EFFECTS OF SELF-INSTRUCTIONAL TRAINING ON VIGILANCE IN HYPERACTIVE CHILDREN

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BY

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Abstract

The purpose of the present study was to evaluate the impact of a brief cognitive-behavioural intervention on vigilance performance in hyperactive children. Douglas (1980) has argued that the primary deficit of hyperactive children is in their ability to sustain attention. Although a number of studies in recent years have demonstrated that cognitive-behavioural interventions have a positive impact on social and academic behaviours, there is little evidence to suggest that the interventions produce effects on more basic cognitive functions, such as sustained attention. Using a multiple-baseline design, five subjects were assessed with a continuous performance task (C.P.T.) under baseline and intervention conditions. The intervention was based on the model of cognitive-behaviour therapy developed by Meichenbaum and Goodman (1971), and was aimed at assisting the subjects to more effectively attend to the continuous performance task. No significant changes in vigilance performance were observed, suggesting that the cognitive-behavioural intervention had no effect on the ability of the subjects to sustain attention. However, the failure of the changes in

vigilance performance, in the intervention condition, to reach significance may be related to flaws in the design of the present experiment. It is suggested that future studies of the link between cognitive-behavioural interventions and vigilance utilize experimental designs including group comparisons. Studies designed to assess the impact of a cognitive-behavioural treatment on hyperactive children might also include a measure of vigilance.

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INTRODUCTION

Attentional Deficits in Hyperactivity

Until recently it has been the components of activity level and impulsivity that have been the defining features of hyperactivity. Both in school and at home these children were identified by parents and teachers as problem children due to their high activity level and lack of control. The children also failed to perform academically, a finding frequently ascribed to non-compliant or disruptive classroom behaviours and difficulty in maintaining on-task behaviours (Barkley, 1981). Teachers frequently noted that the hyperactive child exhibited inconsistent academic performance and therefore suggested that the child was simply lazy and not willing to try the tasks at hand (Douglas, 1972). With this emphasis on overt problem behaviours, little was done in terms of describing and defining the cognitive components of the disorder.

Until the mid-1960's the notion of hyperactivity as a syndrome secondary to brain damage was firmly entrenched in the clinical literature. This was based on the observation that children with demonstrable brain damage occasionally exhibited a high level of impulsive behaviour (Lahey, Delamater & Kupfer, 1981). The utility of this notion was rather limited since there were many children in whom no brain damage could be demonstrated but who exhibited a large number of the behaviours which made up the syndrome of hyperactivity.

Efforts were made to devise a purely behavioural/quantitative definition of hyperactivity, which could provide an objective criterion by which to diagnose the disorder (Ross & Ross, 1976).

More recently, however, the emphasis in the definition of hyperactivity has shifted to cognitive deficits in these children, especially deficits in sustained attention. Douglas' (1972) article, which summarized a large body of research on cognitive deficits in hyperactive children, played an important role in redefining the nature of the disorder. Many researchers currently acknowledge that attentional deficits are a primary component of the pattern of behaviours labelled hyperactivity (Schierberl, 1979; Firestone & Douglas, 1975; Charles, Schain, Zelniker & Guthrie, 1979; Goldberg & Konstantareas, 1981; Wallander & Conger, 1981). Indeed, the American Psychiatric Association recently redefined its "hyperkinetic syndrome of childhood" as "attention deficit disorder-with and without hyperactivity" (D.S.M.-III, 1980, p.41).

Sustained Attention

Douglas (1972) presented the first comprehensive model of hyperactivity in which deficits in sustained attention played a primary role. She noted that a wide variety of cognitive and learning difficulties had been associated with hyperactivity but little research had been conducted to define these deficits in a systematic and controlled fashion. She observed that hyperactive children frequently have a "short attention span". This is manifested by concentration problems, distractibility, and difficulty in sustaining attention to an extended task or play activity. Douglas and her collegues carried out a series of well-controlled studies to investigate the abilities of hyperactive children to sustain attention. In this research four measures were used most frequently. These measures, and the findings which resulted from them, will be described below.

1. The delayed reaction time task required the subject to respond as rapidly as possible to a stimulus signal, which was preceded by a warning signal and preparatory interval. Douglas and Peters (1979) reported three studies using this task. In each study the hyperactive children showed a steeper decline in response speed over trials and greater variability in response speed than the normal children.

2. The continuous performance task required the subject to observe a continuous display of letters, appearing one at a time, and to push a button whenever a target sequence of letters (the letter "A" followed

by the letter "X") appeared. Douglas and Peters (1979), citing a number of studies that employed this task, showed that hyperactive children made fewer correct responses, and more incorrect responses than normal children, and that performance for the hyperactive children deteriorated with time on task.

3. The serial reaction task required the subject to observe five lights, each of which was associated with a push-button on a display. As each light went on in random order the subject is required to push the button to extinguish the light and another light did not appear until the first light had been switched off. Douglas and Peters (1979) showed that no significant differences were observed in the reaction times of hyperactive and normal children in several studies using this task.

4. The choice reaction task required the subject to press buttons which corresponded to geometric figures as these figures appear on a screen. The trials were discrete and the subject's attention is redirected to the task following each trial. Douglas and Peters (1979) reviewed several studies which used this task and found that no differences in response times were observed for hyperactive and normal children.

In summary, the hyperactive subjects used in this research showed the greatest deficits on the continuous performance task and the delayed reaction time task but showed relatively similar performance to the normal controls on the serial reaction task and the choice reaction task. These tasks differed on at least two dimensions. First, the choice reaction task and the serial reaction task employed discrete trials, in that a new stimulus did not appear until a response was made to the first stimulus. Second, in the choice reaction task the subject's attention was redirected to the task before each trial. The continuous performance task and the delayed reaction-time task were both experimenter-paced and thus required the subject to maintain a relatively rapid response time and did not include any redirecting of attention between trials. The data suggested that hyperactive children show the greatest deficits on tasks which require the ability to sustain attention to a stimulus for an extended period of time without external prompts.

Selective Attention and Distractibility

The findings presented previously regarding vigilance performance in hyperactive children represent one category of research into the attentional processes of these children. A second category of research and theory, concerned with the selective aspects of attention in hyperactive children, involved filter theories of attention like the one developed by Broadbent (1958). These theories have been used to account for data regarding distractibility in hyeractive children.

Broadbent observed that it was difficult to carry on two tasks adequately at one time or to perceive two sets of data accurately at one time. He suggested that there are multiple input channels through which data may be input to be processed. The perceiver would be bombarded by unmanageable amounts of data if all input channels had access to processing simultaneously. A mechanism was therefore required to select from the incoming data that information that was of high priority for the organism. This selection mechanism allowed only one channel of data into processing at any one time and made selections based on current task demands.

Based on this model, it can be argued that hyperactive children have a deficit in the filter mechanism in that they fail to screen out those data that are irrelevant to the current task demands and which elicit a response from the child. These distractor stimuli may be external noises, visual stimuli or internal data from sources such as kinesthetic sensations or autonomic functions. This model has considerable explanatory power in that it accounts for the clinical observations on overt distractibility as well as poor academic performance and deficits in vigilance task performance. Any task involving stringent processing time demands would reflect selection mechanism deficits, as extra processing time would be required to evaluate all the distractor stimuli as well as the task-relevant ones. It could be predicted from this model that hyperactive subjects would be indiscriminately attentive to a wide variety of stimuli and dimensions.

Studies of distractibility in hyperactive children have employed a variety of approaches. One set of studies involved the administration of a cognitive task while introducing various distractor elements to the task situation, including white noise and irrelevant cues for task solution. Another type of study involved the administration of a cognitive or academic task for solution together with both relevant and irrelevant information for task solution. The subject was tested following task solution to determine how much learning of the irrelevant material had taken place, Douglas and Peters (1979) reviewed a wide range of both these types of studies and found no significant differences between hyperactive children and controls. These findings suggest that hyperactive children are no more impaired by distractor information than normal children and the findings are not consistent with a filter model of selective attention.

Denton and McIntyre (1978) assessed distractibility in hyperactive children using a task which measured the span of apprehension. The span of apprehension is the period of time during which information may be picked up, analyzed and encoded from a brief visual display (100 MSEC.). Information from these brief displays is available after presentation (in the form of a rapidly decaying after-image) for only a short period of time and any processing has to be carried out before the decay of the after-image. Denton and McIntyre suggested that a distractible subject's performance on this task would be severely affected if noise stimuli were presented along with target stimuli. It was argued that this task represented a pure measure of attention since performance was not affected by non-perceptual variables.

Denton and McIntyre (1978), using a task which measured span of apprehension, demonstrated that when a target stimulus was presented without any noise letters no differences were observed between hyperactive and control subjects. However, with the addition of an increasing number of noise letters the spans of the hyperactive children fell below those of the normal controls. Denton and McIntyre concluded that several alternative hypotheses might account for these findings: (1) the pick-up of information from the decaying after-image may have been slower for hyperactive boys; (2) the decaying after-image may have faded more rapidly in the hyperactive boys; (3) noise letters may have acted as more potent distractors for the hyperactive boys.

In a subsequent study, McIntyre, Blackwell and Denton (1978) demonstrated that when signal-to-noise similarity and noise redundance were varied, the performance of hyperactive and normal boys was affected in a similar way. Therefore, the noise letters did not have a differential effect on the hyperactive boys and the normal controls. These data lend support to the first two alternative hypotheses regarding speed of information uptake from the after-image and speed of after-image decay. The findings also support the notion that hyperactive children are not excessively distractible, and that the deficit may be in the child's perception and processing of stimuli.

Theories of Sustained Attention.

The finding that hyperactive children were no more distractible than normal children could not be accommodated by filter theories of attention. For this reason the theoretical focus shifted to models which emphasized the sustained aspects of attention such as those developed by Neisser (1976), Kahneman (1973) and Gibson and Rader (1979). These theories suggested that attention to multiple inputs is not limited by a structural mechanism or filter, but by the dynamic capacity of the information processing system. Douglas and Peters (1979) suggested that these theories and others (Hebb, cited in Douglas and Peters, 1979) have two elements which have important implications for understanding the hyperactive child's cognitive processes and for formulating treatment strategies for these children. First, these theories emphasize prior learning and experience as important in current perception and processing of stimuli. Second, emphasis in these theories is placed on attention as under voluntary and intentional control. Neisser's (1976) model is a good example of these concepts, and this model will be described below.

Neisser argued that all perceptual processes are guided by schemata, "...pre-existing structures...which direct perceptual activity and are modified as it occurs." (1976, p.14). This notion of schemata as structures based on previous experience and modified by on-going perception is central to Neisser's theory. He also argued that the perceiver actively selects those stimuli to which he will attend. This is in contrast to the filter notion of perception, where the perceiver is flooded by stimuli and must actively filter out the irrelevant ones and only admit to processing those that are currently task-relevant. The purpose of attention, that is of perceiving one stimulus rather than another, is to pick-up relevant information in as efficient a manner as possible.

Neisser, therefore, conceived of attention as the selection by the perceiver of particular stimuli or stimulus elements to which to attend based on current task demands, on-going perception and previous experience. Data from past experience are applied to current perception in such a way as to increase the efficiency with which data pick-up occurs. Neisser has coined the term "perceptual cycle" to refer to the process whereby schemata direct the exploratory strategies, and are modified by data during the exploration. As the schema is modified by new data the exploration strategies are altered and new data are picked up and the cycle continues.

Gibson and Rader (1979) argued that perception is not always efficient and active with regard to task performance, and that it is this variable aspect of perception that we refer to as attention. They argue that attention is the perception of information that has optimal utility for the task at hand, and there is no attention independent of task performance. Gibson and Rader also linked attention to action plans and strategies in an approach similar to Neisser's. They argued that with perceptual development the efficiency with which data are picked up from the environment increases. In particular, they referred to affordances or action strategies, which consist of data regarding the most efficient means to carry out a particular activity or response. With development, the perception of affordances occurs more and more efficiently and optimally for task performance. Furthermore, as the perceiver develops, particular strategies become automatic as the steps involved drop out of awareness and are carried out with little use of processing capacity.

This theoretical approach places the findings regarding the deficits in sustained attention and impulse control of hyperactive children in a somewhat different light. Douglas (1980) has suggested that such deficits are primary and lead to the syndrome of cognitive, academic and social difficulties exhibited by these children. She based this argument on theories such as those outlined above. Hyperactive children may begin the process of cognitive development with attentional and impulse control deficits. These deficits prevent the child from attending adequately to environmental stimuli and inhibit accurate analysis. The child responds impulsively to stimuli, before adequate analysis can be completed and therefore without sufficient information. According to the theoretical models discussed above, adequate observation and analysis of environmental stimuli is central to later cognitive development, including basic perceptual skills. Children who maintain a superficial and impulsive style of analysis would be unlikely to develop the complex and subtle schemata needed to cope with the demands of a complex environment. The failure to develop such schemata leads to the syndrome of impulsivity, academic failure and behavioural problems observed in these children.

Treatment Approaches

A variety of treatments have been applied to the behaviours which fall under the category of hyperactivity. The behaviours targeted have included compliance, on-task behaviour, aggression, social behaviours, task performance and cognitive and intellectual test performance. The treatments may be divided into two categories. There is a group of treatments which consists of pharmacological or medical interventions. These approaches usually involve the administration of various CNS stimulants which have the effect of improving performance on vigilance tasks (Charles et. al, 1979; Sykes, Douglas, Weiss & Minde, 1971), increasing social and compliant behaviours (O'Leary, 1980), and producing improvements on parent and teacher ratings of hyperactive behaviour (Williams, Cram, Tausig & Webster, 1978).

Another treatment approach may be referred to as behaviour modification. This category may be separated into two groups of related treatment strategies: (i) contingency management and, (ii) cognitive behaviour modification. Contingency management procedures generally involve targeting various component behaviours of hyperactivity such as overall activity level, voice volume, frequency of on-task behaviour, aggression and out-of-seat behaviour. The procedures involve altering the events consequent to the target behaviour to alter some aspect of the behaviour (Lahey, Delameter & Kupfer, 1981).

The cognitive behaviour modification approach employs the subject's own overt and covert self-verbalizations to change overt behaviours. With hyperactive children, training is focused upon the child's self-statements as they pertain to attention deployment and impulsivity in task performance, particularly in academic situations. The goal is to provide the child with a set of basic self-statements, focused on problem solving, which can be applied to a wide variety of tasks and situations. Furthermore, problem solving strategies included in the self-instructional training may be employed in social or interpersonal situations. The procedure involves a number of components and teaching strategies. Included are teacher modelling of appropriate self-statements, overt and covert rehearsal, prompts, feedback and social reinforcement.

The notion that we use self-verbalizations to control our overt behaviour arose from different sources of evidence. Meichenbaum observed a group of schizophrenic patients involved in a social skills program designed to decrease the frequency of their bizarre or "sick" conversation. One component of this treatment was specific, explicit instructions on how to converse and categories of conversation to avoid. During a follow-up interview the patients were overheard repeating the trainers exhortations to themselves. It seemed that these self-verbalizations augmented and indeed may have mediated the behaviour change shown (Meichenbaum, 1968).

A second line of argument came from Vygotsky's work on cognitive development in childhood (Zivin, 1979). He argued that overt and covert self-statements function, in the young child, to regulate behaviour and guide motor performance. He also suggested that self-verbalizations function in other ways as well and have concrete effects on behaviour. He argued that cognitive development has two components. One corresponds to innate, pre-verbal intelligence and problem-solving skills, independent of any symbol-based language. The second component is social speech which derives from the child's earliest babbling and cries. With the development in the pre-school years of rudimentary speech and communicative behaviours, these two processes merge. Both processes are changed by this merger and affect one another. Vygotsky argued that children become able to verbalize a large proportion of the cognitive processes, creating the phenomenon of thinking in words. Social speech is gradually fully comprehended, and cognitive development is affected by the meanings derived from the social speech and verbalized thoughts. The two original components of cognitive development merge and allow the child to start thinking in words for problem-solving and organizing activity.

Vygotsky also described a model of the function of inner speech in self-regulation. He suggested that a first- and second-signal system functions in the development of self regulation through inner speech. The first-signal system functions in infancy and early childhood and represents a response to the stimulus properties of the environment. Children operating within the first-signal system respond to spoken words based simply upon the physical and perceptual data from the sounds in the same way they respond to a touch and an odor. Gradually the response to the spoken word changes and the second-signal system comes into effect. Children begin to respond not only to the stimulus properties of the word but also to the significance or meaning underlying the word. They gradually come to react more strongly to the semantic qualities of the verbal stimuli than to the auditory properties of the words. Furthermore, as the children react more strongly to the word meanings they become able to elicit responses in themselves by presenting themselves with the words; they become able to elicit their own behaviour. The children become able to take on the executive role by regulating their own behaviour. It was argued that such self-regulatory verbalizations are initially spoken aloud but gradually become covert and eventually, for many activities, may drop out of awareness entirely. However, an adult who has tried to learn a new motor skill or alter an existing one is well aware of the mediational and controlling function of self-verbalization.

Training in the use of cognitive strategies and self-verbalization has been used to change a variety of behaviours in children. A number of studies have investigated the effectiveness of cognitive-behavioural strategies for changing an impulsive cognitive style, and for improving the performance of hyperactive children on various measures of academic performance.

Cognitive style refers to a set of dimensions upon which individuals differ and which affect their general mode of cognitive functioning and problem solving (Readence & Bean, 1978).

Research in Cognitive Behaviour Modification

This section will first briefly review two studies which employed different methods to train children to use their cognitions to change their behaviour. Secondly, more recent research, focused upon the application of cognitive-behavioural strategies to the behaviour of hyperactive children, will be reviewed. Finally, a brief review will be presented of research which has examined the effectiveness of a variety of specific components of cognitive-behavioural interventions.

An early example of cognitive behaviour modification, applied to impulsive behaviour in non-hyperactive children, is found in Palkes, Stewart and Kahana (1968). They employed visual reminder cards with self-commands and line drawings relevant to the training paradigm. The visual reminder cards included statements regarding the nature of the task ("This is a STOP, LISTEN, LOOK, and THINK experiment!) and the subjects' required responses to the tasks (Before I start any of the tasks I am going to do, I am going to say: 'STOP!, LISTEN, LOOK and THINK' before I answer")(Palkes et.al., 1968, p.819). The cards with these statements were spread out before the subjects throughout the training. The trainer instructed the subjects to read particular statements at appropriate times during the training. Prompts were used if the subject failed to read or verbalize the appropriate self-statement. The tasks used for training in this study were the Matching Familiar Figures Task, Embedded Figures Task, and the Trail Making Test. The authors found that the group exposed to the self-commands showed significant improvement in their performance on the Porteus Mazes using pre-post assessments. The Porteus Mazes was the only dependent variable used.

Meichenbaum and Goodman (1971) took a somewhat different approach than Palkes et.al. (1968) in applying cognitive behaviour modification to impulsivity and hyperactivity. Meichenbaum and Goodman relied much more heavily on experimenter modelling of appropriate self-verbalizations while performing tasks. Their procedure required the experimenter to model a set of self-verbalizations while performing a task. The self-verbalizations were composed of statements from four categories: (i) questions regarding the nature and demands of the task; (ii) answers to these questions in the form of cognitive rehearsal and planning; (iii) self-instructions in the form of self-guidance while performing the task; (iv) self-reinforcement. Subjects initially observed the experimenter/model and then performed the task while the experimenter instructed them in the self-verbalizations for task solution. They then performed the task again while saying the self-statements aloud, performed the task a third time while whispering the self-statements and finally performed the task a fourth time while making the self-statements covertly (without lip movements). In this study there were efforts to make the subjects responsible for their own behaviour by requiring the covert rehearsal of the self-statements. Palkes et.al. only measured changes in Porteus Maze performance, a task sensitive to impulsive responding. Meichenbaum and Goodman, however, showed that self-instructional training produced effects on a variety of measures, including performance measures, such as the Porteus Mazes, Matching Familiar Figures Task and performance subtests from the Wechsler Intelligence Scale for Children; in-class observations of inappropriate behaviours; and teacher ratings of the child's self-control, activity level, cooperation and likeability.

Douglas, Parry, Marton and Garson (1976) evaluated a broadly based, cognitive training package for hyperactive children over a three-month period and a three-month no-treatment follow-up period. This package included consultation sessions with parents and teachers and training sessions with children. The children were taught to cope more effectively with cognitive tasks and social situations where care and planning were required. A problem-solving procedure was taught whereby the child worked through the following general steps: (i) problem definition and formulation; (ii) generation of alternative solutions; (iii) formulation of a plan; (iv) implementation of the plan; (v) evaluation of the solution selected. Both modelling and direct instruction were used to teach these strategies. Techniques for enhancing memory and cooperative play were also taught. Following the training period, subjects obtained significantly fewer errors and longer latency on the Matching Familiar Figures Task, more positive response to frustration based on the results of a story completion task, longer completion time for the Bender-Gestalt and significant improvement in oral and listening comprehension. These gains were maintained during the follow-up period.

Barkley, Copeland and Sivage (1980) examined the effectiveness of a package of self-control strategies in a classroom setting. Six hyperactive boys were taught a standard problem solving procedure to be used with all academic problems. As well, they were taught to monitor and reinforce their own time-on-task behaviour. The training took place over an eight-week period. These procedures were effective in decreasing the frequency of misbehaviour in class as well as increasing the time-on-task for each child. No significant reduction was noted in activity level.

Cameron and Robinson (1980) examined the effects of cognitive training on the academic and on-task behaviour of hyperactive children. Three hyperactive children were taught self-instructional strategies based on the Meichenbaum and Goodman (1971) model, as well as self-monitoring and reinforcement procedures for a mathematics task. Improvements were observed in on-task behaviour and mathematics and reading accuracy following the intervention. These changes were maintained during a self-management phase during which all active training was withdrawn, and the children independently maintained their monitoring of on-task behaviour and math and reading accuracy.

Kendall and Urbain (1981) demonstrated the effectiveness of a cognitive-behavioural intervention in a single case study of a hyperactive girl. Cognitive self-instructions were used to teach self-control on academic tasks. Self-instructions were also used to aid in the taking of another's perspective, affect recognition and interpersonal problem solving. Behavioural contingencies were used to manage the child's behaviour during treatment sessions. Therapist modeling was used extensively to teach the use of self-instructions, task-analysis and planning procedure. Significant reductions were observed in a variety of problem behaviours including verbal aggression, and out-of- seat and off-task behaviours. Changes were also noted in performance on a number of cognitive tasks, including the Matching Familiar Figures Task and a means-ends problem solving task.

Parrish and Erickson (1981) evaluated the effectiveness of several cognitive strategies for changing the cognitive style of impulsive children. The subjects' performance was evaluated on the Matching Familiar Figures Task, behaviour rating scales and quizzes in various curriculum areas such as reading comprehension, arithmetic and spelling. Three groups of children were taught one of: a scanning strategy alone; verbal self-instruction alone; or a combination of the two. Parrish and Erickson found that each form of cognitive training produced significant decreases in Matching Familiar Figures Task errors but not in latency. The three interventions also produced significant decreases in errors on classroom quizzes. No differences were observed on behaviour rating scores between the pre- and post-test phases of the experiment.

A number of studies have examined various components of cognitive behavioural interventions to determine the contribution which each component made to the overall effect. For example, Heider (1971) found that an explanation of an appropriate task strategy was more effective than either an enforced response delay or reinforcement for accuracy in terms of increasing latency and decreasing errors on the Matching Familiar Figures Task. Palkes, Stewart and Freedman (1971) showed that vocalized, self-directed commands were more effective than those silently read for improving Porteus Maze Test scores.

Kendall and Wilcox (1980) studied differences in the effectiveness of concrete and conceptual training in self-instruction. Concrete training involved teaching the subject strategies and self-statements appropriate for solving a particular problem or class of problems. Conceptual training involved teaching the child a set of procedures which were appropriate for use in any problem or task situation, and with which the child generated his or her own solution plans and self-statements. Kendall and Wilcox found that only the conceptual training produced significant, positive changes in a number of dependent measures including Matching Familiar Figures Task latencies and errors, activity level, behaviour and self-control ratings.

There is, therefore, evidence that cognitive strategies and self-instructional training are effective in altering the impulsive cognitive style of both hyperactive and non-hyperactive children. As well, there is evidence that self-instructional training produced significant improvements in academic performance and significant decreases in problem behaviours in hyperactive children. It may be that those manipulations which were successful in changing the behaviour of hyperactive children were also successful in altering the central deficits of hyperactive children in sustained attention and impulse control. However, it is not clear, from the studies which have evaluated the effectiveness of cognitive strategies with hyperactive children, whether they have, in fact, changed the child's ability to sustain attention.

The improvements in performance observed in many of the studies may be confounded with a variety of other effects, such as differences in task characteristics, memory and motivation. Finally, none of the studies employed a task which made particular demands on sustained attention, such as the continuous performance task.

We have, therefore, a body of literature which suggests that deficits in sustained attention and impulse control are the primary deficits exhibited by hyperactive children and which lead to the later cognitive and behavioural problems exhibited by these children. There is another body of literature that suggests that training in the use of self-instructions produces positive changes in the performance of hyperactive children on various cognitive and academic tasks as well as measures of social behaviour. However, there does not appear to be evidence linking training in the use of self-instructions to measurable changes in sustained attention. None of the studies which addressed treatment issues included measures of sustained attention such as the continuous performance task. The investigators who demonstrated significant differences between normal and hyperactive children on measures of sustained attention did not utilize psychological treatment procedures to alter sustained attention.

The mechanisms by which cognitive behaviour modification produces its effects are not well explained and have not been adequately investigated. The cognitive behaviour modification procedures used by Meichenbaum and Goodman (1971), for example, focused on teaching the child to carefully analyze the task, to use self-statements to guide performance when completing the task and to self-reinforce upon task completion. The careful analysis and self-guided performance match quite closely the deficits in sustained attention and impulse control which some suggest characterize hyperactive children. By teaching the children to analyze the demands of the task Meichenbaum and Goodman provided them with skills not previously learned, possibly due to deficits in sustained attention. Not only were the children shown how to use these strategies but they also had to be trained to actually use it during task solution. Although the Meichenbaum and Goodman procedure produced significant positive changes in the performance of impulsive and hyperactive children none of the studies utilized tasks which made significant demands on sustained attention.

The purpose of the present experiment was to demonstrate that a hyperactive child's deficits in sustained attention, as measured by vigilance task performance, may be improved upon by training in cognitive strategies and self-instruction aimed at focusing and sustaining attention to the task over time. One hypothesis is that the self-instructions will produce significant increases in the proportion of targets correctly detected. A second hypothesis is that the intervention will produce significant decreases in the proportion of non-target stimuli to which responses are made. It is also hypothesized that the intervention will produce a significant increase in response time. The predicted changes in response time are based on findings with the Matching Familiar Figures Task which showed that training in the use of cognitive strategies produced an increase in latency to first response (Heider, 1971; Douglas, Parry, Marton & Garson, 1976; Kendall & Wilcox, 1980; Kendall & Urbain, 1981; Parrish & Erickson, 1981). One of the effects of the present training may be to slow the response time while increasing the accuracy on the continuous performance task.

Evidence in support of the above hypotheses would support the notion that the deficits in sustained attention observed in these children are associated with a failure to acquire and/or utilize cognitive strategies necessary for the effective deployment of perceptual and attentive processes. Such evidence would also provide support for the notion that cognitive behaviour modification can effect changes in the ability to sustain attention.

Method

Subjects:

The subjects for the present experiment were selected initially from among the children attending the Diagnostic and Remedial Unit, Faculty of Education, Memorial University of Newfoundland. Children are referred to the Unit by schools and parents for the assessment and remediation of learning disabilities and other disorders which affect the process of development. One additional subject was obtained from the Child Health Services Unit, St. John's Regional Health Unit, Department of Health, Government of Newfoundland and Labrador. This organization provides pediatric community health services, including consultation to parents and teachers on child behaviour problems, to the St. John's area. In all cases subjects were selected from the population on the basis of the following criteria: (i) WISC-R I.Q. of 80 or greater; (ii) Conners' Parent Symptom Questionnaire (PSQ): mean rating of 1.5 or greater on the hyperactivity index (See Appendix B); (iii) onset of hyperactivity at school age (5 years) or earlier; (iv) no positive history of brain injury based upon parent responses to a medical history questionnaire (See Appendix A) and interview; (v) hyperactivity or attention deficit must be a primary complaint.

Subject selection moved through the following stages:

1. Initial selection was based upon the recommendation of the director of the Diagnostic and Remedial Unit or a physician with the Child Health Services Unit.

2. WISC-R I.Q. scores were obtained for all children, either from available records or from tests administered by the investigator.

3. The parents of subjects selected in Step 1 were contacted and given the Conners Parent Symptom Questionnaire and Medical History Questionnaire (See Appendix A).

4. Subjects were next excluded on the basis of the rating scale data. Parents of subjects who met the inclusion criteria were interviewed to clarify and expand the medical history. Subjects whose parents reported positive evidence of brain injury (seizures, meningitis, encephalitis, severe head injuries, extended periods of unconsciousness) were excluded from the study.

Children who were receiving stimulant medication had their 1200 and 1600 hours doses witheld, as testing began at 1700 hours and medication effects had to be ruled out. Only Subject 5 was receiving medication, in this case Ritalin. The dosages for Subject 5 were as follows: On weekdays he received 20 mg. at 0700 and 10 mg. at 1200 hrs.. With both the parents' and physician's consent Subject 5's 1200 hrs. dose was witheld.

Of 20 subjects referred to the study, 9 met the above criteria. Of these subjects, 3 were used as practice subjects to test the apparatus and training procedures. The remaining 6 subjects were used for the study. One subject was excluded after the study because, due to error, he had viewed a set of continuous performance task stimuli different from those viewed by the other subjects (See Table 1, Page 33).

Measure

The dependent measure in the present experiment was a continuous performance task (Rosvold, Mirsky, Bransome and Beck, 1956; Sykes, Douglas and Morgenstern, 1973). In this instance it consisted of 12 different letters of the alphabet randomized over 100 visual presentations. The subject was required to detect a specific target (letter X only with the letter A before it), and to make a response (button push) when a target was detected. There were seven letters other than "A" followed by "X" and nine letters other than "X" preceded by "A". This leaves 69 letters not associated with "A" or "X" in any way. There were

Table 1

Subject Characteristics

Subject	Sex	Age	Conners' P.S.Q. Hyperactivity Index	W.I.S.C.-R Full-Scale I.Q. Scores
1	F	8-9	1.89	102
2	M	7-9	2.10	110
3	M	11-6	2.30	101
4	M	7-11	1.90	91
5	M	7-11	2.20	133

fifteen targets within a trial of one hundred stimuli and there were twelve trials in each testing session. There was a pause of approximately fifty seconds between each of the twelve trials during which data were recorded. A practice set of twenty-five stimuli, including five targets, was also used.

The stimuli were timed as follows: Stimulus duration: 0.2 seconds; interstimulus interval: 1.5 seconds. The stimuli were presented by way of a BASIC program and a Sorcerer micro computer. The subjects viewed the stimuli on an Exidy video monitor and made responses using a button box interfaced with the computer. The routine presented each stimulus and then counted down from 1.7 seconds and stored either the time remaining when the subject made a response or, if no response was made, a zero was stored. A second computer program was used to sort the response times thus obtained such that each response time was paired with the target which was on the monitor at the time of the response. It was then possible to make frequency counts of accurate and inaccurate responses and to calculate the accuracy score and various error rates.

Testing Procedure

Those subjects selected for participation in the experiment were seen once per day for four to six days in a row, with a single test session of twelve trials on each day. All testing on the C.P.T. and the self-instructional training took place in laboratories in either the Diagnostic and Remedial Unit or the Department of Psychology, Memorial University. A multiple baseline design was used with Subjects 1 and 4 having baseline phases of two sessions, Subjects 2 and 3 with baseline phases of three sessions and Subject 5 with a baseline phase of four sessions. For all subjects two sessions of testing on the C.P.T. were administered after the intervention was implemented.

Subjects were given the following instructions at the beginning of the first testing session: " Today we're going to play a game that is similar to a video game. You're going to see some letters appear on this screen one at a time. But they won't stay on the screen long; in fact they'll just flash on the screen and then disappear. What I would like you to do is to watch the the screen and look for the letter "X" with the letter "A" before it. When you see the letter "A" and then the letter "X" I want you to push the button on the box there. Let's play a practise game."

The experimenter then administered a practise trial of twenty-five stimuli, including five targets. During the task the experimenter observed the subject's performance and verbally reinforced accurate target detections.

Following the practise trial subjects were told: "Now you're going to play the same game only with more letters and targets. This one will take a little bit longer but I want you to do exactly the same things you did on the practise game: Press the button when you see the "X" but only when there is a letter "A" before it." No reinforcement was presented during the actual baseline or intervention phases.

The baseline sessions were followed by intervention sessions during which subjects were taught to make a set of self-statements, elicited from the child and modelled by the trainer at the beginning of the intervention session. Approximately thirty minutes were required to elicit the self-statements and train the subject to make the statements. The training period was followed by a test session consisting of twelve trials on the C.P.T.. At the beginning of each trial the child was prompted to make the agreed-upon self-statements and was verbally reinforced for doing so.

Training Procedure

The cognitive self-instructional training used in the present study is based loosely on the model presented by Meichenbaum and Goodman (1971). The subjects were trained to emit four categories of self-statements: (i) questions regarding the nature and demands of the task; (ii) answers to these questions; (iii) self-instructions in the form of self-guidance while performing the task; (iv) self-reinforcement for successful task performance.

The process of training was divided into four phases. The first phase involved an orientation to the training approach to be used. The second phase of the training was a task analysis activity in which the trainer and student worked together to determine the components of the task and decided which behaviours facilitated task performance and which behaviours degraded it. The third phase of training involved a modelling procedure in which the trainer performed the task while employing the self-statements selected in the second phase, drawing the subject's attention to the verbal and motor activities which the trainer was using. The fourth phase of training was a rehearsal phase in which the subject carried out the task while making the self-statements independently and out loud (See Appendix C for a sample training dialogue).

Results

For all subjects data were obtained for each trial regarding response times and the number of targets correctly detected. An accuracy score was calculated by expressing the number of targets correctly detected as a proportion of the total number of targets in each series of one hundred stimuli (fifteen). Responses to non-target stimuli were divided into three categories : 1. responses to 'X' preceded by letters other than 'A' (Non-A-X); 2. responses to letters other than 'X' following the letter 'A' (A-Non-X); 3. responses to random letters not associated with either 'A' or 'X' (Random). Error rate for each type of stimulus was calculated by expressing the number of targets erroneously detected as a proportion of the total number of possible error detections. In the series of 100 letters used in the present version of the C.P.T., there were seven occasions when letters other than 'A' preceded the letter 'X'; 69 occasions where letters were associated with neither the letters 'A' or 'X'; and 9 occasions when letters other than 'X' followed the letter 'A'. Therefore, the number of responses to 'X' not preceded by "A' is expressed as a proportion of seven; the number of responses to non-'X' letters following the letter 'A' is expressed as a proportion of nine, and the number of responses to random letters, not associated with either 'A' or 'X' is expressed as a proportion of sixty-nine. Mean response time was also calculated for each trial by dividing the total response time by the total number of responses.

This approach to calculating scores from the C.P.T. data differs from that used in most studies using this task. Some studies have used as dependent variables the raw frequencies of correct target detections and errors of omission (missed targets) (Rapoport, Jenswold, Elkins, Buschsbaum, Weingartner, Ludlow, Zahn, Berg, and Neims, 1981; Levy, 1980; Sykes, Douglas and Morgenstern, 1972, 1973). Rapoport, Buschsbaum, Weingartner, Zahn, Ludlow and Mikkelson (1980) applied a log transformation to the raw numbers of correct detections and errors of commission. This was used to normalize the distributions of the measures derived from the C.P.T. data. Sykes, Douglas, Weiss and Minde (1971) applied data analysis techniques to an accuracy score which was the percentage of targets correctly detected. A simple frequency count of errors of commission was also used. Sostek, Buschsbaum and Rapoport (1980) used signal detection analysis to derive values for d' (attentiveness or sensitivity) and beta (response bias). They argued that these two measures correspond to the two hypothesized primary deficits of hyperactive children: respectively, failure to sustain attention and impulsive responding. However, Sostek et. al. noted that although d' and beta are assumed to be independent parameters, their data yielded a significant correlation between the two measures. This covariation was linked to the greater complexity of the C.P.T. when compared to simple signal detection tasks and to a partial violation of the basic assumption of signal detection analysis. This finding by Sostek et. al. casts doubt on the validity of d' and beta as measures of performance on the C.P.T. when used with hyperactive children.

The decision to use proportions in the present study was based on several factors. Proportions allow for meaningful comparisons between measures especially where the total number of possible responses differs between measures. Such is the case with the three error measures in the present study. In addition, proportions also allow comparisons between subjects where the total number of possible responses differs from subject to subject. A majority of studies previously completed reported results in terms of raw frequencies rather than derived measures such as d' and beta. The use of proportions allows for comparison with a larger number of other studies utilizing the C.P.T., since it is a simple matter to convert raw frequencies to proportions and vice versa.

The present study utilized a multiple baseline design where subjects 1 and 4 were tested for two sessions of twelve runs each for the baseline phase and two sessions for the intervention phase. Subjects 2 and 3 were tested for three sessions for the baseline phase and two sessions for the intervention phase. Subject 5 was tested for four sessions for the baseline phase and two sessions for the intervention phase. For those subjects where there was more than two sessions of baseline to compare to the two session intervention phase, the baseline was divided into two segments each of which was compared to the intervention phase. For the baseline phases which consisted of three sessions of testing sesions 1 and 2 formed the first baseline segment, while sessions 2 and 3 formed the second baseline segment. For baseline phases which consisted of four sessions of testing sessions 1 and 2 formed the first segment, and sessions 3 and 4 the second segment. Each segment was treated as a separate baseline and was compared independently to the intervention phase.

In the past many researchers have employed visual inspections of plotted data to determine the magnitude of change in a dependent variable as a result of an intervention in a time-series experiment. This method is not satisfactory for a number of reasons. It depends, in part, on a subjective judgement regarding the direction and magnitude of change in a time series and it fails particularly in this regard when the time-series is serially dependent. Serial dependency is a common statistical property of time-series data wherein there is a relationship among scores in the series: A score may be predicted on the basis of the scores that went before it. As a property of a time-series, serial dependency is difficult to appraise by visual inspection of a graph. Furthermore, serial dependency tends to depress the variance of a set of scores relative to a set with no serial dependency. Therefore, conventional statistics, such as analysis of variance, are also inappropriate for making inferences from time-series data. The reader is referred to Jones, Vaught and Weinrott (1977) and McCain and McCleary (1979) for a more detailed discussion of the implications of serial dependency for the analysis of time-series data.

There are several ways to solve the problem of serial dependency in time-series data. The most well-developed of these is the Auto Regressive Integrated Moving Averages (ARIMA) approach. The procedure involves the empirical construction of a complex mathematical model that best represents the time-series. The model is used to extract serial dependency from the time series data. Standard inferential statistics are then used to evaluate changes in the mean level and slope of the time-series.

One major limitation of this procedure is the large number of data points required to use the procedure with confidence. Hartmann, (cited in Tryon, 1982) suggests that 50 to 100 data points are required for adequate model construction. As the number of data points decreases, the power of the procedure is diminished and the probability of Type II error increases.

Tryon (1982) has proposed a simpler method for dealing with time-series data, which he suggested may be used with confidence with as few as eight data points. This procedure, labelled the C statistic, is based on the same logic as visual analysis: variability in successive data points is evaluated relative to changes in slope from one phase to another. For any time-series, there are two orthogonal estimates of variance. The first is the variance calculated as indicated in the following equation : $S^2 = \frac{1}{N}\sum_{i=1}^{N}(X_i - \overline{X})^2$. This estimate of variance increases in direct proportion to changes or trends in the mean value of the time-series. The second estimate of the variance of a time-series is the Mean Successive Difference statistic (MSSD). This statistic is calculated by squaring the successive differences among data points and then averaging them as indicated in the following equation : $MSSD = D^2 = \sum_{i=1}^{N-1}\frac{(X_{i+1} - X_i)^2}{N - 1}$. This estimate of variance is independent of changes in the mean of the time-series and, therefore, of the stationarity of the series. The C statistic is calculated as shown in the following equation : $C=1-\frac{\sum_{i=1}^{N-1}(X_i-X_{i+1})^2}{2\sum_{i=1}^{N}(X_i-\overline{X})^2}$. The numerator of the right hand term is the sum of the N-1 squared consecutive differences associated with the time-series. The denominator of the right hand term is twice the sum of the N squared deviations of the time series data points from their mean. The standard error of the C statistic is directly related to the number of data points in the time-series and is calculated as follows : $Sc=\sqrt{\frac{N-2}{(N-1)(N+1)}}$. The ratio of the C statistic to its standard error is the Z statistic : z=C/Sc. It is normally distributed for time-series with twenty-five or more data points. According to Tryon (1982) the deviation from normality is not significant even for time-series with as few as eight data points.

The procedure is first applied to baseline data to evaluate the significance of any trends. The absence of trends in data suggests that responding has stabilized and an intervention may be implemented. When baseline data are stationary (absence of significant trend) the effect of an intervention may be assessed by appending the intervention phase to the baseline phase and applying the C statistic to the complete series as described above. There are cases, however, where baseline data are not stationary. Tryon presents methods for testing for intervention effects in such cases.

The first involves initially quantifying the trend identified in the baseline phase. This may be accomplished by using curve-fitting procedures such as those described by Velleman and Hoaglin, (cited in Tryon, 1982). They describe how to fit a "resistant line" which pases through the medians of each third of the data. This line is less severely affected by a few atypical data points than standard regression equations and the slope and intercept values of the resistant line agree favourably with the corresponding values in the regression equation. A comparison series is obtained by subtracting the trend line values asociated with the first baseline point from the first treatment point, then subtracting the trend line values associated with the second baseline point from the second treatment point and so on until all baseline and/or treatment values are exhausted. The comparison series thus obtained is tested with the C statistic and a significant value for C demonstrates that the trend in the treatment phase departs significantly from that observed in the baseline phase.

The second procedure for testing for intervention effects where there are significant trends in the baseline phase also involves obtaining a comparison series. The series is obtained directly by subtracting the first baseline value from the first treatment value and so on until all baseline and/or treatment values are exhausted. The C statistic is then calculated on the comparison series. A significant value for C indicates that the trend in the intervention phase differs significantly from the trend observed in the baseline phase.

Both of these alternative procedures share a common limitation. The C statistic will fail to reach significance when the slopes of the data points in the experimental phases under consideration are equal even when there has been an upward or downward shift in one series relative to the other. This occurs because the comparison series is stationary. The second alternative procedure was chosen over the first for use in the present analysis on the basis of its simplicity and ease of calculation.

The first step in the analysis involved calculating the C statistic for the baseline phases of each measure for each subject. This was performed on the time-series formed by linking the two, three, or four days of baseline testing together. Comparisons were then made between baseline and intervention phases using Tryon's procedures as outlined above (1982).

With this type of design and task, there are three sources of uncontrolled variability : 1. fatigue built up during each daily session, 2. habituation both within and across days and 3. recovery between days. In order to make an accurate assessment of the intervention effects this variability within and between days had to be controlled. This was accomplished by dividing each day into thirds and then combining the first third of each day into one time-series, the second third into a second series and the third third into a third series. This was done for all measures and for both baseline and intervention phases. The C statistic was then applied to these time-series and comparisons made between baseline and intervention phases. It should be noted that with ARIMA time-series analysis procedures such comparisons would be very difficult to make due to the small numbers of observations in each fraction of a day.

In addition, mean values for accuracy score, latency, an aggregate error score and total response frequency were calculated for each trial across sessions. The aggregate error score included responses to all non-target stimuli and was expressed as a proportion of the total number of non-target stimuli. Total response frequency represents the total number of responses, both detections and errors, within a trial. By averaging values across sessions the variability between days resulting both from chance and from the intervention were removed. With these sources of variability removed it was possible to assess change in performance over time, within a session. This calculation yielded a time series consisting of twelve mean values for each measure and to which the C-statistic was applied to assess the significance of change over time.

Comparisons were also made between mean latencies for error versus correct responses and for mean latency on first response following an error versus a correct response. Analyses of variance were also calculated on the three error measures plus errors of omission.

A Z-test for the significance of the difference between two independent proportions was calculated for the error rate on the first letter following an error versus a correct response. In this case errors were defined as responses to the first letter following a correct response to a target or following an error of omission, a missed target. These errors were expressed as a proportion of the total number of correct detections and missed targets, respectively.

Subject 1

Data for subject 1 are summarized in Tables 2 through 5 (pages 67 to 70) where means and standard deviations for each phase and measure are presented. Time-series for each measure are presented in Figures 1 through 5 (pages 96 through 100). A significant decrease was observed in the overall baseline for accuracy score ($Z=3.301, p<.01$). Significant increasing trends were observed in the random error rate ($Z=2.742, p<.01$), and A-Non K error rate

(Z=2.674, p<.01). All other overall baselines showed non-significant trends. When the A-Non-X overall intervention phase was compared to the overall baseline phase, a significant decreasing trend was observed (Z=1.767, p<.05). All other tests for intervention effects were non-significant in the overall analysis.

Thirds of Days

In the first third of the day, a significant decreasing trend was observed in the baseline for accuracy score for subject 1 (Z=2.701, p<.01). A significant increasing trend was obtained in the baseline for random error rate (Z=2.604, p<,01). All other baseline values for Z were non-significant. No significant trends were obtained in the first third of the day when the intervention phase was compared to the baseline phase.

A significant increasing trend for baseline response time was obtained for the second third of the day (Z=1.7774, p<.05). Baseline values for all other measures were non-significant. A significant decreasing trend for accuracy score was obtained when the intervention phase was compared to baseline for the second third (Z=2.573, p<.01). A significant decreasing trend was also obtained for the intervention phase for A-Non-X error rate (Z=2.5703, p<.01). All other comparisons between baseline and intervention phases for the second third of the day were non-significant.

For the third third of the session, the baseline A-Non X error rate yielded a significant decreasing trend (Z=2.1076,p<.05). All other baseline trends yielded non-significant values. The accuracy score for the intervention phase yielded a significant downward trend (Z=2.308,p<.01). No other significant intervention effects were obtained during the third third of the day.

Time series for all measures averaged within trials, across sessions are presented in Figures 6 through 9 (pages 101-104). Summary data with regard to the C-statistic analysis on these time series for all subjects are provided in Tables 29 and 30 (pages 94 and 95). When accuracy score was averaged across sessions, within trials a significant declining trend was obtained (Z=3.217, p<.01). A significant increasing trend was observed in the time series for aggregate error score averaged across sessions (Z=3.167, p<.01). A significant increasing trend was also observed for total response frequency, averaged across sessions (Z=2.3907, p<.01). No significant trend was observed for mean latency within trials.

The results of an analysis of variance on mean latency for error versus correct trials for all subjects is presented in Table 25 (page 90). For Subject 1 this analysis yielded a non significant value for F. Response time on the first response following an error versus a correct response were also compared using analysis of variance and yielded a significant difference ($F(1,89)=6.889, p<.05$) (See Table 26, page 91). Response time on the first letter following an error was significantly longer than following a correct response. Error rates on the first letter following an error versus a correct response are presented in Table 27 on page 92. A Z-test for the significance of the difference between two independent proportions (Ferguson, 1966) was calculated and yielded a significant value ($Z=6.948, p<.01$). Significant differences were found among the three error variables, Non-A-X, A-Non-X, and random ($F(2,43)=5.0936, p<.01$). Using Tukey's honest significant difference (HSD) procedure (Hopkins and Glass, 1978) significant differences were obtained between Random and A-NonX error rates (See Table 28, page 93).

Subject 2

Data for Subject 2 are summarized in Tables 6 through 10 (pages 71 through 75) where means and standard deviations for each measure and phase are presented. Time series for Subject 2 for each measure are presented in Figures 10 through 14 (pages 105 to 109). Subject 2 was tested using a baseline of three days. This baseline phase was divided into two segments for analysis purposes: segment 1 consisted of days 1 and 2 and segment 2 consisted of days 2 and 3.

Segment 1 shall be referred to as Baseline 1 and segment 2 shall be referred to as Baseline 2. Significant declining trends were observed in both overall Baseline 1 ($Z=2.48, p<.01$) and overall Baseline 2 ($Z=3.22, p<.01$) for accuracy score. A significant increasing trend in response time was observed in overall Baseline 1 ($Z=1.779, p<.05$) while Baseline 2 revealed a decreasing trend ($Z=4.1251, p<.01$). All overall error baselines yielded non-significant values for z.

Tests for overall trends following the intervention revealed non-significant values for Z when Baseline 1 for accuracy was compared to the intervention phase. However, a significant increasing trend in accuracy score was obtained when the intervention phase was compared to Baseline 2 ($Z=2.62, p<.01$). The overall intervention phase for response time yielded a non-significant value for Z when compared to Baseline 1 and Baseline 2. The Non-A-X error rate for the overall intervention phase yielded a non-significant value for Z when compared to Baseline 1 but revealed a significant increasing trend when compared to Baseline 2 ($Z=1.8029, p<.05$). The Random error rate overall intervention phase yielded a significant increasing trend when compared to Baseline 1 ($Z=2.11, p<.05$) but when compared to Baseline 2, the result was non-significant. Significant increasing trends were observed in the overall A-Non-X error rate intervention phase when compared to Baseline 1 ($Z=2.733, p<.01$) and when compared to Baseline 2 ($Z=1.6818, p<.05$).

Thirds of Days

In the first third of the day a significant decreasing trend was observed in the accuracy score, Baseline 2 ($Z=2.412, p<.01$). Baseline 2 for response time yielded a significant increasing trend ($Z=1.895, p<.05$). All other baseline values for Z were non-significant. Significant declining trends were observed when the accuracy score intervention phase was compared to Baseline 1 ($Z=3.7245, p<.01$) and Baseline 2 ($Z=1.8629, p<.05$). The intervention phase for response time produced a non-significant result when compared to Baseline 1 but a significant increasing trend was obtained when the comparison was made with Baseline 2 ($Z=1.895, p<.05$). The Random error rate yielded a significant increasing trend when compared to Baseline 1 ($Z=2.708, p<.01$), but produced a non-significant value for Z when compared to Baseline 2. Intervention phases for both Non-A-X error rate and A-Non-X error rate yielded non-significant values for Z in comparison to both Baseline 1 and 2.

In the second third of the day the response time Baseline 2 yielded a significant increasing trend ($Z=1.7173, p<.05$). Baseline values for all other measures in the second one-third were non-significant. A significant declining trend was obtained when the accuracy score intervention phase was compared to Baseline 1 ($Z=2.96, p<.01$) but no significant trends were observed in the Baseline 2 comparison. For reaction time, no significant trend was obtained when the intervention phase was compared to Baseline 1 but a significant increasing trend was observed in the Baseline 2 comparison ($Z=1.7173, p<.05$). The intervention phase produced non-significant values for Z when compared to Baselines 1 and 2 for both Non-A-X error rate and Random error rate. However significant increasing trends were observed in the intervention phase comparison to Baseline 1 ($Z=1.9888, p<.05$) and Baseline 2 ($Z=1.8387, p<.05$).

In the third third of the day Baseline 2 of A-Non-X error rate yielded a significant decreasing trend ($Z=1.935, p<.05$). All other baseline values for Z were non-significant. The accuracy score intervention phase produced a significant decreasing trend when compared to Baseline 1 ($Z=1.832, p<.05$), but yielded a non-significant value for Z when compared to Baseline 2. The response time intervention phase yielded a non-significant value for Z when compared to Baseline 1 but produced a significant increasing trend when compared to Baseline 2 ($Z=1.714, p<.05$). No significant values for Z were obtained for the Non-A-X error rate intervention phase or for the A-Non-X error rate intervention phase. The Random error rate intervention phase produced a non-significant value for Z when compared to Baseline 1, but a significant decreasing trend was observed in the Baseline 2 comparison ($Z=1.7533, p<.05$).

When the scores were averaged within trials across sessions significant trends were observed in only two measures (See Tables 29 and 30, pages 94 and 95 and Figures 15 to 18, pages 110-113). A significant decreasing trend was observed in the accuracy score time series ($Z=2.131, p<.05$). Total response frequency yielded a significant increasing trend ($Z=2.748$, $p<.01$). Latency and aggregate error score yielded non-significant trends.

Analysis of variance on latency for error versus correct trials yielded a significant value for F ($F(1,102)=5.316, p<.05$) indicating that response time on correct trials is significantly longer than on error trials (See Table 25, page 90). Latency on the first letter following a correct response was also significantly greater than on the first letter following an error ($F(1,101)=18.398, p<.01$) (See Table 26, page 91). A z-test on the error rate on the first letter following an error versus a correct response yielded a non-significant value (See Table 27, page 92). Analysis of variance on the three error rates yielded a non-significant value for F (See Table 28, page 93).

Subject 3

Time series data for subject 3 are summarized in Tables 11 through 15 (pages 76-80). Time series are presented in Figures 19 through 23, pages 114 to 118. For subject 3, the baseline consisted of three sessions of testing. For analysis purposes the baseline was divided into two segments : sessions 1 and 2 formed Baseline 1 and days 2 and 3 formed Baseline 2. Significant increasing trends were observed in Baseline 1 for Non-A-X error rate ($Z=1.7175, p<.05$) and for A-Non-X error rate ($Z=2.1515, p<.05$). All other measures showed no significant trends in either baseline.

The Intervention phase for accuracy when compared to Baseline 1 yielded a significant increasing trend ($Z=2.3875, p<.01$). No significant trend was observed when the intervention phase was compared to Baseline 2. The response time intervention phase yielded significant increasing trends when compared to both Baseline 1($Z=2.2087, p<.01$) and Baseline 2 ($Z=2.8036, p<.01$). A significant upward trend was observed when the intervention phase for Non-A-X error rate was compared to Baseline 1($Z=1.6947, p<.05$). However no significant trends were observed in the comparison to Baseline 2. For Random error rate significant trends were not observed in comparisons with either Baseline 1 or 2.

Thirds of Days

No significant trends were observed in the baselines of any measure during the first third of the day. No significant trends were observed in comparisons between the intervention phase and the baseline phases for accuracy score, Non-A-X error rate and A-Non-X error rate. The response time intervention phase showed significant increasing trends when compared to both Baseline 1 ($Z=2.333, p<.01$) and Baseline 2 ($Z=2.5207, p<.01$). A significant decreasing trend was observed when Random error rate was compared to Baseline 2 ($Z=2.1416, p<.05$) but no significant trend was observed for the Baseline 1 comparison.

In the second third of the day, a significant decreasing trend was observed in the A-Non-X error rate for both Baseline 1 ($Z=2.5461, p<.01$) and Baseline 2 ($Z=2.0257, p<.05$). Baseline values for Z for all other measures were non-significant. Non-significant values for Z were obtained in comparisons between the intervention phase and baseline phases for accuracy score, Non-A-X error rate, and Random error rate. The response time intervention phase produced a non-significant value for Z when compared to Baseline 1 but yielded a significant increasing trend when compared to Baseline 2 ($Z=1.6976, p<.05$). The A-Non-X error rate intervention phase produced a significant decreasing trend in comparison to Baseline 1 ($Z=2.1293, p<.05$) but the value for Z resulting from the comparison to Baseline 2 failed to reach significance.

In the third one-third of the day, only Baseline 1 for the Non-A-X error rate yielded a significant value for Z ($Z=2.4045, p<.01$). All other baseline values for Z failed to reach significance. Comparisons between baseline phases and the intervention phase for response time, Random error rate and A-Non-X error rate yielded non-significant values for Z. The accuracy score intervention phase in comparison to Baseline 1 yielded a significant decreasing trend ($Z=1.6958, p<.05$) while the comparison to Baseline 2 produced a non-significant value for Z. A significant decreasing trend was obtained when the Non-A-X intervention phase was compared to Baseline 1 ($Z=2.2972, p<.01$). The Baseline 2 comparison resulted in a non-significant value for Z.

Scores were averaged within trials, across sessions to produce a mean, within sessions time series. These time series are found in Figures 24 through 27, pages 119 to 122, and the data are summarized in Tables 29 and 30, pages 94 and 95. Significant decreasing trends were observed in accuracy ($z=2.615$, $p<.01$) and total response frequency ($z=1.8389$, $p<.05$) for this time series. The aggregate error score and latency time series did not yield significant trends.

No significant differences were obtained for response time on either error versus correct trials or on the first response following an error versus a correct trial, using one-way analysis of variance (See Tables 26 and 27, pages 91 and 92). A significant difference was obtained for error rate on the first letter following an error versus a correct response with significantly more errors occurring following an error trial ($Z=5.5595$, $p<.01$) (See Table 27, page 92).

A one-way ANOVA was calculated for error rate on the three different non-target stimuli and a significant value for F was obtained ($F(2,57)=31.226$, $p<.01$) (See Table 28, page 93). Tukey's HSD analysis showed that Subject 3 responded significantly more often to the A-Non-X stimuli than to the other non-target stimuli.

Subject 4

Time series data for Subject 4 are summarized in Tables 16 through 19, pages 81 to 84 and Figures 28 through 32, pages 123 to 127. Baseline data for this subject were collected during two sessions of testing. For analysis purposes the baseline data were treated as one phase. Analysis of the overall baseline data revealed significant increasing trends in the error rate on Non-A-X stimuli ($z=2.456$, $p<.01$) and on random stimuli ($z=3.70$, $p<.01$). All other values for z in the baseline analysis failed to reach significance.

The intervention phase for accuracy score produced a significant increasing trend when compared to the baseline phase (Z=2.7959,p<.01). Significant increasing trends were also observed for error rate on Non-A-X stimuli (Z=1.9681,p<.05) and on random stimuli (Z=3.1754,p<.01). Comparisons between the intervention phase and baseline phase for response time and the error rate on A-Non-X stimuli produced non-significant values for Z.

Thirds of Days

For the first one-third of the day a significant increasing trend was observed in the baseline of the error rate on random stimuli (Z=2.7164,p<.01). Baseline values for Z for all other measures failed to reach significance. For all measures comparisons between the intervention and baseline phases produced non-significant values for Z.

Baseline values for Z in the second one-third of the day were significant for error rates on Non-A-X (Z=2.2572,p<.01) and random (Z=2.2572,p<.01) stimuli. In both cases there were increasing trends. All other baseline analyses yielded non-significant values for Z. A significant increasing trend was observed in Non-A-X error rate when the intervention phase was compared to the baseline (Z=1.8309,p<.05). All other measures produced non-significant values for Z.

The third one-third of the day produced no significant trends in either the baseline analysis or the intervention/baseline comparison.

When scores for each measure were averaged within trials, across sessions to produce an average, one-session time series only one measure yielded a significant trend (See Figures 33 through 36, pages 128 to 131 and Tables 29 and 30, pages 94 and 95). A significant decreasing trend was observed in the total response frequency time series ($z=1.7079$, $p<.01$). Time series for all other measures yielded non-significant results.

A one way ANOVA for latency on error versus correct trials showed that response times for correct trials were significantly slower than error trials ($F(1,93)=171.438, p<.01$) (Table 25, page 90). A one-way ANOVA on latency on the first letter following on error versus a correct trial showed that latency on the first letter following an error was significantly slower that following a correct trial (Table 26, page 91) ($F(1,93)=4.417, p<.05$). A z-test on the error rate on the first letter following an error versus a correct response showed that there was a significantly greater error rate following a correct response ($Z=3.9937, p<.01$)(See Table 27, page 92). No significant differences were observed among the error rates on the three non-target stimuli, Non-A-X, A-Non-X and Random (See Table 28, page 93).

Subject 5

Time series data for subject 5 are presented in Tables 20 through 24, pages 85 to 89, and Figures 37 through 41, pages 132 to 136. Baseline testing for subject 5 was carried out over four sessions and the first two sessions of which became Baseline 1, the second two sessions, Baseline 2. Significant decreasing trends for accuracy score were observed in both Baseline 1 ($Z=2.8171, p<.01$) and Baseline 2 ($Z=1.7493, p<.05$). A significant increasing trend was observed in Baseline 1 for response time ($Z=2.8771, p<.01$) but the trend became non-significant in Baseline 2. The error rate on Non-A-X stimuli yielded a significant increasing trend in Baseline 1 ($Z=2.9538, p<.01$) but this trend reversed itself in Baseline 2 and produced a significant decreasing trend ($Z=1.7886, p<.05$). A significant increasing trend was observed in Baseline 1 for the error rate on Random stimuli ($Z=1.7229, p<.05$). No significant trends were observed in Baseline 2. The error rate on A-Non-X stimuli produced no significant trends in either baseline.

A significant decreasing trend was observed when the accuracy score intervention phase was compared to Baseline 1 ($Z=2.4301, p<.01$) and an increasing trend was observed in the Baseline 2 comparison ($Z=2.1408, p<.05$).

No significant differences were observed between the response time intervention phase and either Baseline 1 or Baseline 2. Significant decreasing trends for Non-A-X error rate were observed in the comparison between the intervention phase and Baseline 1 ($Z=2.451, p<.01$). The comparison with Baseline 2 yielded no significant trends. No significant trends were observed in the intervention phase for error rate on Random stimuli when compared to either Baseline 1 or 2. Significant decreasing trends were found when the error rate on A-Non-X stimuli intervention phase was compared to Baseline 1 ($Z=1.7961, p<.05$) and Baseline 2 ($Z=2.9905, p<.01$).

Thirds of Days

In the first third of the day the Baseline 1 accuracy score yielded a significant decreasing trend ($Z=2.769, p<.01$) while Baseline 2 showed no such trend. Baseline 1 for the error rate on Non-A-X stimuli yielded a significant increasing trend ($Z=1.6953, p<.05$) and no trend was observed in Baseline 2. The error rate for random stimuli, Baseline 1, produced no significant trends while Baseline 2 showed a significant downward trend ($Z=1.6803, p<.05$). Baseline 1 for the error rate on A-Non-X stimuli produced a significant increasing trend ($Z=1.8516, p<.05$) while Baseline 2 produced no trend. No trends were observed in either baseline for response time.

The intervention phase for accuracy score produced a significant decreasing trend when compared to Baseline 1 ($Z=2.0788, p<.05$) and an increasing trend when compared to Baseline 2 ($Z=3.7608, p<.01$). The response time intervention phase produced a significant increasing trend when compared to Baseline 1 ($Z=1.8403, p<.05$) but no trends were observed in the Baseline 2 comparison. No significant trends were produced by the intervention phase for error rate on Non-A-X stimuli when compared to either baseline. A significant downward trend was obtained when the intervention phase for error rate on random stimuli was compared to Baseline 1 ($Z=1.6676, p<.05$) but no trend was observed in the Baseline 2 comparison. A significant downward trend was also observed in the error rate for A-Non-X stimuli when the intervention phase was compared to Baseline 1 ($Z=2.0197, p<.05$) and the Baseline 2 comparison yielded no significant trends.

In the second one-third of the day no significant trends were observed in the baselines of any measure. A significant upward trend was observed in the accuracy intervention phase comparison to Baseline 2 ($Z=2.4972, p<.01$) while the Baseline 1 comparison yielded no significant result. Intervention phases failed to produce significant results for all other measures.

In the third one-third of the day, Baseline 2 for error rate on Non-A-X stimuli produced a significant decreasing trend ($Z=2.0153, p<.05$). Baseline values for Z for all other measures were non-significant. The intervention phase for Non-A-X error rate produced a significant decreasing trend when compared to Baseline 1 ($Z=1.7051, p<.05$) but the Baseline 2 result failed to reach significance. No significant results were obtained from the intervention phases of the measures in the last one-third of the day.

Scores for each measure were averaged within trials, across sessions to produce an average, one session time series. Data from these series are summarized in Tables 29 and 30, pages 94 and 95, and in Figures 42 through 45, pages 137 to 140. For Subject 5 only the accuracy score time series, analyzed in this fashion, yielded a significant result. A significant decreasing trend was observed in the accuracy score time series ($z=2.852$, $p<.01$). All remaining measures, including an aggregate error score, latency and total response frequency yielded non-significant results.

A one-way ANOVA for latency on error versus correct trials produced a non-significant result (See Table 25, page 90). No significant differences were found for latency on the first response following an error versus a correct response (See Table 26, page 91). The error rate on the first response following an error was significantly greater than following a correct response ($Z=4.8804, p<.01$) (See Table 27, page 92). A one-way ANOVA on error rate for the three non-target stimuli (Non-A-X, A-Non-X and Random) yielded a non-significant result. (See Table 28, page 93).

Table 2

Subject 1

Means(standard deviations) for accuracy score and latency in the various phases of the experiment

Analysis on Complete Phases

Phase	Accuracy Score	Latency(Secs)
Baseline 1	.648(.230)	.672(.089)
Intervention	.435(.260)	.756(.119)

Analysis on Thirds of Phases

Phase	Accuracy Score	Latency(Secs)
Baseline 1.1	.757(.228)	.662(.102)
Intervention 1	.583(.252)	.765(.104)
Baseline 1.2	.680(.170)	.693(.089)
Intervention 2	.383(.254)	.741(.175)
Baseline 1.3	.487(.296)	.658(.061)
Intervention 3	.237(.185)	.765(.070)

Table 3

Subject 1

Means(standard deviations) for error rate on three types of non-target stimuli

Analysis on Complete Phases

Phase	A-Non-X	Non-A-X	Random
Baseline	.372(.229)	.199(.154)	.126(.077)
Intervention	.232(.153)	.093(.260)	.157(.073)

Analysis on thirds of phases

Phase	A-Non-X	Non-A-X	Random
Baseline 1.1	.208(.218)	.161(.151)	.062(.042)
Intervention 1	.208(.171)	.054(.099)	.105(.049)
Baseline 1.2	.458(.141)	.232(.159)	.125(.057)
Intervention 2	.250(.121)	.071(.101)	.161(.066)
Baseline 1.3	.460(.201)	.204(.129)	.201(.048)
Intervention 3	.238(.150)	.163(.178)	.211(.056)

Table 4

Subject 1

Results of comparisons between baseline and intervention phases using the C-statistic for all measures on the C.P.T.

Measure	Value for C (Value for z)
Accuracy Score	.059 (0.29)
Latency	.191 (1.32)
Error Rate Non-A-X	.113 (0.78)
Error Rate A-Non-X	.352 (1.77)+
Error Rate Random	.124 (0.62)

P<.05

Table 5

Subject 1

Results of comparisons between thirds of baseline phases and thirds of the intervention phase using the C-statistic for all performance measures of the C.P.T.

Value for C(Value for z)

Measure	1st Third	2nd Third	3rd Third
Accuracy Score	.067(0.22)	.603(2.57)*	.573(2.31)*
Latency	.036(0.16)	.084(0.27)	.285(1.15)
Error Rate Non-A-X	.000(0.00)	.208(0.89)	.305(1.22)
Error Rate A-Non-X	.326(1.39)	.602(2.57)*	.501(1.55)
Error Rate Random	.056(0.18)	.172(0.74)	.049(0.20)

+ $p<.05$ * $p<.01$

Table 6

Subject 2

Means(Standard Deviations) for accuracy score and latency in the various phases of the experiment

Analysis on Complete Phases

Phase	Accuracy Score	Latency(Secs)
Baseline 1	.878(.167)	.548(.079)
Baseline 2	.629(.308)	.515(.125)
Intervention	.567(.212)	.640(.145)

Analysis on Thirds of Phases

Phase	Accuracy Score	Latency(Secs)
Baseline 1.1	.992(.022)	.505(.044)
Baseline 2.1	.808(.272)	.541(.062)
Intervention 1	.658(.127)	.659(.124)
Baseline 1.2	.867(.133)	.604(.061)
Baseline 2.2	.558(.340)	.499(.147)
Intervention 2	.409(.196)	.626(.175)
Baseline 1.3	.775(.225)	.536(.086)
Baseline 2.3	.505(.195)	.504(.138)
Intervention 3	.619(.201)	.643(.130)

Table 7

Subject 2

Means(standard deviations) for error rate on three types of non-target stimuli

Analysis on Complete Phase

Phase	A-Non-X	Non-A-X	Random
Baseline 1	.102(.126)	.077(.084)	.022(.023)
Baseline 2	.092(.119)	.106(.098)	.045(.058)
Intervention	.111(.126)	.123(.194)	.051(.081)

Analysis on Thirds of Phases

Baseline 1.1	.069(.095)	.089(.099)	.002(.005)
Baseline 2.1	.139(.144)	.054(.069)	.016(.028)
Intervention 1	.069(.077)	.054(.069)	.024(.030)
Baseline 1.2	.042(.054)	.054(.069)	.022(.021)
Baseline 2.2	.028(.073)	.125(.112)	.051(.066)
Intervention 2	.190(.165)	.225(.284)	.095(.122)
Baseline 1.3	.194(.144)	.089(.069)	.042(.018)
Baseline 2.3	.111(.084)	.125(.088)	.073(.054)
Intervention 3	.079(.078)	.102(.100)	.037(.024)

Table 8
Subject 2

Results of comparisons between baseline and intervention phases using C-statistic for all performance measures from the C.P.T.

Value for C(Value for z)

Measure	Baseline 1 versus Intervention	Baseline 2 versus Intervention
Accuracy Score	.220(1.08)	.532(2.62)*
Latency	.003(0.02)	.516(2.54)*
Error Rate Non-A-X	.322(1.64)	.425(2.13)+
Error Rate A-Non-X	.409(2.09)+	.048(.242)
Error Rate Random	.175(.893)	.126(.149)

* $p<.01$ + $p<.05$

Table 9
Subject 2

Results of comparisons between thirds of Baseline 1 and thirds of the intervention phases using the C-statistic for all performance measures of the C.P.T.

Value for C(Value for z)

Measure	1st Third	2nd Third	3rd Third
Accuracy	.873(3.72)*	.713(2.96)*	.441(1.83)+
Latency	.364(1.55)	.248(1.03)	.182(.754)
Error Rate Non-A-x	.167(.710)	.097(.402)	.031(.129)
Error Rate A-Non-X	.077(.328)	.480(1.99)+	.116(.482)
Error Rate Random	.634(2.71)*	.042(.172)	.038(.159)

+ $p<.05$ * $p<.01$

Table 10
Subject 2

Results of comparisons between thirds of Baseline 2 and thirds of the intervention phase, using the C-statistic, for all performance measures of the C.P.T.

Measure	1st Third	2nd Third	3rd Third
Accuracy	.575(1.86)+	.284(1.18)	.258(1.04)
Latency	.444(1.90)+	.554(1.72)+	.425(1.71)+
Error Rate Non-A-X	.200(.853)	.084(.350)	.125(.504)
Error Rate A-Non-X	.056(.240)	.443(1.84)+	.124(.384)
Error Rate Random	.634(2.71)*	.042(.172)	.038(.159)

+ p<.05 *p<.01

Table 11

Subject 3

Means(standard deviations) for accuracy score and latency in the various phases of the experiment

Analysis on Complete Phases

Phase	Accuracy Score	Latency(Secs)
Baseline 1	.931(.093)	.396(.077)
Baseline 2	.883(.116)	.368(.088)
Intervention	.896(.124)	.478(.125)

Analysis on Thirds of Phases

Baseline 1.1	.958(.066)	.392(.062)
Baseline 2.1	.942(.070)	.339(.099)
Intervention 1	.925(.070)	.433(.153)
Baseline 1.2	.925(.062)	.421(.091)
Baseline 2.2	.900(.075)	.377(.082)
Intervention 2	.950(.055)	.526(.063)
Baseline 1.3	.908(.129)	.374(.068)
Baseline 2.3	.808(.143)	.386(.074)
Intervention 3	.800(.167)	.475(.124)

Table 12

Subject 3

Means(standard deviations) for error rate on three types of non-target stimuli

Analysis of Complete Phases

Phase	A-Non-X	Non-A-X	Random
Baseline 1	.278(.140)	.030(.073)	.012(.013)
Baseline 2	.356(.160)	.066(.130)	.022(.020)
Intervention	.190(.118)	.036(.074)	.024(.031)
Baseline 1.1	.222(.079)	.018(.047)	.011(.019)
Baseline 2.1	.264(.156)	.036(.062)	.013(.018)
Intervention 1	.208(.117)	.036(.095)	.013(.013)
Baseline 1.2	.389(.147)	.018(.047)	.013(.009)
Baseline 2.2	.500(.079)	.089(.188)	.027(.015)
Intervention 2	.250(.073)	.036(.062)	.025(.023)
Baseline 1.3	.222(.111)	.054(.099)	.011(.010)
Baseline 2.3	.305(.121)	.071(.101)	.025(.023)
Intervention 3	.111(.111)	.036(.062)	.034(.040)

Table 13

Subject 3

Results of comparisons between baseline and intervention phases using C-statistic for all performance measures from the C.P.T.

Value for C(Value for z)

Measure	Baseline 1 versus Intervention	Baseline 2 versus Intervention
Accuracy Score	.341(2.39)*	.131(0.92)
Latency	.315(2.21)*	.400(2.80)*
Error Rate Non-A-X	.332(1.69)+	.036(0.26)
Error Rate A-Non-X	.351(1.80)+	.423(2.99)*
Error Rate Random	.050(0.36)	.055(0.39)

+ $p < .05$ * $p < .01$

Table 14

Subject 3

Results of comparisons between thirds of Baseline 1 and thirds of the Intervention phase using the C-statistic for all performance measures of the C.P.T.

Value for C(Value for z)

Measure	1st Third	2nd Third	3rd Third
Accuracy Score	.041(0.17)	.111(0.48)	.409(1.70)*
Latency	.547(2.33)*	.072(0.31)	.096(0.41)
Error Rate Non-A-X	.324(1.38)	.180(0.77)	.709(2.30)*
Error Rate A-Non-X	.188(0.80)	.657(2.13)+	.300(1.28)
Error Rate Random	.274(1.17)	.283(1.21)	.041(0.17)

+ $p<.05$ * $p<.01$

Table 15

Subject 3

Results of comparisons between thirds of Baseline 2 and thirds of the Intervention phase, using the C-statistic, for all performance measures of the C.P.T.

Value for C(Value for z)

Measure	1st Third	2nd Third	3rd Third
Accuracy Score	.057(0.24)	.127(0.54)	.054(0.22)
Latency	.591(2.52)*	.398(1.70)+	.129(0.54)
Error Rate Non-A-X	.200(0.85)	.153(0.65)	.131(0.56)
Error Rate A-Non-X	.204(0.87)	.261(0.85)	.042(0.18)
Error Rate Random	.502(2.14)+	.159(0.68)	.044(0.19)

+ $p<.05$ * $p<.01$

Table 16

Subject 4

Means(standard deviations) for accuracy score and latency in the various phases of the experiment

Analysis on Complete Phases

Phase	Accuracy Score	Latency(Secs).
Baseline 1	.553(.155)	1.15(.106)
Intervention	.597(.170)	1.05(.097)
Analysis on Thirds of Phases		
Baseline 1.1	.558(.123)	1.13(.135)
Intervention 1	.717(.179)	1.02(.101)
Baseline 1.2	.542(.161)	1.20(.094)
Intervention 2	.558(.105)	1.05(.098)
Baseline 1.3	.558(.201)	1.11(.080)
Intervention 3	.526(.152)	1.06(.089)

Table 17

Subject 4

Means(standard deviations) for error rate on three types of non-target stimuli

Analysis on Complete Phases

Phase	A-Non-X	Non-A-X	Random
Baseline 1	.032(.052)	.054(.092)	.047(.036)
Intervention	.013(.037)	.097(.122)	.072(.037)

Analysis on thirds of phases

Phase	A-Non-X	Non-A-X	Random
Baseline 1.1	.056(.056)	.036(.062)	.042(.031)
Intervention 1	.014(.037)	.143(.160)	.096(.028)
Baseline 1.2	.042(.054)	.054(.099)	.056(.040)
Intervention 2	.014(.037)	.089(.099)	.063(.045)
Baseline 1.3	.000(.000)	.071(.101)	.044(.032)
Intervention 3	.012(.035)	.064(.071)	.058(.019)

Table 18

Subject 4

Results of comparisons between baseline and intervention phases using the C-statistic for all measures on the C.P.T.

Measure	Value for C (Value for z)
Accuracy Score	.391 (2.80)*
Latency	.182 (1.30)
Error Rate Non-A-X	.385 (1.97)+
Error Rate A-Non-X	.184 (1.31)
Error Rate Random	.621 (3.18)*

* $p<.01$ +$p<.05$

Table 19

Subject 4

Results of comparisons between thirds of the baseline phase and thirds of the intervention phase using the C-statistic for all performance measures of the C.P.T.

Value for C(Value for z)

Measure	1st Third	2nd Third	3rd Third
Accuracy	.307(1.31)	.204(0.87)	.034(0.15)
Latency	.201(0.86)	.110(0.47)	.256(1.12)
Error Rate Non-A-x	.272(1.16)	.565(1.83)+	.198(0.87)
Error Rate A-Non-X	.273(1.17)	.167(0.71)	.062(0.27)
Error Rate Random	.283(0.92)	.196(0.64)	.060(0.27)

+p<.05

Table 20

Subject 5

Means(standard deviations) for accuracy score and latency in the various phases of the experiment.

Analysis on complete phases

Phase	Accuracy Score	Latency(Secs)
Baseline 1	.875(.149)	.557(.139)
Baseline 2	.693(.206)	.649(.130)
Intervention	.795(.137)	.603(.104)

Analysis on thirds of phases

Baseline 1.1	.942(.062)	.484(.087)
Baseline 2.1	.767(.219)	.612(.127)
Intervention 1	.850(.099)	.598(.122)
Baseline 1.2	.908(.138)	.543(.157)
Baseline 2.2	.708(.128)	.643(.095)
Intervention 2	.812(.114)	.559(.089)
Baseline 1.3	.785(.176)	.633(.134)
Baseline 2.3	.590(.229)	.697(.166)
Intervention 3	.726(.155)	.646(.078)

Table 21

Subject 5

Means(standard deviations) for error rate on three types of non-target stimuli

Analysis on Complete Phases

Phase	A-Non-X	Non-A-X	Random
Baseline 1	.142(.145)	.109(.150)	.046(.052)
Baseline 2	.063(.084)	.093(.111)	.050(.044)
Intervention	.089(.079)	.051(.081)	.026(.018)

Analysis on thirds of phases

Phase	A-Non-X	Non-A-X	Random
Baseline 1.1	.139(.164)	.161(.219)	.053(.069)
Baseline 2.1	.056(.111)	.161(.132)	.076(.053)
Intervention 1	.111(.056)	.036(.062)	.033(.019)
Baseline 1.2	.208(.151)	.036(.062)	.020(.029)
Baseline 2.2	.069(.095)	.072(.072)	.033(.025)
Intervention 2	.097(.103)	.089(.099)	.020(.016)
Baseline 1.3	.086(.070)	.127(.081)	.064(.037)
Baseline 2.3	.063(.055)	.041(.065)	.039(.030)
Intervention 3	.062(.055)	.041(.065)	.026(.015)

Table 22

Subject 5

Results of comparisons between baseline and intervention phases using the C-statistic for all performance measures from the C.P.T.

Value for C(value for z)

Measure	Baseline 1 versus Intervention	Baseline 2 versus Intervention
Accuracy Score	.467(2.43)*	.445(2.23)*
Latency	.267(1.39)	.112(0.80)
Error Rate Non-A-X	.471(2.45)*	.168(0.84)
Error Rate A-Non-X	.151(1.09)	.152(1.08)
Error Rate Random	.100(0.52)	.102(0.72)

* $p < .01$

Table 23
Subject 5

Results of comparisons between thirds of Baseline 1 and thirds of the intervention phase using the sures of C-statistic for all performance measures of the C.P.T.

Value for C(Value for z)

Measure	1st Third	2nd Third	3rd Third
Accuracy Score	.641(2.08)+	.179(0.76)	.339(1.52)
Latency	.431(1.84)+	.228(0.97)	.152(0.68)
Error Rate Non-A-X	.497(1.61)	.011(0.05)	.380(0.12)
Error Rate A-Non-X	.623(2.02)+	.068(0.29)	.167(0.75)
Error Rate Random	.391(1.67)+	.090(0.38)	.307(1.38)

+ $p<.05$

Table 24

Subject 5

Results of comparisons between thirds of Baseline 2 and thirds of the intervention phase, using the C-statistic, for all performance measures of the C.P.T.

Value for C(Value for z)

Measure	1st Third	2nd Third	3rd Third
Accuracy Score	.881(3.76)*	.585(2.50)*	.368(1.57)
Latency	.075(0.32)	.134(0.57)	.105(0.45)
Error Rate Non-A-X	.345(1.47)	.011(0.46)	.125(0.38)
Error Rate A-Non-X	.137(0.58)	.231(0.99)	.016(0.07)
Error Rate Random	.493(1.60)	.066(0.28)	.262(1.12)

* p<.01 + p<.05

Table 25

Means(standard deviations) and results of one way ANOVA on latencies for error versus correct trials for all subjects

Subject	Latency on Error Trials	Latency on Correct Trials	F
1	.686(.179)	.744(.190)	2.24(1,89) N.S.
2	.494(.292)	.599(.157)	5.32(1,102) P<.05
3	.355(.174)	.399(.111)	1.90(1,93) N.S.
4	.264(.219)	.807(.180)	171.438(1,93) p<.01
5	.605(.341)	.610(.148)	.123(1,144) N.S.

Table 26

Means(standard deviations) and results of one-way ANOVA on latency(seconds) on the first response following a correct versus error trial

Subject	Latency on the 1st letter following an error trial	Latency on the 1st letter following a correct trial	F
1	.749(.146)	.651(.201)	6.89(1,89) $p<.05$
2	.446(.172)	.601(.188)	18.40(1,101) $p<.01$
3	.398(.248)	.430(.122)	.784(1,115) N.S.
4	.619(.202)	.534(.190)	4.42(1,93) $p<.05$
5	.603(.261)	.622(.140)	.288(1,140) N.S.

Table 27

Means and results of a Z-test for error rate on the first response following a correct versus an error trial

Subject	Error Trial	Correct Trial	Z
1	.263	.076	6.95*
2	.061	.075	.774
3	.500	.080	5.56*
4	.161	.286	3.99*
5	.164	.062	4.88*

* $p<.01$

Table 28

Means(standard deviations) and results of one-way ANOVA for error rate on three categories of non-target stimuli

Subject	Non-A-X Stimuli	A-Non-X Stimuli	Random Stimuli	F
1	.146(.153)	.302(.203)	.142(.075)	5.09(2,43)*
2	.105(.140)	.105(.126)	.042(.063)	1.83(2,54)
3	.041(.098)	.265(.153)	.020(.024)	31.23(2,57)*
4	.076(.108)	.023(.045)	.060(.038)	1.48(2,46)
5	.084(.118)	.099(.113)	.041(.041)	2.23(2,70)

* $p<.01$

Table 29

Summary of C-Statistic analysis on accuracy score and response frequency for mean within-trial time-series for all subjects

Value for C(Value for z)

Subject	Accuracy Score	Response Frequency
1	.851(3.22)*	.632(2.39)*
2	.563(2.13)+	.727(2.75)*
3	.692(2.62)*	.486(1.84)+
4	.213(0.80)	.452(1.71)+
5	.754(2.85)*	.259(0.97)

* p<.01 + p<.05

Table 30

Summary of C-statistic analysis on latency and error rate for all non-target stimuli for mean within-trial time-series for all subjects

Value for C(Value for z)

Subject	Latency	Error Rate
1	.017(0.06)	.837(3.17)*
2	.159(0.60)	.267(1.01)
3	.062(0.23)	.331(1.25)
4	.104(0.40)	.122(0.46)
5	.287(1.08)	.011(0.04)

* $p<.01$

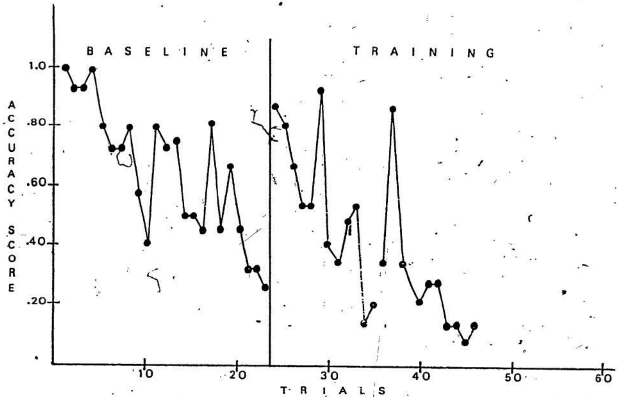

Fig. 1 Accuracy score on the continuous performance task, over trials, for Subject 1.

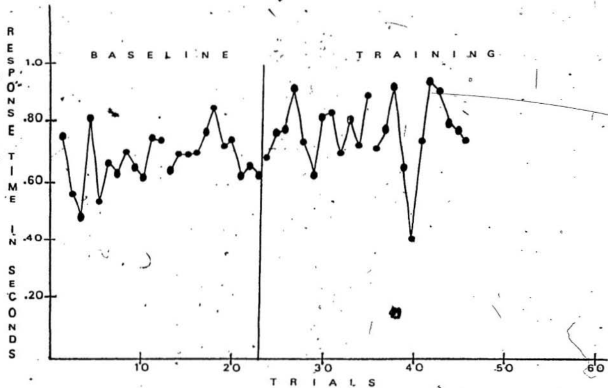

Fig. 2 Latency on the continuous performance task, over trials, for Subject 1.

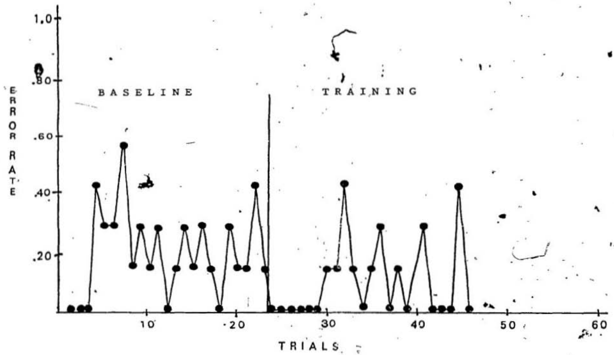

Fig. 3 Error rate on Non-A-X stimuli, on the continuous performance task over trials, for Subject 1.

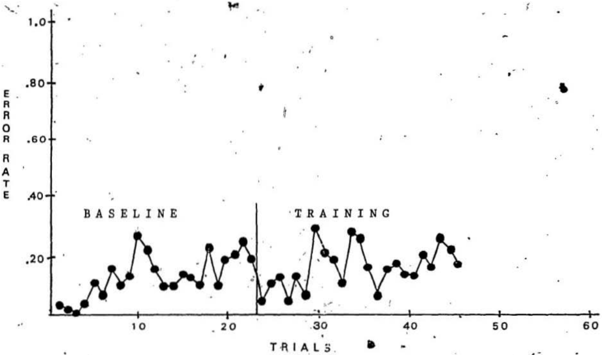

Fig. 4 Error Rate on Random non-target stimuli, on the continuous performance task, over trials, for Subject 1.

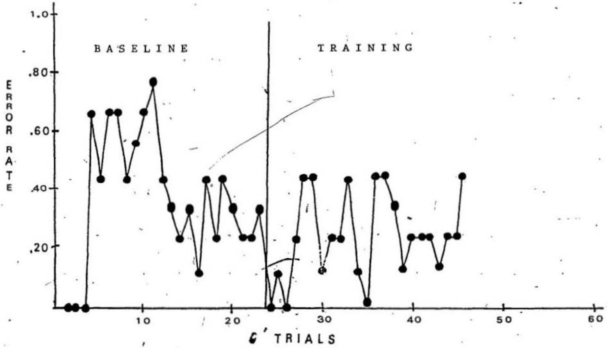

Fig. 5 Error rate on A-non-X stimuli, on the continuous performance task, over trials, for Subject 1.

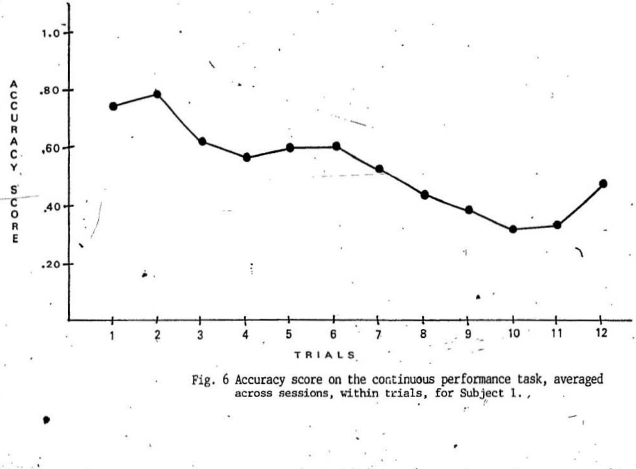

Fig. 6 Accuracy score on the continuous performance task, averaged across sessions, within trials, for Subject 1.

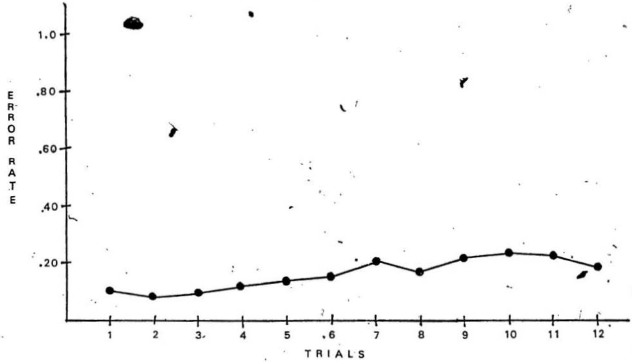

Fig. 7 Aggregate error rate, on the continuous performance task, averaged across sessions, within trials, for Subject 1.

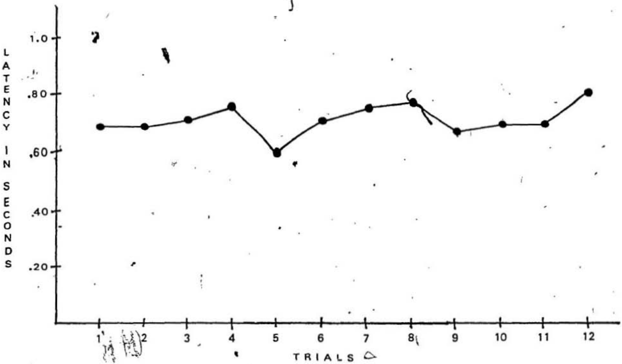

Fig. 8 Latency in seconds, on the continuous performance task, averaged across sessions, within trials for Subject 1.

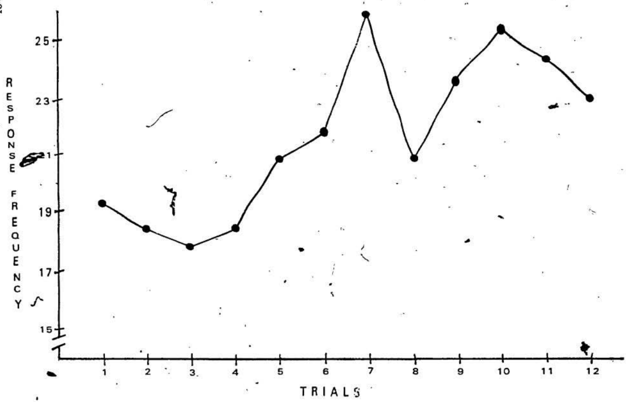

Fig. 9 Response frequency on the continuous performance task, averaged across sessions, within trials, for Subject 1.

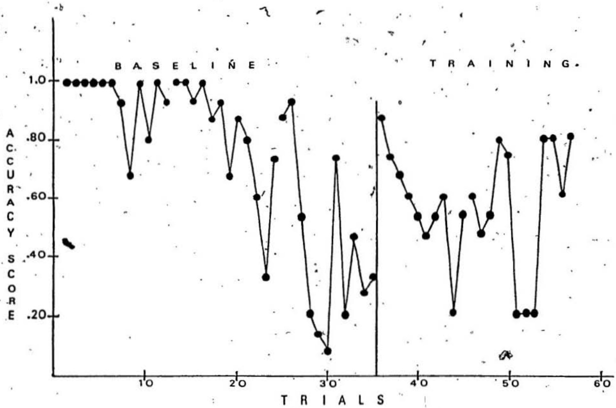

Fig. 10 Accuracy score on the continuous performance task, over trials, for Subject 2.

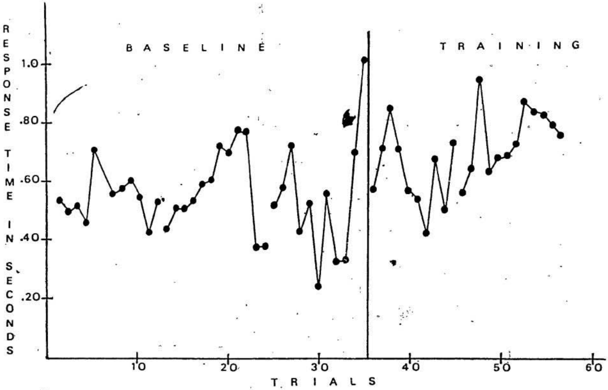

Fig. 11 Latency on the continuous performance task, over trials, for Subject 2.

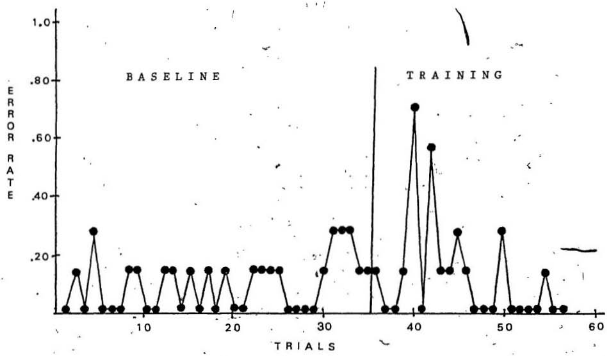

Fig. 12 Error rate on Non-A-X stimuli, on the continuous performance task over trials, for Subject 2.

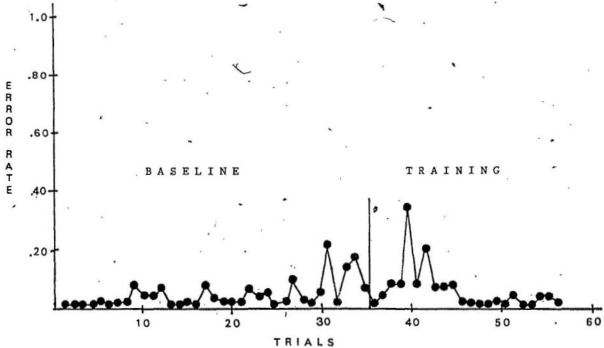

Fig. 13 Error Rate on Random non-target stimuli, on the continuous performance task, over trials, for Subject 2.

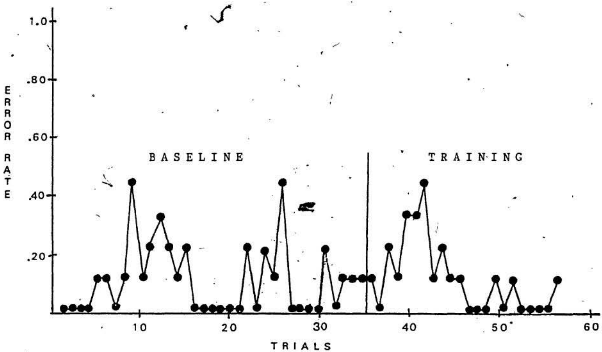

Fig. 14 Error rate on A-non-X stimuli, on the continuous performance task, over trials, for Subject 2.

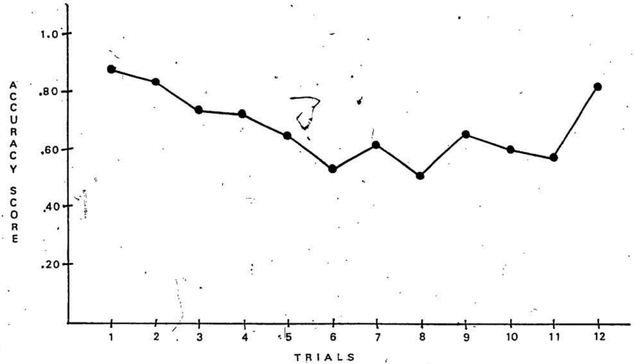

Fig. 15 Accuracy score on the continuous performance task, averaged across sessions, within trials, for Subject 2.

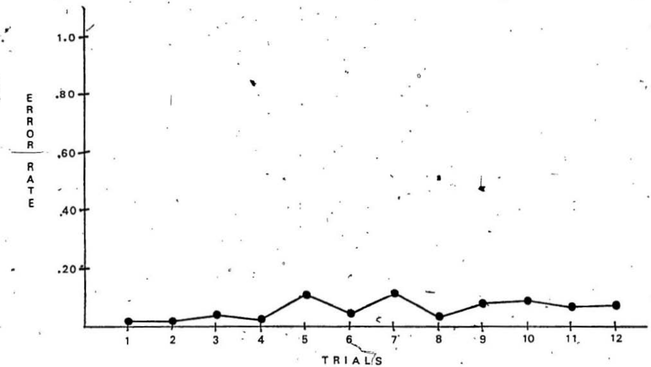

Fig. 16 Aggregate error rate, on the continuous performance task, averaged across sessions, within trials, for Subject 2.

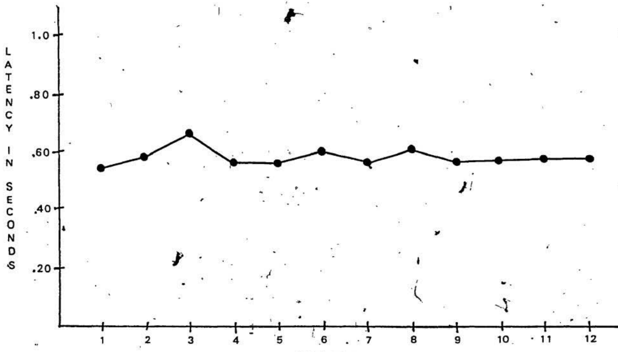

Fig. 17. Latency in seconds, on the continuous performance task, averaged across sessions, within trials for subject 2.

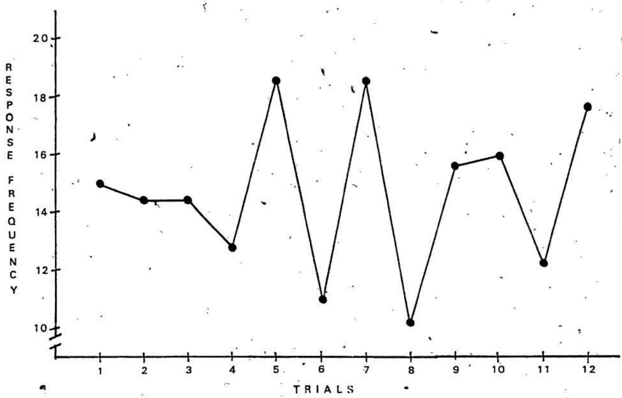

Fig. 18 Response frequency on the continuous performance task, averaged across sessions, within trials, for Subject 2.

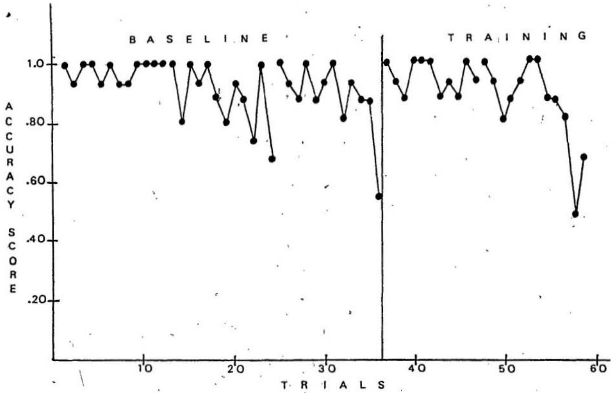

Fig. 19 Accuracy score on the continuous performance task, over trials, for Subject 3.

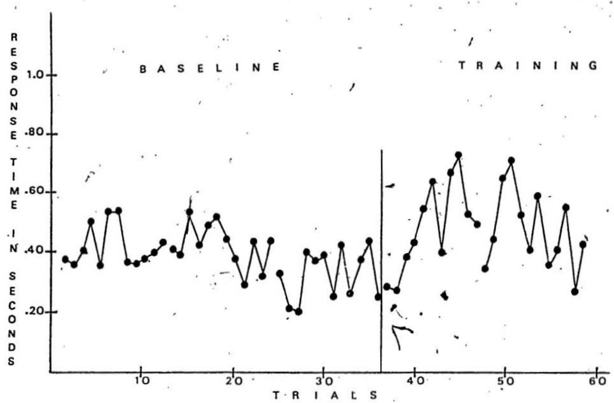

Fig. 20 Latency on the continuous performance task, over trials, for Subject 3.

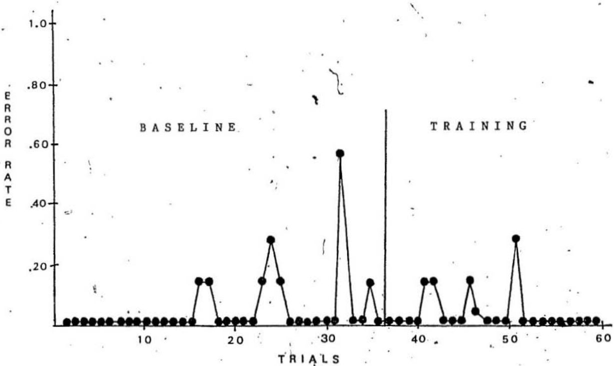

Fig. 21 Error rate on Non-A-X stimuli, on the continuous performance task over trials, for Subject 3.

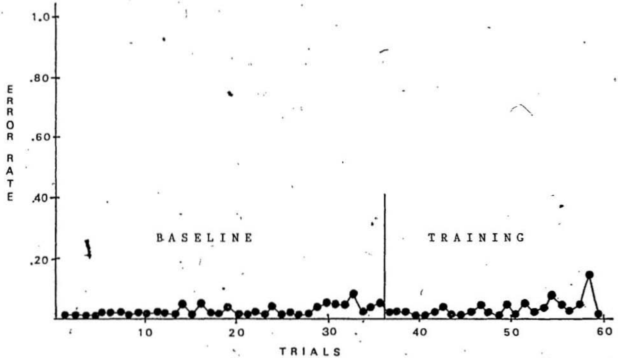

Fig. 22 Error Rate on Random non-target stimuli, on the continuous performance task, over trials, for Subject 3.

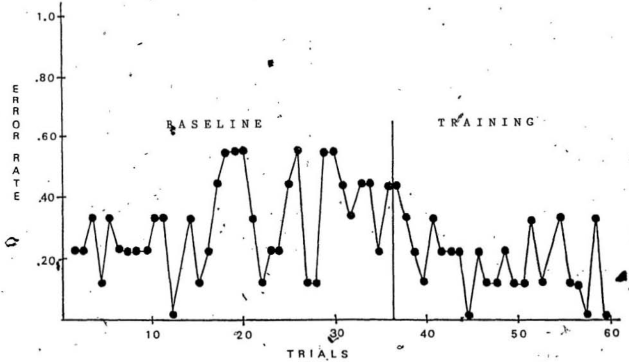

Fig. 23 Error rate on A-non-X stimuli, on the continuous performance task, over trials, for Subject 3.

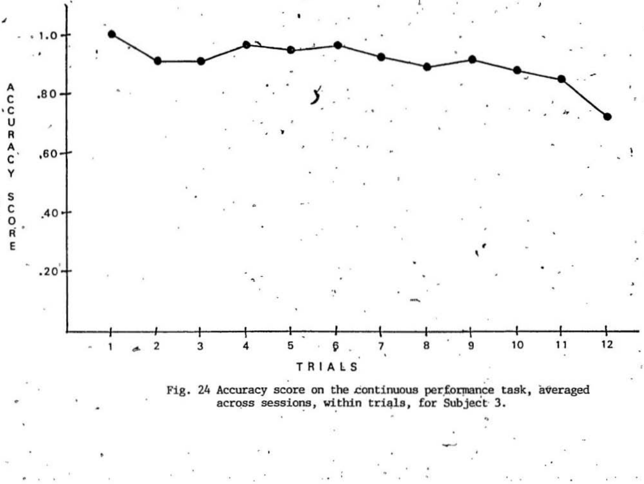

Fig. 24 Accuracy score on the continuous performance task, averaged across sessions, within trials, for Subject 3.

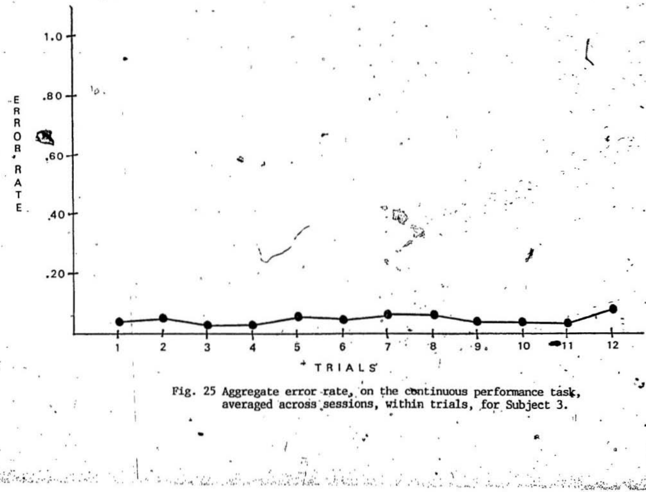

Fig. 25 Aggregate error rate, on the continuous performance task, averaged across sessions, within trials, for Subject 3.

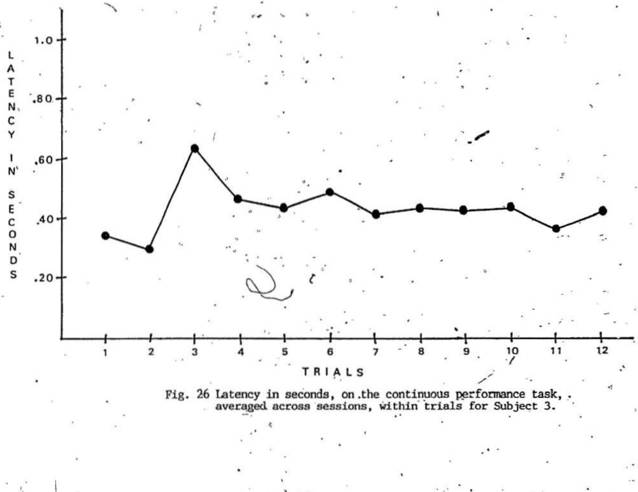

Fig. 26 Latency in seconds, on the continuous performance task, averaged across sessions, within trials for Subject 3.

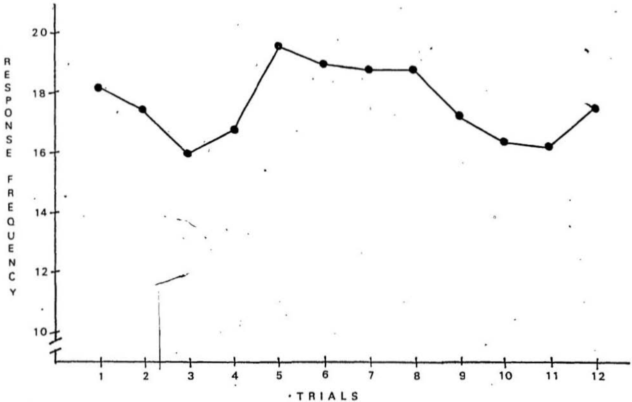

Fig. 27 Response frequency on the continuous performance task, averaged across sessions, within trials, for Subject 3.

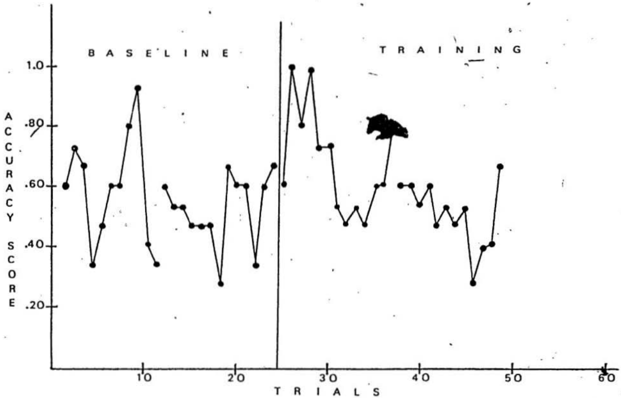

Fig. 28 Accuracy score on the continuous performance task, over trials, for Subject 4.

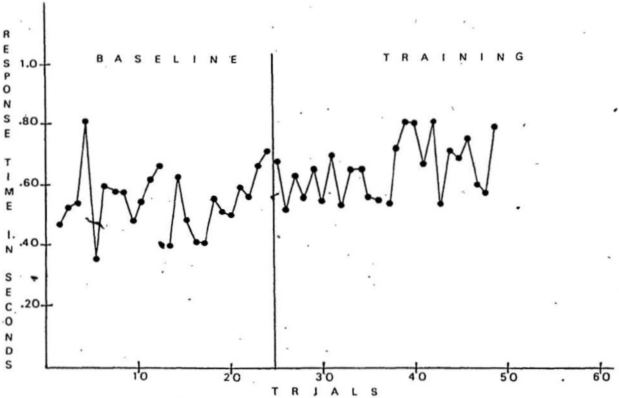

Fig. 29 Latency on the continuous performance task, over trials, for Subject 4.

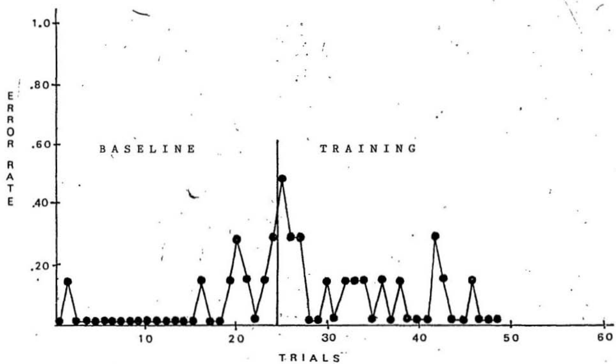

Fig. 30 Error rate on Non-A-X stimuli, on the continuous performance task over trials, for Subject 4.

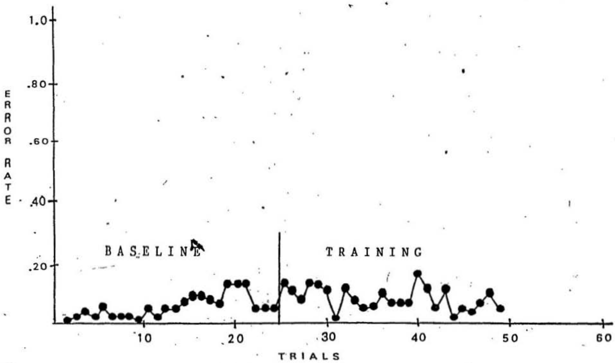

Fig. 31 Error Rate on Random non-target stimuli, on the continuous performance task, over trials, for Subject 4.

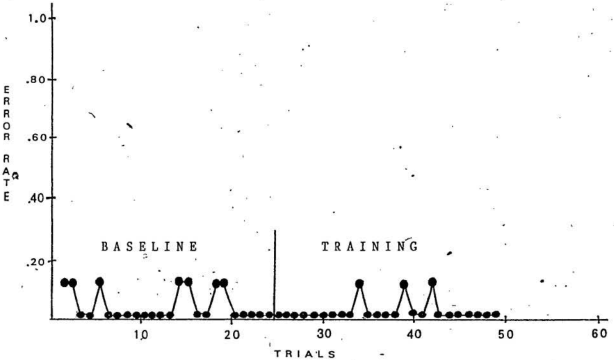

Fig. 32 Error rate on A-non-X stimuli, on the continuous performance task, over trials, for Subject 4.

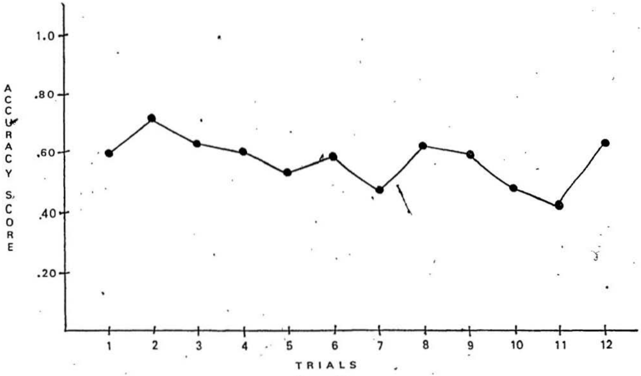

Fig. 33 Accuracy score on the continuous performance task, averaged across sessions, within trials, for Subject 4.

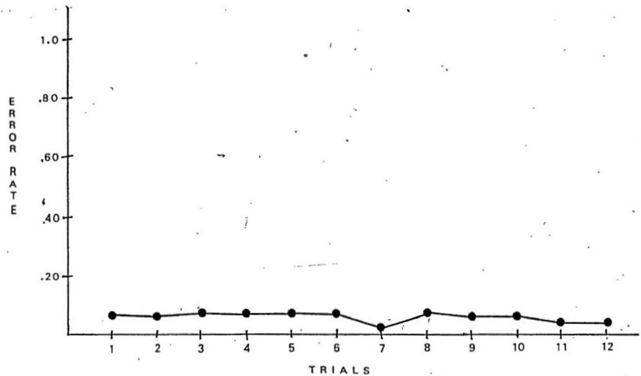

Fig. 34 Aggregate error rate, on the continuous performance task, averaged across sessions, within trials, for Subject 4.

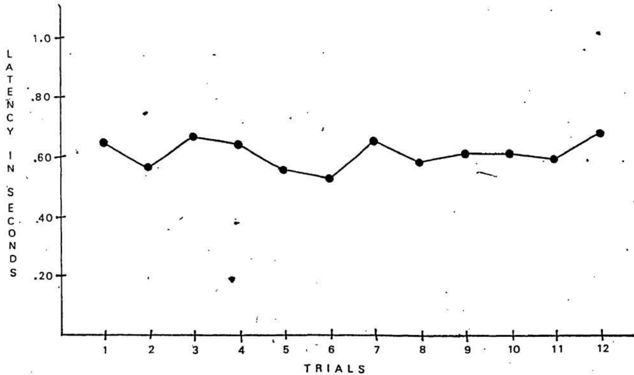

Fig. 35 Latency in seconds, on the continuous performance task, averaged across sessions, within trials for Subject 4.

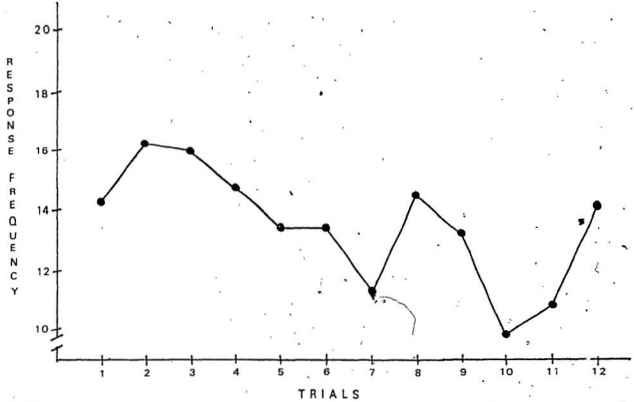

Fig. 36 Response frequency on the continuous performance task, averaged across sessions, within trials, for Subject 4.

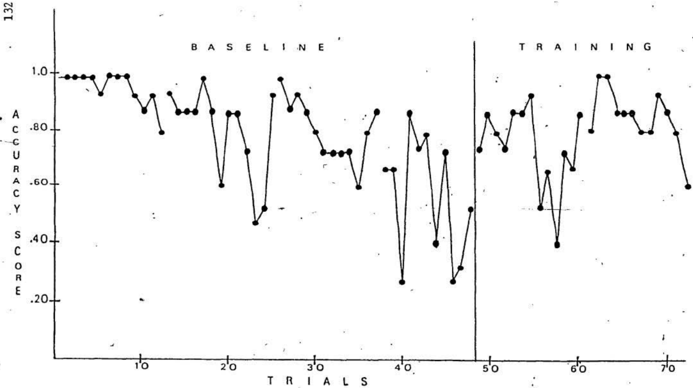

Fig. 37 Accuracy score on the continuous performance task, over trials, for Subject 5.

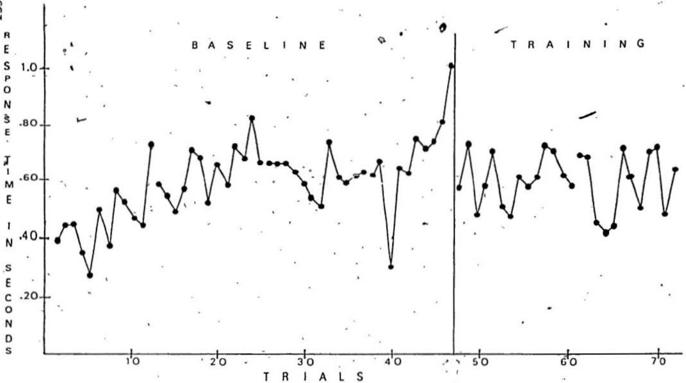

Fig. 38 Latency on the continuous performance task, over trials, for Subject 5.

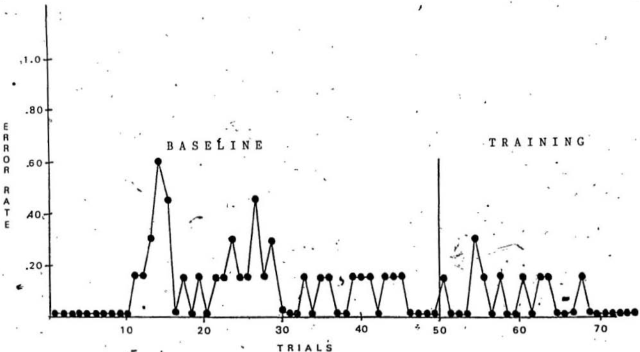

Fig. 39 Error rate on Non-A-X stimuli, on the continuous performance task over trials, for Subject 5.

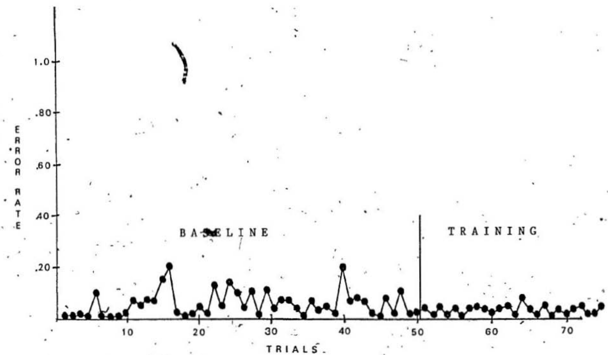

Fig. 40 Error Rate on Random non-target stimuli, on the continuous performance task, over trials, for Subject 5.

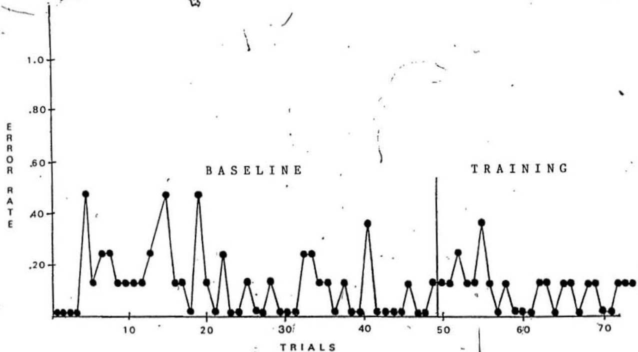

Fig. 41 Error rate on A-non-X stimuli, on the continuous performance task, over trials, for Subject 5.

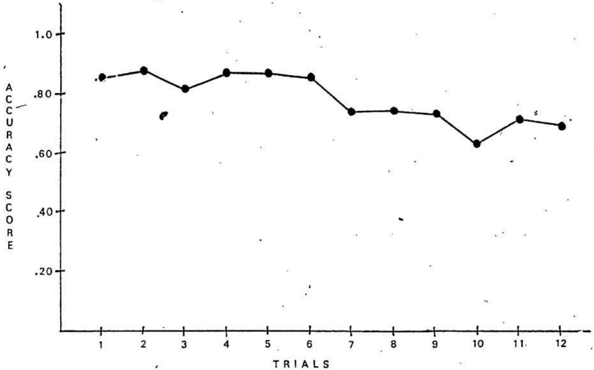

Fig. 42 Accuracy score on the continuous performance task, averaged across sessions, within trials, for Subject 5.

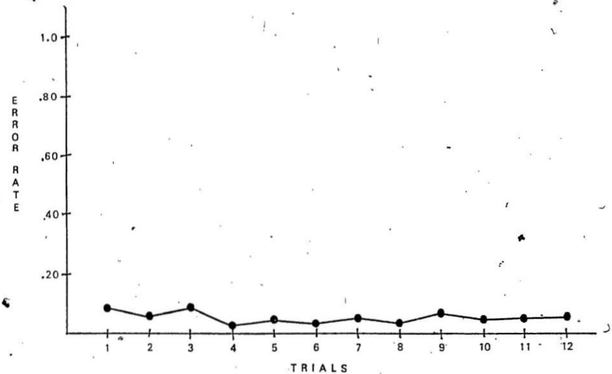

Fig. 43 Aggregate error rate, on the continuous performance task, averaged across sessions, within trials, for Subject 5.

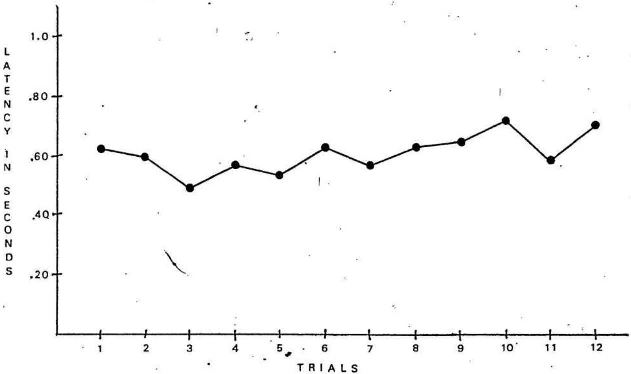

Fig. 44 Latency in seconds, on the continuous performance task, averaged across sessions, within trials, for Subject 5.

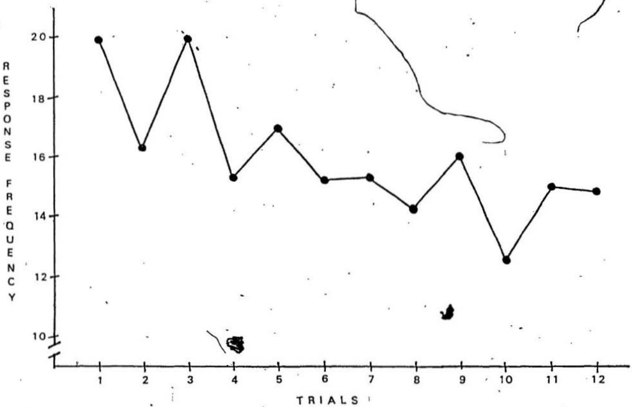

Fig. 45 Response frequency on the continuous performance task, averaged across sessions, within trials, for Subject 5.

Discussion

The results of the present study generally failed to support the present hypothesis that self-instruction will produce significant performance increments on the C.P.T. in hyperactive children. An extremely large number of significance tests were calculated on the time-series data and only a small number of these yielded significant values. An even smaller number of these significant results were in the direction predicted. For several subjects the overall analysis yielded significant results in the predicted direction; i.e., increases in accuracy score. However, these results were eliminated when the analysis on thirds of sessions was calculated. In the overall analysis a majority of the significance tests on the time series data yielded non-significant values. A small number of the significant shifts in trend were in the direction opposite to that predicted by the present hypothesis.

The secondary analysis on thirds of sessions served to control for any effect of recovery between test sessions. The elimination in the analysis on thirds of sessions, of significant effects found in the overall analysis, suggested that it was recovery between sessions which produced the overall effects. This hypothesis is supported by the results of the analysis of the mean within-sessions time-series.

These data showed that four of five subjects exhibited significant decreasing trends in accuracy within a session. Only one subject exhibited a significant increasing trend in accuracy within sessions and there were no significant trends observed for latency. Response frequency within sessions was much more variable, as two subjects exhibited significant increasing trends, two exhibited significant decreasing trends and one showed no significant trend.

The within-session analysis results suggest that time on task and possibly fatigue significantly affected the subjects' ability to detect targets. Of the four subjects exhibiting decreasing trends in accuracy score, only one exhibited an increasing trend in error rate. Although the subjects tended to make fewer responses to targets as the task progressed, they tended not to make more errors. The two subjects for whom response frequency increased while accuracy score decreased within sessions (Subjects 1 and 2) probably became increasingly impulsive with time on task. They were unable to sustain attention and made increasing numbers of responses. Only Subject 1 exhibited an increasing trend in error rate. This result suggests that for this subject the responses became increasingly inaccurate, responding more often to non-targets. For Subject 2 the increases in response frequency were not reflected in the analysis of the error rate time series within sessions.

There were significant decreasing trends in response frequency within sessions exhibited by Subject 3 and Subject 4. This means that these two subjects made fewer responses as the test session progressed. However only Subject 3 exhibited a significant decreasing trend for accuracy score while Subject 4 exhibited a non-significant trend in this measure. This result suggests that Subject 3 was not able to sustain attention to the task, but did not continue responding and did not exhibit an increasing impulsivity as observed in Subjects 1 and 2. Subject 4 did not exhibit the decline in accuracy score observed in the other subjects but showed a significant decreasing trend in response frequency. This result suggests that Subject 4 was able to sustain attention to the task within a session while decreasing the number of responses. Visual inspection of Figures 33 and 36 suggested that for Subject 4 there were decreasing trends in both accuracy score and response frequency although only the trend in response frequency is significant. Accuracy score within sessions did not decline as rapidly as response frequency. With accuracy score relatively stable Subject 4 must have made fewer errors over time within a session. The analysis on the within sessions data failed to demonstrate a siginificant change in error rate.

Subject 5 was the one subject who exhibited a significant decreasing trend in accuracy score but no significant change in error rate or response frequency within sessions. These results indicate that Subject 5 made fewer accurate responses over time but maintained a stable response frequency. The implication of these results is that since response frequency did not decline with accuracy score, there should be a gradual increase in error rate as the subject makes more responses to non-targets. No significant trends were observed in the error rate data within sessions. A similar situation was described above for Subject 2 in which a significant increasing trend was observed for response frequency and a significant decreasing trend for accuracy score but no significant change was found in error rate. The data for Subject 4 yielded a similar set of circumstances. Subject 4 maintained a relatively stable accuracy score while exhibiting a significant decreasing trend in response frequency and no significant change in error rate. These are situations where significant changes in error rate might be expected. The changes in error rate over time were obviously not of sufficient magnitude to reach significance despite significant changes in one or both of the other measures of performance on the C.P.T..

Shifts in error rate within sessions may be masked by the considerable variation observed in the error rate time series. Since it was possible to make only fifteen accurate responses within a session, a single response has a greater impact on accuracy score than on error rate for which it is possible to make many responses. A greater magnitude of change is required in order to yield a significant trend in the error rate time series than in the accuracy score series. This factor may partially account for the absence of significant change in error rate observed in most subjects in the present study. The large random variations found in error rate time series for most subjects necessitate large changes over time to yield a significant trend. Subject 1 obtained a significant increasing trend in error rate within sessions and Figure 7 shows the time series for that measure. Visual inspection of this figure in comparison with the error rate time series of other subjects suggested that Subject 1 demonstrated the least random variation and that her increase is much closer to a linear trend than any of the other subjects (See Figures 16, 25, 34, 43).

No significant differences were observed on mean latency for error versus correct trials or on mean latency on the first letter following an error versus a correct trial. The differences in latency between error trials and the first letter following an error and between correct trials and the first letter following a correct trial also failed to reach significance. These results suggest that the present subjects did not establish a consistent pattern with respect to response time. A consistent latency was maintained regardless of stimulus. The subjects were also basically unaffected, with respect to latency, by making errors or correct responses, and by the intervention. No significant changes in latency were found in the analysis of the mean within session time series. Although there was evidence of changes over time for other performance measures these changes were not associated with shifts in latency.

Significant differences in error rate on the first letter following an error versus a correct response were observed for four of five subjects. For Subjects 5, 3, and 1 a significantly greater error rate was observed on the first letterfollowing an error. Subject 4 exhibited a significantly greater error rate on the first letter following a correct response. This result suggests that for three subjects there is a greater probability of one error being followed by another than there is of a correct response being followed by an error. This result may reflect a tendency, in these subjects, of responding randomly, in bursts, consisting of responses to several non-target stimuli. Such a pattern might reflect the impulsivity which some suggest is characteristic of hyperactive children.

The one subject who obtained a higher error rate on the first letter following a correct response requires a different explanation. The data for this subject indicate that following a correct response there was an increased probability of another response being made to a non-target stimulus. The correct detection of a target may produce a response set such that the ability to inhibit responding is diminished following a correct response. This notion is consistent with the findings of Douglas (1980) regarding the effects of reinforcement and arousal on the performance of hyperactive children. Firestone and Douglas (1975) used a delayed reaction time task to examine the responses of a group of hyperactive children and a normal control group to verbal rewards for rapid responses on the task. Conditions included reward-only, punishment-only and reward plus punishment. In the reward condition the hyperactive subjects made significantly more impulsive responses than the controls and this was the only condition where significant differences in performance were found. The reward condition also led to the greatest increase in arousal for both the hyperactive and control group. Firestone and Douglas suggested that the increase in impulsive responses in the reward condition observed in the hyperactive group may have been associated with the changes in arousal observed under that condition. Both the control and hyperactive children demonstrated the increases in arousal but only the performance of the hyperactive children was adversely affected by it. It was argued that the control children were able to modulate arousal to inhibit impulsive responses while the hyperactive children were unable to do this.

In a subsequent review of studies of arousal patterns in hyperactive children Douglas (1980) argued that more recent evidence indicated that these children are not chronically under- or over-aroused. Rather, they seem unable to modulate arousal to meet the demands of specific situations.

All subjects in the present study were reinforced for correct detections during practise sessions with the C.P.T. prior to the actual testing. In addition the self-instructional training included a strong emphasis on detecting targets and on self-reinforcement for accuracy. The subject from the present study who exhibited an increase in error rate following a correct detection may have experienced the arousal-related disinhibition described by Douglas. The increase in arousal and subsequent disinhibition may have been elicited by the correct target detections which had been previously positively reinforced.

Only two subjects obtained significant differences in error rate among the three types of non-target stimuli. For both Subject 3 and Subject 1 the A-Non-X stimuli elicited the highest error rate and represented the main source of variation in the analysis. The differences between the Non-A-X and random error rates were non-significant. This finding suggests that these two subjects responded more often to non-target letters preceded by the letter "A" than to other non-target letters. This may represent a strategy of using the letter "A" as a warning signal to prepare for an upcoming target. This is a reasonable strategy and would increase the probability of detecting targets with only a limited increase in error rate. It is an effective strategy which the remaining subjects did not adopt. For these subjects error responses were spread relatively evenly among the three classes of non-target stimuli. The failure of these subjects to adopt this strategy may reflect the difficulty of hyperactive children in thinking reflectively and problem solving (Douglas, 1980).

The failure of the self-instructional training to facilitate subject performance requires explanation. The training focused on sustaining the subjects' attention to the task by making self-statements about the behavioural task requirements. This would include looking at the screen, looking for targets, responding only to the targets and self-reinforcement for task performance. In the present study no observations of subject behaviour were made and it is impossible to determine if the self-instructions produced changes in these behaviours. Some studies using the C.P.T. with hyperactive children obtained frequency counts of gross movements of the subject's head and eyes away from the C.P.T.. These frequency counts, along with C.P.T. performance, differentiated hyperactive from normal control groups in one study (Sykes, Douglas and Morgenstern, 1973).

Sykes, Douglas, Weiss and Minde (1972), using the C.P.T., demonstrated that the stimulant, methylphenidate, in comparison to a placebo, produced significant decreases in non-observing responses. The active drug also produced significant improvements in subject performance on the C.P.T.. Obviously the frequency of non-observing responses is an important component of performance on this task. A more detailed analysis would have been made of the effect of self-instructional training had data regarding non-observing responses been obtained in the present study. Had the intervention produced no change in accuracy, error rate and non-observing responses, the negative results might be explained as a failure of the intervention to effect the necessary behavioural change. However, significant decreases in non-observing responses associated with no change in accuracy or error rate would require a different explanation. Such a result would suggest that despite eliciting the behaviours necessary for improved performance, this was not sufficient to produce a significant performance increment.

A factor which made the assessment of the effect of the self-instructions on sustained attention more difficult was the design of the experiment. The use of repeated measures and within-subjects analysis meant that while the intervention was aimed at improving the subjects' performance on the C.P.T. there were other factors acting to degrade performance. Habituation is one phenomenon which affects responses to stimulation over time. Habituation refers to the waning of the orienting response after repeated presentations of a neutral stimulus (Kling, 1971). The pattern of changes in responding during habituation is best described by a negatively accelerating curve as the reaction to the stimulus decreases with successive presentations. An immediate response recovery can be produced in habituation by the introduction of a different stimulus or alteration of the pattern of the original stimulus. This immediate response recovery associated with novel stimulation characterizes habituation and allows it to be distinguished from response decrements associated with fatigue and sensory adaptation. Response decrements associated with either of these factors would not show immediate recovery with the introduction of a novel stimulus. It has been suggested that the effects of habituation are both short- and long-term. For example, Kling (1971, p. 591) cited a study by Kling, Chase and Graham in which habituation in responding to repeated auditory stimulation in human infants was observed. In the study response decrements following repeated stimulation were observed over a twenty-four hour interval suggesting that habituation effects can persist over at least one day.

It seems unlikely that the decline in accuracy score observed within sessions in the present study would be caused by habituation to the task stimuli. As described above, habituation refers to the waning of responses to a neutral stimulus. The subjects in the present study were reinforced, prior to the actual testing, for responding to the targets. The target stimuli, in this case, were not neutral but conditioned stimuli. Although the pattern of presentation of stimuli in the present C.P.T. was fixed, the targets were placed randomly within the series of 100 stimuli and the non-target letters were selected randomly from among twelve letters of the alphabet. Habituation is not likely to be a strong factor when there is such variation in the configuration of the stimuli. Some may suggest that although the task characteristics are not likely to produce habituation, it has not been demonstrated that hyperactive children do not habituate more easily or quickly than normal children. This question cannot be answered using the present data and may be the subject of future research with hyperactive children.

Another factor which produces response decrements to stimuli presented repeatedly is fatigue. Fatigue is defined as a reduction in efficiency of an organ or muscle following prolonged activity. Response decrements caused by fatigue require rest or significant changes in a major stimulus parameter to produce recovery. Recovery from fatigue may be associated with changes in the intensity or the inter-stimulus interval of stimuli and occurs gradually following the change in the stimulus parameter.

Douglas (1980) has argued that on simple, repetitive tasks the performance of hyperactive children deteriorated over time or with repeated exposure to the task. The present data reflect deterioration over time in accuracy score for four subjects. This result may simply be consistent with the findings cited by Douglas (1980) which are based on differences between hyperactive and normal subjects. As there is no control group to which to compare the performance of the present subjects it is impossible to determine whether the within-sessions decline in accuracy score is a typical response of hyperactive children to a simple, repetitive task.

An alternative explanation is that the decline in accuracy score within sessions is an effect of fatigue. The present results obtained from analyses between experimental phases (baseline versus intervention) tend to support this notion. The overall analysis, for some subjects, yielded evidence of increasing trends in accuracy score in the intervention phase of the study. These results were not obtained when the sessions were divided into thirds and the intervention phase compared to the baseline phases within thirds of sessions. The division of the sessions into thirds eliminated the effect of change within sessions and allowed comparisons between baseline and intervention phases to be made with any effect of recovery between sessions removed. The elimination in the analysis of thirds of a session of significant results obtained in the overall analysis suggests that recovery between sessions was a significant factor in producing the significant overall results. This evidence when combined with the within-sessions changes in accuracy score suggests that time-on-task led to significant decreases in accuracy score and that there was recovery in performance between sessions. The build-up of fatigue within sessions is the most likely cause of such a pattern of changes in performance.

Another factor which must be examined in assessing the present negative results is the potency of the treatment used. Although limited treatments have produced positive performance changes in similar subjects in the past (eg. Palkes, Stewart and Kahana, 1968) the changes were measured using techniques which made less stringent demands for sustained attention such as Porteus Mazes. In addition, none of the studies required subjects to sustain attention over extended periods of time as in the present study.

Many more recent studies of the effects of cognitive-behavioural techniques have employed much more extensive treatment programs than used in the present study. In a study of two different types of cognitive-behaviour modification Kendall and Wilcox (1980) used six sessions of training and assessed the effects of the training by performance on the Matching Familiar Figures Test, Porteus Mazes, a subject self-report measure and rating scales of impulsivity, hyperactivity and therapist perceptions of improvement. No indication was given of the length of treatment sessions.

A study of cognitive-behaviour modification aimed at developing self-control in aggressive boys was carried out by Camp, Blom, Hebert and VanDoorninck (1977). In this case treatment was carried out in daily, thirty-minute sessions in a school setting over a period of six weeks. Dependent measures included performance subtests from the WISC-R, reading subtest from the Wide Range Achievement Test, auditory reception test from the Illinois Test of Psycholinguistic Abilities and the Matching Familiar Figures Test. Teacher ratings of subject behaviour were also obtained. Parrish and Erickson (1980)compared the effects of three cognitive strategies in modifying the cognitive style of impulsive, third-grade children. Training was provided in six, thirty- minute sessions and training effects were assessed using scores from the Matching Familiar Figures Test and teacher ratings of subject behaviour. In each of the studies discussed above the treatment procedure produced improvement on some or all of the dependent measures.

By comparison the present study utilized an extremely limited, brief training procedure and evaluated it using an extremely demanding performance task. It is a strong possiblity that the present training was insufficient to produce changes on a task which makes such strong demands for sustained attention. The content of the present training may be adequate but significantly longer training periods or more sessions, separate from the test sessions is probably required in order to produce changes on such a demanding task. The use of the C.P.T. repeatedly in sessions of up to fifty minutes may also require modification. In a within-subjects design single administrations of the C.P.T. in several separate sessions may be one solution. A between- subjects design with control groups would eliminate the problem of repeated measures entirely. The inclusion of a C.P.T. measure in a broader study of cognitive behavioural treatments of hyperactive children would be most informative. It would allow an assessment of the impact of the treatment on sustained attention. It would also permit an examination of the interaction between sustained attention and other behavioural and social variables such as teacher ratings of subject behaviour and social problem solving.

The present study failed to determine whether self-instructional training produced measurable changes in sustained attention. The design limitations of the present study may have contributed to this result and the evidence clearly does not support the present hypothesis. Future studies of cognitive treatment procedures would be strengthened by the inclusion of performance measures such as the C.P.T.. Measures such as these make demands on sustained attention not usually made by measures typically used in such studies.

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Appendix A

Medical History Questionnaire

Child's Name...

Parent's Name..

1. How long was your child hospitalized following his/her birth?

   ....

2. Was your child admitted to an intensive care unit nursery following his/her birth?

   ....

3. If so, how long was your in the nursery?

   ....

4. Was your child placed in an incubator?

   ....

5. Has your child ever had seizures, convulsions or fits?

   ....

6. If so, when was the last seizure, convulsion or fit?

   ....

7. Has your child had any serious illnesses besides the common childhood diseases (colds, flu, mumps, chicken pox, measles)?

   ....

8. If so, what illnesses has your child had?

1.............................

2.............................

3.............................

4.............................

5.............................

9. Has your child ever been hospitalized except at birth?

....

10. If so, for what reason?

....

11. Please list any medications your child is currently taking or has taken within the past three months.

1.............................

2.............................

3.............................

4.............................

5.............................

12. Why was your child first referred to the Diagnostic and Remedial Unit?

....

....

13. Before your child was referred to the Diagnostic and Remedial Unit did you have any other concerns regarding his/her behaviour

....

14. If so, briefly describe these concerns in the space provided.

....

....

....

....

15. Is your child presently under a physicians care?

....

16. If so, for what reason?

....

17. What would you say is your child's major problem?

....

Parent's Questionnaire

Name of Child **Date**

Please answer all questions. Beside *each* item below, indicate the degree of the problem by a check mark (✓)

	Not at all	Just a little	Pretty much	Very much
1. Picks at things (nails, fingers, hair, clothing).				
2. Sassy to grown-ups.				
3. Problems with making or keeping friends.				
4. Excitable, impulsive.				
5. Wants to run things.				
6. Sucks or chews (thumb; clothing; blankets).				
7. Cries easily or often.				
8. Carries a chip on his shoulder.				
9. Daydreams.				
10. Difficulty in learning.				
11. Restless in the "squirmy" sense.				
12. Fearful (of new situations; new people or places; going to school).				
13. Restless, always up and on the go.				
14. Destructive.				
15. Tells lies or stories that aren't true.				
16. Shy.				
17. Gets into more trouble than others same age.				
18. Speaks differently from others same age (baby talk; stuttering; hard to understand).				
19. Denies mistakes or blames others.				
20. Quarrelsome.				
21. Pouts and sulks.				
22. Steals.				
23. Disobedient or obeys but resentfully.				
24. Worries more than others (about being alone; illness or death).				
25. Fails to finish things.				
26. Feelings easily hurt.				
27. Bullies others.				
28. Unable to stop a repetitive activity.				
29. Cruel.				
30. Childish or immature (wants help he shouldn't need; clings; needs constant reassurance).				
31. Distractibility or attention span a problem.				
32. Headaches.				
33. Mood changes quickly and drastically.				
34. Doesn't like or doesn't follow rules or restrictions.				
35. Fights constantly.				
36. Doesn't get along well with brothers or sisters.				
37. Easily frustrated in efforts.				
38. Disturbs other children.				
39. Basically an unhappy child.				
40. Problems with eating (poor appetite; up between bites).				
41. Stomach aches.				
42. Problems with sleep (can't fall asleep; up too early; up in the night).				
43. Other aches and pains.				
44. Vomiting or nausea.				
45. Feels cheated in family circle.				
46. Boasts and brags.				
47. Lets self be pushed around.				
48. Bowel problems (frequently loose; irregular habits; constipation).				

Appendix B

Orientation

"You did really well on that game where you had to find the two letters. What I'd like to find out is whether you can do even better. There's some tricks I know about that can really help you to do better in that game. One of the tricks that I find helpful is to talk to myself and tell myself things about what I'm doing. There's a couple of different kinds of things you can tell yourself about what you're doing and if you put them all together they can help you to do a lot better on games like this one. I'd like to teach you some of these tricks and figure out some others with you so that you can do better on this game."

Problem Solving/Task Analysis

"The first thing I want you to do is to imagine that you have a friend who wants to play this game but he has never played it before. But you have played this game a lot and your friend has asked you to give him some hints and ideas to help him play the game and get a good score."

"Let's try to figure out what you have to do. How do you play the game? You have to push the button when the 'X' comes on the screen after the 'A'. Sounds pretty easy to me! Can you think of anything that makes the game hard? The letters don't stay on the screen very long and there's not much time between letters so you have to think pretty fast. What could you tell your friend about that? If he wanted to do well in the game should he look at the floor or the wall? No? Where should he look? Okay, your friend should look at the screen to see the letters. Should your friend watch the screen all the time or just once in a while? So, he should watch the screen all the time if he wants to see all the 'X's' and 'A's'. Should your friend push the button even if he's not sure he saw an 'A' and then an 'X'. No, he should only push the button when he's sure he saw first an 'A' and then an 'X'. It's important to tell your friend that he should tell himself when he's done a good job, pushed the button when the 'X' came up after the 'A'. What could he say? How about 'Hey, I did a really good job there, I got a lot of the target letters!'"

"It looks like there's four things you could tell your friend to help him: 1. He's got to push the button when the 'X' comes up on the screen after the 'A'; 2. He should watch the screen all the time so he doesn't miss any of the 'A's' or 'X's'; 3. He should push the button only when he's sure that he saw an 'X' after an 'A' and no other time; 4. He should tell himself when he did a good job and got a lot of the 'A's' and 'X's'."

"Suppose you had somebody who could stand next to you while you were playing the game who could remind you about those four hints that we gave your friend. He could say 'Don't forget now, push the button when an 'X' comes up after an 'A'' and 'Don't push the button except when you're sure you saw an 'X' after an 'A'' and 'Watch the screen all the time so you don't miss any of the 'A's' or 'X's'' and 'You did a good job, you got a lot of the 'A's' and 'X's''. But if you couldn't have somebody do that for you, what would be the next best thing? You could tell yourself those things once in a while as you played the game."

Modelling

The self statements were made at the beginning and end of a trial of one hundred stimuli. "Now, you watch and listen to me while I play the game for a few minutes. Watch what I do and listen to what I say to myself because I'll want you to try it this way when I'm done. Okay, what do I have to do here. I've got to watch the letters that appear on the screen. I'm looking for an 'A' followed by an 'X'. When I see the 'A' and then the 'X' I've got to push the button. Now, remember push the button only when the 'X' comes after the 'A' and only when I'm sure. Well let's see what happens! (start task) I think I did pretty good! (stop task).

"Do you see what I mean about talking to yourself? I told myself the four things that we decided would be helpful for your friend. Now, I'd like you to try talking to yourself as you play the game. What's the first thing to say to yourself as you play the game? That's right, 'What do I have to do, what's the game?'. The next thing you say is how to play the game: 'I have to watch the screen all the time so I don't miss any letters' and 'Only push the button when you're sure you saw the 'X' after the 'A'. And when you're done you say 'I did a good job, I got most of the letters this time!"

"Let's try now with you playing the game. (administer task) You did really good, you've got a good idea of how to talk to yourself using the hints we thought up. It sounds a little funny at first, to talk to yourself, but it really helps you do better in the game"

Overt rehearsal I

"This time I'd like to see if you can tell me what things you are supposed to tell yourself. Okay, let's play the game again and say your part out loud."