE FOR EACH PHASE ON THE CPT.

	BASELINE	INTERVENTION I			INTERVENTION II		
	B	B	VR	VI	B	VR	VI
NUMBER OF TIME PERIODS	12	14	14	14	17	17	17
MEAN OF P(S|s)	.32	.05	.09	.04	.04	.08	.07
MEAN OF P(S|n)	.02	.10	.09	.08	.14	.11	.11
z(S|n)	2.05	1.28	1.34	1.41	1.08	1.23	1.23
$P(\bar{A})$	.81	.24	.50	.24	-0.15	0.40	.37
log response bias	-0.27	-0.31	-0.29	-0.38	-0.33	-0.37	-0.30

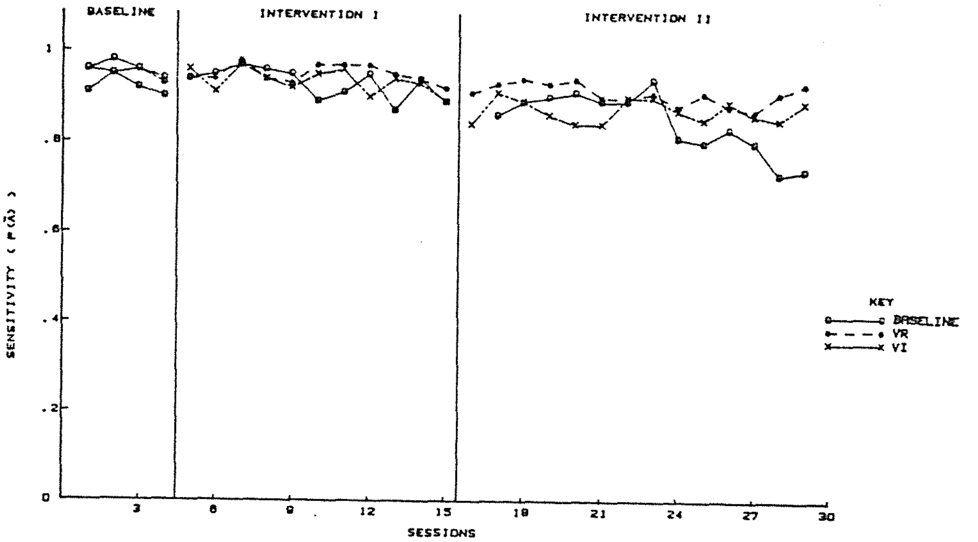

FIGURE 42. SENSITIVITY PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT C.

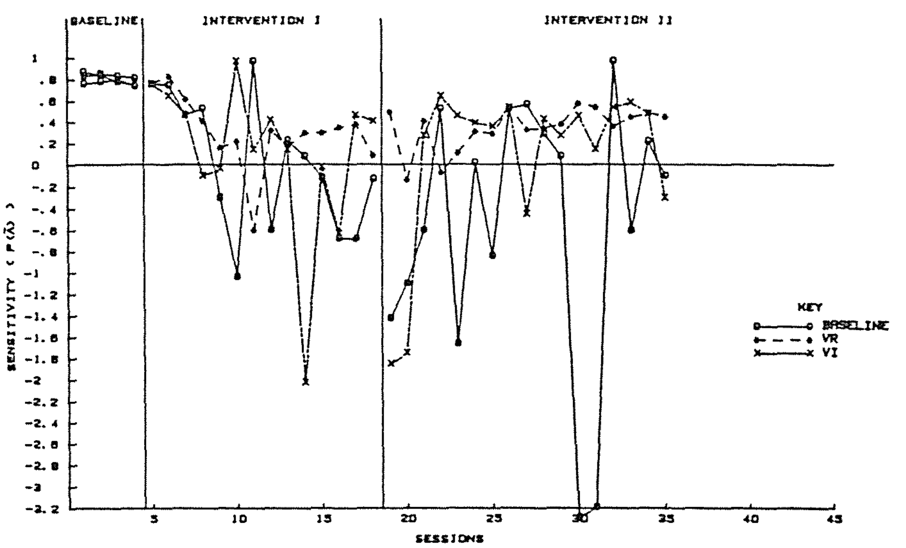

FIGURE 43. SENSITIVITY PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT G.

Tables 23 and 24 show the figures for sensitivity for each treatment of each phase for subjects C and G. Figures 42 and 43 show $P(\bar{A})$ as a function of sessions for subjects C and G.

Subject C

As for the previous two subjects, $P(\bar{A})$ appeared quite stable across all sessions, although there was some evidence of a small but consistent downward trend in sensitivity. This was noticeable for the baseline component during the last few sessions of Intervention II, and less so for the VR and VI components (see Figure 42).

Subject G

Note that the scale for $P(\bar{A})$ for subject G had to be changed from the usual range (0 to 1.0) to -3.2 to 1.0 to accommodate this subject's widely fluctuating data (see Figure 43). The data were highly variable with sensitivity during the baseline component being lower than during the reinforcement components, especially during Intervention II.

In summary, sensitivity was high and relatively stable throughout the phases for three subjects. The wide variability in sensitivity seen for subject G is consistent with earlier results relating to this subject. It would seem that he was unable to properly follow the rules of the task.

Decision Criterion Measure

In SDT analysis of decision criterion, decision criterion cutoff ($z(S|n)$) is a measure of the subjects cautiousness in deciding that a 'signal' event occurred. For example, a high $z(S|n)$ reflects a high degree of caution while a low $z(S|n)$ means a high degree of risk in decision making. Previous research in a related task (the vigilance task) has shown inconsistent results of decision bias changes with reinforcement (see Davies and Parasuraman, 1982). $P(S|n)$ values were used to derive $z(S|n)$ from tables found in McNicol (1972).

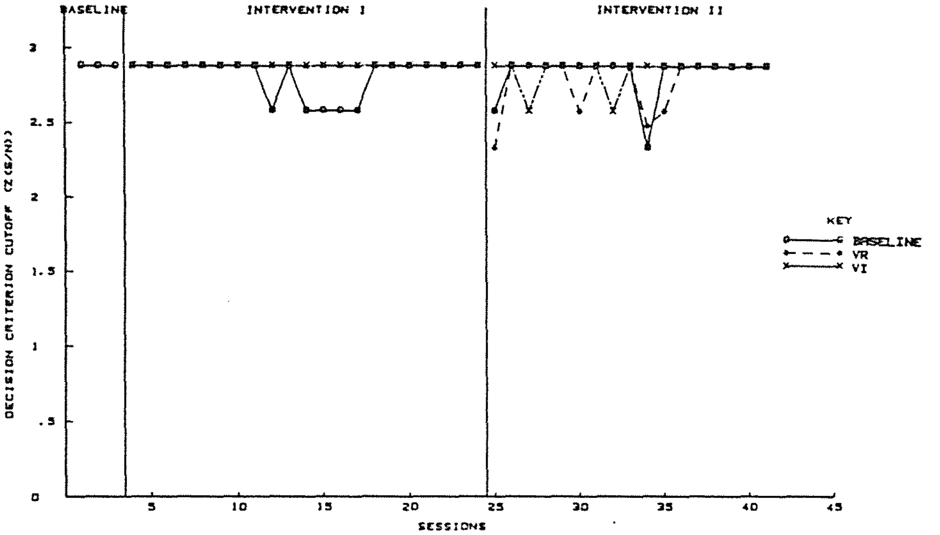

FIGURE 44. DECISION CRITERION CUTOFF (z(S|n)) PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT A.

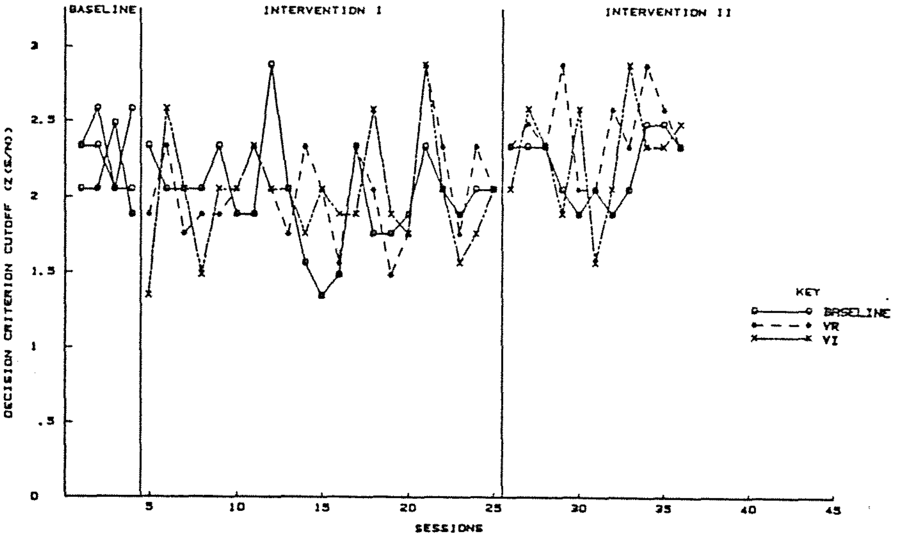

FIGURE 45. DECISION CRITERION CUTOFF (z(S|n)) PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT B.

Tables 21 and 22 show the z(S|n) values for each treatment condition for subjects A and B, and Figures 44 and 45 show the value of z(S|n) as a function of sessions for subjects A and B.

Subject A

Interventions I and II saw z(S|n) values at a high level with no real difference between treatment conditions. It should be noted that false alarm rates were so small that there must be some doubt about the reliability of these decision criterion values (see McNicol, 1972).

Subject B

There were wide fluctuations in the data. Intervention I saw no clear pattern emerge between treatment conditions. Intervention II saw the decision criterion cutoff values during the VR component being equal to or greater than that during the baseline component (see Figure 45). The decision bias during the VR component of Intervention II was towards greater caution.

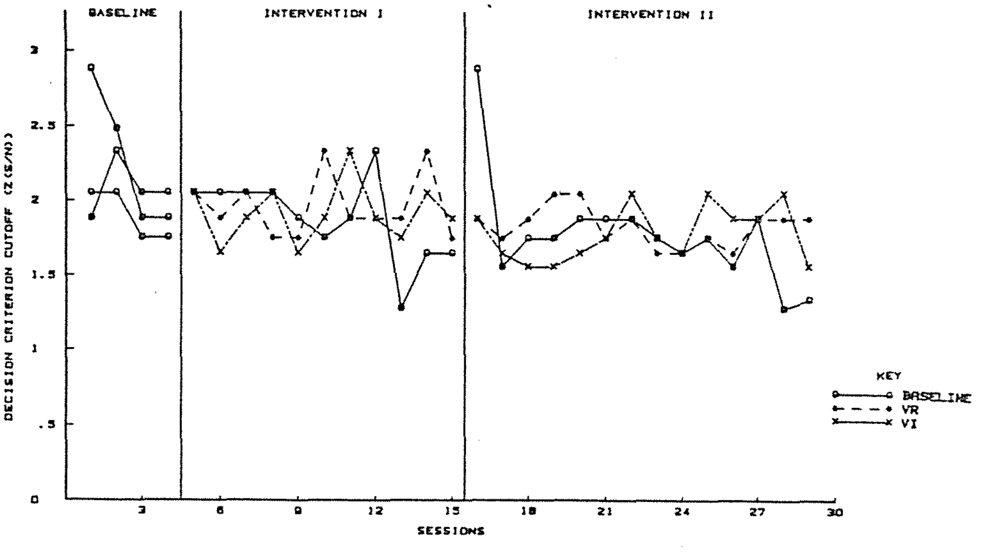

FIGURE 46. DECISION CRITERION CUTOFF (z(S|n)) PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT C.

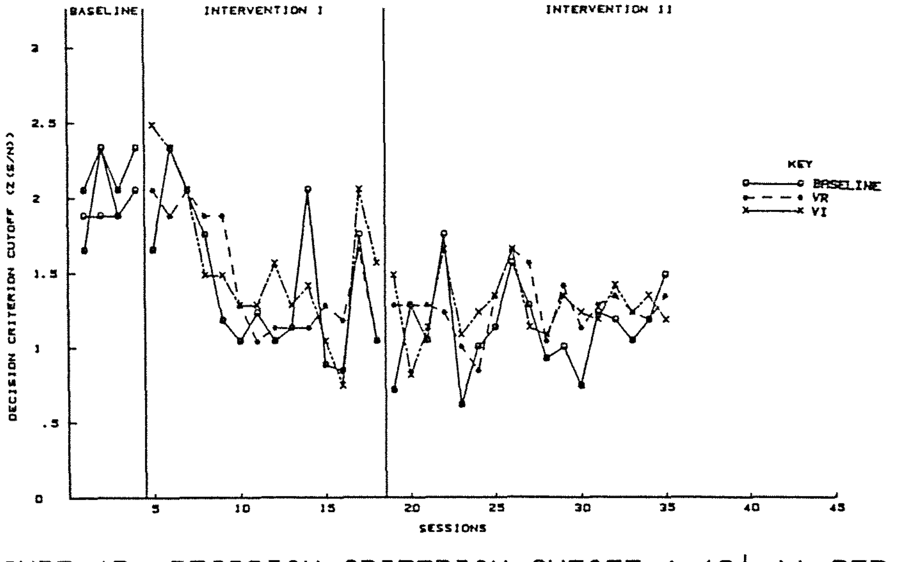

FIGURE 47. DECISION CRITERION CUTOFF (z(S|n)) PER SESSION FOR EACH TREATMENT CONDITION FOR SUBJECT G.

Tables 23 and 24 show z(S|n) values calculated for each of the treatment conditions for each phase for subjects C and G. Figures 46 and 47 show the z(S|n) values per session for subjects C and G.

Subject C

The data were variable with no clear pattern between treatment conditions across the phases (see Figure 46).

Subject G

The data were highly variable and no clear pattern was evident between treatment conditions across the phases (see Figure 47).

In summary the decision criterion cutoff (z(S|n)) showed no systematic changes across conditions.

Response Bias

An indication of response bias was obtained from the Matching Law variable, log response bias. Each subject's log response bias is found in each subject's own signal detection summary table (Tables 21 to 24).

All four subjects response bias showed 100 percent bias to the right key. No effect was noticeable as a function of sessions or interventions.

Summary of Results II

Overall summary of results:

(1) Correct detections and total duration on-task were greatest during the VR component of Intervention I.

(2) Intervention II saw both the reinforcement conditions having the greater hits, correct rejections, correct detections and total duration on-task as compared to the baseline condition.

(3) Comparisons between the reinforcement conditions indicated that the VR component had the greater correct rejections, correct detections and total duration on-task during Intervention II.

(4) All phases saw sensitivity being relatively stable and at a high level, with no systematic changes in decision bias.

(5) As expected response bias was strongly in favour of the right key and did not vary across phases.

(6) Impulsive responding was at a low level for most subjects, irrespective of the type of response and experimental condition.

CHAPTER 9

DISCUSSION II

This experiment aimed to find out if reinforcement had any effect on performance over baseline conditions on the simplified CPT (detecting one signal), and to compare the effects of two reinforcement schedules (variable ratio or variable interval) on the various parameters of performance on the CPT.

The variable ratio component was programmed to reinforce correct detections on a variable ratio schedule, which for Intervention I was a variable ratio of 16 and for Intervention II a variable ratio of 8. The VR component reinforced correct detections while the variable interval component reinforced the subject for any response on either key on a tandem Variable Time - Fixed Ratio 1, schedule. Therefore, the VR component reinforced for accuracy while the VI component reinforced for on-task behaviour. An equal number of reinforcements were available during the variable interval component as in the variable ratio component (see Method II).

Briefly, the results showed that impulsivity was low and the variable ratio component of Intervention II was the more effective intervention. Sensitivity values and response bias showed relative stability throughout the phases.

During the VR component of Intervention I the subjects' accuracy in terms of correct detections, and the overall level of responding as revealed by total duration on-task, increased above baseline and VI components. This shows that reinforcement did establish some degree of control over behaviour when reinforcement was made available for accurate responding rather than for just being on-task.

When the rate of reinforcement was doubled during Intervention II, responding under both reinforcement conditions were more accurate in terms of hits, correct rejections and correct detections, and more frequent in terms of total duration on-task. Therefore reinforcement per se increases accuracy and responding on the simpler version of the CPT.

When the two schedules of reinforcement are compared in Intervention II, accuracy in terms of correct rejections and correct detections, and total responding in terms of total duration on-task, were higher under the VR component. Again, reinforcing the subjects for correct responses on both keys was better than just reinforcing them for being on-task. It was noted that correct rejections rather than hits were detected more often during the VR component. As in experiment I it could be argued that non-signals (non-A letters) were more often presented than signals ("A"). When subjects were reinforced for accuracy, more reinforcement could be obtained for correct rejections as compared to hits. Since correct rejections did increase, it may be assumed that the subjects were trying to maximize their gains by concentrating on the more frequent stimuli, the non-signals.

Comparing the level of responding during the reinforcement conditions between Interventions I and II it was observed that, for two subjects, greater accuracy and more frequent responding were achieved during Intervention II. This is probably a result of the richer reinforcement schedule which is known to control greater responding (e.g. see Catania 1979). Further learning as a result of practice may also have occurred by the latter stages of the experiment making the subjects more proficient on the CPT.. The lack of proper stimulus control could explain why a similar result was not seen for the other two subjects.

Reinforcement had minimal effect in raising performance above the baseline levels possibly due to the operation of strong rule-governed behaviour already established during baseline, as in experiment I. The stability of sensitivity levels across treatment conditions and phases suggest that that detectability of stimuli may have reached ceiling levels for the subjects.

When two different schedules alternate in a session, for example, a reinforcement schedule alternates with a baseline schedule, each in the presence of a different stimulus, a multiple schedule is said to be operating. Discrimination effect refers to the rates of one schedule change in relation to the other. Therefore, the subject is discriminating between the two schedules and responding differently to one. Contrast effect is when one of the schedules in one stimulus is varied and behaviour in the other schedule changes. Further, response rates change in opposite directions in the two schedules.

In the present study, discrimination effects were present mainly between the reinforcement conditions and baseline. This was seen for three subjects for hits, for two subjects for correct detections and for two subjects for total duration on-task, during Intervention II. Two subjects showed discrimination effects for correct rejections during Interventions I and II. Subject G showed discrimination effects for impulsive hits during Intervention II. When discrimination effects occurred, responding during the reinforcement components generally remained at an unaltered level while responding during the baseline component dropped in level. Discrimination effects were also seen between the reinforcement components. As the definition suggests, the subjects were discriminating between the treatment conditions and responding accordingly. That implies that they were becoming sensitive to the schedules that were operating. As to why this effect was not consistent across conditions and subjects may be explained by the lack of complete stimulus control.

Thus, summarizing for all four subjects, it was shown that reinforcement did have a positive effect on performance as shown by more time on-task, compared with baseline conditions. Of the two reinforcement schedules, the variable ratio component, in general, seemed to exert the greater control, especially during the more relaxed contingency of VR8 as compared to VR16.

Operant literature would predict that greater accuracy in responding would occur during the VR schedule, while longer time on-task during the VI schedule. However, the results of this study showed that both accuracy and time on-task were enhanced during the VR schedule. Since accuracy of responding and time on-task are useful parameters to consider in the choice of a reinforcement schedule, these results imply that the VR schedule maybe a better schedule to employ in settings like sheltered workshops.

In addition to discrimination effects, behavioural contrast seemed to emerge in this experiment as well. When two responses are maintained by different schedules of reinforcement and the density of reinforcement for one of the responses is increased the rate of the other response associated with the unchanged schedule typically decreases (Williams, 1983). In the present case the variable ratio component and the variable interval component provided equal numbers, or estimated equal numbers, of reinforcements per session. Thus the density of reinforcement for the responses during both schedules was approximately equal while that during the baseline component was nil. When the density of reinforcement for the variable ratio component was increased during Intervention II (and therefore increased by a similar amount for the variable interval component), according to Williams, responding during the baseline component should decrease. This was seen for subject G for impulsive correct rejections and for total duration on-task during Intervention II. It should be noted that the relative rate of reinforcement was a key variable(or the only variable) controlling contrast. It should be noted that this subject was seen not to properly follow the rules of the task. It can be argued that rule-governed behaviour on this task might be a hinderance for contrast effects, since only subject G displayed it. There is clearly room for further research in this area.

Looking at impulsive responding during reinforcement conditions, only impulsive hits (for subject G), and impulsive correct rejections (for subject G) during Intervention II, appeared to be generally higher than baseline levels. It therefore seems that by adopting a shortened period for anticipatory responses to occur may have reduced impulsivity as expected. Responses up to 700ms. after the disappearance of a 'non-X' letter was recorded as impulsive responding in the difficult version (experiment I), while responses up to only 50ms. after the disappearance of any letter was considered impulsive on the simpler version (experiment II). Therefore, a great deal less time (over 90% less time) was available for impulsivity in the simpler version of the CPT. It is highly likely that the decreased time allowed for impulsive responding was responsible for the decrease in impulsivity. However, due to the different specifications of the CPT task in experiments I and II, it is not possible to say whether the nature of the task (the difficult version as compared to the simpler version) played a part in the minimal impulsivity with reinforcement, seen in experiment II. There is opportunity for further research in this area as well.

SIGNAL DETECTION ANALYSIS

For subjects A, B and C, sensitivity ($P(\bar{A})$ values) was relatively high and stable throughout the phases. There was no noticeable difference between treatment conditions. This is in accordance with previous research (see Davenport, 1968,1969). For subject G, sensitivity fluctuated during Interventions I and II. Sensitivity during the baseline component of Intervention II was lower than the reinforcement components. Once again these could be due to individual variability. But a more concrete explanation could be that subject G was not following the rules of the task properly as seen by his overall poor (variable) performance.

Decision criterion cutoff($z(S|n)$ values were based on very low false alarm rates

for Subject A and were therefore unreliable. Subject B showed more tendency towards caution during the variable ratio component of Intervention II. Subjects C and G showed no clear patterns in the decision criterion cutoff across treatment conditions in each phase of the experiment. These results are in line with previous research in a related area, which showed a lack of consistency in the effects of reinforcement on decision bias (see Davies and Parasuraman, 1982).

Response was biased on the right hand key across treatment conditions. It will be recalled that detecting stimuli (signals or non-signals) is reinforcing in its own right (Smith, 1966). Since there were more non-signals to be detected, more reinforcement were available for correct responding on the No key (the right hand key). Therefore responding would be concentrated on the No key if the subject aimed to maximize gains, or obtain more reinforcement in the absence of discrimination, or while discrimination was being learned. This argument is supported by the fact that the right key biases were also observed during baseline when extrinsic reinforcements were not available.

Therefore, considering that sensitivity showed no obvious change from baseline and decision bias were unsystematic for most of the subjects, SDT analysis did not really provide any usefull information. (see Discussion I as well). It may be that there is no need to consider SDT in future CPT analysis, especially where rule-governed behaviour is involved. But if rule-governed behaviour is not present then SDT analysis may need to be considered. Further research can explore SDT analysis when subjects are placed on the CPT which has only contingencies shaping behaviour rather than rules.

In summary, Experiment II has shown that performance on the simplified CPT has less anticipatory responding associated with reinforcement mainly due to the shortening of the time interval for impulsivity to occur. (The nature of the task may be another possible reason for the low impulsivity.) The study has provided weak evidence that reinforcement did have an effect on performance on the simplified CPT. Weak evidence was further provided that under a less stricter contingency of VR8 as compared to VR16, the variable ratio component (reinforcing correct detections on a VR8) was better than the variable interval component (reinforcing responses on a tandem VT-FR schedule with an accumulating component) along the parameters of increased accuracy, time on-task and sensitivity to the schedule. Operant research would predict that under the VR schedule greater accuracy and more caution in responding would occur as compared to more time on-task and less caution under the VI schedule. This was partially confirmed in this experiment.

CHAPTER 10

GENERAL DISCUSSION

The major aim of Experiments I and II was to conduct exploratory research to investigate the CPT as a research tool and a field technique for the comparison between different schedules of reinforcement. Experiment I set out to compare the effects of two reinforcement conditions on the difficult version of the CPT (A-X version). The CPT was modified with the addition of a second response key, introduced primarily to objectively measure time on-task. If reinforcement did facilitate responding on the CPT a comparison between the two conditions would help discern which was better at enhancing responding. Three parameters, sensitivity to the rate of reinforcement, accuracy of performance and time spent on-task were used to compare between the two conditions. The conditions compared were both CRF schedules, which reinforced either, correct responding on the Yes key (hits) or reinforced correct responding on either key (correct detections). The outstanding result from Experiment I was that reinforcement per se for correct responding on the CPT resulted in not only increased time spent on-task but also increased impulsive responding by the subjects. Most subjects showed no change in sensitivity across conditions. For most subjects the patterns of response bias seemed to alternate between the two response keys depending on the reinforcement schedule in force; the left key during the reinforcement of hits, and the right key during the reinforcement of correct detections. This was to be expected if reinforcement was having a controlling effect on performance. Based on rather weak evidence from increased correct detections, total time on-task and efficiency, it was tentatively concluded that reinforcing correct detections (reinforcement available for correct responding on either key), was more effective at enhancing performance, than reinforcing hits, only (reinforcement available for correct responding on one key).

Experiment II aimed to further investigate the usefulness of the CPT and to show that reinforcement had a facilitating effect on performance, on the simplified version (the A version), also modified with the addition of a second response key. It was hypothesized that impulsivity associated with reinforcement would be minimal on this task if impulsivity was redefined, allowing less time for anticipatory responses to occur. Further, it was aimed to use this CPT to compare between two schedules of reinforcement (the VR and the VI). Unfortunately, it was discovered at the end of the experiment that the VI schedule used was in fact a tandem VT-FR schedule with an accumulating component. Given a reasonable rate of responding (which occurred for all subjects) this schedule behaved the same as a real VI schedule. A comparison between the two schedules of reinforcement could be made because the overall performance under both schedules received an equal number of reinforcements. The primary aim, that of developing the CPT as a research tool for comparing between schedules of reinforcement was achieved. The main result from Experiment II, was that reinforcement did have a positive effect on performance, as seen by increased time on-task and discrimination effects between baseline and interventions. Impulsive responding was generally low compared to

Experiment I, as would be expected. A relaxed contingency for reinforcement(VR8) compared to a strict one (VR16) brought about improved stimulus control and heightened responding. There was no change in sensitivity for most subjects and an inconsistent change in decision bias across subjects. The response bias was on the right hand key for all subjects as expected. Comparing between the two reinforcement schedules, the variable ratio schedule seemed to exert the greater control on performance, especially during the richer contingency (VR8). This occurred for both accuracy of responding and on-task behaviour, for which the rate of reinforcement was the same as VI.

What was learned from Experiment I, using the difficult version of the CPT, was that impulsivity could mask the effects of reinforcement. It was also found that reinforcement effects could be enhanced if made available for correct responding on both keys. Experiment II, using the simpler version of the CPT, showed that impulsivity was not a deterimental factor in the study of reinforcement effects if impulsivity was redefined. (This could also be due to the use of the simpler task.) Although the results were not dramatic, it was shown that two schedules of reinforcement could be compared on this task, especially if the reinforcement contingency of the schedules were richer as compared to being strict. However this may only be a consequence of the richer schedule assisting discrimination.

In the analysis of the data, the three parameters of sensitivity to the rate of reinforcement, accuracy of performance and total duration on-task were found useful for the comparison. Accuracy of performance should take on a broader definition than just correct responding. Since impulsivity has the potential to mask reinforcement effects, accuracy of performance should include impulsivity as a sub-category. Impulsivity needs to be considered because it is undesirable in clinical or therapeutic settings like sheltered workshops.

The tasks utilized in this study showed, as in previous studies with the traditional CPT, that mentally retarded subjects frequently perform at a low level on the task. Even during reinforcement conditions detection rate (hits or correct rejections), did not increase by very much. Generally, effects were limited in both experiments because besides the rise in impulsivity in Experiment I, both studies showed relatively high and stable sensitivity levels across phases and treatment conditions. This implied that reinforcement may not have been able to change sensitivity levels because of the ceiling created by the limited capacity of the subjects. This limited capacity is explained by the mentally retarded subjects having an inability to sustain attention (Krupski, 1981), a skill needed in discrimination learning. It seems that having been taught the correct way of responding on the CPT most of the subjects immediately commenced and continued to respond as well as they could. This ceiling, created by rule-governed behaviour limited the degree to which reinforcement could change behaviour in Experiments I and II. However the (weak) results from Experiments I and II have shown that reinforcement does aid in improving accuracy on-task. That is, help in sustaining attention so that greater accuracy is achieved.

It is worth noting that the stability criteria used in both experiments

I and II were arbitaryly chosen. The subjects were slowly getting more proficient on the task as the experiments progressed, as seen by the move towards stability in the dependent variables during the reinforcement conditions. The operant literature would predict that if the experiments were of a longer duration the subjects behaviour on the CPT would shift from being under the stong control of rule-governed behaviour, as seen in both experiments, to being under the strong control of contingency shaped behaviour. Further research is needed in this area.

The original CPT was shown to be a good diagnotic tool to help differentiate between people who could sustain their attention (e.g.,. normal population) and people who could not (e.g., brain damaged, schizophrenics, etc.) But the original CPT was limited to this use. The version of the CPT developed in the present research may be useful not only as a diagnostic tool but also as a research tool having the potential to compare between different schedules of reinforcement.

With the availability of two response keys it was possible to record the duration the subject actually spent on the task during the 15 or so minutes the subject was meant to be responding. Thus not only correct responding was recorded but also the duration on-task. With only one key, such recording would not be possible. Though the subject may be on-task there would not be any objective way of knowing that the subject consciously ignored the non-signals. On-task behaviour is worthy of examining in its own right. For example, for the mentally retarded population one of the aims is to improve on-task behaviour not only because if the subject is on-task, learning might be facilitated but also production may be increased and disruptive behaviour may be reduced.

The present methodology made available the possibility of studying both time on-task and impulsive responding. From the present results it was seen that impulsive responding may be manipulated by redefining the term.

The application of the Matching Law in the signal detection analysis of performance on the CPT showed that the sensitivity measure (log d) had high consistency with the traditional sensitivity measures derived from SDT ($P(\bar{A})$ and d'). Therefore log d values provided superflous information which could have been more easily derived from traditional SDT measures. However, the response bias variable was useful in investigating the effects of reinforcement on response patterns. When reinforcement schedules focussed on one of the two keys for a certain time period, this variable was sensitive in showing a shift in bias to that particular key. Such information is useful in showing that a schedule of reinforcement actually affects responding on the CPT.

In hindsight there were many weaknesses in the present study. The data from Experiment I indicated that most of the dependent variables had a sharp downward trend during the last baseline phase, but the sessions were terminated abruptly before the data could stablize. This was unavoidable because by the time the experiment was setup and running the Christmas holidays got in the way. This downward trend in the data could have provided interesting information about reversal behaviour.

The variable interval schedule of reinforcement, planned for in Experiment II, was actually reinforcing responding according to a tandem schedule. As stated before, the comparison between the two schedules could still be made because responding during both schedules received an equal number of reinforcements, and the primary aim of the study was not contravened.

The definitions of impulsive responses in the CPT, stated in the literature, are not fully justified by scientific methods. Before undertaking the study, the reaction times of Intellectually Handicapped subjects to target stimuli on the CPT should have been determined. Based on this data, an idea of the duration for impulsive response to occur could be found. From this, a definition for impulsivity could be formulated and applied consistently across the different versions of the CPT in experiments I and II.

Very few problems were faced in dealing with the client population. The experimenter got along very well with all the subjects and had little difficulty in carrying out the initial instructions and training the subjects. Only one subject from each experiment did not adhere strictly to the rules of the task. This was unexpected since both subjects passed the screening procedures before being put on the task proper. This suggests that the screening procedure may need to be stricter.

Further Research

Despite the shortcomings in design and the difficulties experienced, the modified CPT has potential for further development both as a tool in applied settings and as a tool for research. The present investigations can be developed further in a number of ways.

The duration of the CPT was very short (about twenty minutes for Experiment I and about 15 minutes for Experiment II). This may be too short to be used as a sensitive tool to compare between different schedules of reinforcement. Further studies could explore the possibility of increasing the duration of the task to, for example, two hours. Maybe, the first hour could utilize only rule-governed behaviour while the second hour could follow with reinforcement (rule-governed behaviour and contingency shaped behaviour). Long duration vigilance tasks have been shown to have a reliable drop in the average number of correct responses as the vigil progresses (see Mackworth, 1950). Allowing behaviour to be primarily controlled by rule-governed behaviour initially, and then introducing reinforcement to attempt to maintain performance in the later stages may prove to be the most useful method. Another study could allow both rule-governed and contingency shaped behaviours to operate for two hours to explore if there is a bias in any of the two behaviours during different time stages of the experiment. However, the length of time required may limit the frequency of its use.

Another area for further research may consider developing the CPT along the influence of contingencies alone. Therefore, contingency shaped behaviour would operate alone. The effects of reinforcement on performance may be more pronounced. A possible limitation would be the length of time required in learning the task.

More schedules of reinforcement should be compared on the CPT. More parameters for evaluating the effects of reinforcement should also be explored. For example, efficency on-task, a measure of productive use of time, could be found by dividing the accuracy variable (e.g., correct detections) by the total time on-task. This variable is useful when the sheltered workshop wants to implement a reinforcement schedule that will get the job done in the shortest amount of time.

It is worth examining whether the deficit in target performance is seen in other populations besides the mentally retarded. For example, the CPT may be useful with schizophrenics. The original CPT had shown deficits in performance with schizophrenics (Orzack and Kornetsky, 1966). Now it is necessary to see if this new modification of the CPT also shows this deficit in performance. This would extend the diagnostic versatility of the modified CPT. It would also be interesting to examine the effects of reinforcement on populations such as schizophrenics. Interesting comparisons in terms of impulsivity, duration on-task etc., could be made.

Further research needs to be done with respect to impulsivity, especially on the A-X task where the rise in impulsivity was dramatic during reinforcement conditions. Research might focus on the effects of particular drugs like anti-anxiety drugs (e.g., Valium), to see whether a subject's impulsive responding could be reduced without effecting increased detection levels during reinforcement conditions. The definition for impulsivity needs to be examined further. It needs to be determined what the average reaction times are for different populations, when reacting on the CPT. The reaction time helps determine what an appropriate definition for an impulsive response should be. By using a consistent and reliable definition for impulsivity, schedules of reinforcement may be reliably compared along the parameter of impulsivity. Using the same definition for impulsivity, both versions of the CPT could also be compared for impulsivity with reinforcement, to determine if the simplicity of the task affects anticipatory responding.

Further, experiments might examine the different factors which could bring about behavioural contrast. Experiment I (using the difficult version of the CPT) had shown a rise in impulsivity with reinforcement. Experiment II had shown behavioural contrast for some dependent variables. Utilizing the difficult version of the CPT and the experimental design of Experiment II (alternating treatments design) reinforcement effects, contrast effects and impulsivity could be studied to see if any of the effects are related.

The modified CPT could also be used to study the inhibition deficit hypothesis, as it relates to discrimination learning deficits in the retarded population. Evans (1982) has outlined areas which should be looked at as criteria for demonstrating the existence of inhibition. The use of stimulus generalization gradients where generalization tests around the S- should reveal an incremental U-shaped gradient with the base value at S-. This would be one piece of evidence showing that S- has developed inhibitory properties (Hearst, Besley and Farthing, 1970). The CPT could present letters one after another. A particular letter could be S+, for the "YES" key, while another could be S- for the "NO" key. Thus stimulus generalization gradients could be examined for responding on a wide variety of dependent variables including time on-task. Peak and area shifts, by S- during discrimination learning, are other pieces of evidence to be considered (Terrace, 1966,1971). The data which produce stimulus generalization gradients could also be used to examine these peak and area shifts. These data could utilize Grusec's (1968) technique of mean 'shift' to calculate area shift. The slope of the inhibitory gradient would be additional data to consider, but rather than using intradimensional designs as suggested above, interdimensional designs that involved correlating the amount of responding S- with the extent of stimulus suppression that came about by superimposing S+ on S- in comparison to S+ presented alone (Evans and Hogg, 1981). Obviously, all these could be researched through other means in the experimental laboratory, but the CPT is economical in that it has the advantage of among other things, monitoring sustained attention, being easy to administer in the field setting, having the potential to compare between different schedules of reinforcement and possessing the capability of being used as a diagnostic tool with dysfunctional populations.

Summary and Conclusion

The aim of the research was to explore the use of the CPT as a research tool to be used in the field to compare different schedules of reinforcement. If this could be done, suitable reinforcement schedules could be found for the field setting to enhance appropriate responding. An additional response key was included in the design of the CPT to objectively measure time on-task, an essential variable when dealing with a dsyfunctional population like the mentally retarded. The lack of literature in the use of reinforcement with the CPT made the research novel.

Experiment I looked at whether reinforcement affected performance on the difficult version of the CPT, and evaluated which of the two reinforcement conditions was better at enhancing this. That is, reinforcing correct responding either on one key or on both keys. It was found that impulsivity increased with reinforcement per se. Nevertheless, reinforcement available for correct responding on both keys was more effective at enhancing accuracy, time on-task and efficiency.

Experiment II examined the simpler version of the CPT to compare between schedules of reinforcement. As a way of reducing impulsivity, the time period for impulsivity to occur was drastically reduced. (This did not exclude the possibility of the nature of the task affecting anticipatory responding.) Assuming that impulsive responding would be minimal, two reinforcement schedules were compared.

Impulsivity was minimal. Reinforcements made available for responding on either key, and, with a schedule of reinforcement having a richer contingency as compared to a leaner one, did show that reinforcement enhanced responding. It was found that responding under the VR8 (as compared to VR16) schedule was better than the corresponding tandem VT-FR schedule with the accumulating component.

It has therefore been shown that the CPT has good potential for further development as a research tool examining schedules of reinforcement.

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